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RESEARCH

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20110039

BREEDING AND SELECTING HASKAP FOR NUTRACEUTICAL AND AGRONOMIC SUITABILITY

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ADF Project Final Report Format

1. Project title and ADF file number.

20110039-Breeding and Selecting Haskap for Nutraceutical and Agronomic Suitability

2. Name of the Principal Investigator and contact information.

Bob Bors, bob.bors@usask.ca, Plant Sciences Dept., 51 Campus Dr. Saskatoon, SK S7N 5A8

3. Name of the collaborators and contact information.

Ellen Sawchuk (tech), James Dawson (grad Student), Rick Sawatzky (tech) Same address as above.

4. Abstract/ Summary: *This must include project objectives, results, and conclusions for use in publications and in the Ministry database. Maximum of 300 words in lay language.*

Over 15,000 haskap seedlings were field evaluated. The best 248 were intensively evaluated in lab tests and additional field studies. The 3 varieties that were released ('Aurora', 'Boreal Blizzard' and 'Boreal Beauty') are fast growing and adaptable to mechanical harvesting and are breakthroughs in fruit quality, low acidity, fruit size and extend the growing season by over a month.

Anthocyanin levels were correlated with flavonoid and phenolic levels. Comparing genotypes, phenolic levels varied by 50%, but anthocyanins and flavonoids varied by as much as 300%. Anthocyanin testing is faster and cheaper than flavonoids or phenolics tests and will be used as the first stage screening for nutraceutical potential in the breeding program. Antioxidant testing in cooperation with Dalhousie University rated our varieties highest in antioxidants compared to other berries and grapes.

The Johanna Harvester used in our program showed excellent adaptability for use with Haskap. Branches did not get damaged and fruit was much less damaged compared to shaking branches by hand. Fruit on branches lower than one foot did not get harvested. Also, the Johanna and other harvesters could handle larger bushes.

Seedlings were intensively screened for plant vigour. Previous generations typically kept the most vigourous 70% at the greenhouse stage. In this project, only the 33% most vigourous were kept.

700 combinations of parents resulted in over 30,000 seedlings and 10,000 seedlings after greenhouse screening for field planting. 80% of the crosses done were amongst advanced selections that could result in new varieties.

Genetic diversity of our program was enhanced by introgressing wild Canadian, new Japanese and highly vigourous germplasm into our breeding program.

Outreach activities included dozens of talks, many workshops, several articles, a few TV shows and by 2014 over 1.8 million hits on our website with "Growing Haskap in Canada" as the most read article.

5. Introduction: *Brief project background and rationale.*

This project used Haskap germplasm bred or gathered during ADF projects 20060140 and 20080042; both of those earlier projects had the same title 'Haskap Breeding and Production'. The first haskap project mostly involved obtaining and evaluating germplasm and making wide crosses between haskap plants from different regions. The second Haskap project emphasized evaluation of our hybrid seedlings and selection for mechanical harvesting characteristics. During that 2nd grant our first varieties became commercialized and we obtained a mechanical harvester for the program the last year of that grant.

This project differed from previous projects by having a mechanical harvester from the start and large numbers of second generation seedlings reaching bearing age. Using improved germplasm as parents the resulting seedlings were of much higher quality so we could select with higher standards. Screening for plant vigour occurred in the greenhouse and fruit size doubled in the best field selections. We also developed protocols for screening haskap for nutraceutical value. With far greater numbers of seedlings and recombination of traits, we were able to select for different harvesting times. Previously, Haskap varieties

available in Canada (Including our 1st varieties) were all early season ripening in Late June or very early July. But this project has selected for varieties that will ripen from mid-July through early August.

Perhaps 30,000 seeds from controlled crosses were germinated and after greenhouse screening about 15,000 were field planted. About 80% of the crosses done were done with a goal of creating new varieties. 20% were done to introgress new germplasm obtained from our native Canadian collection and gathered directly from Japan. The seedling created during this project will insure genetic diversity future breeding activities and future varieties will also result.

This project has generated more information on growing and using haskap. With many workshops talks and articles written we have maintained a close connection to growers who are starting to commercialize this crop. Our website has been a major source of information for growers.

We have also had many meetings with companies and individuals interested in creating value added products. We have provided fruit for various projects and given advice in product development.

Note on the term 'Haskap': Growers of our new varieties will be marketing their fruit under the name 'Haskap' to help set them apart from the many poorer quality cultivars, many of which have commonly been called 'honeyberries', 'sweet berry honeysuckles' or 'blue honeysuckles'. For the purposes of reducing confusion for this report, all Lonicera caerulea plants will be referred to as 'Haskap'.

Why do Research on Haskap?

Haskap, also known as blue honeysuckles or honeyberries, is a new fruit crop for North America. It has been receiving much interest from consumers, farmers, and the press because this fruit:
+Can have a wonderful blueberry/raspberry flavour (best cultivars)
+It is the earliest fruit to ripen (Mid June)
+Has extreme winter hardiness
+High in antioxidants and vitamins
+Can be mechanically harvested
+Few pests and could be grown organically or at least pesticide free on the Prairies
+Strong Interest in Japan to buy the crop from Canada
+Has a natural adaptation to northern climates, so it will be difficult for potential competitors in warmer regions
+There is much interest in food processors, especially those manufacturing dairy products and alcoholic beverages.

Thanks to support from Saskatchewan Agriculture (ADF) and royalties from growers, our Haskap program has grown over the years and is at the forefront of research and breeding of this crop. With our huge wild Canadian collection and large numbers of seedling derived from Russia and Japan we have a very diverse Haskap collection with much potential for use in research and breeding.

6. Methodology: *Include approaches, experimental design, methodology, materials, sites, etc.*

General Breeding Strategy

All breeding activities occurred at the U of SK. Plants were field crossed at the horticulture field, grown in our greenhouse, transplanted to our field plots and later fruit was evaluated on campus. The overall breeding strategy was to make many crosses and evaluate the resulting families to find the best combinations of parents. In future years the best combinations can be done in greater numbers.

As with most fruit breeding programs, high yields, good fruit quality and vigourous plants were of major concern in the selection process. Earlier ADF Haskap projects identified and crossed vigourous selection into breeding lines having good fruit quality. In this project, we increased our standards as to what was considered vigourous.

Evaluation of parents used in breeding became more selective. At the start of this project we had about 1000 plants each of Wild Canada and Hokkaido seedling gathered by Dr. Bors during his sabbatical in 2008/2009. Previously we used bulk pollen from these collections, using as many parents as possible. But by 2013 and 2014 we only used the best 5% of wild haskap and the best 12 plants from the Hokkaido collection in making crosses.

Similarly, we further scrutinized our collection of germplasm obtained from Maxine Thompson's program. We had about 50 clones and had enough seeds to grow out 2000+ seedlings during the previous ADF projects. Previously we used almost all of the clones in breeding based on observations made when visiting her program in Oregon. But we have now had time to judge them under Saskatchewan conditions. The 2000+ seedlings we waited to see what would result. For this project we used the best 5 clones, and the best 20 seedlings as parents in crosses.

Selecting for rare traits

There was also the expectation that interbreeding 2nd generation hybrids would result in recombination for various traits. Tables 1 and 2 list common traits for Russian, Japanese, and Kurile germplasm and what usually results when these types of germplasm are intercrossed. Fortunately, several desirable traits seem to be dominant: productivity, even ripening, strong branches, and mildew resistance. Fruit shape and size were intermediate and likely will have much variability in later generations.

Late blooming and tall plant characteristics seem to be recessive and should emerge in smaller numbers in 3rd generation seedlings. Plant size is easy to measure at any time of the year but bloom time must be evaluated during the first 3 weeks of May. But bloom time is of critical importance in understanding for releasing any new variety of haskap. Plants with compatible pollen must bloom in sync in order to have fruit set. Late bloom is also correlated with late fruit ripening, so identifying late bloomers can lead to season extension. Some years bloom is stretched out and easy to observe differences between varieties. But in springs where warming happens rapidly, bloom time is compressed. Because bloom is more difficult and time critical to assess, our strategy was to evaluate plants for all other characteristics and assess bloom time for the advanced selections the following season.

We also scrutinized the Japanese collections of seedlings and marked the last to bloom plants and used them in breeding. There were only 4 very late blooming Japanese plants and none of these were of excellent quality. It is expected that 2 or 3 more generations might be required to introgress the very late blooming characteristic.

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Table 1. Usual results of intercrossing Russian and Japanese germplasm in the F1 generation. This is based on the most common traits found in Russian and Japanese germplasm in our collection. Exceptions can be found in each group.

		Japanese Traits				
		Late Bloom	Round shaped Fruit	Larger Fruit	Uneven ripening	Fruit holds on strongly
Russian Traits	Early Bloom	Early bloom				
	Cylindrical Shaped Fruit		Long but thicker fruit			
	Smaller Fruit			Intermediate size		
	Even Ripening				Even ripening	
	Fruit Falls off easy					Variable

Table 2. Usual results of intercrossing Kurile with Japanese or Russian germplasm in the F1 generation. While Russian and Japanese germplasm is highly variable, Kurile germplasm originates from one plant gathered from the Kurile islands that open pollinated with others in a Russian collection. Our experience with Kurile germplasm is based on 'Kiev#8' and 'F-1-9-58'.

		Kurile Traits				
		Very Late Bloom	Not productive	Short plants	Strong thick upright branches	Very Highly mildew resistant
Russian or Japanese Traits	Early or late Bloom	Early-Mid season bloom				
	Productive		Productive			
	Tall plants			Short-intermediate plants		
	Thinner branches. Can spreading, upright or weeping				Strong thick upright branches	
	Mildew susceptibility common, variable resistance					Highly mildew resistant

Types of crosses

Crosses fell into the following categories:

a. Main stream breeding: parents chosen for mutually complimentary characteristics.

b. Verification of cross compatibility. Advanced selections that bloom at similar times are intercrossed to see if they could cross pollinate each other if grown together. (Haskap is out-crossing and can't self-pollinate)

c. Introgression of wild germplasm. Wild germplasm gathered from Canada or sent to us from Russian was crossed to germplasm with greater economic potential. Often, wild germplasm was used as male parents with pollen bulked from several superior plants.

Crosses from groups 'A and B' could result in new cultivars while group 'C' crosses may require 2 or more generations before worthwhile cultivars may result.

It is estimated that 75% were main stream crosses, 20% verification crosses and 5% wild introgression crosses.

Haskap is a self-incompatible species so there is no need to remove anthers when making crosses. For field crosses we bag branches or complete plants before flowers open and those bags remain on plants until the ripe fruit is ready to be picked. Pollen is gathered from flowers about to bloom, desiccated and later applied to styles.

Greenhouse Crosses in 2012

In previous years we had attempted greenhouse crossing of haskap with very poor results at temperature in the range of 20 to 25C. But in 2011 we did a few crosses in a greenhouse that had temperatures at 10 to 15C. There was good set on those plants so crosses were done at a larger scale early in 2012. Large mother plants were dug up from the field and placed in large pots during the fall and then placed in the greenhouse in December so that they would flower in January. We also placed greenhouse grown seedlings (vigour hybrids) in the cooler in the fall so that they could be brought out before Christmas and they too would flower. The greenhouse thermostat was set to 10C night and 12C days. This was thought to be closer to spring temperatures in the field when Haskap is in full bloom.

Our crosses consisted of 89 different combinations of parents done in January, February and March of 2012. This was the first year that we were able to get relatively good fruit set doing crosses in the greenhouse. However, set was not as good as field crosses. A rough estimate could be that greenhouse crossing is about 25% as efficient as field crossing. One explanation is that the field dug plants are more stressed and so don't set as well. While greenhouse temperatures tried to somewhat mimic field conditions, actual night temperatures in the field when Haskap blooms are often -5 to +5C. But to allow a greenhouse to get that cold at night during winter could cause pipes to freeze. With lower efficiency and high greenhouse rental costs we chose not to do greenhouse crosses in 2013 nor 2014.

Field Crosses: 2012, 2013, 2014

The general strategy was to make many small families of 50 to 150 plants per combination. Not all combinations produced seeds as there can be pollen incompatibility. Especially with wild crosses, some combinations resulted in just a few seeds. A listing of the combinations appears in Appendix A. There were 306 combinations of parents in 2012, 280 in 2013, and 152 in 2014.

Figure 1. Haskap plants bagged during cross-pollination. Test crosses for cross pollination and also introgression of wild germplasm often only require a few berries so only a few branches are bagged. When larger numbers of seeds are needed, whole plants are often bagged.

Greenhouse seedling selection

Seeds are germinated in our greenhouse starting December. By February or March the plants are well rooted in their plug trays. Slower growing or spindly seedlings are discarded at a rate of 40 to 50%. The most vigourous seedlings (about 25%) are transplanted into much larger containers (see figure 2). At the time of field planting more plants are discarded when showing low vigour, poor root systems or diseases. During the 3 years of this project perhaps 40,000 seeds were germinated but only 20,000 seedlings were field planted.

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Figure 2. Greenhouse screening for plant vigour. Seeds from crosses are germinated in plug flats show much variability (top); weaker and smaller seedlings are discarded (middle) and larger healthier seedlings are transplanted into larger flats (bottom). The larger Styrofoam flat hold 3 to 5 times more soil, allowing plants to get 3 to 5 times larger before planting in the field. It is estimated that seedlings screened in this way will come into production a year or so earlier, thus speeding up the breeding cycle.

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Field Planting & Selection

In the breeding fields, haskap plants are spaced at a high density of 3 or 4 plants per meter. (This is about 5x denser than spaces used by most growers). After planting, an additional 3 or 4 years are required for the plants to grow large enough to evaluate.

Field selecting involved judging plants for high productivity, good flavour, large size berries, and suitability for mechanized harvesting. Superior plants are tagged in the field and fruits are gathered from the best to be evaluated in the lab. Fruits are photographed for a record of berry shape. (Haskap have so many shapes that they are hard to describe with words.) Berries with smooth skin and oval shapes are more desirable that bumpy, cylindrical or points or pear shapes. Following successful lab reports, advanced selections are observed in more detail about time of bloom, harvest time, disease resistance, etc. More fruit testing is done the next years. Field notes are taken about unusual characteristics particularly if it could impact commercialization. For example, berries that holds onto stems or leaves after being shaken off are very rare and undesirable. A plant with such a characteristic might be kept for breeding if it has some other rare but desirable trait such as very large but firm berries.

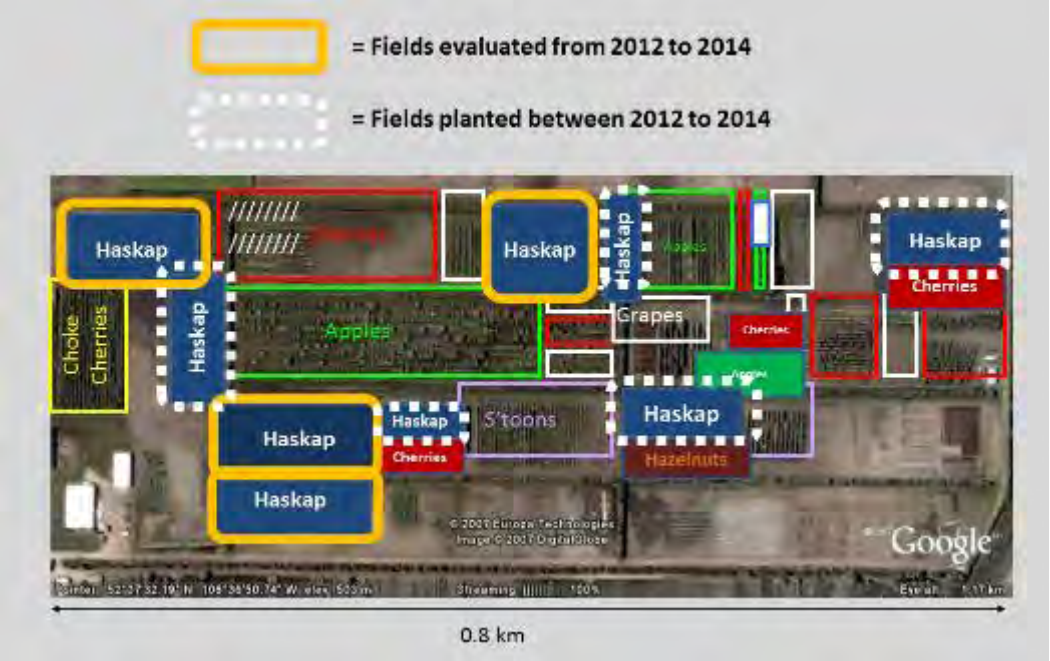

Figure 3. Haskap fields that were evaluated or planted from 2012 to 2014.

Lab Tests and selections

Lab tests are done on frozen fruit stored in our -40C freezer. Fruit are weighed and measured for length, width and depth. Soluble solids, total acidity and pH are also measured.

Notes are also taken on flavour of the fruit that had been frozen. While Bob Bors was mostly made notes on the flavour in the field, Technician Ellen Sawchuk rated them when frozen on a 5 point scale where 1 was bad and 5 excellent. Special notes were made of unusual flavours; good or bad. In most cases flavour notes were fairly consistent between Bob and Ellen, but it was recognized that firmness and berry texture was best judged when fruit was raw.

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Nutraceutical screening

Fruit Samples and extraction

During 2012, the protocols described below were being adapted by James Dawson as part of his PhD thesis. These protocols were put into use during late fall and early winter for the advanced selections harvested in 2013 and 2014. Fruit of advanced selections and control varieties were handpicked, placed in 200ml containers and frozen in a -40°C freezer until screened for nutraceutical content. 50 g of frozen fruit was blended with 200mL methanol at top speed in a tabletop blender. The extract was then filtered through 6 layers of cheese cloth to remove particulate matter.

Total Phenolic Content by Folin-Ciocalteu

The method was modified from that described by Rupasinghe et al 2012. 200µL of fruit extract was combined was mixed with 1mL 0.2 N Folin-Ciocalteu reagent in a plastic vial. After 5 min, 800µL of 7.5% sodium carbonate solution was added. The mixture was left in the dark at room temperature for 2 hours. The absorbance of the resulting mixture was read at 760nm on a UV/vis spectrophotometer. Total phenolic acid was calculated using a standard curve of gallic acid.

Total Flavonoid Content by Aluminum Chloride Method

The method was run as described by (Marinova et al 2005). 1 mL of fruit extract was combined with 4mL of distilled water and 0.3mL of 5% $NaNO_2$. After 5 mins, 0.3 mL of 10% $AlCl_3$ was added; one min later 2mL of 1M NaOH was added. The total volume was then made to 10mL. The absorbance of the resulting mixture was read at 510nm on a UV/vis spectrophotometer. Total flavonoid was calculated using a standard curve derived from rutin.

Total Anthocyanin Content

The method was modified by that described by Abdel-Aal and Hucl 1999. Briefly 1 mL of fruit extract was added to 4mL of acidified methanol (HCl, pH 1), and absorbance was read at 535nm on a UV/vis spectrophotometer. Total anthocyanin was calculated from a curve made from cyanidine 3 glucoside.

7. Research accomplishments: *(Describe progress towards meeting objectives. Please use revised objectives if Ministry-approved revisions have been made to original objectives.)*

Objectives	Progress
1) Evaluate ~15,000 Haskap seedlings for agronomic traits and identify the best ones for commercial production	**During the 2012-2014 growing seasons an estimated 15,000 seedlings came into full production for the first time. Initial evaluation and selection were done in the field by a variety of fruit program employees. Plants were selected based on extraordinary flavour profile, growth habit of the plant and size and shape of the berry. Coloured flags were used by each employee and each employee had a unique colour. Rows upon rows of Haskap were evaluated in this manner and approximately 150 selections were made. Some selections were ones from the 2012 season that were re-evaluated and still marked as promising. 2012 selections were also evaluated for time of flowering. This was done in an attempt to group the selections based on pollination timing.** **Lab evaluations were later conducted to measure weight, sugar level and acidity. The selections were grouped into commercial selections, backyard gardener selection and "rejects" that need additional evaluation.**

2) New cultivars released	**'Aurora' was released to propagators in the fall of 2012. This variety has very low acid and pollinates well with our previous varieties. It also has larger berry size than 'Tundra' and the 'Indigo' series** **'Boreal Blizzard' and 'Boreal Beauty' were released to propagators in 2014. PBR applications have been filed and trials established. These varieties are major breakthroughs. Not only do they ripen later in the growing season, but they have berries twice as large as any cultivars currently on the market.**
3) Previous cultivars received full PBR certification	**'Tundra' and 'Borealis' trials were inspected by the PBR office and became fully certified.**
4) To measure nutraceutical differences between *Lonicera caerulea* subspecies and if hybrids between them are superior and incorporate this information into our breeding strategy.	**Full analysis of specific subspecies was done by graduate student James Dawson as part of his PhD Thesis. We cannot include that analysis as he needs to publish it in scientific journals. However, this report gives his analysis of our advanced selections, which are hybrids between different subspecies.**
5) Techniques for measuring nutraceuticals were investigated	**In addition to HPLC investigations (which are expensive and time consuming) 3 bench top methods were investigated to judge general levels of Anthocyanins, Flavonoids and Phenolics. The three types of nutraceuticals were highly correlated to each other. The anthocyanin test is the easiest to do and is the technique we will be using in the future for rapid screening.**
6) Advanced selections were rated for nutraceutical value	**Advanced selections of 2013 and 2014 were analysed for Anthocyanins, Flavonoids and Phenolics. Superior parents for future breeding were identified. Understanding variability within our best selections will help in the planning of future breeding.**
7) To observe effects of mechanical harvesting of Haskap bushes and investigate genetic and cultural solutions for any problems identified. This will include determining workable and optimal canopy structures	**The early summer of 2013 produced the largest Haskap crop that we have ever harvested at the U of S. We are able to mechanically harvest the largest block of Haskap that is planted in the U of S Hort Research plots. Once we finish running the harvester through a row we are able to walk down the row and see what plants harvest the best and in turn what growth habit is the most conducive. We have noticed that the lower branches (bushes that have a low sprawling growth habit) do not harvest well. The harvester is not able to get low enough to get the fruit off of those branches. This has led us to try different pruning methods on these types of plants. We have tried removing all of the branches except for the upright ones, removing just the low growing branches (ones that are not tall enough to reach the harvester) and simply thinning the plant. All of this was done in the late summer of 2013. We will be monitoring the pruned plants during the 2014 growing season to see what kind of new growth these plants produce. We are hoping to develop a pruning technique that would force the plants to grow in a way that is acceptable for mechanical harvesting.** **We are also taking note of the berries as they are harvested. Some berries seem to have a bit of a thicker skin and can survive the bashing the harvester gives the berries.**
8) New Germplasm from Russia, Japan and Canada analysed for use as parents in breeding	**Plants were evaluated and tagged in the field and used in crosses. Some Russian germplasm was found superior for plant vigour, Japanese germplasm for fruit size and late bloom, and Canadian germplasm for adaptability and upright plant structure.**

9) Establish hybrid seedlings in the field for future selection	**Controlled crosses were done each year generations resulting in perhaps 30,000 seedlings which were greenhouse screened down to about 15,000 seedlings and then planted in the field. Seeds resulting from crosses done in 2011 (previous ADF project) were germinated and planted in 2012. Seeds from crosses done in 2014 were germinated but will be planted in 2015.**
10) Cooperation with companies developing Haskap products	**Now that haskap growers are coming into production, there was less intense demand from us for fruit samples to experiment with. We did give out many samples to potential growers and processors, and lent advice to several processors. However, we exceeded the original goal by doing our own investigations into combining haskap with other ingredients and using Haskap as a food dye.**

8. Discussion: *Provide discussion necessary to the full understanding of the results. Where applicable, results should be discussed in the context of existing knowledge and relevant literature. Detail any major concerns or project setbacks.*

Evaluating Haskap seedlings

In 2012 only 27 advanced selections were intensively scrutinized in lab tests. In 2013 two additional fields came into production and nutraceutical screening tests had been adopted so 140 plants were tested as advanced selections. In 2014, we began narrowing down the list of advanced selections and adding a few move, resulting in 81 advanced selections. Below are population distribution graphs that show the changing demographics for 3 important berry traits over the 3 years of this project (Figures 4, 5, 6).

Fruit Size Fruit size has increased tremendously in our breeding program (figure 4). In our previous trial of 17 Russian varieties, the largest ones were only 1.05 grams (Bors et al, 2012). Our first varieties released in 2007 have produced fruit in the range of 1.25 to 1.5g/berry over the years. Fifteen Recent releases from Russia and Poland have ranged from 1.0 to 1.8g/berry with 1.4 being the average (http://in-vitro.pl/oferta.php?m0=3&jez=ang&p=16) , Malodobry, 2010; Ochimian, 2010). However, three of those reported varieties that are in our collection where our trials indicated fruit was on 66% the size of what was reported in Poland. In a study of 4 named varieties and 4 advanced selections, berry size ranged from 0.39 to 0.93 g/berry with 0.6 g/berry being average size. In a 2012 visit to Maxine Thompson's program in Oregon, Bob Bors observed she had advanced selections greater than 2.0 grams.

