Project Identification

1. **Project Title:** Haskap Agronomy and Variety Trial
2. **Project Number:** 20180423 SFP
3. **Contractor Undertaking the Project:** Conservation Learning Centre
4. **Project Location(s):** SW 20-46-26 W2 RM #461 (Prince Albert)
5. **Project Start and End Dates (Month & Year):** January 18, 2019 to February 15, 2023
6. **Project Contact Person & Contact Details of Project Manager:**
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Objectives and Rationale

7. Project objectives:

To determine best management practices for production of Haskap in Saskatchewan, including irrigation, fertilization and mulch covers.

8. Project Rationale:

Haskap production is the most rapidly expanding component of the fruit industry, but the agronomics are poorly defined. Haskaps are a high-value crop that lends itself well to value-added processing. It has a strong appeal to local and export markets, and therefore fit the province's growth strategy very well.

Methodology and Results

9. Methodology:

Experimental design:

2020 was year 2 of the 4-year haskap agronomy project. Three blocks were planted in 2019 in a randomized complete block design (RCBD): mulch treatment, fertilizer treatment and irrigation treatment. Twenty varieties were chosen, and four plants of each variety were planted per row, resulting in each row having 80 plants. Haskap cultivars were randomized within the block in subgroups that have overlapping cross-pollination and blossom windows. Plants were spaced 1 meter apart within the row and 4 meters apart between the rows. A complete list of treatments and varieties may be found in Table 1 below.

Table 1. Mulch, fertilizer and irrigation treatments and varieties used in haskap agronomy project.

Block	Row	Treatment
Mulch	1	Black Plastic
	2	White Plastic
	3	Red Mulch
	4	Landscape Fabric
	5	Control
Fertilizer	6	2x Granular Fertilizer
	7	3x Granular Fertilizer
	8	4x Fertigation
	9	6x Fertigation
	10	7x Fertigation
Irrigation	11	1 dripline 2x/week
	12	1 dripline 3x/week
	13	2 driplines 2x/week
	14	2 driplines 3x/week
	15	Tensiometer (2 driplines ?x/week)
Mulch	16	Natural Mulch

Subgroup		Variety
U of S	1	Honeybee
	2	Tundra
	3	Blue treasure
U of S	4	Indigo treat
	5	Indigo yum
	6	Indigo gem
U of S	7	Aurora
	8	Boreal beast
	9	Boreal beauty
	10	Boreal blizzard
Russian	11	Blue banana
	12	Happy giant
	13	Blue diamond
	14	Blue Jewel
	15	Blue moose
Polish	16	Evie
	17	Larissa
	18	Rebecca
	19	Sveta
Oregon X	20	Kawai

Table 2. Additional information for haskap agronomy trial.

Legal Land Location	SE-20-46-26-W2 RM 461
Coordinates of Corners	N53°01.448' W105°45.795' N53°01.498' W105°45.783' N53°01.453' W105°45.835' N53°01.503' W105°45.821'
Soil Type	Clay loam
Soil Zone	Black

The "Mulch Treatment" block is testing black plastic, white plastic, sierra red wood chip, and landscape fabric against a control treatment (where weeds were controlled using mechanical weed control methods such as mowing and hand-weeding, and herbicides including dichlobenil, trifluralin, Fluazifop-P-butyl, Sethoxydim, paraquat, et cetera). The same benchmark fertilizer and irrigation rates were applied to all treatments in this block (soil tests determined specific fertilizer and irrigation rates). An additional natural wood chip mulch treatment was added to replace the raised bed treatment.

The second "Fertilizer Treatment" block is designed to test the effect of fertilizer rates. Haskap varieties were randomized in the same way as the "Mulch Treatment" and the fertilizer was applied in split applications according to Eric Gerbrandt & Andrew Hammermeister specified benchmarks (example 18-12-12 N-P-K +n1 Ca, 0.5 Mg, with 5S and micronutrients at a rough minimum equivalent of 47 g/plant in the first application, and 78 g/plant in the second application). The minimum is expressed as "2x", and the "3x" treatment included an additional 78g fertilizer application prior to leaf senescence in late summer. Three other treatments were tested in which water-soluble 20-20-20 + micronutrient (Plant-Prod) fertilizer was applied via drip irrigation at a rough equivalence of 40g/plant per treatment application. The lowest-rate fertigation treatment will occur 4x, whereas higher rates will be 6x and 7x the fertilizer applications at 40/g per plant rate. Haskap are shallow rooted, and some research has suggested they benefit from more frequent low-level fertilizer applications.