As can be seen in Figure 4, many of our heaviest advanced selections are much larger than published descriptions. Our largest berries all have Maxine's germplasm as one of the parents hybridized with Kurile Island germplasm or the larger Russian varieties. Perhaps there is a hybrid vigour effect from some of these combinations which is resulting in berries larger than the parents. Not yet in production are seedlings derived from newer germplasm that Bob Bors gathered in Japan which also had very large berries

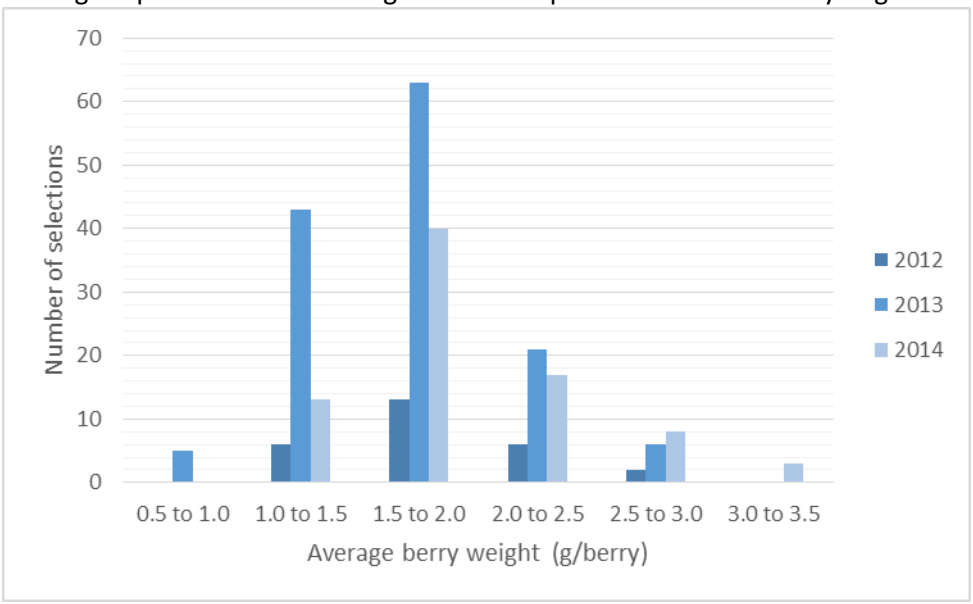

Figure 4. Average weights of advanced selections. Weights were based on a sample of 10 fruit. The average weights for 2012, 2013, and 2014 were 1.85, 1.64, and 1.92g /berry respectively.

Sugar and Acidity Sugar and acidity levels of advanced selections are shown in figures 5 and 6. Many higher sugar selections were found in 2013 and 2014 in the newer fields with a large shift in population trends. Lower acidity is generally good for fresh fruit sales but may be irrelevant for many processing needs. There was a slight shift to lower acidity in the more recent advanced selections.

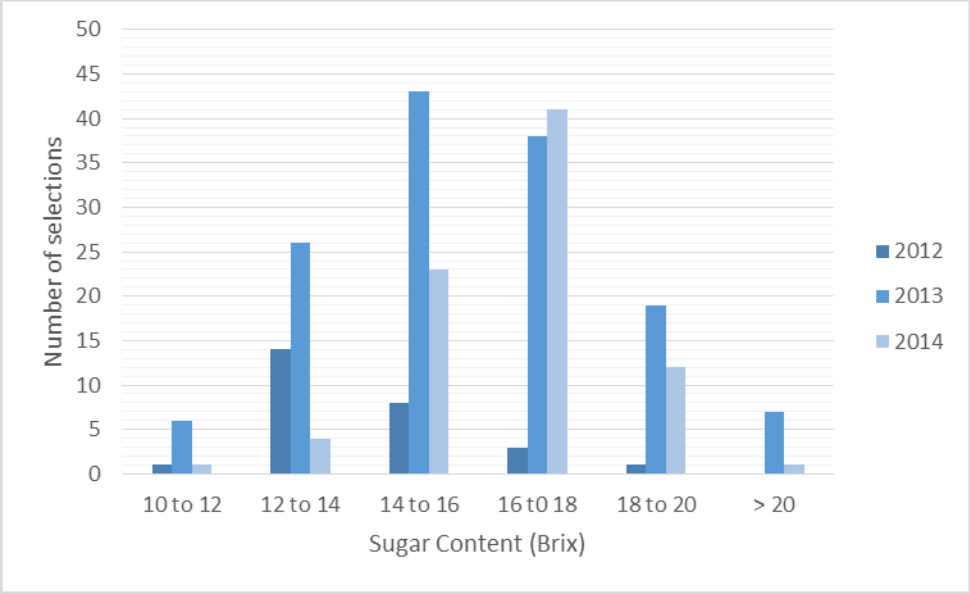

Figure 5. Sugar content of advanced selections. Average brix levels for 2012, 2013, and 2014 were 14.2, 15.8, and 16.4 respectively.

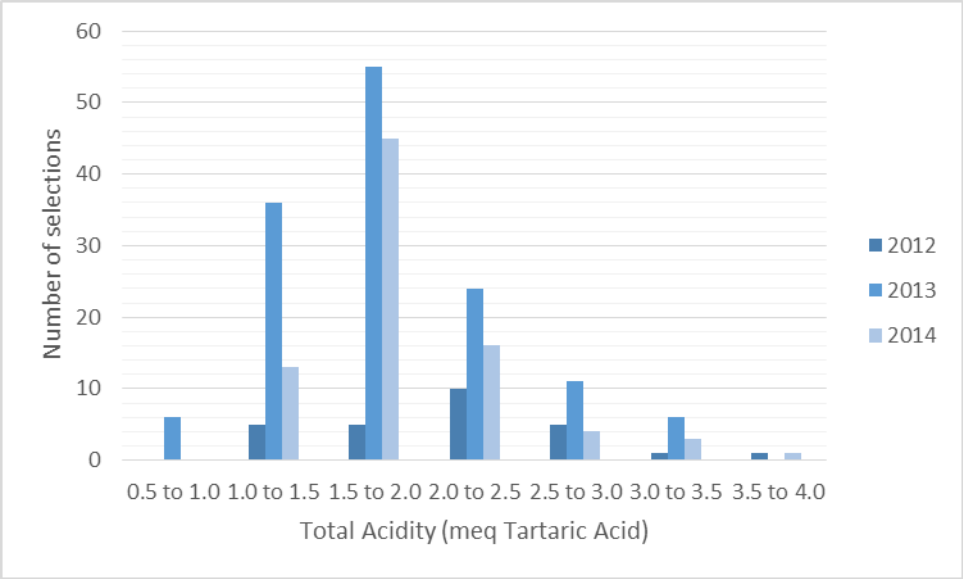

Figure 6. Total acidity levels for advanced selections. Average acidity levels for 2012, 2013, and 2014 were 2.17, 1.83, and 1.89 meq tartaric acid respectively.

Fruit size, Sugar and acidity levels are the easily quantified fruit traits with scientific equipment, but we also quantify sweet sour bitterness and aroma based on a 5 point scale (table 3). Notes are also taken on picking ability, texture and productivity. Flavour both fresh and frozen, texture, aroma are all subjective and are analysed for advanced selection. All the varieties we have released in the past as well as the new ones during this project need to have a flavour rating of 4 or 5 on a 5 point scale. Texture has to be at least average. We have used selections with lower flavour ratings as parents if other worthwhile traits were observed

Haskap berries vary in berry length, width and depth and there can be unusual shapes. In a processed product shapes are irrelevant but could be important for fresh market appeal or of interest to gardeners. Rounder or oval fruit shapes are desirable for mechanical harvesting. Thicker berries are slower to dehydrate and can have a longer harvest window as long as the fruit doesn't drop after ripening. In addition to basic measurements we attempt to describe the berry shapes (Table 4). But there is no substitute for looking at photographs of the berries, so each fruit sample is photographed. A few samples are shown in figure 7.

Field notes listed in table 5 are related to mechanical harvesting. Almost all advanced selections are acceptable, otherwise we would not select them. However some attributes are indicative of higher qualities than needed, but which might be great for breeding. For example "Holds on a Bit" types might be crossed to selections that don't hold on enough and might result in 'berries that pick well.. 'Average' berry texture is fine for mechanical harvesting using our sideways harvester. But a berry that is firm or crispy would be even tougher. As noted in previous haskap breeding projects, very firm berries were very rare, but what is considered average now is firmer than before.
Tundra has been sporadically planted in our fields and serves as a comparison in the selection process. Tundra has been seen to vary from year to year and from different fields (figure 8).

Variety Trial established

The most promising 16 advanced selections were planted in 2013 along with the recently named varieties 'Honeybee', 'Aurora', 'Boreal Blizzard' and as a standard 'Tundra'. In 2014 and 'Boreal Beauty' was added to that trial. That trial will be inspected by CFIA in few years to complete applications for Plant Breeder's Rights.

Mechanical Harvesting

During this project, our haskap plants became large enough to mechanically harvest. We found practically no damage to bushes and fruit had much less damage than expected. Fruit were so clean that we felt no need to use our sorting line. Already having several years' experience using the Johanna harvester on Saskatoons and sour cherries, it seem that Haskap is the most adaptable species for that machine. For many years previous we had selected plants based on shaking branches, feeling texture of berries, considering canopy shape all with a goal of making haskap better adapted for mechanized harvesting. It seems like such methods were right on the mark. Thus there was no need to change our selection criteria when selecting plants for mechanization.

A negative aspect of the Johanna machine (and we have heard similar results with some other harvesters) is that it will not pick fruit lower than about 1 foot. On 3 year old plants often half the fruit is less than 1 foot off the ground.

An area to emphasize in future varieties would be to make plants grow up faster and get taller. The Johanna harvester could likely handle 2.5m tall plants but most Haskap are closer to 1.5m tall. Our strategy to select for plant vigour in greenhouse seedlings and the introgression of vigourous germplasm in 2012 crosses should help in this are in the years to come.

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Table 3. Ratings for flavour components of advance d selections. There were 248 advanced selections evaluated in this way during this project; this is just a small sample of the data. Breeding codes are replaced with '100+' numbers.

code	Flavour	Sweet	Sour	Bitter	Aroma	Brix	Acidity	Ratio
100	sour	3	3	0	3	18.2	1.80	10.11
101	good flav but tad sour	2	3	0	3	14.8	2.07	7.15
102	sour, bit bitter, ok aroma	3	2	2	2	15.1	2.05	7.37
103	good flav, fairly sweet	3	3	1	3	17.0	1.92	8.85
104	sour	3	3	0	3	16.3	1.75	9.31
105	okay flavour	2	3	0	2	16.2	2.04	7.94
106	okay flavour, tad sour	4	3	1	3	16.1	1.84	8.75
107	sour, underipe	2	4	1	2	16.4	3.30	4.97
108	good aroma, tad sour	3	3	0	3	17.4	2.46	7.07
109	sour	4	2	0	4	17.6	2.77	6.35
110	good aroma, tad sour	4	3	0	3	16.9	2.75	6.15
111	fairly sweet, good flav	3	2	1	2	18.7	2.22	8.42
112	good flav	5	3	0	5	17.6	1.74	10.11
113	good aroma but sour	4	2	0	4	16.2	1.91	8.48
114	fairly good flav	5	3	0	3	18.9	1.93	9.79
115	sweet, nice aroma	4	2	0	4	17.2	1.97	8.73
116	tad bitter	4	1	0	4	16.0	2.05	7.80
117	good flav, nice aroma	4	2	0	3	17.8	1.96	9.08
118	odd flav, no sour	5	1	0	5	14.7	1.26	11.67
119	excellent flav	5	2	0	5	17.9	2.33	7.68
120	good aroma, slight bitter	5	2	0	5	16.6	1.66	10.00
121	good flav	5	3	0	4	18.3	1.97	9.29
122	trong flav, excellent arom	4	2	1	4	18.2	1.81	10.06
123	different flav, not juicey	4	1	0	4	17.4	1.77	9.83
124	fair flavour	4	3	0	3	15.3	1.52	10.07
125	grape likw flavour	4	2	0	4	17.3	1.59	10.88
126	very sweet, strawberry?	4	2	0	4	17.1	2.01	8.51
127	sour	4	3	1	3	15.9	2.67	5.96
128	odd flav, no sour	4	2	0	2	16.3	1.33	12.26
129	alright flav	3	2	0	2	16.2	1.52	10.66
130	good flav	4	3	0	3	18.8	1.79	10.50
131	good strong flav	3	3	0	3	16.7	2.22	7.52
132	ood tang, good aroma, sou	4	3	0	4	17.2	1.83	9.40
133	sour, good aroma	4	3	0	3	17.1	2.05	8.34
134	odd flav, not too sour	5	1	0	5	20.5	1.04	19.71
135	good flav, fairly sweet	5	2	0	5	13.6	1.26	10.79
136	decent flavour	3	3	0	3	17.2	1.87	9.20
137	poor flavour	5	2	0	4	14.6	1.37	10.66
138	good aroma, very sweet	5	1	0	5	16.7	1.02	16.37
139	good flav	3	2	0	2	17.2	1.93	8.91
140	okay flavour, slight bitter	3	3	0	3	15.2	2.25	6.76
141	poor flav, bitter	4	2	1	2	18.3	1.52	12.04
142	fair flav, slight bitter	5	2	0	4	16.2	1.19	13.61
143	okay flavour	5	1	0	4	18.7	1.78	10.51
144	alright flav, tad bitter	4	2	1	4	15.4	1.53	10.07
145	okay flavour	4	2	0	5	15.1	2.32	6.51

Table 4. Description of berry size and shape for advanced selections. There were 248 advanced selections evaluated in this way during this project; this is just a small sample of the data. Breeding codes are replaced with '100+' numbers.

	Berries									
code	Size	Length	Width	Depth	Weight	Shape	side view	distal end	Distal end size	Hairs
100	large	25.5	13.5	11.1	1.86	long oval	slight flat	belly button	medium	slight
101	large	29.6	14.4	12.1	2.77	fat oval	slight flat	pointy	large	some
102	large	29.7	15.4	12.5	3.03	fat oval	slight flat	pointy	large	heavy
103	variable	24.8	12.1	10.0	1.64	long oval	rounded	round	small	some
104	small	23.7	13.5	11.5	1.82	oval	rounded	pointy	small	heavy
105	average	23.9	15.1	13.0	2.40	fat oval	rounded	round	medium	none
106	large	21.0	15.0	13.3	2.44	fat oval	rounded	round	small	slight
107	average	18.7	13.4	12.2	1.75	round oval	rounded	pointy	medium	none
108	average	29.0	13.9	12.3	2.74	long oval	slight flat	pointy	medium	some
109	average	31.6	12.3	10.8	2.27	long oval	rounded	belly button	small	none
110	large	32.0	13.8	13.2	3.36	long oval	rounded	round	medium	none
111	large	23.7	12.4	10.0	1.46	long oval	slight flat	point	medium	slight
112	large	24.3	10.8	9.4	1.32	oval	slight flat	point	small	slight
113	average	24.8	13.1	10.6	1.63	oval	slight flat	round	small	slight
114	average	23.8	11.6	10.9	1.60	oval	rounded	point	large	slight
115	average	21.0	11.5	10.1	1.36	oval	slight flat	belly button	medium	slight
116	small	18.0	12.2	11.2	1.42	oval	rounded	round	small	slight
117	large	29.4	12.2	10.9	1.93	long oval	slight flat	point	small	slight
118	large	28.5	11.5	10.4	1.98	long oval	slight flat	point	small	none
119	large	26.0	11.6	11.1	1.99	long oval	slight flat	point	small	slight
120	large	25.4	11.8	11.2	1.74	oval	slight flat	point	medium	none
121	small	24.2	11.1	9.5	1.52	long oval	slight flat	belly button	small	some
122	large	24.4	11.6	10.9	1.65	oval	rounded	point	large	none
123	large	25.5	12.3	10.9	1.62	long oval	slight flat	point	medium	none
124	average	22.0	13.6	10.7	1.61	oval	slight flat	point	large	none
125	average	21.0	12.2	11.2	1.73	oval	slight flat	belly button	medium	slight
126	average	20.9	12.5	11.2	1.65	square	slight flat	round	medium	slight
127	large	20.7	13.1	10.8	1.61	oval	rounded	pount	medium	slight
128	large	30.5	13.3	11.8	2.16	surf board	rounded	point	large	none
129	large	27.1	10.8	9.1	1.62	long oval	slight flat	belly button	small	none
130	large	27.8	12.4	12.1	2.17	long oval	slight flat	belly button	small	slight
131	large	24.6	11.7	11.7	1.96	long oval	rounded	belly button	small	none
132	large	31.4	14.8	12.6	3.02	long oval	rounded	belly button	medium	none
133	large	28.0	11.6	10.7	1.93	fat oval	slight flat	point	large	none
134	average	25.5	10.8	10.3	1.73	long oval	slight flat	belly button	small	none
135	large	24.8	11.2	10.6	1.82	long oval	rounded	belly button	small	slight
136	large	24.9	13.9	13.1	2.28	fat oval	slight flat	point	medium	none
137	small	21.3	12.0	9.3	1.36	oval	slight flat	rounded	large	slight
138	large	24.1	12.9	11.6	2.22	oval	slight flat	belly button	medium	slight
139	average	21.1	12.8	11.0	1.72	fat oval	slight flat	round	small	slight
140	large	28.1	13.0	10.8	1.86	long oval	slight flat	belly button	medium	none
141	average	16.3	13.7	12.7	1.67	round	rounded	round	small	none
142	average	27.3	14.9	11.6	2.52	oval	slight flat	belly button	large	some
143	average	22.8	12.5	10.8	1.68	round oval	rounded	point	small	slight
144	small	19.9	12.4	10.7	1.56	oval	slight flat	round	medium	none
145	small	20.1	10.9	9.3	1.13	oval	slight flat	point	small	some

Figure 7. Fruit shapes of some advanced selections. It is hard to describe in words the skin texture and berry shapes.

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Table 5. Field notes for advanced selections regarding attributes important in mechanical harvesting: picking ability, texture and productivity and miscellaneous comments. There were 248 advanced selections evaluated in this way during this project; this is just a small sample of the data. Breeding codes are replaced with '100+' numbers.

code	Picking ability	Texture	Productivity	other
100	holds on a bit	average	average	pointy end
101	holds on a bit	average	high	
102	picks well	average	average	
103	holds on a bit	average	average	
104	holds on	firm	low	
105	holds on a bit	average	low	
106	picks well	average	average	
107	picks well	average	low	
108	holds on a bit	crisp	average	
109	picks well	crisp	average	
110	picks well	average	average	
111	picks well	average	high	
112	picks well	average	good	
113	falls off	average	average	
114	holds on a bit	firm	average	pointy tips on berries
115	picks well	average	high	leaves stay attached to berries
116	holds on a bit	average	high	
117	picks well	average	high	larger and better flav then 1.4, 1.7
118	picks well	average	high	
119	picks well	average	high	
120	holds on a bit	average	high	pointy end berries,
121	picks well	average	high	
122	picks well	average	good	hides its fruit
123	picks will	crisp	average	
124	holds on a bit	average	average	
125	holds on a bit	average	average	hides its fruit
126	holds on a bit	crisp	average	
127	picks well	squishy	high	
128	falls off	rubbery	average	
129	picks well	mealy	high	
130	picks well	squishy	good	
131	picks well	average	high	
132	holds on a bit	firm	high	
133	picks well	average	high	
134	holds on a bit	average	low	
135	holds on	squishy	high	too soft to pick
136	picks well	crisp	high	precocious
137	picks okay	mushy	average	hides its fruit
138	falls off	average	high	chlorosis
139	holds on a bit	average	average	plump fruit
140	picks well	average	good	
141	holds on	average	high	
142	hard to pick	squishy	average	
143	picks well	crisp	high	
144	picks well	average	high	hides it fruit
145	holds on a bit	average	average	

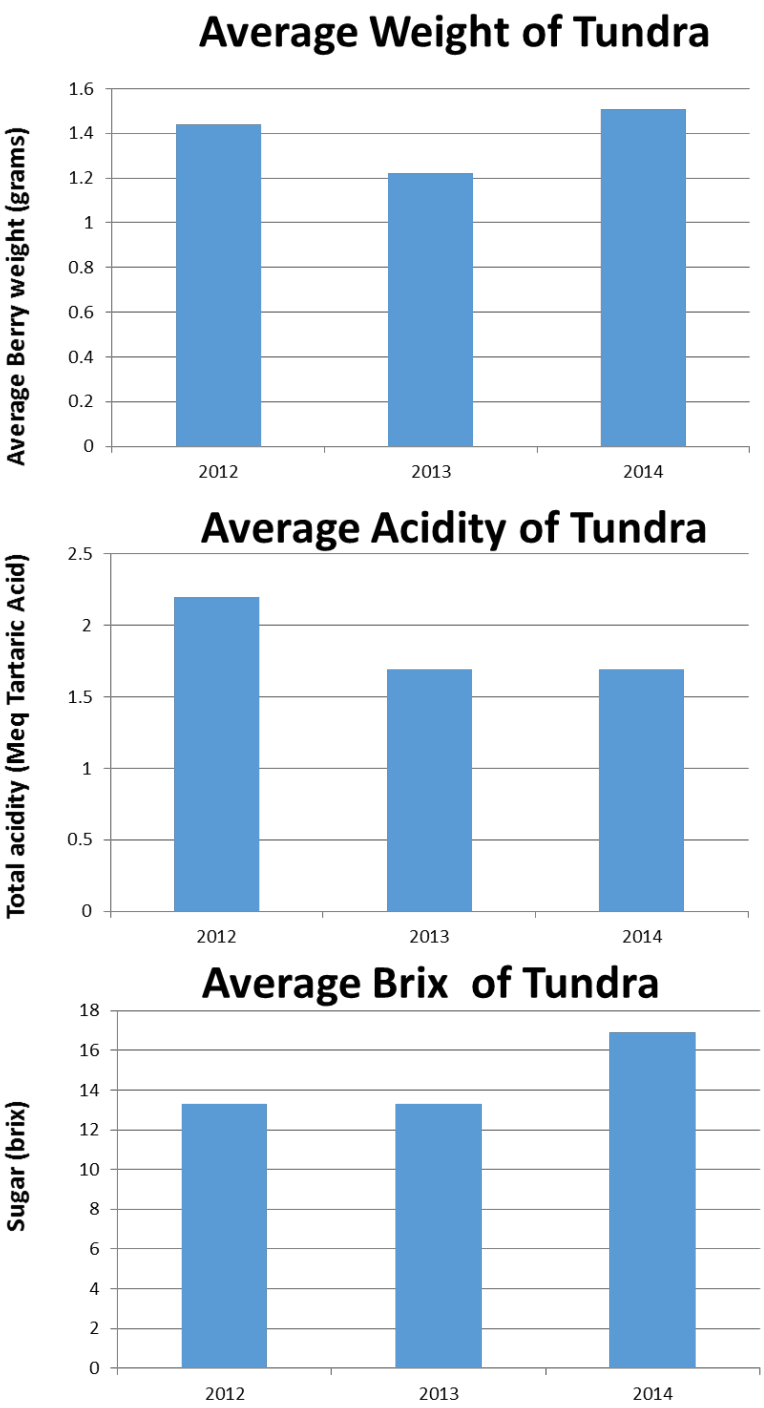


Figure 8. Average fruit quality measurements of 'Tundra' berries over 3 years. Tundra is planted in each of our seedling fields to serve as a standard for comparison.

New varieties released Three varieties were released during this project. Web articles written to describe them are included in Appendix B. Below is a synopsis of exceptional characteristics. They are shown in figures 9, 10, and 11.

'Aurora', released in 2012 was a breakthrough in low acidity and exceptionally good flavour. It was found to bloom closely in sync and was pollen compatible with our existing varieties. The original bush is much taller and more productive than the 'Tundra' and 'Indigo gem' plants in that field and in other fields. Its berry size is 50% larger than 'Tundra'

Figure 9. Aurora Haskap Berries. The breeding code is shown in the photo.

'Boreal Blizzard' was named and released in 2014. It is a breakthrough for large fruit size and extends harvest time into mid-July. Its fruits are 2 to 3x heavier than other varieties on the market and 4x larger than a dozen Russian varieties we trialed a decade earlier. Large fruit size would be an advantage for you-pick operations. The large fruit may have an advantage for fresh fruit sales. (Figure 10)

'Boreal Beauty' was also released in 2014. Ripening in early August, it is a breakthrough in late ripening. Its berries are almost as heavy as 'Boreal Blizzard' but are more oval. (Figure 11). It also has excellent flavour and is productive. A photo of 'Tundra' berries (Figure 12) helps to appreciate the gains made in fruit size.

Figure 10. 'Boreal Blizzard' berries are the largest but good tasting berries of our breeding program. The surfboard shape is also unique. The plant is upright and productive too. Note that haskap berries have a 'bloom' or waxy coating on the berries similar to grapes, plums and blueberries. Had the picker harvested wearing gloves the colour would be an even blue.

Figure 11. 'Boreal Beauty' berries can be oval or heart shaped.

Figure 12.' Tundra' berries weight about half as much as 'Boreal Blizzard' or 'Boreal Beauty' berries. Figures 11, 11 & 12 each have the same teaspoon used for comparison.

Four potential pollinators have been identified that could be companions for 'Boreal Blizzard'. However none of them are as outstanding as 'Boreal Beauty'. We intend to cross pollinate the boreal varieties in 2015. If they are in sync for bloom time and are pollen compatible there will be no need to release a pollinator.

Nutraceutical Selections and research:

In cooperation with Nova Scotia Agriculture College (now part of Dalhousie University), research occurred comparing our Haskap varieties and other popular berries grown in Canada. A poster was presented at the annual meeting of the Canadian Society of Horticulture Science and scientific publication resulted:
H. P. V. Rupasinghe, L. J. Yu1, K.S. Bhullar, and B. Bors. 2012. Haskap (*Lonicera caerulea*): A new berry crop with high antioxidant capacity. Can. J. Plant Sci. 92: 1311-1317. Table 8 is a reproduction of the main table taken from the poster.

Our program prepared the fruit samples, provided photos and assisted with writing the poster and subsequent paper. And of course bred the varieties being tested. This study was later published in November of 2012 in the Canadian Journal of Plant Science

Table 6. Excerpt from a 2012 poster comparing antioxidants and phenolics of haskap to other fruits. The Haskap varieties listed are all from the U of Sk breeding program. The complete poster is in Appendix C.

Fruit name	ORAC (μmol TE/g FW)	DPPH (IC_{50}, mg FW/mL)	FRAP (μmol TE/g FW)	Folin-Ciocalteu mg GAE/100g FW)	Total Flavonoid (mg QE/100g FW)
Haskap 'Borealis'	237.19*b*	5.83*b*	46.38*a*	622.52*a*	699.29*a*
Haskap 'Indigo Gem'	237.77*b*	7.80*b*	46.90*a*	500.78*b*	638.55*b*
Haskap 'Tundra'	262.44*a*	6.45*b*	27.96*b*	428.14*b*	594.43*b*
Partridgeberry	110.89*e*	6.23*b*	17.71*bc*	278.42*c*	476.57*c*
Blueberry	160.66*c*	32.27*a*	16.24*bc*	166.77*d*	343.00*d*
Blackberry	105.97*e*	3.37*b*	15.03*bc*	429.81*b*	171.35*e*
Strawberry	61.73*f*	3.23*b*	8.00*c*	201.79*c*	63.46*f*
Raspberry	61.94*f*	18.10*ab*	7.57*c*	169.41*d*	54.70f
Red table grape	128.90*d*	37.67*a*	8.09*c*	265.22*c*	195.22*e*

TE, Trolox equivalents; GAE, gallic acid equivalents; QE, quercetin equivalents; FW, Fresh weight; g-f Means followed by different letters within the same column represent significant differences ($p < 0.05$). Data are the average of triplicates

Haskap nutraceutical Research: Overview of James Dawson PhD research

Note: This section on graduate student research is necessarily generalized so that James will be able to publish in scientific journals.

HPLC vs Anthocyanin measurements for screening

Maximizing phytochemical content of fruit has become an important objective in modern fruit breeding programs. This stems from public awareness of the health benefits associated with these phytochemicals. Unfortunately most of the more rigorous methods for quantification of these compounds are both time consuming and relatively expensive, such as high pressure liquid chromatography. The current HPLC method employed by the fruit program to quantify these compounds requires approximately one hour, and cost approximately $10 per sample. This long and expensive method represents a significant lag to the screening of large amounts of germplasm. For this reason we have developed an inexpensive high throughput method to approximate the content of polyphenols in the fruit of Haskap. In this method we use anthocyanin content to approximate the total flavonoid content; we have gotten sufficient accuracy to employ the method for initial screening of large amounts of germplasm. The anthocyanin quantification is fast, 20-30 samples an hour, and inexpensive requiring only acidified methanol as a solvent.

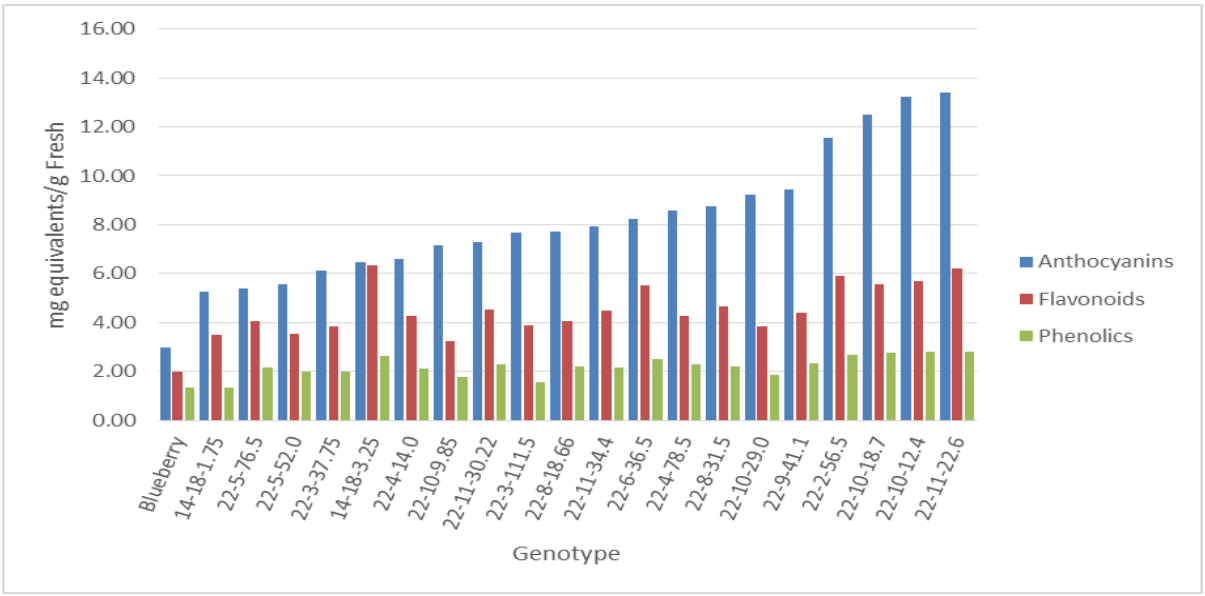
Estimating fruit phytochemical by using leaf tissues

Haskap has a juvenile period of approximately two years; this means that seedlings do not produce fruit until their second year. This represents a significant lag in the evaluation of new seedling populations were they must be house for several years before being evaluated for phytochemical content. To hasten selection, we are investigating a method to approximate the phytochemical content of the fruit by analysing leaf tissues.

Screening of *Lonicera caerulea* germplasm for nutraceutical content

The U of S fruit breeding program is one of, if not the, largest repository of *Lonicera caerulea* L. germplasm in the world. The program holds over 1200 accessions of wild germplasm (*L. caerulea var. villosa*) collected across the Canadian Boreal Forest. This subspecies is relatively unknown to science and has never been used in *L. caerulea* genetic improvement until now. In addition the program holds wild germplasm collected from Japan and China. However this material has to be evaluated before it is used in genetic improvement.

Phytochemical screening of this germplasm indicated stark differences between Canadian and Asian material. The Canadian material had a high content of two monoterpenoid compounds known as iridoids, these compounds are known to have human health promoting activities and have been used to market several tropical fruit crops most notably the Asian Noni fruit. Conversely the Asian germplasm contains high polyphenol content; these compounds are much more well-known and occur in several fruit crops. The screening of these materials will lead to hybrids with appreciable amounts of both classes of the important phytochemicals. In addition we have also screened fruit of the subspecies *L. caerulea var. stanatha*. This subspecies has highly unpalatable fruit but may contain a high content of bioactive compounds. Early results indicate relatively high content of both polyphenols and terpenoid compounds.



flavonoids and Phenolic levels

Figure 13. Nutraceutical content of 20 haskap selections compared to store bought blueberries. Anthocyanins = Cyanidin-3-glucoside Equivalents; Flavonoids = Rutin Equivalents, Phenolic = Gallic Acid Equivalents. This study emphasized the 'Block 22' field which had been planted in 2008. Fruit were harvested in 2012 and analysed that winter.

Data of the 'Block 22' selections (figure 13) demonstrates that anthocyanins had the most variability, phenolics had the least variability while Flavonoid variability was intermediate. The test for anthocyanins is fast, cheap and easy to use with a fairly good correlation to the other nutraceutical compounds (table 12) and seems to be most promising for an initial screening method for nutraceuticals. Testing for flavonoids would be a logical next test to consider.

Table 7. Correlations between three groups of nutraceutical compounds based on data from 20 haskap selections.

Correlations:	R^2
Anthocyanins & Flavonoids	0.740149
Anthocyanins & Phenolics	0.764223
Flavonoids & Phenolics	0.907031

The genotypes in 'Block 22' were mostly first generation hybrids resulting from either 'Russian x Japanese' or 'Russian x Kurile' crosses. But in 2013 and 2014, seedlings from 2nd and 3rd generation crosses began fruiting plus many more

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selections were being evaluated. Greater variability and larger content values were noted in all 3 categories of nutraceuticals (see figures 14, 15, 16). In 2013 we deliberately selected twice as many selections than most years in order to get a better picture of variability for nutraceutical content. The population curves of 2014 selections show an average increase of the population towards higher nutraceutical content.

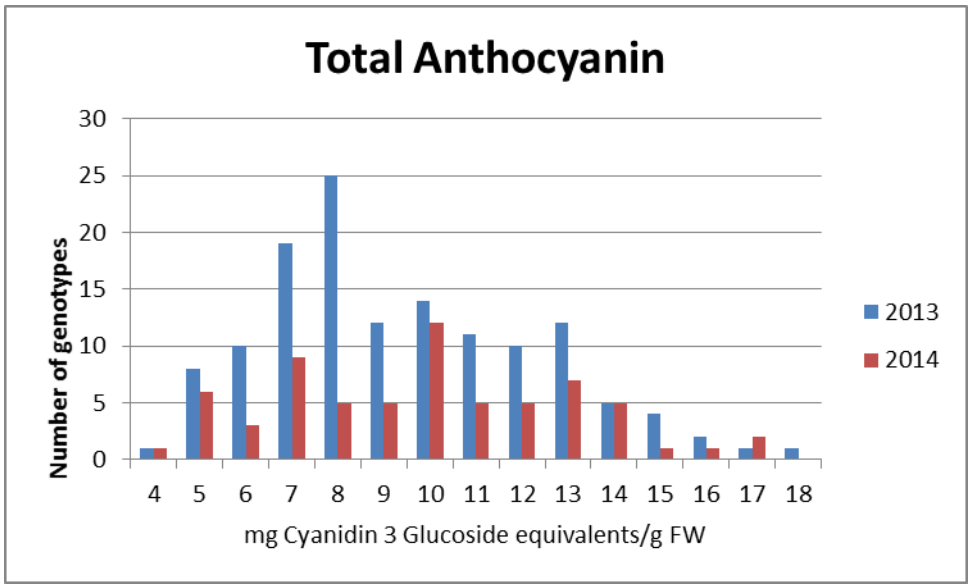

Figure 14. Variability of advanced selections in 2013 and 2014 for total anthocyanin content.

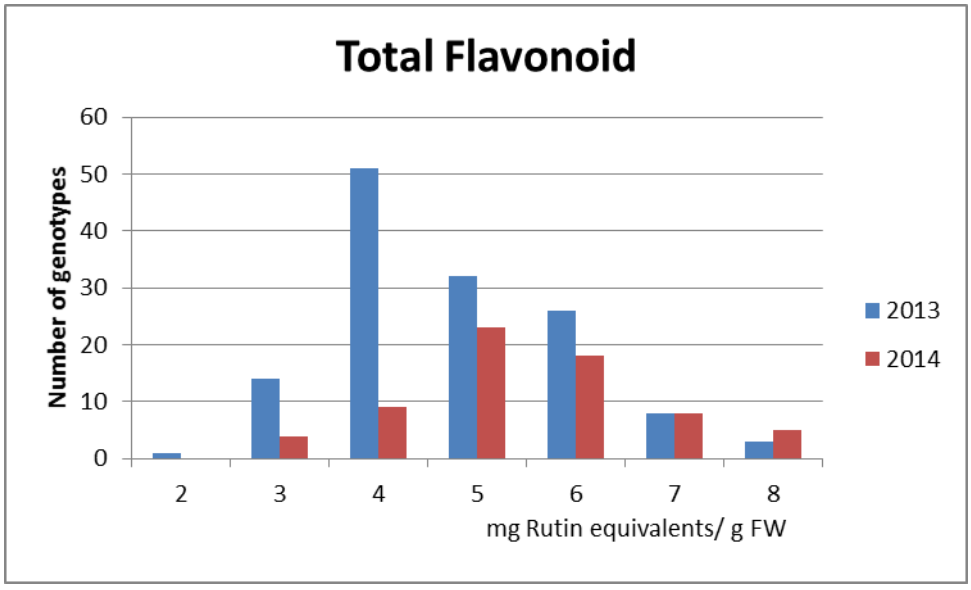

Figure 15. Variability of advanced selections in 2013 and 2014 for total flavonoid content.

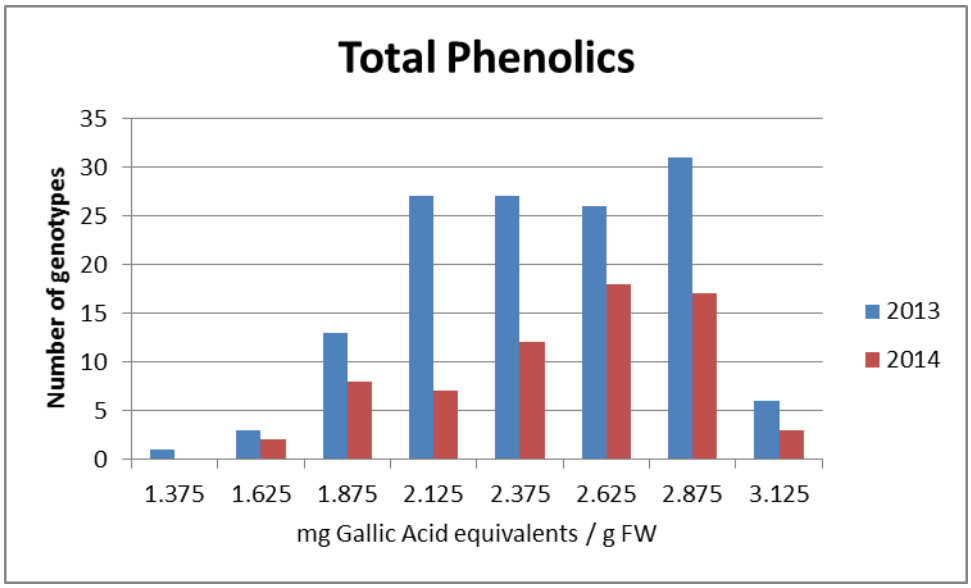

Figure 16. Variability of advanced selections in 2013 and 2014 for total Phenolic content.

Crosses

The types and numbers of crosses are summarized in figure 17, with details listed in Appendix A. Over the last 3 years, 80% of the crosses done were 'Main' crosses whereby we brought together germplasm from Russian, Japan and Kuril in our breeding lines. Almost all of the resulting seedlings have all 3 types of germplasm in their lineage. We also did field evaluations and selected better specimens to use as parent for introgressing new germplasm.

In 2011 we tagged fast growing plants that we then used for breeding in 2012. The 'vigor' parents were impressively fast growing, seeming to grow almost twice as fast as most breeding lines. But their fruit size and flavour was not desirable. Mostly these were plants related to the subspecies stenantha or pallissi. Vigour parents were identified that were less bad tasting and somewhat larger fruit. Many of the vigour parents had mildew problems but some plants were identified that had some resistance.

In 2012, the best 10% or so of the wild haskap from Canada was tagged. Wild Canadian germplasm had desirable traits of even ripening, good flavours and sturdy branches but small fruits and short stature. It seemed that intercrossing Japanese and Canadian germplasm could be beneficial, although a few generations may be needed. Pollen was bulked from the wild Canadian collection according to the province of origin and used to pollinate mostly Japanese germplasm in 2013.

The seeds gathered from Hokkaido in 2008 and planted in 2009 began producing enough to see productivity and observe fruit characteristics during this project. Better plants were identified and used in crosses in 2013 and 2014. It was noted that none of this germplasm seemed superior to our breeding lines but some of it was notably later in blooming and fruiting. But perhaps there could be hybrid vigour when this material is combined with other germplasm. Most of the new Japanese germplasm that was selected had good fruit shape and reasonable fruit size.

In addition to controlled crosses, open pollinated seeds were gathered. A large collection of wild Canadian seeds (47 lines) were gathered in 2012 and shared with the Vavilov Institute in Russia. In 2014 very large quantities of open pollinated seeds were gathered from 20 genotypes to be used in experiments of students

and in another pending ADF project. Open pollinated seeds were also saved from fields which were being cleared for future use.

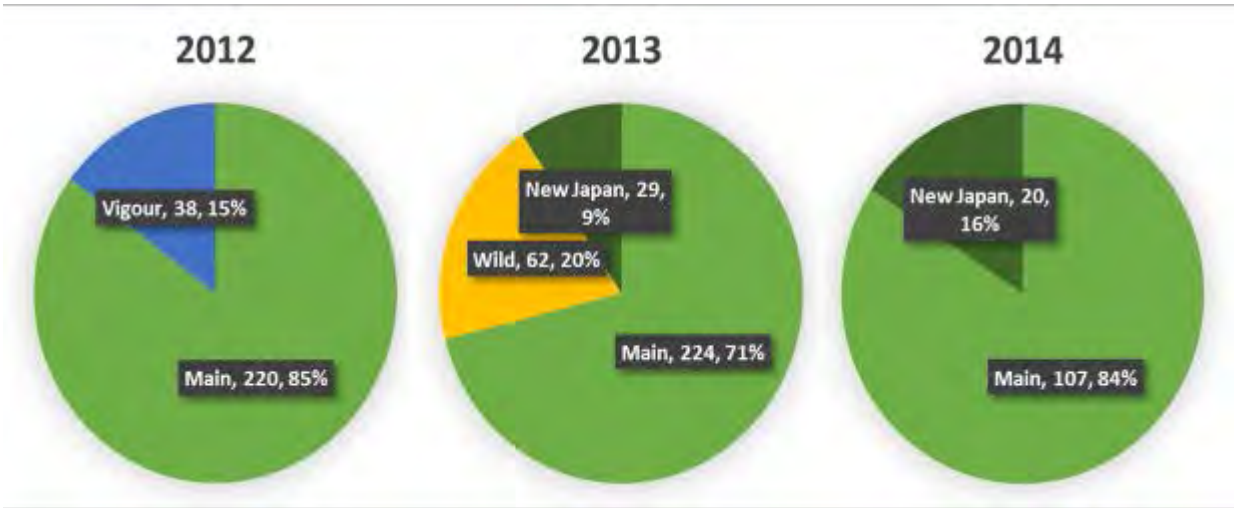

Figure 17. Types and numbers of controlled crosses done from 2002 through 2014. Main crosses are those between superior breeding lines which could produce new varieties. 'Vigour' crosses involved parents known to be rapid growing but had poorer fruit quality. 'Wild' crosses done in 2013 used germplasm gathered from Canada that was crossed with Japanese germplasm. 'New Japan' crosses used germplasm that Bob Bors gathered in 2008 from Hokkaido crossed with advanced breeding lines. For most crosses 10 to 20 flowers were pollinated. But some of the 'Main' and 'New Japan' crosses involved up to 50 flowers being pollinated resulting in hundreds of seeds per cross.

Evaluation of bloom time and Compatibility Crosses

Bloom time was monitored for advanced selections and our previous varieties. Advanced selections that bloomed at a similar time were intercrossed to see if they could be companions in crosses. If seed resulted, the combination was recorded in Appendix A1. AS can be seen in figure 18, most of our advanced selections are in the early and mid-bloom categories. However, many crosses were done among late bloomers so a higher percentage of future selections may also be late blooming. As previously mentioned the bloom time data from 2012 was used to determine some of the crosses for 2013. This process is being repeated with the seedlings resulting from 2014 crosses.

All of the 2013 seeds were planted in the beginning of the 2013/2014 winter and will be ready to be planted out in the 2014 growing season.

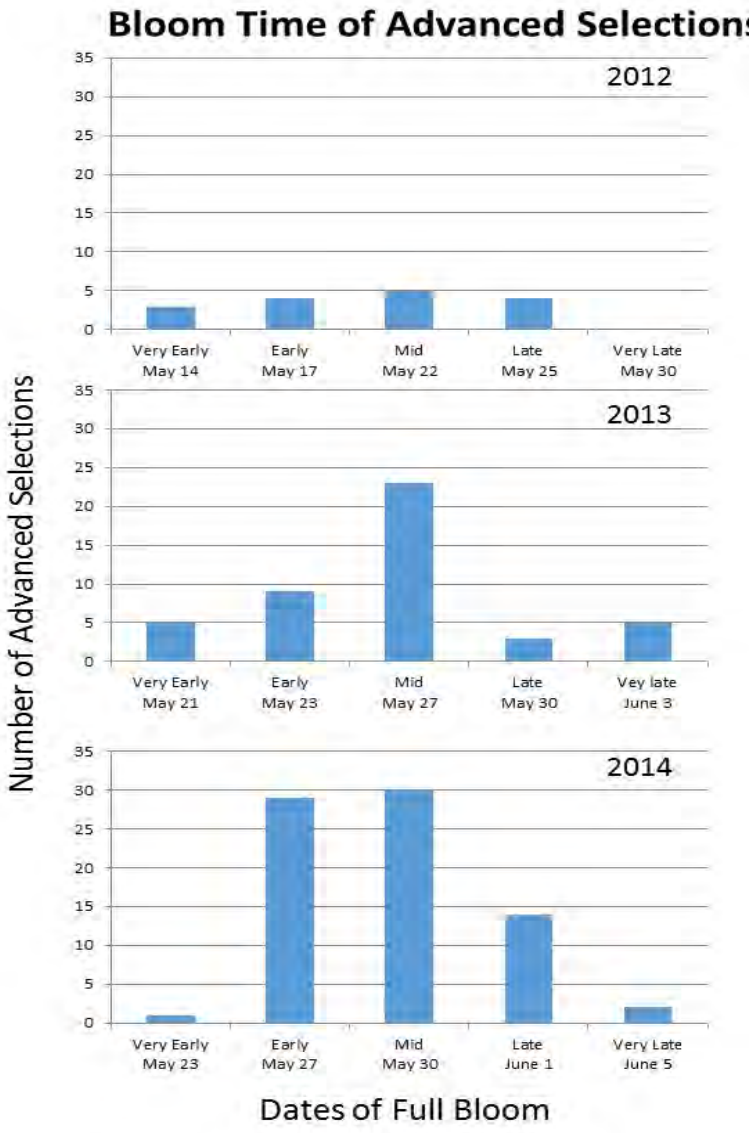

Figure 18. Time of full bloom for advanced selections. Only the better advanced selections are evaluated for bloom timing the following season. We categorize bloom time into 5 periods regardless of the date. For example, 2012 warmer up sooner so very early bloom occurred around May 14. In 2013 and 2014 very early bloom occurred May 21 to 23.

Table 8. Pollination compatibility of advanced selections and U. of Sask. Varieties, 2012. *Haskap varieties need cross pollination, so advanced selections were intercrossed to see if they are compatible. Under bagged conditions, medium size fruit usually result. Large fruit are common during open pollination when bees pollinate during optimum conditions. Many successes with few failures are ideal. Some of the crosses had few flowers tested and may need to be repeated in subsequent years. Because 22.6.26.5 gave good set with Tundra and Indigo gem, it was decided to release that selection as the new variety 'Aurora'.*

Female	Males	Large Fruit	Medium Fruit	Small Fruit	Failure
Indigo Gem	22-6-26.5	0	10	0	0
Indigo Gem	Tundra	0	0	0	3
Indigo Gem	Borealis	0	7	0	0
Indigo Gem	14.1.45.0	0	4	0	0
Indigo Gem	22.6.25.5	0	14	0	2
Indigo Gem	14.1.35.5	0	3	0	0
22.6.25.5	14.16.17.25	0	3	0	1
22.6.25.5	14N KR8	0	2	0	0
22.6.26.5	Tundra	0	15	1	1
22.6.26.5	Indigo Gem	0	12	0	0
22.6.26.5	Borealis	0	1	0	0
22.6.26.5	14.16.42.0	0	5	0	0
Borealis	Borealis	0	0	0	10
22.10.2.0	22.5.26.5	0	4	0	0
22.10.2.0	14.18.06	0	0	2	0
22.10.2.0	RJ T3	2	0	0	0
14.16.18.25	14.16.0.5	3	2	0	0
14.16.18.25	22.9.10.0	2	0	0	0
14.16.18.25	14.20.5.0	2	0	0	0
14.16.18.25	Borealis	1	0	0	0
14.16.18.25	22.10.3.7	0	5	0	0
14.20.5.0	22.6.26.5	0	3	0	0
14.20.5.0	14.17.2.0	0	3	0	0
14.20.5.0	22.9.10.0	0	1	0	0
14.20.5.0	14.17.5.0	0	2	0	0
14.20.5.0	14.17.5.5	0	1	0	1
14.20.5.0	Tundra	0	0	0	?
14.18.3.25	14.17.2.6	2	1	2	0
14.18.3.25	Tundra	0	1	0	0
14.17.2.0	22.6.26.5	0	4	0	0
14.17.2.0	14.20.5.0	1	2	0	1
14.17.2.0	Tundra	1	0	0	0
14.17.2.6	14.20.5.0	0	3	0	0
14.17.2.6	Tundra	0	0	3	0
14.17.2.6	22.6.25.5	1	3	0	0
14.17.5.5	14.18.06	1	1	0	1
14.16.17.75	22.2.25.5	1	0	2	1
14.16.17.75	14.18.1.75	2	0	0	1
14.16.17.75	Tundra	0	3	0	0
14.16.17.75	22.6.26.5	0	2	0	0

Propagation Trial 2013

Cuttings from promising selections were taken from the plants in the field in the summer of 2013 and rooted in the greenhouse. One half of the cuttings were placed in sphagnum moss and the other was rooted in coconut coir. These were placed in a heated mist bed or a capillary mat. Results are in Figure 19. Normally, haskap propagation is done in June. By trying it in August this would allow us to propagate advanced selections right after the fruit harvest season, instead of waiting for the following year.