The third "Irrigation Treatment" block started with lower irrigation rates as the plants are young and will increase as the plants grow through the four-year project lifespan. Irrigation need is partially soil and climate-dependent. Still, it is anticipated the plants need an additional 300-400 mm of water with higher rate applications occurring during hot dry periods in the summer. The first treatment in this block saw irrigation applied 2x per week along one drip line and up to a level just below soil saturation according to tensiometer readings (if, for example, it rained and the soil was already near saturation, no irrigation occurred at that time). The second treatment used one drip line and ran at a lower rate (length of time of application and lower tensiometer reading) 3x per week. These drip lines deliver water directly to the centre of the plant's crown. The third treatment used 2 drip lines (at the same rate as the 2x single drip line treatment) so that delivery of water was more spread out. In this way, the shallow spreading haskap roots may be better served via more widespread water availability. The fourth treatment did the same as the third treatment (at corresponding rates to 3x/week treatment applications from 1 dripline found in the second treatment) but 3 x per week. The irrigation block's final treatment relied on 2 drip lines applying water to a level below saturation, set by the tensiometer readings. The fifth treatment could require watering at low levels more than 5 times per week, or not at all if soil moisture is well retained. Due to issues with the moisture probes and tensiometers, the tensiometer row of the haskaps was watered weekly with the trial's other treatments until the issues were corrected.

In all blocks, measurement of growth, yield, labour demand, and fruit quality will be taken and analyzed. Winter-hardiness and genotype-by-environment parameters will also be measured (like blossom and harvest windows, winter-kill, et cetera). Soil quality parameters will be measured throughout the four-year project lifespan.

In the second year of the trial, both wood mulch treatments received new mulch to widen the area covered with mulch and add mulch to thin or missing portions due to deterioration/wind. The wood shaving mulch was also thickened and widened with natural wood chip mulch. Additional forage seed was spread in the pathways to help them fill in, and extra borders were

seeded using the same forage mixture. Haskaps were scouted periodically throughout the growing season to monitor survival, disease and flowering. Berries were harvested on July 2, 2020. Bravo ZN was sprayed in late summer for control of powdery mildew. A soil test was completed at the end of September by sampling soil at the base of several plants per row. Samples were taken as close to the roots of the plant as possible without damaging the plants. A full list of data collection, weeding and fertilizer applications by date can be found in Table 3 below. Numerical data was analyzed by ANOVA using IBM SPSS software. Any nonparametric data was analyzed using Kruskal Wallis H-test.

Table 3. Schedule of data collection, weeding and fertilizer applications in year 2 of the haskap agronomy trial.

Date	Data Collection/Weeding/Fertilizer Applications
May 20, 2020	Granular fertilizer application to 2x and 3x fertilizer treatments.
May 21, 2020 – May 23, 2020	Fertigation in all treatments.
May 27, 2020	Flowering and survival observations, weeding.
June 2, 2020	Flowering and survival observations, vigour ratings.
June 5, 2020	Granular fertilizer application to 2x and 3x fertilizer treatments.
June 16, 2020	Weeding.
June 22, 2020 – June 24, 2020	Fertigation in all treatments.
July 2, 2020	Berry harvest.
July 20, 2020	Fertigation in 4x, 6x, and 7x fertigation treatments, and in all mulch treatments.
July 28, 2020	Fertigation in 6x and 7x fertigation treatments.
August 4, 2020	Fertigation in 6x and 7x fertigation treatments.
August 10, 2020	Fertigation in 7x fertigation treatment.
August 13, 2020	Flowering, berry and survival observations.
August 15, 2020	Granular fertilizer application to 3x fertilizer treatment. Fertigation in 4x fertigation treatment.
August 17, 2020	Fertigation in 7x fertigation treatment.
September 22, 2020	Growth characteristics and plant height.
September 22, 2020 – October 2, 2020	Date of start of leaf loss.

Year 2 (2020):

<u>Irrigation</u>

Irrigation treatments began the week of May 20th, after there was no longer a risk of freezing overnight temperatures. Single lines were irrigated two at a time for 1 hour per pair. Double lines were irrigated one at a time for 30 minutes each. When single lines were irrigated alone, they were irrigated for 30 minutes. All the mulch and fertilizer treatments, as well as the 2x irrigation treatments were irrigated on Tuesday and Thursday each week. The 3x irrigation treatments were watered additionally on Friday each week. Due to issues with the moisture probes and tensiometers, the tensiometer row of the haskaps was watered weekly with the other treatments of the trial until the issues were corrected.