The cuttings that rooted were kept growing in the greenhouse and once shoots developed they were taken and placed into tissue culture. These tissue culture plants were monitored for growth as well. Selections that culture quickly are greatly desirable as that is one of the main ways that plants are given to our propagators.

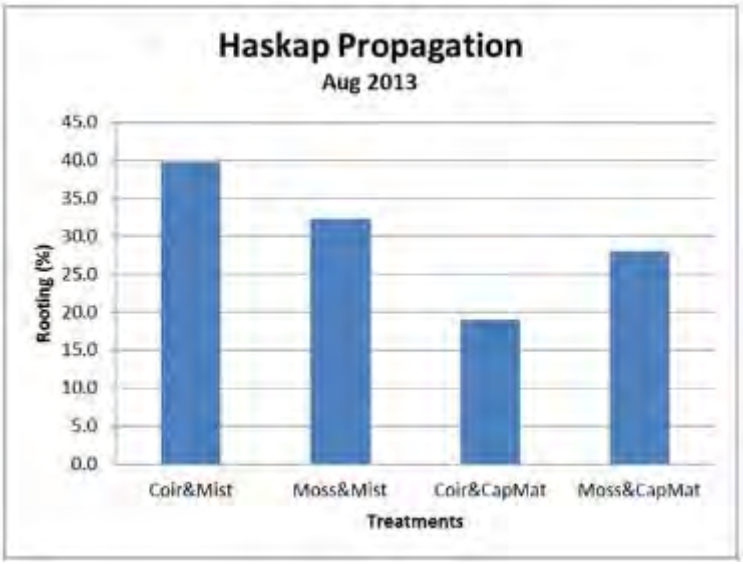

Figure 19. Haskap propagation trial in 2013. Coconut coir was compared to sphagnum peat moss with either mist or capillary mats as a water source. Mid-June has traditionally been the best time to root haskap cuttings in our area. However fruit and bush health ratings are not done for most selections until early August. If cuttings could be successfully rooted in August it would speed up the trialling and release of new varieties. It could also reveal which advanced selections are easier to propagate.

Disease research

Additional observations were made regarding mildew and sunburn in Haskap. The mildew on Haskap was identified as powdery mildew. Photographs were taken in the 2012 that better showed differences between sunburn and powdery mildew. A web article was created that combined last year's observations with previous experiment in this area (Appendix D).

Value added research

Previous ADF projects regarding haskap investigated wine, juice, drying, and jam. Also we gave out fruit to others for product R & D. In this project we continued to give fruit samples to interested companies but we investigated using haskap as a food dye and combined it with various juices and milks. The goal of such investigations was to give ideas to growers and processors that may help in product development. The trials are more fully explained in Appendix E but some of the highlights are in figures 20 to 25.

Many growers and processors were aware that Haskap juice has intense red or burgundy concentrated colour. It had not been known that changing the pH of the juice could drastically change the colour to be

purple blue or green. It seems Haskap could be used as a natural food dye. Also the research indicated haskap could be blended with apple juice, grape juice, soy milk and rice milk with the flavour of haskap coming through quite well.

Figure 20. Haskap has an intensely colourful juice. At 5% levels it is as colourful as most red juices,

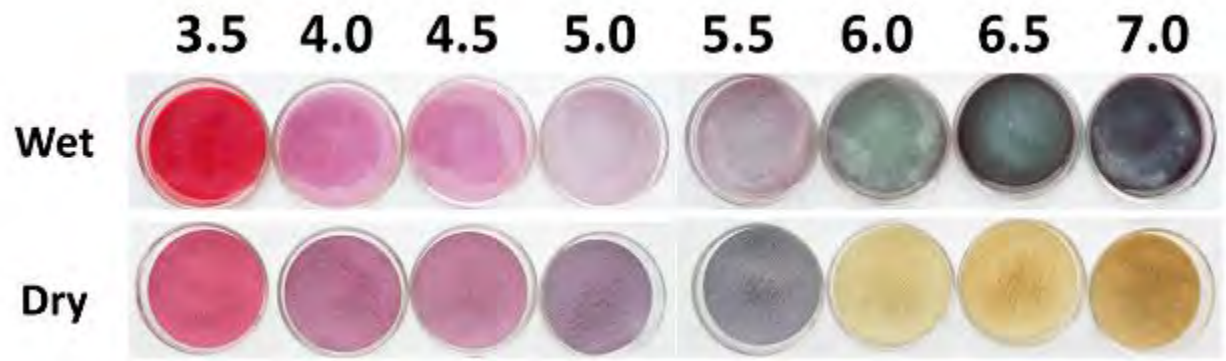

Figure 21. Haskap juice at different pH levels. 3 mls of juice was place in small petri dishes that had filter paper in the bottom. When the juice was allowed to dry it had changed colour at the higher pH levels.

Figure 22. Haskap juice added to various milk products. Haskap flavour came through in soy and rice milk. Whole and 2% milk was curdled by Haskap juice. The flavour of coconut milk overshadowed haskap flavour in mixtures.

Figure 23. Haskap juice combied with various juices. With 20% haskap, grape and apple juice tasted like haskap. Pineapple juice = haskap tasted like a new flavour. Orange and lemon juice overshadowed haskap flavour.

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Figure 24. Haskap juice added to cake batter with altered pH levels. Upper left had lemon juice added making it more acidic. Upper right had nothing added. Bottom had baking soda added making it more basic. The added baking soda caused the cupcake to rise and fall slightly.

Figure 25. Icing coloured with Haskap puree or juice. ¼ cup of icing had the following additional ingredients, starting with the upper left going clockwise: 1 tablespoon puree + ¼ teaspoon baking soda; 1 Tablespoon puree + 1 teaspoon lemon juice; 1 tablespoon puree; 1 tablespoon juice.

9. Conclusions and Recommendations: *Highlight significant conclusions based on the previous sections, with emphasis on the project objectives specified above. Provide recommendations for the application and adoption of the project.*

The project produced new varieties that are breakthroughs in flavour and fruit size. While many of our advanced selections would extend the harvest season a few more weeks, one of the new varieties extends it six weeks further than varieties currently on the market. While we have a few late season haskap varieties, the 4 fields of new Haskap seedlings will likely result in more late and early season varieties in the future.

This project implemented a more intense screening of young seedlings for plant vigour which should result in faster growing, larger plants that may out yield previous varieties in upcoming generations of advanced selections. Some crosses were done deliberately to introgress vigourous germplasm into our germplasm. New germplasm from Japan and wild Canadian germplasm was also used in crosses that may be beneficial in breeding.

This project investigated protocols for screening germplasm for nutraceutical potential. A screening of advanced selections showed that haskap can vary tremendously for several major nutraceutical. For anthocyanins and flavonoids the best selections had 4x more than the worst. For total phenolics, the highest levels were 2½ X more than the worst.

Investigations into using Haskap in combinations with other foods revealed new information. Not only could haskap be used as a natural food dye but that it could be different colours according to pH.

10. Success stories/ practical implications for producers or industry: *Identify new innovations and /or technologies developed through this project; and elaborate on how they might impact the producers /industry.*

When used by growers, the new varieties 'Boreal Blizzard' and 'Boreal Beauty' have substantially later ripening times. This could allow a steady stream of fresh berry production for 2 months of summer. Growers doing processing can spread out their labour and production. But there is also a better potential to create a fresh market. The much larger berries will be easier to hand pick and might be get grower higher prices. Increased berry size and larger bushes likely means higher yields for our growers. No other berries grown on the prairies have such a long harvest season.

Information about haskap juice changing colours at different pH will be especially useful for processors designing new products. That haskap could turn some foods red, purple, blue, or green had not been known by either food processors or scientists.

The new early season variety 'Aurora' has half the total acidity of most other haskap varieties. That variety may have special appeal for the fresh market or processing where lower acidity is desirable. In light of the research on the influence of pH on haskap juice, likely 'Aurora' juice would be easier than other haskap varieties to turn blue or green in food products.

Nutraceutical levels of haskap berries were found to widely differ amongst our advanced selections. Some nutraceuticals can have 2x to 4x more nutraceuticals than others. Processors wanting to make nutraceuticals from haskap will need to choose their varieties wisely. The amount of variation indicates potential for breeding in this area.

11. Patents/ IP generated/ commercialized products: *List any products developed from this research.*

Plant Breeder's Rights applications were submitted for the 4 varieties released during this project: 'Honey Bee', 'Aurora', 'Boreal Blizzard' and 'Boreal Beauty'. Once the applications are submitted the varieties can be sold and royalties can come to the program. With woody plants we have up to 7 years to grow a variety trial for inspection. PBR Trials have been planted for 'Honey Bee', 'Aurora', and 'Boreal Blizzard'. Plants for a trial of 'Boreal Beauty' have been propagated and will be planted in 2015.

Previous PBR applications for haskap varieties were completed: 'Tundra' cert# 4923 and 'Borealis' cert# 4922.

12. List technology transfer activities: *Include presentations to conferences, producer groups or articles published in science journals or other magazines.*

U of SK Website

During this project our fruit website (www.fruit.usask.ca) had 1.2, 1.6, and 1.7 million hits respectively for 2012, 2013, and 2014. Hit on our website have more than tripled since 2011. Our website tracking program indicates that 50% of the visitors are reading Haskap specific articles; 21% are reading articles about other crops; and 29% are reading general articles. The most read article was "Growing Haskap in Canada" which had been updated each year. That article is read about 15% of the time.

Searching for "Fruit Program" or "Haskap" on Google usually results in our website coming up first, even when searching on computers in other provinces or countries. A couple years ago a speaker at the Saskatchewan Fruit Growers Association explained that Google considers educational content, regularity of new input being added, amount of cross referencing, and actually visits websites to determine which to rank highly for searches.

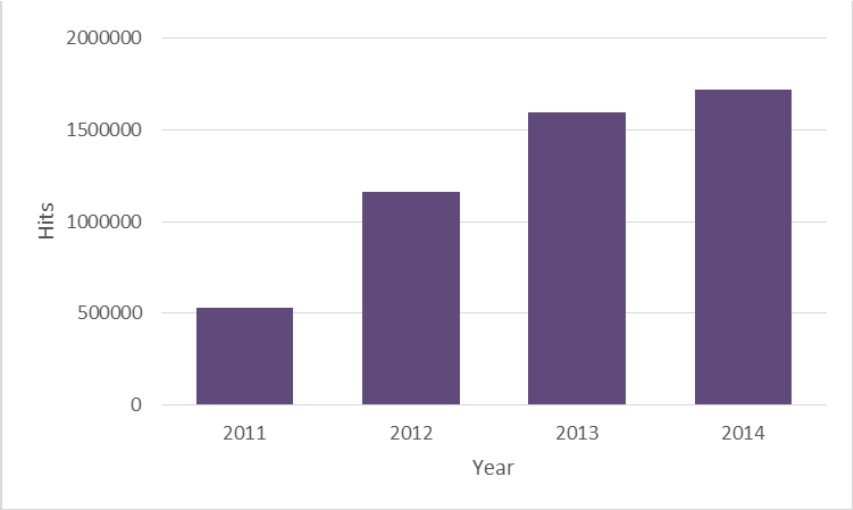

Figure 26. Hits for the University of Saskatchewan fruit program website www.fruit.usask.ca . Haskap articles are the most often viewed pages.

Television and Press conferences

The program received much attention in the spring of 2013 . The show 'The Nature of Things' aired its 2 part documentary 'The Fruit Hunters'. The film crew had filmed at the U of SK for 2 days in 2011, but in 2012 at their request, we sent 8 Haskap products and arranged other growers to send them more. Also dozens of haskap photos were sent plus many questions were answered via email or phone as they finalized editing of the show. Also in May, Bob Bors participated in a press event associated with Loblaws in both Calgary and Toronto. Loblaws began selling Haskap plants in their garden centres in 2012, which will likely made more people aware of this crop and make it more understood when growers have enough fruit to begin selling into stores. Loblaws has expressed an interest in contracting some growers to provide fruit in the future. Our fruit website had been averaging about 60K hits per month for the previous 6 months. That month the website had 324K hits!

Pruning demonstration

A small pruning demonstration was done prior to haskap day in 2013 and was again viewed in 2014. Styles of pruning done included: no pruning, open centre, thinning randomly, thinning to be upright (removal of only low branches), ornamental/bonsai style. This was done in time for haskap day on seedlings. This demo will be

useful for visitors and will likely make a good pruning handout when the plants get bigger.

Harvesting demonstration / observations

Harvesting with our Johanna harvester was done as a demonstration during Haskap days each year but was also done to all our seedlings as part of the evaluation process. An advantage to this machine for breeding evaluations is that it harvests half a bush at a time. When the machine is run down a row we can compare the harvested side to the not harvested side for damage, holding on fruit or dropping fruit. Haskap bushes were not damaged by our harvester and it seemed that berries did not hang on higher up in bushes. Only a few bushes were rejected as not being suitable for the harvest machine because fruit had readily fallen off even on the side where harvesting was not done. Notes taken about the harvesting operation will be used in writing an article.

Bob Bors continues to be a director on the board of Haskap Canada and the Saskatchewan fruit Growers association. Various extension talks and articles are summarized in table 9.

Table 9. Extension Activities from Bob Bors' cv that have to do with Haskap. Some are focused on Haskap others are general topics that include some info on Haskap.

Scientific papers:
Accepted:
H.P. Vasantha Rupasinghe, Mannfred M.A. Boehm, Satvir Sekhon-Loodu, Indu Parmar, Bob Bors, and Andrew R. Jamieson. 2013 Anti-inflammatory activity of haskap (Lonicera caerulea L.) cultivars is dependent on their polyphenol content. Journal of Agriculture and Food Chemistry.
Rupasinghe, H. P. V. , L Juan Yu, S. Khushwant, S. Bhullar, and B. Bors. 2012. Haskap (Lonicera caerulea): A new berry crop with high antioxidant capacity. Can. J. Plant Sci. 92: 1311-1317.
INVITED GOVERNMENT AND INDUSTRY PRESENTATIONS:
Bors, B. 2014. What Fruits should be grown father north? Rural Agri-Innovation Network Symposium, Bruce Mines, Ontario
Bors, B. 2014. U of Sk Fruit Program Research Update. Rural Agri-Innovation Network Symposium, Bruce Mines, Ontario
Bors, B. 2014. Evolution of Fruit at the U. of Sask. Soils & Crops Conference, Saskatoon. SIA invited speaker, lunch presentation.
Bors, B. 2014. Recent Advances in Prairie Fruit Breeding. Alberta Farm Fresh School., Olds, Alberta.
Bors, B. 2014. U of Sk Fruit Program Update. Saskatchewan Fruit Growers Association Annual Conference, Saskatoon.
Dawson, J. and B. Bors. 2014. Antioxidant compounds from the fruit of U of S Dwarf Sour Cherries and comparison to other store bought fruit. Saskatchewan Fruit Growers Association Annual Conference, Saskatoon.
Bob Bors, Ellen Sawchuk, Peter Reimer, and Tyler Kaban. 2014. Update on Fruit Research & Production. Saskatchewan Agriculture's Agronomy Research Update conference.
B. Bors. 2012. Summary of Haskap Breeding & Production, Final ReportADF2008-0042. Haskap Canada annual meeting.
E. Sawchuk and B. Bors, 2013. Fruit Research Update. Saskatchewan Fruit Growers Association Annual Conference.
B. Bors. 2013. Experimenting with Fruit. Haskap Ontario's grower workshop.
B. Bors. 2013. Growing Haskap. Haskap Ontario's a grower workshop.
B. Bors. 2012. Introduction to growing fruit in Alaska. Alaska Pioneer Fruit Growers.
Bob Bors, Ellen Sawchuk, Peter Reimer, and Tyler Kaban. 2012. Update on Fruit Research & Production.

Saskatchewan Agriculture's Agronomy Research Update conference.
B. Bors. 2012. Introduction to Haskap. UAA Matsu College.
B. Bors. 2012. Growing Haskap. UAA Matsu College.
B. Bors, 2012. Fruit Research Update. Saskatchewan Fruit Growers Association Annual Conference.
INVITED PUBLIC/ EXTENSION PRESENTATIONS:
Bors, B. 2013. Favourite Fruit Growing Tips. Bruno Cherry festival.
Bors, B. 2013. How Volunteers helped bring about new varieties of Haskap, Cherries and Coleus at the University of Saskatchewan (+ Favourite Tips). Friends of Gardens Manitoba annual general meeting.
Bors, B. 2014. Expert Panel Q & A period. Gardenscape Show, 2014.
B. Bors. 2013. Haskap Day Workshop. Haskap Ontario, Warren, ON.
B. Bors. 2012. Favourite Future Fruits. Central Peninsula Garden Club (Alaska).
B. Bors. 2012. Secrets of great fruit production in cold climates. Central Peninsula Garden Club (Alaska).
B. Bors, 2012. Experiment with Fruit. Saskatoon Rotary Club, Saskatoon, SK.
B. Bors, 2012. Fruit for the Prairies. Kamsack Gardening Club, Kamsack, SK
B. Bors, 2012. Favourite Fruits. Calgary Horticulture Society, Calgary, AB.
B. Bors, 2012. Garden Experts Question and Answer Session. Gardenscape Show, Saskatoon, SK.
B. Bors, 2012. University of Saskatchewan Haskap varieties. Loblaw Lawn and Garden Event in Toronto. Loblaw Companies Limited.
B. Bors, 2012. University of Saskatchewan Haskap varieties. Loblaw Lawn and Garden Event in Calgary. Loblaw Companies Limited.
Scientific Oral presentations:
J. Dawson, B. Bors and D. Waterer. 2013. Iridoids and Flavonols in Fruit of Haskap (Lonicera caerulea L.). ISHS Neutraceutical Conference, Montreal.
Scientific Posters:
Rupasinghe, H. P. V. , L Juan Yu, S. Khushwant, S. Bhullar, and B. Bors. 2012. Haskap (Lonicera caerulea): A new berry crop with high antioxidant capacity. Can. Soc. Hort. Sci. Conference.
E.M. Gerbrandt, B. Tar'an, and R.H. Bors, 2012. A Genetic Distance Estimate for Various Blue Honeysuckle (Lonicera caerulea L.) Subspecies Using ISSRs. Plant and Animal Genetics Conference XIX.
Misc. Outreach/engagement activities
2013: Submitted 21 photos to 'SleelEye Films' to be used in the documentary 'The Fruit Hunters" which was also used on 'The Nature of Things' TV show..
2012-13: Gave interviews, tours and arranged visits to growers for 'SleelEye Films' to be used in the documentary 'The Fruit Hunters" as part of the tv show 'the Nature of Things'. This involved 30 hours of phone conversations (over a 5 month period), 2 long days of filming, and arranging haskap samples to be sent to their studio.

2012: Submitted 30 photos and text to Haskap Canada for use in their 'Indulge in Healthiness' flyer. This involved creating a dozen haskap products to be photographed specifically for this project. Some photos were also used in their posters and webpage.
Website Usage: www.fruit.usask.ca is our program website maintained by myself and Peter Reimer. Almost all articles were written by me. The website had 1,160,159 successful requests and 315,000 successful requests for pages in 2012. As of May 20, 2013 there were 664,067 and 162,709 requests respectively.
2013: I was the major contributor of photos for the new Haskap grower website www.haskap.ca.
Presentations at U of SK Fruit Program events
B. Bors. 2013. Fruit Program Overview. Haskap Day.
B. Bors. 2013. Introduction to Haskap. Haskap Day.
B. Bors. 2013. Tour of Haskap breeding plots. Haskap Day

B. Bors. 2013. Haskap Research Update. Haskap Day.
Bors, B. 2013. Fruit Program Overview. On-campus presentation to Campbell's Foods.
B. Bors. 2012. Fruit Program Overview. North American Fruit Explorers conference at U of SK.
B. Bors. 2012. Introduction to Haskap. North American Fruit Explorers conference at U of SK.
J. Dawson and B. Bors. 2012. Haskap nutraceutical research . North American Fruit Explorers conference at U of SK.
E. Gerbrant and B. Bors. 2012. Blue Honeysuckles on the Canadian West Coast.. North American Fruit Explorers conference at U of SK.
E. Sawchuk and B. Bors. 2012. Side-Row Mechanical Harvesting: A Prairie Solution. North American Fruit Explorers conference at U of SK.
Hosting On Campus Workshops, Tours, Conferences, events
2006-14. Hosted 'Haskap Day' at U of S. Talks and tours for growers
2001-14. Hort Week tours of Horticulture Field Plots.
Extension articles in magazines
B. Bors, 2014. 'Popular Fruit Varieties' (updated)
B. Bors, 2014. 'Boreal Blizzard'
B. Bors, 2014. 'Boreal Beauty'
B. Bors, 2013. 'How far south can Haskap be Grown?' Fruit Program website.
B. Bors, 2013. 'Aurora' and 'Borealis' Haskap. Fruit Program website.
B. Bors, 2013. Haskap introduction slideshow. Fruit Program website.
B. Bors, 2012. Popular Fruit Varieties 2012. Fruit Program Website,
B. Bors, 2012. Haskap and blue honeysuckles. Prairie Gardener p135-139.
Handouts for talks and inquiries
2012. Haskap photo album: Haskap photos with text were created for use at Loblaw events in Toronto and Calgary. This was also posted to www.Flicker.com as self-explanatory slideshow, and given to 'Haskap Ontario" to use at a trade show.
B. Bors, 2012. Popular Fruit Varieties 2012.
B. Bors, 2012. Prairie Fruit Summary 2012.

NAFEX Conference + Haskap Day 2012

In 2012 the Fruit Program hosted the annual North American Fruit Explorers (NAFEX) meeting and conference. The directors of this 300+ member organization had specifically wanted to 'piggy back' onto our 'Haskap Day'. 'Piggy Backing' onto the Nafex meeting was the Canadian Society for Horticulture Science, Canadian Society of Agrology, Certified Crop Advisors - Prairie Board and Agricultural Institute of Canada. Occurring after haskap day, the Saskatchewan Fruit Growers Association had their annual summer tour, which our groups arranged. These multiple events ran from the 16th-22nd of July.

Although the NAFEX conference covered all fruit crops, Haskap day was included in this conference. We had about 160 paid attendees for Haskap day of which 60 were members of NAFEX. Also, we allowed research scientists and extension people from the other professional agriculture societies to attend our NAFEX talks and haskap plots in exchange for those societies helping with expenses of the banquet. An estimated 30 others were in attendance from the other organizations. Attendance was almost 3 times larger than previous years!

Haskap Days 2012, 2013, 2014

Haskap days were held each year of this project during mid-July. Agendas were similar with an introduction lecture given, then tours until noon, and later talks by researchers, graduate students, and growers.

Attendance was around 150 in 2012 due to the joint conference with NAFEX. Attendance was about 75 for both 2013 and 2014.

13. List any industry contributions or support received.

The main support from industry had been in the form of royalties paid when buying our varieties. Growers pay propagators 50¢ per plant. 65% of the royalties go directly to the fruit program while 35% goes to an equipment fund for Horticulture research.

It is estimated that royalties paid for approximately half the research done in this project. Royalties paid for supplies, greenhouse and equipment rental and part of graduate student stipends and part of technician salaries.

Volunteers, which included farmers and master gardeners, helped plant and transplant haskap seedlings in the greenhouse. They also helped propagate various plants for our annual plant sale (first Friday in June) which helped to raise about $40,000 over the 3 years of this project.
The University of Saskatchewan pays the salary of PI Bob Bors and technician Rick Sawatzky and provide lab and field space for the fruit program.

14. Is there a need to conduct follow up research? *Detail any further research, development and/or communication needs arising from this project.*

The controlled-cross seedlings generated in this project will need to be evaluated in a few years.