Fertilizer Details

All treatments were given liquid fertilizer through fertigation at a rate of 40g/plant of Plant Prod 20-20-20 fertilizer. The first round of fertilizing began on May 21 and was completed May 23. The second round of fertilizing occurred between June 22 and June 24, resulting in 80g/plant of Plant Prod in total. The 4x fertigation treatment received additional fertilizer on July 20 and August 15. The 6x fertigation treatment was fertilized on July 20, July 28, August 4 and August 17. The 7x fertigation treatment was fertilized on July 20, July 28, August 4, August 10 and August 17.

On June 5, the granular fertilizer treatments 2x and 3x were given 40g/plant of Terico 25-10-10 granular fertilizer. The 3x granular fertilizer treatment received another 75g on August 15.

Crop Protection

Casaron granular herbicide was applied to the entire control treatment, as well as along the sides of the mulch for each of the other treatments. Weeds were controlled mechanically throughout the growing season by mowing, whipper snipping and hand pulling. Bravo fungicide was applied at a rate of 6L/ha using a handheld boom on August 18th to control mildew. Glyphosate was spot applied in late summer to control perennial weeds along the sides of the mulch.

10. Observations and Results:

Weather

The spring and summer at the CLC saw good precipitation compared to past years (Table 4). Temperatures throughout the growing season were slightly cooler than in past years but similar to 2019. The first fall frost occurred earlier than normal on September 8th (-3.6°C) and another hard frost occurred on September 16th (-5.3°C). Precipitation was lower in the fall months relative to the 2019 growing season. Overall, growing degree days were lower than the historical average. Growing degree days were especially low in May and June.

Table 4. Weather conditions in the 2020 growing season at the Saskatchewan Conservation Learning Centre.

	May	June	July	August	September	October	Average/Total
				--- Temperature (°C) ---			
2020	9.2	13.4	17.6	16.1	10.9	1.0	11.4
2019	9.5	15.8	17.4	15.1	11.6	1.0	11.7
2012-2018	11.8	16.1	18.5	17.3	11.6	3.5	13.1
				--- Precipitation (mm) ---			
2020	68.4	91.4	32.2	33.2	31.6	10.1	266.9
2019	30.0	54.4	57.4	16.8	59.6	11.6	229.8
2012-2018	36.4	80.6	96.1	48.0	25.8	26.0	310.5
				--- Growing Degree Days (base 5°C) ---			
2020	143.7	252.4	391.0	342.9	178.8	38.6	1347.4
2019	164.7	322.7	383.5	314.1	207.3	13.1	1405.4
2012-2018	211.1	332.7	419.0	381.6	203.2	38.2	1585.9

Soil Test Results

Soil tests were completed for each fertilizer treatment and sent to Agvise Laboratories for analysis. Contrary to what was expected, soil test results indicated that the end of season soil N, P, K and S levels were lowest in the fertigation 6x and 7x treatments (Table 5). N, P and S levels were high in the granular 2x treatment. In granular 3x and fertigation 4x, N and P were high but S was medium. In the 6x fertigation treatment, N and P were high and S was low. N, P and S were low in the fertigation 7x treatment.

Table 5. September 24, 2020 basic soil test results.

Area	Depth	N	P	K	S	Zn	OM	pH	Salts
	(cm)	(lb/ac)	(ppm)	(ppm)	(lb/ac)	(ppm)	(%)		(mmho/cm)
Granular 2x	0 – 15	50	40	350	42	1.73	5.2	6.3	0.55
	15 – 30	71			54			6.5	0.62
	0 – 30	121							
Granular 3x	0 – 15	45	36	373	26	1.17	4.8	5.8	0.36
	15 – 30	41			22			6.3	0.33
	0 – 30	86							
Fertigation 4x	0 – 15	43	47	367	24	1.71	5.0	5.7	0.3
	15 – 30	99			24			6.5	0.4
	0 – 30	142							
Fertigation 6x	0 – 15	20	33	277	8	1.34	4.7	5.8	0.16
	15 – 30	32			8			6.5	0.28
	0 – 30	52							
Fertigation 7x	0 – 15	17	6	202	8	1.09	4.8	6.2	0.16
	15 – 30	13			8			6.8	0.13
	0 – 30	30							

Chloride was very low in 6x and 7x fertigation, low in 3x granular, and high in 2x granular and 4x fertigation (Table 6). Boron was low in 3x granular and very low in all other treatments. Iron, manganese, magnesium and calcium levels were high in all treatments. Copper levels were low in 6x and 7x fertigation, and medium in 2x and 3x granular and 4x fertigation. Sodium was low in the 2x granular and 4x fertigation treatments and very low in the 3x granular and 6x and 7x fertigation treatments.