The nutraceutical screening protocols developed in this project will be utilized in the future. It may be worthwhile to investigate how heritable high nutraceutical content can be and if there is enough interest in industry to make this worthwhile.

Research to follow up on using Haskap as a food dye might best be done within companies developing products or in a food science department. Although, screening germplasm for higher dye potential could be worthwhile for the fruit program.

Bob Bors will begin a sabbatical this summer with the main purpose being to write a Haskap Grower's manual. Many components of this project and previous ADF haskap projects will be further communicated.

15. Acknowledgements. *Include actions taken to acknowledge support by the Ministry of Agriculture and the Canada-Saskatchewan Growing Forward 2 bilateral agreement.*

Acknowledgements to Saskatchewan Agricultures funding through ADF have been given in dozens of talks and web articles. Handouts given at talks also include acknowledgements.

Information posters on Haskap research are poster in the Agriculture Building at the U of SK, which include acknowledgement.

Talks & handouts have also included the website http://www.agriculture.gov.sk.ca/ADF/search along with instructions to find more information about previous ADF projects.

16. Appendices: *Include any additional materials supporting the previous sections, e.g. detailed data tables, maps, graphs, specifications, literature cited*

Appendix A: Crosses and Crossability Data

Table A1: List of Parents and crosses for 2012, 2013, 2014 haskap breeding. These lists reflect successful crosses where seeds were obtained.

Haskap Crosses done in 2012											
		Female	Male			Female	Male			Female	Male
12	1	46.55	Tundra	12	41	G14	66.89	12	81	VG24	Tundra
12	2	G14	46.55	12	42	G14	6.15.40	12	82	VG30	14.18.3.25
12	3	Tundra	14.1.35.5	12	43	G14	VG8	12	83	VG16	Tundra
12	4	71.64	Tundra	12	44	G14	VG5	12	84	BV	71.64
12	5	6.1.23.25	6.15.10	12	45	G14	6.15.10	12	85	VG15	22.6.26.5
12	6	6.1.36	46.55	12	46	G14	22.14	12	86	BV	66.89
12	7	6.1.23.25	vg5a	12	47	G14	VG6	12	87	VG5	46.55
12	8	g14	J3	12	48	G14	VG7	12	88	VG8	6.15.10
12	9	BV	22.14	12	49	6.1.36	6.15.10	12	89	VG8	46.55
12	10	G14	VG5A	12	50	6.1.36	VG5	12	90	6.1.36.0	46.55
12	11	66.89	14.1.21.75	12	51	6.1.36	66.89	12	91	22.4.30.0	22.8.18.66
12	12	66.89	14.3.5.80	12	52	6.1.23.25	J3	12	92	22.4.30.0	14.16.17.25
12	13	71.64	14.1.21.75	12	53	Tundra	22.6.26.5	12	93	22.4.30.0	22.8.16.5
12	14	G14	VG7	12	54	G23	J7	12	94	22.4.30.0	BULK X'S
12	15	22.14	14.1.21.75	12	55	Tundra	J3	12	95	22.4.88.0	14.16.17.25
12	16	6.15.10	Tundra	12	56	46.55	Tundra	12	96	22.4.88.0	14.16.21.75
12	17	VG7	46.55	12	57	46.55	14.3.80	12	97	22.4.88.0	22.8.12/3
12	18	6.1.36	6.15.40	12	58	46.55	14.1.21.75	12	98	22.4.88.0	BULK X'S
12	19	VG31	22.6.26.5	12	59	71.64	14.1.3.80	12	99	22.4.121.75	22.12.23.75
12	20	6.15.10	6.1.35.5	12	60	46.55	14.1.95D	12	100	22.4.121.75	VG15
12	21	66.89	14.1.35.5	12	61	71.64	14.1.21.75	12	101	22.4.121.75	14.16.18.25
12	22	61.36	71.69	12	62	BV	6.15.40	12	102	22.6.25.5	14N.KRB
12	23	66.89	Tundra	12	63	71.64	Tundra	12	103	22.6.25.5	VG16
12	24	66.89	14.1.45.0	12	64	BV	46.55	12	104	22.6.25.5	14.16.18.25
12	25	6.15.40	14.0.21.75	12	65	71.64	14.1.35.5	12	105	22.6.25.5	14.16.17.25
12	26	6.15.40	14.1.35.5	12	66	BV	22.14	12	106	22.6.25.5	BULK X'S
12	27	6.15.40	14.3.5.80	12	67	VG11	22.6.26.5	12	107	AURORA	Tundra
12	28	6.15.40	Tundra	12	68	VG6	6.15.26.5	12	108	AURORA	9.15
12	29	22.14	14.1.35.5	12	69	VG11	Tundra	12	109	AURORA	BOREALIS
12	30	46.55	14.1.35.5	12	70	6.1.23.25	71.64	12	110	AURORA	14N.KRB
12	31	6.1.35.5	VG7	12	71	VG6	14.17.5.5	12	111	AURORA	14.16.42.0
12	32	6.1.35.5	VG6	12	72	6.1.23.25	66.89	12	112	AURORA	BULK X'S
12	33	6.1.35.5	22.14	12	73	VG7	22.14	12	113	22.8.16.5	71.64
12	34	6.1.35.5	J3	12	74	VG18	14.1.35.5	12	114	22.8.16.5	14.18.0.6
12	35	6.1.35.5	6.15.10	12	75	VG7	6.15.40	12	115	22.8.16.5	20.3.42.75
12	36	6.1.35.5	VG8	12	76	BV	71.64	12	116	22.8.16.5	BULK X'S
12	37	6.1.35.5	71.69	12	77	VG17	14.17.5.5	12	117	22.8.17.5	14.19.43.0
12	38	G14	VG7	12	78	6.1.23.25	VG5	12	118	22.8.17.5	VG31
12	39	G14	71.64	12	79	6.1.23.25	22.14	12	119	22.8.17.5	BULK X'S
12	40	G14	6.15.10	12	80	VG15	Tundra	12	120	22.8.18.66	VG18

Haskap Crosses done in 2012, continued											
		Female	Male			Female	Male			Female	Male
12	121	22.8.18.66	RJ.B1 20.2.N3	12	161	14.16.18.25	Megawimp	12	201	14.2.58	46.55
12	122	22.8.42.75	20.3.19.75	12	162	14.16.18.25	22.9.10.0	12	202	14.2.58	22.14
12	123	22.8.42.75	22.6.26.5	12	163	14.16.18.25	14.20.5.0	12	203	14.2.58	66.89
12	124	22.8.42.75	22.6.25.5+BULK	12	164	14.16.18.25	Borealis	12	204	14.3.40	46.55
12	125	22.12.23.75	20.3.21.5	12	165	14.16.18.25	22.10.3.7	12	205	14.3.40	66.89
12	126	22.12.23.75	20.1.12.25	12	166	14.17.2.0	22.6.26.5	12	206	14.3.40	14.17.2.6
12	127	22.10.1.5	AURORA	12	167	14.17.2.0	14.20.5.0	12	207	14.3.40	14.18.1.75
12	128	22.10.1.5	RJ.T8 14.18.06 Bulk	12	168	14.17.2.6	22.6.25.5	12	208	14.3.40	22.6.25.5
12	129	22.10.3.75	71.64	12	169	14.17.2.6	14.20.5.0	12	209	14.4.64	22.6.25.5
12	130	22.10.3.75	14.19.43.0	12	170	14.17.2.6	Tundra	12	210	14.4.64	22.8.2/3
12	131	22.10.3.75	20.3.42.75	12	171	14.17.5.5	14.18.0.6	12	211	14.4.64	14.16.18.25
12	132	22.10.12.0	22.8.17.66	12	172	14.20.5.0	14.17.2.0	12	212	14.4.64	20.3.42.75
12	133	22.10.12.0	22.6.21.5	12	173	14.20.5.0	Tundra	12	213	14.4.64	vg15
12	134	22.10.12.0	22.6.25.5	12	174	14.20.5.0	22.9.10.0	12	214	14.4.64	22.6.26.5
12	135	22.10.15.0	14.18.06	12	175	14.20.5.0	14.17.5.5	12	215	14.4.64	14.20.19.25
12	136	22.10.???	RJ.T8 20.2.N3	12	176	14.20.5.0	22.6.26.5	12	216	14.4.64	14.16.3.0
12	137	22.10.18.75	JR9.3	12	177	14.1.21.75	14.16.18.25	12	217	14.4.64	14.18.3.25
12	138	22.10.18.75	14.15.34.0	12	178	14.18.3.25	14.17.2.6	12	218	14.4.64	46.55
12	139	22.10.18.75	VG17	12	179	14.2.72	14.16.21.75	12	219	skip	
12	140	22.10.18.75	BULK X'S	12	180	14.2.72	14.19.43	12	220	14.11.7.75	46.55
12	141	22.10.21.0	RJ.T3-3	12	181	14.2.63	66.55	12	221	14.11.7.75	op
12	142	22.10.21.0	22.4.131.75	12	182	14.2.63	66.89	12	222	14.11.8.0	fell off
12	143	22.10.21.0	VG24	12	183	14.2.63	6.15.40	12	223	14.11.8.0	46.55
12	144	22.10.21.0	BULK X'S	12	184	14.2.63	6.15.10	12	224	14.11.8.0	op
12	145	22.10.32.0	14.15.34.6	12	185	14.2.63	22.14	12	225	14.11.9.2	77.78
12	146	22.10.32.0	RJ.J10 (20.1~26?)	12	186	14.2.63	77.78	12	226	14.11.9.2	14n early
12	147	66.89	Tundra	12	187	14.2.63	22.4.88	12	227	14.11.9.2	g21
12	148	66.89	14.1.45.0	12	188	14.2.58	nown blank t	12	228	14.11.9.2	op
12	149	66.89	14.1.35.5	12	189	14.2.58	20.3.19.75	12	229	14.11.1.5	22.14
12	150	66.89	BULK X'S	12	190	14.2.58	14.16.30	12	230	14.11.1.5	14n early
12	151	9.15	Borealis	12	191	14.2.58	20.3.26.25	12	231	14.11.1.5	op
12	152	9.15	14.1.35.5	12	192	14.2.58	14.17.5.5	12	232	14.10.18.25	fell off
12	153	9.15	14.1.45.0	12	193	14.2.58	14.17.2.6	12	233	14.10.18.25	op
12	154	9.15	22.6.25.5	12	194	14.2.58	RJ.T3#1	12	234	14.11.5.8	22.14
12	155	9.15	22.6.26.5	12	195	14.2.58	14.20.19.25	12	235	14.11.5.8	6.1.36.0
12	156	14.16.17.75	22.6.25.5	12	196	14.2.58	14.18.3.2	12	236	14.11.5.8	14n early
12	157	14.16.17.75	Tundra	12	197	14.2.58	14.20.14.25	12	237	14.11.5.8	op
12	158	14.16.17.75	22.6.26.5	12	198	14.2.58	14.16.3.0	12	238	14.11.15.3	op
12	159	14.16.17.75	14.18.1.75	12	199	14.2.58	6.15.40	12	239	14.12.36.2	op
12	160	14.16.18.25	22.9.22.5	12	200	14.2.58	77.78	12	240	14.12.5.5	77.87

Haskap Crosses done in 2012, continued							
		Female	Male			Female	Male
12	241	14.12.5.5	66.89	12	281	14.22.38.0	op
12	242	14.12.5.5	6.1.23.25	12	282	14.25.18.9	op
12	243	14.12.5.5	op	12	283	14.25.13.6	OP
12	244	14.12.22.7	op	12	284	14.24.9.2	OP
12	245	14.13.31.0	46.55	12	285	14.23.1.9	OP
12	246	14.13.31.0	14n early	12	286	14.25.1.5	OP
12	247	14.13.31.0	fell off in bag	12	287	14.25.23.5	OP
12	248	14.13.31.0	op	12	288	14.22.0.0	OP
12	249	14.11.44.2	op	12	289	14.25.16.6	OP
12	250	14.11.33.25	22.14	12	290	14.23.33.7	OP
12	251	14.11.33.25	op	12	291	14.23.49.8	OP
12	252	14.13.24.6	g14	12	292	14.25.24.0	OP
12	253	14.13.24.6	on ground near bag	12	293	14.25.24.3	OP
12	254	14.13.24.6	op	12	294	14.25.20.8	OP
12	255	14.13.11.4	22.14, teardrop shape	12	295	14.24.32.5	OP
12	256	14.13.11.4	op	12	296	14.24.1.4	OP
12	257	14.12.16.4	6.15.40	12	297	14.23.41.1	OP
12	258	14.12.16.4	dropped, none on plan	12	298	14.24.16.0	OP
12	259	14.13.20.0	66.89	12	299	14.24.32.9	OP
12	260	14.13.20.0	op	12	300	MEGAWIMP	22.2.25.5
12	261	14.13.35.0	op	12	301	MEGAWIMP	14.17.5.5
12	262	14.13.23.6	op	12	302	MEGAWIMP	14.16.17.25
12	263	14.13.19.2	46.55	12	303	MEGAWIMP	OP
12	264	14.13.19.2	g14	12	304	2.14	46.55
12	265	14.13.19.2	2.16	12	305	2.16	G23
12	266	14.13.19.2	op	12	306	BerryBlue	op bl21
12	267	14.11.37.4	op				
12	268	14.11.46.8	op				
12	269	14.9.2.25	6.1.36.0				
12	270	14.9.2.25	2.17				
12	271	14.9.2.25	66.89				
12	272	14.9.2.25	op				
12	273	14.21.35.4	6.1.36.0				
12	274	14.21.35.4	under bag				
12	275	14.21.35.4	op				
12	276	14.21.9.0	op				
12	277	14.21.1.4	66.89				
12	278	14.21.1.4	g23				
12	279	14.21.1.4	op				
12	280	14.22.39.9	op				

Haskap Crosses done in 2013

*13-01	Tundra x Beauty	13-41	Aurora x 22-4-78.5	13-81	Tundra x Elephant	13-122	22-3-41.1 x R10
*13-02	Tundra x 22-8-31.5	13-42	22-6-33.0 x Elephant	13-82	22-2-56.0 x 22-4-12.0	13-123	22-3-41.1 x J11
*13-03	Tundra x J3	13-43	22-6-33.0 x 22-10-18.75	13-83	22-2-56.0 x 22-3-37.75	13-124	22-3-41.1 x 20-15-47.0
*13-04	Tundra x 22-11-34.4	13-44	22-6-33.0 x 22-11-34.4	13-84	22-2-56.0 x 22-4-14.0	13-125	22-3-18.2 x 22-6-33.0
*13-05	Tundra x 22-16-17.0	13-45	22-6-36.5 x 22-18-17.75	13-85	22-2-56.0 x 22-6-16.5	13-126	22-3-18.2 x 22-11-34.4
*13-06	Tundra x 22-16-17.75	13-46	22-6-36.5 x 14-17-47.3	13-86	22-2-56.5 x 22-3-37.75	13-127	14-13-0.5 x 14-13-3.75
*13-07	Tundra x 22-6-33.6	13-47	22-6-36.5 x Adorabelle	13-87	22-2-56.5 x 22-4-12.0	13-128	14-16-0.5 x 14-13-2.75
*13-08	Tundra x 22-5-51.5	13-48	22-6-36.5 x R10	13-88	22-2-56.5 x 22-4-14.0	13-129	14-16-9.25 x 22-4-78.5
*13-09	Tundra x J11	13-49	22-4-14.75 x J1	13-89	22-2-56.5 x 22-8-16.5	13-130	14-16-9.25 x 22-8-18.6
*13-10	Tundra x 22-15-32.5	13-50	22-4-14.75 x 22-5-51.5	13-90	22-4-78.5 x Aurora	13-131	14-16-9.25 x 14-16-10.25
*13-11	Tundra x 14-7-47.3	13-51	22-4-14.75 x 14-7-38.1	13-91	22-4-78.5 x 22-6-16.66	13-132	14-16-9.25 x 22-10-29
*13-12	Tundra x 14-16-0.5	13-52	22-4-14.0 x 22-2-56.0	13-92	22-3-111.5 x Adorabelle	13-133	14-16-9.75 x 20-16-47.6
13-13	Tundra x R10	13-53	22-4-14.0 x 22-2-56.5	13-93	22-3-111.5 x 20-8-17.7	13-134	14-16-9.75 x 20-15-32.25
13-14	Tundra x 14-7-38.1 Yuk	13-54	22-4-14.0 x 22-3-37.75	13-94	22-3-111.5 x 14-7-47.3	13-135	14-16-9.75 x 14-7-47.3
13-15	Tundra x 14-7-38.6	13-55	22-4-12.0 x 22-3-37.75	13-95	22-3-111.5 x R10	13-136	14-16-10.25 x Aurora
13-16	Tundra x 14-17-5.5	13-56	22-4-12.0 x 22-2-56.5	13-96	14-16-17.75 x R10	13-137	14-16-10.25 x 14-16-9.25
13-17	Tundra x 14-13-5.75	13-57	22-4-12.0 x 22-3-56.0	13-97	14-16-17.75 x J11	13-138	14-16-10.25 x 22-8-18.6
13-18	Tundra x 21-6-29.9	13-58	22-3-37.75 x 22-2-56.5	13-98	14-16-17.75 x J3	13-139	14-16-10.25 x 22-10-29
13-19	Tundra x Adorabelle	13-59	22-3-37.75 x 22-2-56.0	13-99	14-16-18.25 x 14-7-38.1 YUK	13-140	14-16-10.25 x 22-4-78.5
13-20	Tundra x 14-17-2.6	13-60	22-3-37.75 x 22-8-16.5	13-100	14-16-18.25 x 20-18-17.75	13-141	14-17-2.6 x 14-13-3.75
13-21	22-10-1.5 x 22-6-29.9	13-61	22-3-37.75 x 22-6-25.5	13-101	14-16-21.75 x 21-6-21.9	13-142	14-17-2.6 x 14-13-2.75
13-22	22-10-18.75 x 22-11-30.0	13-62	22-3-37.75 x 22-4-14.0	13-102	14-16-21.75 x 14-7-38.6	13-143	14-17-5.5 x 14-13-2.75
13-23	22-10-18.75 x 22-6-33.0	13-63	Tundra x 22-4-14.0	13-103	14-16-21.75 x 20-16-47	13-144	14-17-5.5 x 14-13-3.75
13-24	22-10-18.75 x 22-11-34.4	13-64	Tundra x 22-6-25.5	13-104	14-16-21.75 x 22-5-51.5	13-145	14-18-3.25 x J6+J1
13-25	22-10-18.75 x Elephant	13-65	Tundra x 22-4-12.0	13-105	14-20-5.0 x 22-8-51.5	13-146	14-18-3.25 x J4b bulk
13-26	22-10-29.0 x 14-16-10.75	13-66	Tundra x 22-2-56.0	13-106	14-20-5.0 x 22-8-31.5	13-147	14-19-1.0 x 14-7-47.3
13-27	22-10-29.0 x 14-16-9.25	13-67	Tundra x 22-2-56.5	13-107	Elephant x 22-6-33.0	13-148	14-19-1.0 x 14-7-38.7 YUK
13-28	22-10-29.0 x Aurora	13-68	Tundra x 22-8-16.5	13-108	Elephant x 22-8-31.5	13-149	14-19-2.75 x 14-16-0.5
13-29	22-11-34.4 x 22-6-33.0	13-69	Tundra x 22-8-31.5	13-109	Elephant x 22-8-17.75	13-150	14-19-2.75 x 14-17-2.5
13-30	22-11-34.4 x 22-8-16.75	13-70	Tundra x 22-3-37.75	13-110	22-4-78.5 x 14-19-10.75	13-151	14-19-3.75 x 14-17-2.6
13-31	22-11-34.4 x 22-8-31.5	13-71	Tundra x 22-10-29.0	13-111	22-4-78.5 x 14-19-10.25	13-152	14-19-3.75 x 14-17-5.5
13-32	22-11-30.2 x 22-8-16.75	13-72	Tundra x 22-6-33.0	13-112	22-4-78.5 x 14-16-5.5	13-153	20-16-47.0 x Dropped X's
13-33	22-8-16.66 x 14-16-10.75	13-73	Tundra x 14-16-10.25	13-113	22-4-78.5 x 14-16-9.5	13-154	22-15-32.25 x ON Fuzz
13-34	22-8-16.66 x 14-16-9.25	13-74	Tundra x 22-8-16.66	13-114	22-5-76.5 x 14-17-38.1 YUK	13-155	22-15-32.25 x spade
13-35	22-8-16.66 x Aurora	13-75	Tundra x 22-4-76.5	13-115	22-5-76.5 x 21-6-29.9	13-156	22-15-32.5 x B,B
13-36	22-8-16.66 x 22-4-78.5	13-76	Tundra x 14-16-9.25	13-116	22-5-76.5 x 20-15-32.25	13-157	20-16-47.0 x 22-2-25.5
13-37	22-6-25.5 x 22-3-37.75	13-77	Tundra x Aurora	13-117	22-5-76.5 x J3	13-158	22-15-32.25 x Big Heart
13-38	Aurora x 22-8-16.66	13-78	Tundra x 22-10-18.25	13-118	22-8-31.5 x 22-11-34.4	13-159	22-15-32.25 x Mega
13-39	Aurora x 22-10-29	13-79	Tundra x 22-11-30.2	13-119	22-8-31.5 x Elephant	13-160	20-15-24.5 x 22-4-12.0
13-40	Aurora x 14-16-10.75	13-80	Tundra x 22-11-34.4	13-120	22-3-41.1 x 14-7-38.6		

	Haskap Crosses done in 2013. continued				Haskap Crosses done in 2013. continued		
13-161	20-18-27.75 x Spade	13-201	20-16-47.0 x spade	13-241	20-18-27 x dropped	13-281	20-18-27.0 x 22-2-56.5
13-162	20-18-27.0 x Adore	13-202	20-18-27.0 x Mega	13-242	21-10-Pali stem? X J11 bulk	13-282	21-6-13.6 x spade
13-163	22-15-32.25 x Beauty	13-203	20-18-27.75 x Adore	13-243	20-18-27.75 x Pali	13-283	21-6-14.0 x mega
13-164	20-15-24.5 x Spade	13-204	20-18-27.75 x no label	13-244	20-18-27.75 x dropped	13-284	21-10-N Pali x J3 or op
13-165	22-15-32.25 x practically touchin	13-205	22-15-32.25 x Pali	13-245	20-18-27.0 x Big Heart	13-285	21-6-13.6 x Big Heart
13-166	20-16-47.0 x 22-2-56.0	13-206	20-16-47.0 x Aurora	13-246	20-18-27.0 x Fell off	13-286	21-6-14.0 x J3 bulk
13-167	20-16-47.0 x Pali	13-207	20-15-24.5 x 22-2-56.0	13-247	20-15-24.5 x 22-2-56.0	13-287	21-6-13.6 x J11 bulk
13-168	22-15-24.5 x Mega	13-208	20-18-27.0 x Pali	13-248	2-18-27.0 x spade		
13-169	20-16-47.0 x 22-10-29.0	13-209	20-18-26.5 x Spade	13-249	20-15-24.5 x spade		
13-170	20-16-47.0 x 14-16-9.25	13-210	20-18-27.75 x red can	13-250	20-18-27.0 x Beauty		
13-171	20-16-47.0 x 22-4-78.5	13-211	Q1#2 plus/minus 1 x 22-9-41.0 fly	13-251	20-15-24.5 x 22-8-16.5		
13-172	20-16-47.0 x 14-16-10.75	13-212	Lab 5 #1 +1 x 22-10-21.0 Fly	13-252	20-15-24.5 x 22-4-12.0		
13-173	20-18-27.0 x 14-19-2.75	13-213	Lab #3 +1+1 x 22-10-2.0 Fly	13-253	20-15-24.5 x Can red 2009		
13-174	20-16-47.0 x 22-2-56.5	13-214	Lab 5 #3 +1+1 x 22-10-2.0 Control	13-254	20-15-24.5 x 22-2-56.5		
13-175	20-16-47.0 x Beauty	13-215	22-10-6 paces Pali x J3 bulk	13-255	Beauty x creep Lab		
13-176	20-16-47.0 x Big Heart	13-216	22-10-6 pas palli x J11 bulk	13-256	20-18-26.5 Beauty		
13-177	22-15-32.5 x Dop x's	13-217	Lab #5 +1 x 22-10-21.0 control	13-257	21-6-14.3 x Mega		
13-178	20-15-24.5 x 22-2-14.0	13-218	Q2#3 +2 pink flower x Bor Fly	13-258	20-15-24.5 x 22-4-14.0 (misprint)		
13-179	20-15-24.5 x 22-3-37.75	13-219	L2#3 +1+1 x 22-9-18.2 control	13-259	20-18-26.5 x spade		
13-180	20-16-47.0 x 22-8-16.5	13-220	Q2#3+1 x Bor control Fly=0	13-260	20-16-47.0 x mega		
13-181	22-16-47.0 x Mega	13-221	Q2 #3 x Borisl control Fly=0	13-261	20-18-26.5 x 14-17-5.5		
13-182	20-15-24.5 x 22-3-37.75	13-222	6-10'4 paces palli op	13-262	21-6-13.6 x Big Heart		
13-183	20-15-24.5 x 22-8-16.5	13-223	L2##+1+1 x 22-9-18.2 Fly	13-263	20-18-26.5 x Big Heart		
13-184	21-6-29.9 x J11 bulk	13-224	Q2#3+2 pink flower x bor control	13-264	20-15-24.0 x Mega		
13-185	20-16-47.0 x Tundra	13-225	Q1#2 plus/minus 1 z 22-9-41.0 control	13-265	22-8-18.66 x 14-16-10.75		
13-186	220-15-24.5 x 22-8-16.5	13-226	21-6-14.3 sten x J3 bulk	13-266	20-18-27.0 x Adore		
13-187	20-18-27.0 x Beauty	13-227	Blk 10 creeper from (Max op)	13-267	22-6-19.0 (Pali) x J3		
13-188	20-15-24.5 x Beauty	13-228	Beauty x creep QC	13-268	20-16-47.0 x Beauty		
13-189	20-18-27.75 x Beauty	13-229	21-10-Pali/stem x J3 Bulk	13-269	20-16-47.0 x 22-2-56.5		
13-190	22-15-32.5 x 14-19-3.75	13-230	20-18-26.5 x Mega	13-270	20-15-24.5 x 22-6-25.5		
13-191	20-18-27 x spade	13-231	Beauty x Precious	13-271	20-18-27.0 x Pali		
13-192	22-18-27.75 x On Fuzz	13-232	20-18-26.5 x Beauty	13-272	21-6-14.3 x super close to mega		
13-193	20-15-24.5 x 22-6-25.5	13-233	20-18-26.5 x 14-17-5.5	13-273	20-15-24.5 x big heart		
13-194	20-18-27.75 x Big Heart	13-234	21-6-13.6 stem x J11	13-274	Pali Row 10N x J11		
13-195	20-18-27.75 x Mega	13-235	20-18-26.5 x Big Heart	13-275	20-16-47.0 x Spade		
13-196	20-18-27.75 x 71.64	13-236	20-15-24.5 x 22-2-56.5	13-276	20-16-47.0 x Big Heart		
13-197	20-18-27.0 x 22-2-56.5	13-237	20-15-24.5 x Fell off	13-277	21-6-13.6 x Jll bulk		
13-198	22-15-32.25 x Beauty	13-238	20-18-26.5 x dropped	13-278	Pali Row 10N x J3 bulk		
13-199	20-18-27.0 Dropped	13-239	21-6-13.6 sten x spade	13-279	20-15-24.5 x Beauty		
13-200	20-18-27.0 x 14-17-26 or 2.6	13-240	22-15-24.5 x Pali	13-280	20-18-26.5 x fall off		

Haskap crosses done in 2014								
Cross ID	Female Parent	Male Parent		Female Parent	Male Parent		Female Parent	Male Parent
14-001	22-6-25.5	20-20-34.8	14-053	20-01-17.0	22-10-19.1	14-102b	14-19-3.75	22-12-24.8
14-002	22-6-25.5	22-10-19.1	14-054	14-16-0.5	14-17-3.6	14-103a	14-19-3.75	14-17-2.0
14-003	22-6-25.5	22-11-3.3	14-055	14-16-0.5	20-18-26.9	14-103b	14-19-43.5	22-11-33.0
14-004	22-10-19.1	20-31-17.6	14-056	14-16-0.5	14-19-3.75	14-104	14-19-43.5	22-12-30.4
14-005	22-10-19.1	20-03-20.5	14-057	14-16-0.5	14-17-5.5	14-105	14-19-43.5	20-14-19.2
14-006	22-10-19.1	20-05-31.1	14-058	14-16-0.5	14-17-4.2	14-106	14-19-43.5	14-16-9.75
14-007	22-10-19.1	14-20-43.6	14-059	14-17-2.0	22-12-30.4	14-107	14-19-43.5	20-20-34.8
14-008	22-10-29.0	20-03-19.65	14-060	14-17-2.0	22-11-3.3	14-108	14-19-43.5	20-14-19.2
14-009	22-10-29.0	14-20-44.4	14-061	14-17-2.0	22-11-38.95	14-109	14-19-43.5	20-20-34.8
14-010	22-10-29.0	20-01-14.9	14-062	14-17-2.6	22-10-19.1	14-110	14-19-43.5	22-10-19.1
14-011	22-11-3.3	22-06-25.5	14-063	14-17-2.6	22-10-29.0	14-111	14-19-43.5	14-18-1.75
14-012	22-11-3.3	20-02-5.2	14-064	14-17-2.6	20-30-36.8	14-112	14-19-43.5	14-18-3.25
14-013	22-11-3.3	20-01-10.5	14-065	14-17-3.6	21-03-22.4	14-113	14-19-43.5	22-10-1.5
14-014	22-11-3.3	21-03-22.4	14-066	14-17-3.6	20-03-22.5	14-114	14-19-43.5	20-16-25?
14-015	22-12-24.8	22-05-77.0	14-067	14-17-3.6	20-05-31.1	14-115	14-19-43.5	20-01-15.2
14-016	22-12-24.8	20-01-17.0	14-068	14-17-5.5	20-01-14.9	14-116	14-19-43.5	20-01-14.9
14-017	22-12-24.8	20-01-15.3	14-069	14-17-5.5	14-20-44.4	14-117	14-19-43.5	22-19-12.9
14-018	22-12-24.8	20-02-1.4	14-070	14-17-5.5	20-01-15.3	14-118	20-14-19.2	20-14-22.5
14-019	TUNDRA	14-20-44.4	14-071	14-17-4.2	20-03-19.65	14-119	20-14-19.2	14-16-10.5
14-020	TUNDRA	22-6-25.5	14-072	14-17-4.2	14-20-43.6	14-120	20-14-19.2	20-22-19.0
14-021	TUNDRA	20-01-10.5	14-073	14-18-1.75	20-02-1.4	14-121	20-15-24.5	14-17-2.0
14-022	TUNDRA	20-01-15.3	14-074	14-18-1.75	20-01-17.0	14-122	20-15-24.5	20-01-15.3
14-023	TUNDRA	20-05-31.1	14-075	14-18-3.25	20-01-10.5	14-123	20-15-24.5	14-17-3.1
14-024	TUNDRA	14-16-0.5	14-076	14-18-3.25	20-02-5.2	14-124	20-15-24.5	14-17-5.5
14-025	TUNDRA	14-19-2.75	14-077	14-18-3.25	22-5-77.0	14-125	20-15-24.5	14-17-2.6
14-026	TUNDRA	14-19-1.0	14-078	14-18-3.25	14-16-10.5	14-126	20-15-24.5	20-07-42.25
14-027	TUNDRA	20-01-17.0	14-079	14-18-3.25	14-17-2.6	14-127	20-15-24.5	14-18-3.25
14-028	TUNDRA	14-19-43.5	14-080	14-18-3.25	20-14-22.5	14-128	20-15-24.5	20-15-24.5
14-029	# not used		14-081	14-18-3.25	20-15-32.25	14-129	20-15-24.5	14-16-10.5
14-030	22-04-12.7	20-03-22.5	14-082	14-18-3.25	20-07-42.25	14-130	20-18-26.9	20-23-31.8
14-031	TUNDRA	20-06-13.6	14-083	14-19-1.0	14-16-9.25	14-131	20-18-26.9	20-14-19.2
14-032	TUNDRA	20-26-20.6	14-084	14-19-1.0	22-12-24.8	14-132	20-18-26.9	20-23-31.2
14-034	TUNDRA	20-04-17.25	14-085	14-19-1.0	20-20-34.8	14-133	20-18-26.9	22-19-12.2
14-035	TUNDRA	22-04-14.75	14-086	14-19-2.75	20-01-15.3	14-134	20-18-26.9	14-16-10.5
14-036	TUNDRA	20-28-48.0	14-087	14-19-2.75	20-15-24.5	14-135	20-18-26.9	14-17-5.5
14-037	TUNDRA	22-05-81.0	14-088	14-19-2.75	22-10-29.0	14-136	20-18-26.9	22-10-1.5
14-038	TUNDRA	20-03-12.0	14-089	14-19-2.75	20-30-36.8	14-137	20-18-26.9	20-01-15.3
14-039	TUNDRA	20-03-26.0	14-090	14-19-2.75	20-01-14.9	14-138	20-18-26.9	14-18-3.2
14-040	TUNDRA	21-02-17.4	14-091	14-19-2.75	22-11-38.9	14-139	20-16-25?	20-09-15.3
14-041	21-01-24.6	14-20-42.6	14-092	14-19-2.75	22-10-12.7	14-140	20-16-25?	14-17-2.6
14-042	21-01-24.6	14-16-9.75	14-093	14-19-2.75	22-10-9.85	14-141	20-16-25?	20-01-13.3
14-043	21-01-24.6	22-10-29.0	14-094	14-19-2.75	22-10-19.7	14-142	J1 bl20r12	op
14-044	20-1-10.5	20-30-36.8	14-095	14-19-2.75	14-16-9.25	14-143	20-14-13.6	op
14-045	20-1-10.5	22-12-24.8	14-096	14-19-2.75	22-9-36.45	14-144	J11 B20R18	OP
14-046	20-1-10.5	22-11-38.95	14-097	14-19-2.75	14-20-42.6	14-145	20-32-14.0	OP
14-047	20-1-10.5	22-12-30.4	14-098	14-19-3.75	20-22-19.0	14-146	20-32-11.7	OP
14-048	20-01-15.3	14-16-7.25	14-099	14-19-3.75	22-10-9.85	14-147	J3 B20R13	OP
14-049	20-01-15.3	14-20-42.6	14-100	14-19-3.75	14-16-14.1	14-148	J7 B20R15	OP
14-051	20-01-17.0	22-10-29.0	14-101	14-19-3.75	22-10-19.1	14-149-152	TUNDRA	OP
14-052	20-01-17.0	14-16-9.75	14-102a	14-19-3.75	20-32-41.9			

Appendix A2: Timing of Bloom and harvesting, example of data collected. Data was collected each year for superior advanced selections. Partial data is shown to allow possible scientific publication.

Table A2.1. Bloom progression of advanced selections Haskap varieties need cross pollination from another variety to set fruit. This table shows which varieties could potential be cross-pollinators. Additional testing is needed to see if the pollen is compatible (see table 3). Evaluation is based on observational estimates of the following scale: Where 1=swelling buds, 2=can see flower buds, 3=some flowers open, 4=estimates % bloom, 5=full bloom. On cold springs, as in 2012, bloom time is stretched out causing wide separation in bloom times between the early and late bloomers. When hot weather is common at bloom time, early and late bloomers can have overlapping bloom times.

Variety	Apr-26	Apr-30	May-03	May-07	May-10	May-14	May-17	May-22	May-25
1	1.5	1.5	1.5	2	3	4=30%	4=60%	5	5
2	2	2	3	4=30%	4=80%	5	5	5	5
3	1.5	1.5	2	2	4=30%	4=80%	5	5	5
4	2	2	2	2	3	4=30%	5=50%	5	5
5	1.5	1.5	2	2	3	4=50%	4=80%	5	5
6	1.5	1.5	2	2	3	4=10%	4=30%	4=80%	5
7	1	1.5	1.5	2	2	3	4=40%	4=60%	5
8	1.5	2	1.5	2	2	4=10%	4=70%	5	5
9	1	1	1.5	1.5	2	2	3	4=70%	5
10	1	1	1	1.5	2	2	4=20%	5	5
11	1	2	2	2	3	4=10%	4=30%	4=80%	5
12	2	2	2	3	4=10%	4=40%	5	5	5
Aurora *	2	2	2	2	4=40%	4+80%	5	5	5
Tundra	2	2	2	4=10%	4=50%	5	5	5	5
Borealis	2	2	3	3	4=50%	4=90%	5	5	5
Indigo Gem	2	2	2	4=10%	4=40%	5	5	5	5

* formerly 22-6-26.5

Table A2.2. Progression of ripening of advanced selections and U of SK. 1=a few ripe berries 2= 25%, 3=50% 4= 75% and 5=100% ripe. Since all of these selections ripen together, they could be inter-planted within a row for mechanical harvesting.

Variety	Jun-19	Jun-26	Jul-03	Jul-10
1	2	4	5	5
2	3	4	5	5
3	3	4	5	5
4	3	4	5	5
5	3	4	5	5
6	2	3	4	5
7	1	3	4	5
8	2	3	5	5
9	1	3	4	5
10	1	3	4	5
11	1	3	5	5
12	2	3	4	5
Aurora *	2	4	5	5
Tundra	3.5	4	5	5
Borealis	3	4	5	5
Indigo Gem	3	4	5	5

* formerly 22-6-26.5

Table A2.3-Pollination Test Results for 2013 crosses. The number of flowers pollinated as well as the number of berries harvested was recorded. Crosses that had large numbers of flowers but small numbers of fruits harvested are considered to be incompatible.

Cross ID Number	Cross	# flowers pollinated	# of berries Harvested
13-26	22-10-29.0 x 14-16-10.75	40	1
13-27	22-10-29.0 x 14-16-9.25	14	6
13-28	22-10-29.0 x Aurora	19	1
13-29	22-11-34.4 x 22-6-33.0	72	20
13-30	22-11-34.4 x 22-8-18.75	36	21
13-31	22-11-34.4 x 22-8-31.5	32	11
13-32	22-11-30.2 x 22-8-18.75	68	22
13-33	22-8-18.66 x 14-16-10.75	25	45
13-34	22-8-18.66 x 14-16-9.25	15	35
13-35	22-8-18.66 x Aurora	31	28
13-36	22-8-18.66 x 22-4-78.5	14	13
13-37	22-6-25.5 x 22-3-37.75	30	3
13-38	Aurora x 22-8-18.66	10	8
13-39	Aurora x 22-10-29	3	4
13-40	Aurora x 14-16-10.75	8	9
13-41	Aurora x 22-4-78.5	6	1

13-42	22-6-33.0 x Elephant	20	21
13-43	22-6-33.0 x 22-10-18.75	14	15
13-44	22-6-33.0 x 22-11-34.4	34	8
13-52	22-4-14.0 x 22-2-56.0	22	2
13-53	22-4-14.0 x 22-2-56.5	12	4
13-54	22-4-14.0 x 22-3-37.75	9	8
13-55	22-4-12.0 x 22-3-37.75	7	4
13-56	22-4-12.0 x 22-2-56.5	13	10
13-57	22-4-12.0 x 22-3-56.0	12	4
13-58	22-3-37.75 x 22-2-56.5	6	4
13-59	22-3-37.75 x 22-2-56.0	9	3
13-60	22-3-37.75 x 22-8-16.5	6	9
13-62	22-3-37.75 x 22-4-14.0	3	2
13-82	22-2-56.0 x 22-4-12.0	8	3
13-83	22-2-56.0 x 22-3-37.75	24	3
13-84	22-2-56.0 x 22-4-14.0	15	0
13-85	22-2-56.0 x 22-8-16.5	11	6
13-86	22-2-56.5 x 22-3-37.75	12	8
13-87	22-2-56.5 x 22-4-12.0	8	3
13-88	22-2-56.5 x 22-4-14.0	11	10
13-89	22-2-56.5 x 22-8-16.5	13	5
13-110	22-4-78.5 x 14-19-10.75	12	1
13-118	22-8-31.5 x 22-11-34.4	50	36
13-119	22-8-31.5 x Elephant	40	35
13-127	14-19-0.5 x 14-19-3.75	5	8
13-128	14-16-0.5 x 14-19-2.75	3	3
13-129	14-16-9.25 x 22-4-78.5	8	11
13-130	14-16-9.25 x 22-8-18.6	4	0
13-131	14-16-9.25 x 14-16-10.25	3	8
13-132	14-16-9.25 x 22-10-29	4	13
13-136	14-16-10.25 x Aurora	4	5
13-137	14-16-10.25 x 14-16-9.25	3	4
13-138	14-16-10.25 x 22-8-18.6	2	1
13-139	14-16-10.25 x 22-10-29	10	9
13-141	14-17-2.6 x 14-19-3.75	1	3
13-142	14-17-2.6 x 14-19-2.75	6	13
13-143	14-17-5.5 x 14-19-2.75	11	6
13-144	14-17-5.5 x 14-19-3.75	9	5
13-149	14-19-2.75 x 14-16-0.5	7	7
13-150	14-19-2.75 x 14-17-2.5	15	11
13-151	14-19-3.75 x 14-17-2.6	5	7
13-152	14-19-3.75 x 14-17-5.5	8	10

Appendix B. New variety descriptions. All were/are posted as web article on our website www.fruit.usask.ca and are listed in chronological order of their release. Our propagators often reproduce these articles or summarize them. Note that the description of 'Honey bee' was made during this project but the variety was released in the previous ADF Project.

'Honey Bee' Description

By Bob Bors

University of Saskatchewan Fruit Program

'Honey Bee' was selected to be a pollinator for 'Borealis', 'Tundra' and the 'Indigo' series. (I'll call them 'BTI') It blooms at the same time and has given good fruit set when used in controlled crosses with them. It is very fast growing, productive and starts fruiting at an early age.

Figure 1. 'Honey Bee' bush showing productive branches.

Its fruits are cylindrical and look more like its Russian parent (see figure 1); perhaps like the shape of a bee's body. Unlike most Russian varieties used for pollination, 'Honey Bee' holds onto its fruit firmly and stays on the bush longer than most other varieties. Most Russian blue honeysuckles varieties drop their fruit as soon as ripe in late June or early July, but not 'Honey Bee'. In 2011, it was

still holding onto its fruit firmly the 3rd week of August. The stems stay on the fruit about 40% of the time when picked (reminds me of a stinger). That cylindrical shape doesn't roll around very well in equipment and neither do the stems (Stingers) come off very easily, so this variety is definitely not recommended for mechanical harvesting, unless juice is the goal.

The fruit is tarter than 'BTI' but less tart than most Russian pollinators. It has a general flavour like other Haskap but it has a hint of something different. A few growers that tasted it said it tasted good and a few also thought there was something different about it but couldn't put their finger on it. I think that undertone may be a very very slight bitterness or astringency that in the jargon of wine making might be a characteristic that gives better 'mouth-feel' to wines. Or in keeping with the bee theme, it could give a bit of a buzz. I hope some wine makers will one day try this variety and tell me if it makes a better wine. A bit more tartness could be an asset in processing or cooking. However, unless you are prepared to remove all those stems on the berries, it would be better to just crush the berries and use the juice for drinking, wine making, or making jelly.

Figure 2. "Honey Bee's leaves are similar size but slightly wider than our other varieties. (also it has less pubescence (hairs) on it's leaves.

Its leaves are very similar in appearance to 'BTI' and like 'BTI' it has a high degree of resistance to leaf mildew on our test plots (see figure 2). The reason they look similar is because 'Honeybee' is also a hybrid between a variety from Russia (Suvenir) and a variety descendant from the Kuril Islands (F-1-9-58 alias 'Blue

Pacific'). But it pollinates them well because its parents are not closely related to 'BTI's parents. But both of 'Honey Bee's' parents are taller than 'BTI's and it is suspected that it will grow to be 2 feet or so taller than 'BTI'. The original plant of 'Honey Bee' is at least 50% taller than the 'Borealis' plants in the same row.

Figure 3. 'Honey Bee's fruit is cylindrical. The original bush is rather young so fruit size will likely increase when the bush gets older. Notice that some of the stems are still holding onto the berries.

The need for a mildew-resistant pollinator 'BTI' are siblings and do not pollinate each other well. Previously, we recommended trying other Russian varieties that are on the market. We had many complaints, especially from home gardeners, that their pollinators were getting severe mildew in July and looked poorly the rest of the summer (see figure 4). Mildew makes plants look poorly for the latter half of summer but does not seem to greatly reduce productivity or longevity. Fruit farmers don't need to pull out existing pollinators if they get mildew. But bush appearance is likely to be more important for gardeners. If replacing existing pollinators, it would be best to let 'Honey Bee' get a few years old before removing the old pollinator, to assure adequate pollen supply.

History: In 2009, we started a search for a better pollinator by identifying the best 6 seedlings out of about 1000 from the 2006 and 2007 plantings. All 6 were

rated as productive, good tasting, vigourous, and bearing fruit at a young age. 'Honey Bee' was one of the few good producers at only 2 years old. All 6 selections were put into tissue culture to evaluate relative ease of propagation and Honey Bee was the fastest multiplier. The next season we observed the timing of flower opening and did controlled crosses with all 6. 'Honey Bee' was the best choice because it alone bloomed at the right time and gave good fruit set when crossed to 'Borealis' and 'Tundra'. We did not test the 'Indigo' series are siblings of 'Borealis' and 'Tundra' and should work well with 'Honeybee'.

Berry Blue (Czech#17) Cinderella (Zolushka)

Figure 4. These 2 commonly used pollinators have much smaller leaves than our varieties in Figure 2. All leaf photos were taken on July 22, 2011 and are the same scale. The 'Berry Blue' in this photo has a moderate level of mildew, while 'Cinderella' has a severe level. 'Honey Bee' is rated as highly resistant to mildew. Mildew varies from year to year but tends to strike in mid to late July especially if it is hot and humid.

Pollination Myths: Haskap or Honeyberries or Blue Honeysuckles do not have male or female plants; every Haskap (or Honeyberry) variety has both male and female parts but can't pollinate itself...just like apples, pears, plum, and apricots. It's nature's way of making healthy hybrid offspring. A Haskap pollinator will bear fruit that is quite useful. Calling something a "pollinator variety" implies that it is not as desirable as the "main variety". In the case of commercial growers using mechanical harvesters 'Tundra' and possibly 'Indigo Gem' are more durable

in machinery and would be considered the "main varieties" and 'Honey Bee' would be the "pollinator variety". In the case of a homeowner growing 'Borealis,' perhaps 'Honey Bee' might be considered just as desirable and both would could be called "companion varieties". But both need each other to set fruit.

Planting Because of larger plant size, one 'Honey Bee' could provide pollen for 4 to 8 'Borealis' and 'Tundra' plants, if planted in close proximity. There is an article about planting strategies for cross pollination in our website: www.fruit.usask.ca . In a gardening situation, it would be better to put 'Honey Bee' either on the north side of 'Borealis' or far enough away that it won't crowd it out or reduce the sunshine. 'Honey Bee's bush is taller but seems to be similar width to 'BTI' and so can be planted at a similar spacing

Primarily useful for juice production: The fruit will likely need to be handpicked. If a machine is used for harvesting, the berries may become too mashed so it should be frozen soon after picking. It may be best to place it in separate rows. Somewhat mashed berries would still be good for most products. The stems holding onto the berries fruit is a disadvantage for many products, but would not matter if the fruit was used for juice, wine or jelly. The added tartness and different flavour may make it desirable for some products like wine or liquers.

Guard Row Potential Perhaps "Honey Bee" could be used as a guard row to protect inner rows from cedar waxwings. In 2011, we had too many fields of Haskap to protect with netting so we didn't try. We observed that waxwings were nesting in nearby trees and swooped into rows closest to their trees. The outer rows of the field were picked clean 1st! I always observed them in bushes eating fruit, never dining on fallen berries on the ground. In many bushes it appeared that waxwings were knocking off more fruit than they were eating (see figure 5). Since 'Honey Bee' fruit stays on the bushes, waxwings won't be so wasteful and it should take them longer to get to your preferred varieties.

Blue Raisins? If the birds don't get them, 'Honey Bee' may be suitable for drying on the bushes to make blue raisins since it holds onto its berries. Its cylindrical berries should dry much faster than the plump 'BTI' berries. The advantage of drying the berries on the bush is that they remain blue, but if dried in a drying

machine they turn black. We have an article on our website called "Dried Haskap" with more details on this. Drying haskap on bushes should be considered highly experimental and we really don't know if it is feasible.

Figure 5. Two conditions are needed for fruit drop: a variety that lets go of its fruit easily and something to jostle the bushes; something like wind, hail or waxwings.

Future & Availability: 'Honey Bee' will be made available to all of our propagators of 'BTI' and will be able to be sold into the USA. Depending on whether a nursery does tissue culture or traditional cuttings, it may take a year or two after the release of a new variety before propagators have enough to sell. Our website lists all authorised propagators www.fruit.usask.ca .

We have identified new seedlings in our breeding fields that have berries that look like 'BTI' berries and have very similar bushes. Some of those could be worthwhile pollinators too. But we need to observe their time of bloom and test them for pollen compatibility. It would likely take a couple years before such improved pollinators could be propagated made available to the public.

Acknowledgements: Breeding of Haskap is continuing at the University of Saskatchewan. It is made possible through grants from the Agriculture Development Fund of Saskatchewan Agriculture and from royalties from the sale of our varieties. Almost all the royalties received come back to our program to fund more fruit research and breeding.

[Note: 'Aurora' was a new release in 2012 but 'Borealis' had been released previously]

‘Aurora’ & ‘Borealis’ Haskap

These two varieties were named so gardeners buying plants could remember that ‘Aurora’ and ‘Borealis’ go together. ‘Borealis’ had been our favourite for the home gardener since 2007. ‘Aurora’ is our favourite from more recent breeding efforts. Together, they make a good team with complimentary attributes.