Table 6. September 24, 2020 soil test mineral analysis results.

Area	Depth	Cl	B	Fe	Mn	Cu	Mg	Ca	Na
	(cm)	(lb/ac)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)	(ppm)
Granular 2x	0 – 15	56	0.4	81.4	18.9	0.61	467	2794	47
	15 – 30	100							
Granular 3x	0 – 15	30	0.5	66.9	15.3	0.55	434	2398	36
	15 – 30	29							
Fertigation 4x	0 – 15	44	0.4	65.7	21.2	0.66	489	2246	45
	15 – 30	36							
Fertigation 6x	0 – 15	6	0.3	53.9	11.2	0.46	414	2266	25
	15 – 30	6							
Fertigation 7x	0 – 15	7	0.3	53.4	6.1	0.33	390	2410	17
	15 – 30	6							

Cation Exchange Capacity was lowest in the higher rate fertigation treatments and highest in the granular fertilizer treatments (Table 7). % base saturation of Ca was below the typical range in all treatments. % base saturation of H was higher than the typical range in all treatments.

Table 7. September 24, 2020 soil test CEC and base saturation results.

Area	Cation Exchange Capacity (meq)	% Base Saturation				
		% Ca	% Mg	% K	% Na	% H
Granular 2x	21.7	64.5	18.0	4.1	0.9	12.4
Granular 3x	20.1	59.8	18.0	4.8	0.8	16.6
Fertigation 4x	19.8	56.8	20.6	4.8	1.0	16.9
Fertigation 6x	18.9	59.8	18.2	3.8	0.6	17.6
Fertigation 7x	18.7	64.3	17.3	2.8	0.4	15.2
Typical Range		65-75	15-20	1-7	0-5	0-5

Pests

Weed growth was significant in the control treatment, along the sides of the mulches, and at the base of each plant. Additionally, deer, coyote and moose punched holes in the plastic mulch, resulting in even more holes that required weeding. Weeds in the holes and around the plants were hand-weeded, and weeds along the sides of the mulch and in the control were whipper snipped or mowed where possible. Despite thickening and widening the mulch in the wood mulch treatments, weeds were still growing through the mulch and needed to be weeded or whipper snipped fairly frequently. Sphinx moth caterpillars were observed while scouting in late summer, but spraying was not deemed necessary. Animals chewed through the wire of one of the moisture probes and made a hole in a section of the irrigation line in the fall.

Observations

There was a significant difference in vigour between treatments according to Kruskal Wallis H-test ($F(15)=92.491$, $p<0.0005$) (Table 8). Vigour was rated on a scale of 0-5, with 0=dead and 5=most vigorous. The control had the lowest vigour of all treatments in any block. In the mulch block, vigour was highest in the black plastic treatment. In the fertilizer block, vigour was higher in the 6x and 7x fertigation treatments than in the granular fertilizer and lower rate fertigation treatments. In the irrigation block, mean vigour was highest in the 1 drip 3x treatment and lowest in the tensiometer treatment.

The number of berries produced differed significantly between treatments according to Kruskal Wallis H-test ($F(15)=30.562$, $p=0.010$) (Table 8). The number of berries includes both unripe and ripe berries. The control produced the fewest berries per plant of all treatments in any block. In the mulch treatment block, the black plastic and landscape fabric treatments produced the

highest number of berries per plant. In the fertilizer treatment block, the 2x granular fertilizer treatment produced the most berries per plant, and the 4x fertigation treatment produced the fewest. In the irrigation treatment block, the 1 drip 3x and 2 drip 3x treatments had the highest mean number of berries per plant, and the 2 drip 2x treatment had the fewest.

There was a significant difference in the weight of berries harvested between treatments according to Kruskal Wallis H-test ($F(15)=36.473$, $p=0.002$) (Table 8). Both unripe and ripe berries were harvested from each plant and included in the berry harvest weights. The mean weight of berries harvested per plant was lowest in the natural mulch treatment of all treatments of any block. In the mulch treatment, the weight of the berry harvest was highest in the black plastic and landscape fabric treatments. In the fertilizer block, the 2x granular fertilizer treatment produced the largest berry yield by weight, and the 4x fertigation treatment had the lowest yields by weight. In the irrigation block, the mean weight of the berries harvested per plant was highest in the 1 drip 2x and 2 drip 3x treatments, and was observably lower in the tensiometer treatment.