Availability: ‘Aurora’ is a new haskap variety released to propagators in 2012. Likely it will be available to fruit growers and gardeners in 2013 or 2014. ‘Borealis’ was released in 2007 and is widely available. Both ‘Aurora’ and ‘Borealis’ are undergoing Plant Breeder’s Rights Certification with Agriculture Canada.

Compatibility: ‘Aurora’ was selected to be a companion variety for ‘Borealis’ but will also pollinize ‘Tundra’, and ‘Indigo’ series Haskap. ‘Aurora’ gave excellent set when hand crossed to all those varieties and was observed to bloom in sync with them. What are companion varieties? It’s when the varieties are desirable and will pollinize each other for good fruit set.

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Table 1: Similarities & differences between 'Aurora' and 'Borealis' .

Traits	'Aurora'	'Borealis'
Fruit Weight	1.9 grams	1.6 grams.
Fruit Shape	Pointed Pear somewhat	Oval & Boxy
Fruit Seen	Fruit easily seen on bushes	Fruit hidden by leaves
Season (in SK)	Late June / early Aug	July to early August
Mildew Resistance	High Resistance	Very High Resistance
Bush Shape	Upright & spreading	Wide Spreading
Bush Height	5 to 5.5 ft	4 to 4.5 ft
Fruit retention	Easy to pick	Holds onto fruit
Flavour	Excellent	Excellent
Bloom Time (in SK)	Mid May	Mid May
Productivity	High	High
Lineage type	Russian x Japanese	Kurile x Russian
Lineage, parents	Solovey x MT46.55	Kiev#8 x Tomichka

What's a Pollinizer? Sometimes a variety is called a 'Pollinizer', especially in those crops like Kiwi or Seabuckthorn which have male and female plants. Confusion on this term has caused some gardeners to think there are male and female haskap plants, but that's not true. There is no separation of the sexes with Haskap plants. All haskap plants are capable of producing fruit if they have a companion that blooms at the same time, and which is compatible, and if there are bees around. Other fruits that need companion varieties are apples, plums, apricots, pears, and sweet cherries. Sometimes in the nursery trade a variety is called a 'pollinizer' if it works as a companion but maybe you won't want to grow as much of it.

Attributes: Most important is that 'Aurora' and 'Borealis' have similar great flavour, but 'Aurora' tastes

sweeter and is more productive. Several experienced growers at our 2012 'Haskap Day' remarked "I didn't know Haskap could get that sweet". For many other attributes they have differences that should appeal to home gardeners. Having different shapes is fun. Perhaps 'Borealis' berries have a more lovely shape, but 'Aurora' berries are shockingly different and would make a memorable impression when given to someone. But shape only matters for fresh eating and not cooking. 'Aurora's' larger berries are easier to pick will certainly have more appeal to someone who is planting many bushes.

Just because they are companion varieties does not mean that gardeners have to plant exactly the same number of 'Aurora' and 'Borealis' plants. One 'Aurora' could easily pollinize 8 'Borealis' and similarly 1 'Borealis' could pollinize 8 'Auroras'. As long as the plants are easily seen in the same location by bees they will be fine. But if you plant some in the front yard and some in the back yard, it would be best to have both in both locations. I suspect that gardeners who like to freeze fruit or make jam or wine would want to grow more 'Aurora' since they can harvest them faster. But 'Borealis' thick and compact growth habit may have more appeal as a landscape shrub. When planting these two, keep in mind that 'Aurora' will likely grow ½ meter taller than 'Borealis' or 'Tundra' or 'Indigo' haskap varieties. If planting double rows along a fence or next to a building, plant 'Aurora' in the back and 'Borealis' in the front.

'Aurora' is worth trying in commercial operations, especially if one has a harvester that blows off leaves as the fruit is picked. Its odd shape won't allow it to roll on a sorting line like 'Tundra'. We find that our sideways 'Joanna Harvester' makes our sorting line unnecessary for haskap, since it does such a good job on berries of any shape.

Adaptation Zone: Both 'Aurora' and 'Borealis' are hybrids between early and late blooming types. They are fully hardy in Zone 2 at our breeding site in Saskatoon, Saskatchewan. As with all Haskap varieties, open flowers can take -7^{o}C without damage. It is expected that they can be grown farther south than pure Russian varieties but we don't know how far south that could be. They are not the first to bloom which is a good thing for southern areas. In our location, Russian varieties bloom 1 month before the last frost, but these 2 varieties bloom 2 weeks before the last frost. Also, both have good resistance level to mildew which is a problem in more southern locations.

We have a test ongoing in southern BC that will generate more information in 2012 and 2013 about southern adaptation. My guess would be that Zone 5 will be dependable production and that Zone 6 will have problems in some years. Zone 7 may be too warm. Those are just guesses; I'll update this document when we learn more.

Conclusion: The new variety 'Aurora' was selected as one of the best of the mid-season types from among 10,000 seedlings and a decade of breeding. As of its release date, it is the largest fruited haskap on the market in Canada and one of the best tasting. But thanks to royalties from our propagators and Saskatchewan Agriculture's Agriculture Development Fund, we have another 20,000 or so seedlings expected to bear fruit in the next few years. We expect to release more varieties in the not too distant future for orchardists and gardeners.

More Information: www.fruit.usask.ca has many articles, links, and a listing of propagators. In July we have a Haskap Day workshop event.

‘Boreal Blizzard’ by Bob Bors

Available in 2016

Figure 27. 'Boreal Blizzard' berries are huge, for a Haskap. The spoon in the photo is 3.5 cm wide! If this page is printed on 8 ½ x 11 paper the berries should be shown at actual size. Well-pollinated fruits are easily greater than 3 grams and we've weighed a few that were 3.9 grams.

‘Boreal Blizzard’ was so named because the fruit size, productivity, and flavour stopped us in our tracks. Like a major winter storm, ‘Boreal Blizzard’ was hard to forget when evaluating all other haskap in our breeding fields. It has the 3rd largest haskap we have ever seen in our breeding program. The largest one didn’t taste good (‘Boreal Blizzard’ tastes great!) and the 2nd largest had wimpy branches that fell over and crept along the ground. I’ve not seen anything this big elsewhere else. It surpasses the largest haskap that I saw on my visit to Hokkaido and sounds larger than any variety description that I have read. ‘Boreal Blizzard’s berries are more than twice as heavy as ‘Tundra’ or ‘Borealis’ and are 3 times heavier than the largest varieties in our trial a decade ago. I’ve noticed most variety descriptions on the internet neglect to mention the weight of their berries. This is because some haskap can have air pockets within the berries and long thin berries don’t weigh much. But some Haskap are very meaty and heavy, and ‘Boreal Blizzard’ is one of them.

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Does size matter? Of course it does! In Japan, consumers pay a premium for larger berries. Some producers sort through their berries to find the largest ones. It was pointed out to me at a wholesale produce market in Hokkaido that two cases of large Haskap would sell for a similar amount as 20 cases of average-sized fruits. The large haskap berries I saw probably averaged half the weight of 'Boreal Blizzard'. Unless you can ship fresh to Japan, I wouldn't expect a premium price in Japan for large berries for processing.

I don't think anyone cares about fruit size if the fruit is processed. Sugar infusing them as a candy or vodka or other alcohol with whole fruit might be the exceptions. 'Boreal Blizzard' could be used for processing of course. Perhaps the largest fruit could be marketed fresh and the small berries processed. But even its "small" berries would be larger than most varieties.

Perhaps a profitable niche for this variety in North America would be the fresh market. I wouldn't expect such a price differential like Japan has for fruit size in North America, but the larger size is likely worth something. These would certainly be more noticeable on a store shelf than regular-size berries. Their unique shape would not get confused with blueberries! If one is going to the trouble to handpick haskap (less fruit damage than by machines and longer shelf life) picking larger fruit reduces harvesting costs. Fruits are easier to see and each grab of a cluster weighs more. This could be an ideal variety for U-pick farms as customers will fill their pails faster.

Large fruit could also indicate large yields if plants produce many berries. And that does seem to be the case with 'Boreal Blizzard'.

Large size fruit could have disadvantages. They might be more easily damaged by some harvesting equipment. A heavier fruit falling from a taller plant could have more damage. But 'Boreal Blizzard' berries are more firm than 'Indigo Gem' and many growers are mechanically harvesting that variety. If mechanically harvesting, it is good to keep in mind that berries are always more firm with cooler temperatures. Plan to harvest early in the morning before it gets too hot. I've heard of Saskatoon berry growers harvesting before sunrise to take advantage of the firmness but also to have cooler berries going into freezers.

'Boreal Blizzard' holds onto its berries with a similar strength to 'Tundra' or 'Indigo Gem'. Since 'Boreal Blizzard' berries weigh twice as much, they start to drop 3 weeks after ripe. In contrast, Tundra can hold onto its fruit 6 weeks after ripening. Presumably, a very strong windstorm could knock them off a bit easier than some of the U of SK varieties especially when they have been ripe for a week or two. But I have seen many varieties that do not hold onto their fruit as strongly as 'Boreal Blizzard'.

Important to consider, is that 'Boreal Blizzard' blooms and ripens later than other varieties from the U of SK. This could extend the harvesting season of Haskap a week or two. Later bloom time will make the bees happy to stay in the orchard. The late bloom characteristic may indicate a better adaptation to somewhat warmer areas (see article "Shape of things to come" at www.fruit.usask.ca , in the haskap section).

'Boreal Blizzard' Details
Plant Breeders Rights application #: 14-8412 **Breeder denomination:** '22-06-25.5'
Ancestry: 50% Japanese, 50% Russian
Bloom Time Category: Late. Peak bloom is 4 to 7 days after Tundra/Indigo series We categorize haskap bloom into 4 categories early, mid, late and very late. The late category is similar to many Japanese selections but there are many Japanese selections that bloom later.
Harvest Season: Coincides with strawberry season. At Saskatoon in 2014 fruits were good the 1st 3 weeks of July then began dropping. Ripening started 7 days after Tundra & Indigos and 14 days after most Russian varieties in our collection.
Fruit Weight: 2.8 grams avg., 3.9 grams max
Fruit Shape: 'Surfboard'= Rounded narrower ends, wide centre, a bit flattened
Fruit Firmness: Good **Flavour:** Excellent
Sugars: 13.3 Brix **pH:** 3.3 **Total Acidity:** 13.3% Malic Equivalent
Bush Habit and Vigour: Upright and strong grower. The original seedling was 50% taller than 'Indigo Gem' planted at the same time, same field
Mildew and Sunscald Resistance: Excellent
Productivity: Heavy

'Indigo Gem' and 'Tundra' are tentatively recommended as pollinators for 'Boreal Blizzard'. Both worked well in controlled crosses. However they are mid-season bloomers while 'Boreal Blizzard' is a late bloomer. 'Aurora' is unlikely to be a good pollinator since it is closely related to 'Boreal Blizzard'. Mid and Late bloomers usually have an overlap in their bloom time of 60 to 75% in Saskatoon. That could mean the first flowers of 'Boreal Blizzard' that open will be well pollinated but its last flowers will be poorly pollinated. If only the earliest flowers got pollinated would those fewer berries overcompensate and get even larger? Perhaps it would worth the reduction of yield if fruit size got much bigger and one got higher prices.

I advise growers who are the first to plant 'Boreal Blizzard' to leave space for alternate rows in orchards to plant late blooming varieties when they come out. 'Boreal Beauty' is late ripening and is not closely related to 'Boreal Blizzard' making it a highly probable that it will bloom late and be compatible for pollination. But we need to test that to be sure. Another possibility for compatible pollination could be varieties from Maxine Thompson's program when her varieties come on the market. Her breeding program is based on Japanese germplasm which is usually late or very late blooming. In 2015, we will be intercrossing 'Boreal Blizzard' with 'Boreal Beauty' as well as several other selections to identify compatible pollinators.

Keep in mind that 'late' is a relative term. A nursery selling only early Russian varieties might label a plant as 'late blooming' if it blooms 4 days after the first to bloom. But someone growing a diverse

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collection that includes Russian and Japanese hybrids might label plants as 'late' if there is a 2 or 3 weeks difference. A 'late' blooming Russian variety in our collection is much earlier than the earliest blooming Japanese plants.

Some possible orchard plans to maximize pollination are listed in tables 1, 2 and 3. Plan 3 might have an interesting advantage. Perhaps with no pollinator available in the early years, the plants can put more energy into growing faster because they don't have to grow any fruit. Growers of fruit trees frequently deliberately remove flowers and fruits to increase establishment during the first couple years. It might even be desirable to wait 2 years before planting a pollinator. As with many guesses of what could be, the best advice would be to try different scenarios and experiment. Or start small and get more plants when you have gained more experience.

Table 1. Planting strategy for a late harvesting Haskap Orchard. The only problems with this scenario is that the early flowers of 'Tundra' will never be pollinated and smaller Tundra or Indigo berries will be intermixed with 'Boreal Blizzard' in some rows.

Future	BB	BB	BB	Future	Future	BB	BB	BB	Future
Future	BB	Tundra	BB	Future	Future	BB	Indigo	BB	Future
Future	BB	BB	BB	Future	Future	BB	BB	BB	Future
Future	BB	BB	BB	Future	Future	BB	BB	BB	Future
Future	BB	Tundra	BB	Future	Future	BB	Indigo	BB	Future
Future	BB	BB	BB	Future	Future	BB	BB	BB	Future
Future	BB	BB	BB	Future	Future	BB	BB	BB	Future
Future	BB	Tundra	BB	Future	Future	BB	Indigo	BB	Future
Future	BB	BB	BB	Future	Future	BB	BB	BB	Future

BB=Boreal Blizzard, Future=Late blooming varieties not yet on the market. Indigo = Indigo Gem. Tundra or Indigo Gem could be used interchangeably.

Table 2. Strategy for a mixed early and late harvesting Haskap Orchard. In this scenario each row is a different variety. Aurora and Tundra fully pollinate each other. But 'Tundra also pollinates 'Boreal Blizzard'. Fruit set will improve in 'Boreal Blizzard' when the future variety gets established.

Future	BB	Tundra	Aurora	Future	BB	Indigo	Aurora	Future	BB	Tundra
Future	BB	Tundra	Aurora	Future	BB	Indigo	Aurora	Future	BB	Tundra
Future	BB	Tundra	Aurora	Future	BB	Indigo	Aurora	Future	BB	Tundra
Future	BB	Tundra	Aurora	Future	BB	Indigo	Aurora	Future	BB	Tundra
Future	BB	Tundra	Aurora	Future	BB	Indigo	Aurora	Future	BB	Tundra
Future	BB	Tundra	Aurora	Future	BB	Indigo	Aurora	Future	BB	Tundra
Future	BB	Tundra	Aurora	Future	BB	Indigo	Aurora	Future	BB	Tundra
Future	BB	Tundra	Aurora	Future	BB	Indigo	Aurora	Future	BB	Tundra
Future	BB	Tundra	Aurora	Future	BB	Indigo	Aurora	Future	BB	Tundra
Future	BB	Tundra	Aurora	Future	BB	Indigo	Aurora	Future	BB	Tundra

Table 3. Strategy for a late harvesting Haskap Orchard. In this scenario there are twice as much 'Boreal Blizzard' plants as the future variety. When the future variety comes out it will likely be in short supply that 1st year, so it is better to count on not getting as many. Perhaps Boreal Blizzard plants will grow faster without having a pollinator for a while.

BB	Future	BB	BB	Future	BB	BB	Future	BB
BB	Future	BB	BB	Future	BB	BB	Future	BB
BB	Future	BB	BB	Future	BB	BB	Future	BB
BB	Future	BB	BB	Future	BB	BB	Future	BB
BB	Future	BB	BB	Future	BB	BB	Future	BB
BB	Future	BB	BB	Future	BB	BB	Future	BB
BB	Future	BB	BB	Future	BB	BB	Future	BB
BB	Future	BB	BB	Future	BB	BB	Future	BB
BB	Future	BB	BB	Future	BB	BB	Future	BB
BB	Future	BB	BB	Future	BB	BB	Future	BB

'Boreal Blizzard' has excellent flavour, most similar to 'Aurora' to which it is closely related. Table two has a plan to have both of these varieties in an orchard. Despite being closely related, 'Aurora' and 'Boreal blizzard' do not bloom at the same time nor do they ripen at the same time. We've had several growers who tried 'Boreal Blizzard' on Haskap day (but they didn't know what the name would be) and several people tried it at the Agriculture Building at the U of SK. Uniformly, tasters were shocked at how big the berries were and how good they tasted. Several of the tasters proclaimed "You've got a winner there!" This fruit has what I've been calling "tang" or "zing". For many tasters at our haskap days, "zing" is a highly desirable characteristic, second only to sweetness; 'Boreal Blizzard' has both. Others noted that the berries were rather firm for being so big.

Availability: 'Boreal Blizzard' will begin to be available in 2016. When contracts are finalized we will post a list of propagators for Canada, likely in late October, 2014. It may take longer to decide who will offer these in the USA and Europe. Not all currently listed propagators will be carrying this variety. Propagators with the best history of paying royalties will have priority in receiving start-up material.

Acknowledgements: For five years, early Haskap breeding and research was funded by plant sales, workshop fees and volunteer labour. Continuing uninterrupted since 2007, Saskatchewan Agriculture's Agriculture Development Fund (ADF) has given us 3 grants in a row that allowed a 10 fold increase in haskap research. By 2011, royalties paid by growers and collected by our propagators allowed a doubling of research efforts by funding haskap breeding in general and graduate students stipends and their research. 65% of royalties go directly to the fruit program. 35% of royalties go to a general horticulture fund that buys and maintains equipment and facilities.

‘Boreal Beauty’ by Bob Bors

Available in 2017

Figure 28. Boreal Beauty fruits are oval or heart shaped. Berries are thick, firm and meaty. Plant structure and berry characteristics make them ideally suited for mechanical harvesting. The spoon in this photo is 3.5 cm wide. If this article is printed on 8 ½ x 11 paper actual berry size can be seen.

‘Boreal Beauty’ is an exciting new haskap that opens up an entirely new season for Haskap growers: It had fruit fully ripe a month after most varieties were finished in 2014! Its plant and berry characteristics fit all categories that I’ve been looking for in haskap suitable for mechanical harvesting. Berries are heavy, firm, mostly oval, and hold onto branches with just the right amount of force and taste great. Bushes are strong and upright growers and show no signs of mildew and are very productive. Almost all our large-fruited haskap cause branches to bend over, but not ‘Boreal Beauty’, her branches remain strong and upright. I only wish I had early and mid-season ripening versions of this variety! I suppose the occasional tip on some of the berries, which make many of the largest berries look like a heart, could be a disadvantage, but that could be a charming aspect too for fresh sales. Put the heart shape ones on top of the package. Its berries are almost as heavy as ‘Boreal Blizzard’ berries although they are only 2/3rds as long. But they are considerably thicker.

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Figure 2. 'Boreal Beauty' branches full of fruit.

This variety needs a bit more observation and we will have full details next growing season, well before it becomes available to the public in 2017. It was found with great looking and tasting berries in the last few days of July. The berries were great through mid-August but we don't know exactly when they started to taste good. It had been tagged earlier during 'normal' ripening season as "Not ripe yet, check later, looks good". We also need to know when it blooms and whether any of our existing varieties are compatible with it for pollination. Commonly, late ripening plants are also late blooming plants. I'm hoping and am 75% confident that it will be a companion to 'Boreal Blizzard' since both are late ripening and their breeding records indicate that they have no known parents in common. We will be doing cross pollination between 'Boreal Beauty, and 'Boreal Blizzard' and several other advanced selections. If by chance it blooms mid-season, it would be likely to be compatible with Tundra and the Indigo series as they have only a 25% similarity in lineage.

If late ripening is an indication of late bloom, this variety would be worthwhile testing is warmer locations. It may have better southern adaptation.

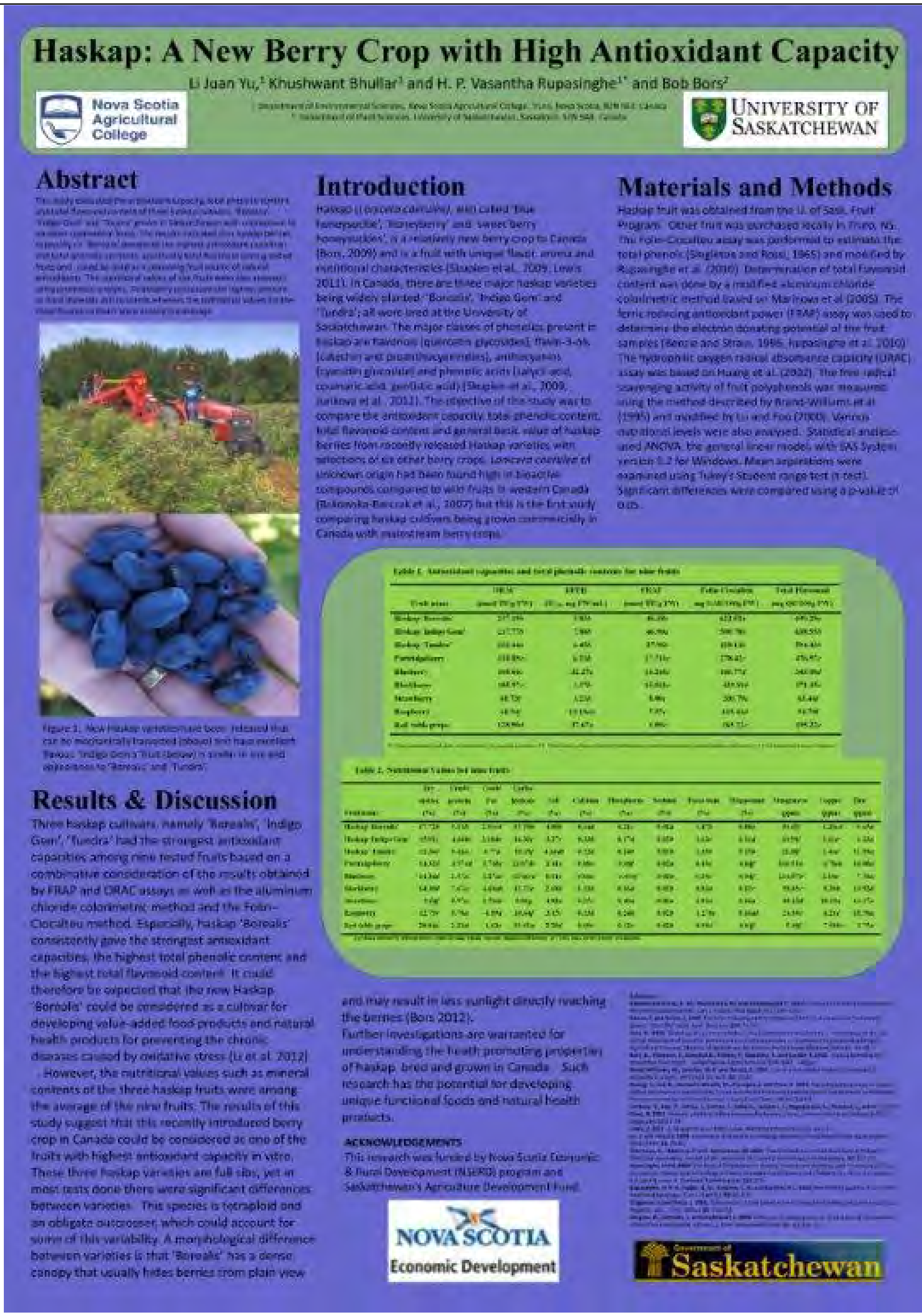
'Boreal Beauty' Details
Plant Breeders Rights application #: 14-8411 **Breeder denomination: '21-12-11.5'**
Lineage: 37.5% Japanese, 37.5% Russian, 25% Kurile
Bloom Time Category: Late or very late, more seasons needed to investigate
Harvest Season : ripens after Saskatoon berries and with our dwarf sour cherries In Saskatoon in 2014 it was good tasting Late July to Early Aug, berries became soft 3rd week August
Fruit Weight: 2.6g avg., 3.7g max
Fruit Shape: Thick Heart or thick Oval
Fruit Firmness Excellent
Flavour Excellent
Pending: lab analysis of haskap fruit characteristics will be done in fall of 2014
Bush Habit Upright Sturdy
Bush Vigour Very Strong
Mildew Resistance Excellent
Productivity Heavy

Plant vigour and productivity: The original plant was in the same field as 'Indigo Gem' plants but was a year younger. Despite having one less growing season, 'Boreal Beauty' plants were 50% larger and much more productive than 'Indigo Gem'.

Availability: Propagation is a year behind 'Boreal Blizzard' so we expect this variety to be available to the public in 2017. We have only recently started a few hundred cuttings. We plan to put buds into tissue culture once the plants have some chilling to fulfill dormancy in mid fall. Very likely those propagators that will carry 'Boreal Blizzard' will also carry this variety.

Acknowledgements: For five years, early Haskap breeding and research was funded by plant sales, workshop fees and volunteer labour. Continuing uninterrupted since 2007, Saskatchewan Agriculture's Agriculture Development Fund (ADF) has given us 3 grants in a row that allowed a 10 fold increase in haskap research. By 2011, royalties paid by growers and collected by our propagators allowed a doubling of research efforts by funding haskap breeding in general and graduate students stipends and their research. 65% of royalties go directly to the fruit program. 35% of royalties go to a general horticulture fund that buys and maintains equipment and facilities.

Appendix C. Nutraceutical Poster done in cooperation with Nova Scotia Agricultural College. (NSAC is now a part of Dalhousie University). This poster was presented at a Canadian Soc. Of Horticulture Science conference and was displayed at various marketing events and in the hallway of our Ag Building.


Haskap: A New Berry Crop with High Antioxidant Capacity
Li Juan Yu,1 Khushwant Bhullar1 and H. P. Vasantha Rupasinghe1* and Bob Bors2
Nova Scotia Agricultural College
UNIVERSITY OF SASKATCHEWAN
Abstract
Introduction
Materials and Methods
Results & Discussion
Three haskap cultivars, namely 'Borealis', 'Indigo Gem', 'Tundra' had the strongest antioxidant capacities among nine tested fruits based on a combinative consideration of the results obtained by FRAP and ORAC assays as well as the aluminium chloride colorimetric method and the Folin-Ciocalteu method. Especially, haskap 'Borealis' consistently gave the strongest antioxidant capacities, the highest total phenolic content and the highest total flavonoid content. It could therefore be expected that the new Haskap 'Borealis' could be considered as a cultivar for developing value-added food products and natural health products for preventing the chronic diseases caused by oxidative stress (Li et al. 2012)
However, the nutritional values such as mineral contents of the three haskap fruits were among the average of the nine fruits. The results of this study suggest that this recently introduced berry crop in Canada could be considered as one of the fruits with highest antioxidant capacity in vitro.
These three haskap varieties are full sibs, yet in most tests done there were significant differences between varieties. This species is tetraploid and an obligate outcrosser, which could account for some of this variability. A morphological difference between varieties is that 'Borealis' has a dense canopy that usually hides berries from plain view and may result in less sunlight directly reaching the berries (Bors 2012).
Further investigations are warranted for understanding the health promoting properties of haskap bred and grown in Canada. Such research has the potential for developing unique functional foods and natural health products.
ACKNOWLEDGEMENTS
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NOVA SCOTIA Economic Development
Saskatchewan

Appendix D. Articles on growing and using Haskap.

[Note: much of this article is based on previous ADF grant research, but the observations regarding sunburn and many of the photos were taken during this project]

Mildew & Sunburn in Haskap (Honeyberries)

By Bob Bors, Ellen Sawchuk and Jill Thomson

Mildew and sunburn are common leaf problems for many varieties of *Lonicera caerulea.* In fact, mildew is the only disease of concern at this time for Haskap in our area. At the University of Saskatchewan we have been aware of this potential problem since 2005 and have been breeding and selecting to minimize this problem. What follows is a summary of various observations and experiments on mildew and sunburn.

Symptoms

Mildew appears at first as white circular patches with a cottony appearance. We are uncertain whether the mildew is 'powdery' or 'downy'. We were unable to full identify them since none of the plants scrutinized were found to have the fungus in the proper stage. Graduate student, James Dawson is convinced that it is 'downy mildew' based on his familiarity with how that disease occurs on grapes.

Figure 29. Mildew in an early stage.

Mildew spores are carried by the wind and can be carried long distances. When a field gets infected it is likely to have an even distribution of the disease. This is quite different from other diseases which can be seen to spread from one plant to another and gradually spread across a field.

In bad mildew years in Saskatoon, symptoms arise outside in mid-July or at any time in the greenhouse. It is quite odd that plants in the field that never have mildew symptoms can come down with the disease in the greenhouse.

The white stage often lasts only a few days, possibly being washed away by rain. Leaves then become partly or completely brown with a blotchy appearance. In some cases a mildew infected leaf will curl in on itself. Sometimes, mildew infected leaves will curl. Then it gets more complicated: the undersides of leaves could face upward toward the sun and get sunburned. Sunburn appears as an even patch of brown on the underside of the leaf often with a clear edge of where the leaf is not sunburned.

Sunburn can also occur without mildew. Early in the season when haskap is growing rapidly, the younger leaves are very flexible. A steady wind can bend the underside of the leaves upward long enough to get sunburned. This is more likely to be a problem when there are several or many cloudy days followed by a bright sunny day with steady winds. . Sunburn can appear on developing branches, but this symptom is not as noticeable as sunburn on leaves. Mildew infected and sunburn plants usually survive and indeed can actually prosper. However, they can become quite ugly and undesirable if in a public location such as in the front yard or as part of a pick-your-own orchard.

Figure 30. One of the worst cases of mildew we've ever seen. These plants looked like this on August 4th in 2011. The plant on the left is showing fall colours a month too soon. But both plants looked healthy at the start of 2012! Luckily, these particular varieties are rarely planted in North America.

Figure 31. This plant has moderate mildew but is very productive.

Figure 32. Mildew has caused these leaves to curl slightly resulting in some leaves being sunburned on the bottom side. Notice that the sunburn stops in a fairly straight line: that's where the sun never reached. The sunburn effect is easier to see on the south side of the bush.

Figure 33. Planted on Friday, burnt by Monday! These plants were already leafed out when planted. It had been cloudy for many days and the plants were in a transition shade house for several weeks after being in a greenhouse. The tops of both seedlings were burned. When this picture was taken the wind was still blowing the leaves and helping to cause more sunburn.

Figure 34. Close-up of sunburn on the underside of a leaf a day or 2 after getting damaged.

In our breeding program we often plant seedlings that already have leaves on them at planting time. Those plants are more susceptible to sunburn compared to when dormant plants are planted. When dormant plants get planted they get more sunlight since the time the buds break and are more likely to build up wax layers

and pigments to protect themselves from UV light damage. Already established plants have far less sunburn damage. Farmers usually buy dormant plants but gardeners might buy plants already leafed out. Gardeners may be alarmed if their plants do this shortly after planting but they should rest assured that the following year they will see far less of this phenomenon.

Variation

Levels of mildew and sunburn vary from year to year. There can be years where no plants show any symptoms and other years where the same plants are almost completely brown by the end of July. But most years there is just a moderate amount of mildew and sunburn. There is a great deal of variability between varieties. But varieties are consistent when compared amongst themselves. Resistant varieties always look better than susceptible ones. Highly susceptible varieties always look worse than moderately susceptible varieties.

Mildew can be a bigger problem in southern areas. Likely, humidity plays an important role. Our prairie weather has far less cloudy days, lower rain and lower humidity than much of the Northern USA. Researchers trying several varieties in Ohio report that all varieties are coming down with mildew including ones that don't show symptoms in Saskatchewan.

Disease Resistance Ratings (excerpted and slightly modified from ADF project 2006-0140)

In August leaf condition was measured by Dr. Jill Thomson. We had 3 main fields that were observed: 2 fields had 6 plants of each variety grown in the same area and the 3rd field had the original stock plants. In most cases each 'n' (number of replications) was based on 6 plants grown in a block.

A type of mildew was observed on many accessions and mycelia was seen under the microscope. As the fungus was not in reproductive mode, fruiting bodies were not present, making identification of precise species impossible. A phenomenon of darkened leaves that showed no signs of pathogens was observed on many plants. It was hypothesized that this could be due to a hypersensitive reaction or possibly sunburn. Data was taken on this as it appeared to have dead leaf tissue involved and could be having a detrimental effect on plant growth and yield.
An overall rating was done which took into account the combined effects of leaf darkening and mildew. This scale may be particularly important for nurseries interested in having healthy looking plants for landscaping purposes.

Figure 35. Lonicera caerulea showing leaf disorders. Leaves on the left have a scorched look where entire leaf sections have died. The leaves on the right have a more spotted appearance. Plants like these were found in the wild and in cultivation.

The two new U of Sk varieties (Borealis and Tundra) and most of the advanced selections currently being propagated for growers showed the highest levels of resistance to mildew and the mysterious leaf darkening. Only Indigo Gem (formally 9-15) showed problems in this area. The evaluations are based on the original plants.

In fall, diseased leaves were gathered and stockpiled for use in inoculating seedlings in the greenhouse. These will be in March 2008 to attempt to create a screening technique to find resistant selections. It has been noted that mildew often occurs in the greenhouse but it is uncertain if this is the same type that occurs in the field.

Table 1. Ratings for sunburn and mildew in August of 2007. The 'overall rating' takes into account both disorders with 1 being unacceptable and 3 being highly desirable. The mysterious 'dark' disorder seems to be physiological as no pathogens have been found; one theory is that it may be sunburn. Perhaps leaves unfolding during cloudy days get sunburn if then exposed to bright sunny days. In the wild many plants were found living as understory plants, perhaps these are more prone to sunburn?

Code	Name(s)	n	% sunburn	% mildew	Overall Rating
		Highly desirable			
9-91	Indigo Treat	1	1.0	1.0	3.0
9-92	Indigo Yum	1	5.0	1.0	3.0
3-03	Blue Pacific (F-1-9-58)	2	1.0	1.5	3.0
3-05	Novinca (Blue Nova)	2	1.0	1.5	3.0
9-94	Borealis	1	1.0	5.0	3.0
9-84	Tundra	1	5.0	1.0	3.0
Ger	Gerda	2	1.0	6.5	3.0
3-02	Magadan (Blue Forest)	2	1.5	8.0	3.0
		Desirable			
3-01	Kamchatskaya (Kamchatka)	2	9.0	5.5	2.5
Ber	Berel	2	1.5	11.5	2.5
2-07	Nimfa	2	3.0	14.5	2.5
2-10	Lebedushka	2	4.0	19.5	2.5
98-11	Tomichka (Blue Belle)	2	8.5	24.5	2.5
98-12	Kiev #8 (Blue Velvet)	2	4.5	31.0	2.5
		Acceptable			
2-09	Volkhova	3	20.0	13.3	2.0
3-09	N-17 (Blue Magic)	2	12.5	14.5	2.0
2-11	Omega	4	11.3	17.0	2.0
2-05	Roksana*	2	3.5	20.0	2.0
2-12	Malvina	2	4.5	20.5	2.0
2-04	Kamchadalka*	2	10.5	20.5	2.0
2-13	Suvenir	2	4.0	21.0	2.0
2-16	Slavyanka	3	3.3	27.7	2.0
		Undesirable			
2-17	Altair	2	28.5	13.0	1.5
2-15	Pushkinskaya	2	7.5	18.5	1.5
2-08	Amfora	2	12.5	20.0	1.5
2-20	Narymskaya or Fialka	3	32.0	12.0	1.3
2-06	Morena	2	20.5	20.5	1.0
98-09	Czech #17 (Berry Blue)	1	21.0	24.0	1.0
2-14	Solovey	2	33.0	29.5	1.0
9-15	Indigo Gem	1	50.0	30.0	1.0
Ogn	Ognennyi Opal	1	56.0	68.0	1.0

Experiment 1. Evaluation of fungicides for control of mildew on haskap seedlings in the greenhouse. (Note: none of these fungicides are currently registered for Haskap. This information should be considered useful if growers want to consider getting a fungicide registered)

Introduction:

Significant levels of mildew have been observed on Haskap seedlings being grown in the greenhouse. This is of concern for two reasons:

1) The mildew infection may reduce plant vigour and have a negative impact on the seedlings when they are transplanted outside
2) Transplanting infected seedlings means that an inoculum source for the disease is present immediately the seedlings are planted out.

A fungicide treatment at the seedling stage may reduce disease levels, and possibly eliminate the pathogen before transplanting. A number of fungicide treatments were evaluated in the spring of 2008, including products available to the home grower and commercial growers.

Materials and Methods:

In early May 2008, 24 seedlings of two lines, all with obvious mildew infection on the leaves, were planted into 5" pots. The two lines chosen were RCT17 and RJJ1; both these lines have been used in the haskap breeding program, and are susceptible to mildew at the seedling stage in the greenhouse. Five fungicide treatments were applied to four plants of each line, and there was an unsprayed check treatment for each line. The fungicide treatments were:

1) No chemical check, sprayed with water only
2) Bordo copper spray (copper from Tribasic Copper Sulphate, 53%) at a rate of 4.5ml/ L water
3) Safers sulphur at 35ml/L water
4) Lance (70% boscalid, BASF Canada) at 1.2g/L water
5) Proline (prothioconazole, 480g/L, Bayer Crop Science Inc.) at 0.8ml/L water
6) Pristine (25.2% boscalid, 12.8% pyraclostrobin, BASF Canada) at 2.0g/ L water.

The copper and sulphur sprays were purchased from a local garden store and would be available to the home gardener. The three other fungicides would only be available to commercial growers

Before spraying the plants were evaluated for disease. All plants had from 75-100% of their leaves infected with mildew, and cleistothecia (the perfect, overwintering stage of the fungus) were present on all except one plant. The plants were sprayed to run-off and were placed on benches in the greenhouse. The RJJ1 plants all had new growth present on the seedlings, but no new growth was present on the RCT17 plants.

The seedlings were evaluated for mildew infection three weeks after the fungicides were applied.

Results and Discussion:

There were no effects of fungicide treatments on leaves that were already infected with mildew before treatment. This is not unexpected as a fungicide treatment is unlikely to remove existing infection. The viability of the infection in terms of transmission of disease to new leaves was not examined directly. However there was very little infection of new leaves for both treated and untreated seedlings. In the RCT17 line there was only infection of new growth on one of the untreated seedlings. In this line, new growth usually occurred not as new leaves but as new side shoots. In the RJJ1 line new leaves were produced on the main shoot, and there was slight infection of the new leaves in all but the sulphur treated plants. However the differences were not great and further testing is necessary before sulphur could be recommended as a control treatment.

Experiment 2: Evaluation of fungicides for control of mildew on haskap under field conditions.

Introduction:

Mildew has often been observed on haskap bushes in the field by the beginning of August. Necrotic damage is also observed on the leaves of some lines, and it is possible that this blackening of the leaves is due to mildew infection (death of the cells due to parasitism), or a reaction of the plant to infection (death of cells to prevent infection). Fungicide application may prevent mildew infection, and also have an impact on the necrotic response of the plants. Three fungicide treatments were evaluated in August 2008 at the University of Saskatchewan orchard.

Materials and Methods:

Six plants of nine lines already established in the cultivar collection orchard at the University of Saskatchewan orchard were selected for the trial, and the plants were identified with coloured flag markers within a row. This trial contains plants that were four years old, and were already fruiting. The lines selected for the trial were: SX2-14 (2 sets), SX2-15, SX2-05, SX98-09, SX2-06, SX2-08, SX2-11, 3-09. Sprays were applied in early August, after harvest, when there was very little mildew present on the bushes. A trace of infection was observed on the lower leaves of some bushes, but the majority of bushes showed no signs of infection prior to fungicide application. There were six bushes of one line within in a row, and the three bushes on the east side were sprayed with fungicide, the other three bushes were not sprayed. The fungicides applied were:

1) Bordo copper spray at a rate of 4.5ml/ L water
2) Safers sulphur at 35ml/L water
3) Pristine at 2.0g/ L water.

These fungicides were previously evaluated in a greenhouse trial and were applied at the same rate. Two L of each fungicide were prepared and the bushes were sprayed to run off. Copper was applied to SX2-15, SX2-11, SZ98-09, Sulphur was applied to SX2-10, SX2-08, SX2-15 and Pristine was applied to SX2-14, SX2-06, SX2-14.

Results and Discussion:

Very little disease had developed by mid August and no differences were observed between treated and untreated bushes. A second spray application was made on August 15. The bushes were rated for presence of mildew and leaf necrosis on September 12. The average values for the treated and untreated bushes are given in Table 1. The data is collected from eight different genetic lines, and is not replicated therefore statistical analysis was not conducted. However, when results are compared within the treatments it can be seen that no mildew developed on the bushes sprayed with copper or Pristine, but low levels did develop on comparable bushes that were not sprayed. Levels of mildew on the sulphur treated bushes were very similar to those on untreated bushes. Thus it would seem that copper and Pristine applications are worth investigating further for control of mildew on haskap bushes. Overall mildew levels were very low, and greater differences might well be observed when infection pressure is higher.

Table 2. The effect of fungicide application on the development of mildew and leaf necrosis of haskap bushes at the University of Saskatchewan orchard, 2008.

Fungicides applied:											
Copper				Sulphur				Pristine			
Sprayed		Unsprayed		Sprayed		Unsprayed		Sprayed		Unsprayed	
%M*	%N**	%M	%N	%M	%N	%M	%N	%M	%N	%M	%N
0	8.3	0.3	13.3	0.7	5	0.3	6.7	0	10	1.7	10
0	20	0.3	25	0.3	5	0.7	5	0	15	0	8.3
0	25	5.3	25	0.3	8.3	0.3	5	0	5	2.3	8.3

*Average % of bush leaf area affected by mildew

**Average % of bush leaf area affected by necrosis.

The percentage of leaf necrosis did not appear to be affected by the spray treatments suggesting this effect is not connected to disease development. It has been suggested that necrosis is a response to the presence of insects, and further investigation is recommended.

Experiment 3: Mildew Prevention in the Greenhouse

Note: The following section is a summary of Ellen Sawchuk's undergraduate thesis. She was a summer student in 2009 when this research was done. She is now a technician in our program. This research is also summarized in reports of ADF 2008-0042.

Thousands of Haskap seedlings are grown per year in greenhouse for backyard gardeners or commercial farmers. Problems begin to occur when the seedlings are being grown in these greenhouses as they can become severely infected with powdery mildew. Cultivars that are thought or seem to be resistant in the field become susceptible in the greenhouse. It is necessary to find an economical and effective way of preventing powdery mildew epidemics for this valuable crop.

Using UV-C (Ultra Violet type C) light seemed to be an attractive alternative and was evaluated against other control methods. In nature UV light often elicits plant protective responses such as more anthocyanins and thicker wax levels on leaves. Our graduate student, Tyler Kaban, was using UV-C light to induce resveratrol production in grapes. Resveritrol has anti-fungal properties. There is no literature to suggest that resveratrol in in Haskap plants, but the idea of using UV light to turn on some defence mechanism seemed like a good idea. In nature UV-C is screened out by the upper atmosphere and is much more damaging than UV-A or UV-B. As it is more intense it requires a much shorter treatment time.

In various papers and magazines it was found that using milk and garlic solutions were effective as well economical. The UV-C, garlic and milk were tested against common greenhouse preventions F-mix and Sulfur. A wide variety of controls were tested as they specific type of mildew we unable to be identified.

The experiment was carried out as follows. Firstly, two year old Borealis plants were placed in a cooler for two months and were brought out of the cooler at three different times so that testing could be done on new leaves as well as mature leaves. All of the plants were transplanted into one litre pots. The amount of UV-C radiation that these plants could take before damage occurred was evaluated. It was found that 80 seconds was the optimum time as the leaves remained green and healthy looking after their exposure. When they were exposed to 90 seconds and higher bleach spots and leaf death ensued. It was also found that the most efficient way to inoculate was to find a naturally infected plant and rub the infected leaves on the healthy leaves in a high humidity environment.

Plants were taken out at different times some plants classified as 'old' were taken out of coolers on Oct 26 but it was decided a few days later (Nov 2) to take out more. Almost a month later (Nov 30) a second batch, labeled 'Young' were taken out.

For the mildew control experiment six plants (3 young, 3 old) were treated with 80 seconds of UV-C radiation and another six plants were treated with powdered sulphur, diluted milk (3 cups water and ¾ cups whole milk), garlic extract (one bulb of blended garlic with 500ml of water), or F-mix (5 grams baking soda, 5ml Safer Soap and 15ml of Canola oil with 500ml of water). Plants were treated once a week starting Dec. 6th and then evaluated on Dec 13th, Dec 20th and January 10th. for number of infected leaves. The experiment had 6 treatment x 2 ages x 3 observation dates x 3 reps.

ANOVA analysis using SAS statistical program is presented in table 28. Treatments, age of the plants and the interaction of Treatment*Age were highly significant while observation date was significant.

Older plants had more than 3 times the infection rate of younger plants averaging 6.5% compared to 1.9% over the 3 observation dates. Older plants had leafed out about 30 days earlier than younger plants. This results was unexpected as younger leaves are usually thought to be more susceptible particularly if wax cuticle layers have not built up on the leaves. However, in the field we often don't see infection until the plants have leafed out about 2 months.

All the treatments were significantly better than the control. Sulfur gave the lowest mean but this was statistically similar to Milk, F-mix, and garlic treatments. Sulfur was the preferred treatment for other reasons beside having slightly lower infection rates. Milk could potentially give a rancid smell to the greenhouse while garlic gave an immediately strong odor that hurt eyes during preparation. F-mix required mixing several ingredients and so was not as convenient. The sulfur and garlic treatments were deemed the best due to their superior effectiveness and economics.

Table 3. ANOVA for various treatments against mildew in the greenhouse for 'Borealis' haskap plants.

Source	DF	Type III SS	Mean Square	F Value	Pr > F
treatment	5	852.407407	170.481481	7.34	<.0001
age	1	560.333333	560.333333	24.12	<.0001
date	2	185.12963	92.564815	3.98	0.023
rep	2	79.796296	39.898148	1.72	0.187
treatment*age	5	1346.777778	269.355556	11.59	<.0001
treatment*date	10	153.648148	15.364815	0.66	0.7559
treatment*age*date	12	259.222222	21.601852	0.93	0.5227

Table 4. Means of treatments used to control mildew infections on 'Borealis' haskap under greenhouse conditions.

Treatment	Means		
Control	9.9	A	
UV-C	4.9	B	
Milk	3.7	B	C
F-Mix	3.5	B	C
Garlic	2.1	B	C
Sulfur	1.2		C

Initially it was difficult to get mildew growing in the greenhouse, which was why leaves from outdoor plants were gathered and used. Often mildew occurs spontaneously in our greenhouse. But once it started, it almost doubled within that 1st week (table 5). But the next 20 days had only an incremental change of about 20%. In the worst treatment combination (Control + Old) The infection rate was 10% on Dec 13th, then 24% on Dec 20th and then only 25% on Jan 10th. These resulting indicate that mildew infects can progress rapidly and that growers should be prepared to immediately treat symptoms when they appear.

Table 5. Progression of mildew infection for all treatments under greenhouse conditions for 'Borealis' Haskap.

Date	Infection %		
Dec-13	2.4	a	
Dec-20	4.5	a	b
Jan-10	5.6		b

The interactions between treatments and age are presented in table 6. As was the case with the treatments by themselves, there is much overlapping of LSmeans groups. Larger sample sizes might be useful in giving more distinction between thee treatment/age combinations. It is surprizing that young control plants did not have infection yet. Perhaps the results would be different if a longer period of time was allowed for observations.

Table 6. Interaction of treatments and age of plants on % mildew infection in greenhouse grown 'Borealis' haskap plants.

Treatment & age combination			Means			
Control	+	old	19.8		A	
Milk	+	old	5.7		B	
UV-C	+	old	5.1	C	B	
UV-C	+	young	4.7	C	B	
Garlic	+	old	4.1	C	B	D
F-Mix	+	young	3.8	C	B	D
F-Mix	+	old	3.2	C	B	D
Milk	+	young	1.8	C	B	D
Sulfur	+	young	1.3	C	B	D
Sulfur	+	old	1.0	C		D
Garlic	+	young	0.0			D
Control	+	young	0.0			D

Summary

Using disease resistant varieties is the best way to combat mildew, especially since no chemical controls are currently registered. If a control were to be registered likely it should be sulfur, but it would need to be used as a preventive treatment. Sprays won't make mildew damage go away once it has happened.

Sunburn can be reduced by using dormant plants at planting time instead of leafed out plants. Fortunately, most of the University of Saskatchewan varieties are highly resistant except Indigo Gem. But even Indigo Gem looks good most years in Saskatchewan.

In most cases mildew and sunburn do not impact survival and mildew susceptible plants have been observed to be productive. However, there have not been any studies to judge if yield is being reduced by mildew or sunburn. Mildew and sunburn can make haskap plants ugly in mid- summer and are likely to be of concern for homeowners using Haskap in the landscape.

Mildew and sunburn are variable conditions dependant on environmental conditions . These conditions can vary widely from year to year and tend to be more severe in southern regions. Mildew can be severe one year and practically non-existent the next.

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Haskap Day Agenda

Agenda: Haskap Day Friday July 20th, 2012
@ Horticulture Field Lab

In addition to growers, propagators and industry liasons usually present at Haskap day, this year we welcome the 2012 NAFEX Conference attendees. NAFEX is a network of individuals throughout the United States and Canada devoted to the discovery, cultivation and appreciation of superior varieties of fruits and nuts. They're here to learn about Haskap, as well as see what else Saskatchewan has to offer. This year's Haskap day features:

- **Tour of the U of S Horticulture facilities** including Haskap, Saskatoons and Sour Cherries.
- **Dr. Artem Sorokin**: Lonicera Breeder, Russia
- **Dr. Maxine Thompson**: Lonicera Breeder, USA
- **Dr. Bob Bors**: Lonicera Breeder, Canada
- **Hot Lunch** featuring Haskap
- **Growers Forum**

Cost is $40(Includes hot Haskap Lunch) or $30 if you bring your own lunch.