Plant height differed significantly between treatments, according to ANOVA ($F(15,285)=9.331$, $p<0.0005$) (Table 8). Across all treatments and blocks, plant height was lowest in the control and in the natural mulch treatments. In the mulch block, mean plant height was highest in the landscape fabric treatment and significantly lower in the natural mulch treatment. In the fertilizer treatment, mean plant height was highest in the 4x fertigation treatment and lowest in the 3x granular treatment. In the irrigation block, plants were tallest in the 2 drip 3x treatment and shortest in the tensiometer treatment.

Table 8. Summary of statistical analysis and means of main effects for haskap agronomy trial by treatment.

Row	Treatment	Mean Vigour Rating on June 2	Mean Number of Berries on July 2	Mean Weight of Berries Harvested on July 16	Mean Plant Height
		0-5	berries/plant	g/plant	cm
1	Black Plastic	3.11	1.81	12.07	50.35 A
2	White Plastic	2.44	0.18	0.67	50.74 A
3	Red Mulch	2.86	0.79	3.85	54.42 A
4	Landscape Fabric	2.71	1.72	13.03	55.19 A
5	Control	1.65	0.05	0.25	42.67 BC
6	2x Granular Fert	2.83	0.80	6.48	50.99 A
7	3x Granular Fert	2.78	0.56	4.77	49.71 AB
8	4x Fertigation	2.79	0.15	2.30	55.03 A
9	6x Fertigation	3.46	0.50	3.51	52.66 A
10	7x Fertigation	3.23	0.40	4.57	50.79 A
11	1 drip 2x	3.44	1.10	6.19	54.59 A
12	1 drip 3x	4.01	1.29	4.97	54.33 A
13	2 drip 2x	3.51	0.39	2.03	54.73 A
14	2 drip 3x	3.68	1.23	6.30	55.43 A
15	Tensiometer	3.00	0.61	0.71	48.58 AB
16	Natural Mulch	2.73	0.33	0.02	40.38 C
	P value	<0.0005	0.010	0.002	<0.0005

Mean vigour differed significantly between varieties according to a Kruskal Wallis H-test ($F(19)=99.209$, $p<0.0005$) (Table 9). Honeybee had the lowest mean vigour of all tested varieties, and Indigo gem had the highest.

There was a significant difference in the mean number of berries produced per plant between varieties according to Kruskal Wallis H-test ($F(19)=111.996$, $p<0.0005$) (Table 9). Berries were counted up to a maximum of 10 berries/plant. Plants containing more than 10 berries were represented as having 10 berries. Indigo gem produced the most berries per plant. Evie and Larissa averaged at 0 berries per plant. The mean number of berries produced was also very low with Blue banana and Happy giant varieties.

The mean weight of berries harvested per plant differed significantly between varieties according to Kruskal Wallis H-test ($F(19)=115.759$, $p<0.0005$) (Table 9). Boreal beast and boreal beauty produced the highest weight of berries per plant of the tested varieties. Indigo gem and Blue jewel also produced high yields. The mean weight of berries harvested was lowest for Evie, Blue moose, Blue banana and Blue treasure.

There was a significant difference in mean plant height between varieties, according to ANOVA ($F(19,285)=35.719$, $p<0.0005$) (Table 9). Blue treasure and Blue moose had the tallest mean plant height. Rebecca and Tundra varieties had the shortest mean plant height.

Table 9. Summary of statistical analysis and means of main effects for haskap agronomy trial by variety.

	Variety	Mean Vigour Rating on June 2	Mean Number of Berries on July 2	Mean Weight of Berries Harvested on July 16	Mean Plant Height
		0-5	berries/plant	g/plant	cm
1	Honeybee	1.52	0.17	1.13	44.24 EFG
2	Tundra	2.64	0.13	0.60	37.31 G
3	Blue treasure	2.45	0.13	0.08	68.69 A
4	Indigo treat	2.77	0.88	7.29	48.50 DEF
5	Indigo yum	3.58	0.70	1.95	41.47 FG
6	Indigo gem	4.16	3.89	12.74	41.50 FG
7	Aurora	3.03	0.92	5.45	55.48 BCD
8	Boreal beast	3.02	1.45	15.58	60.89 AB
9	Boreal beauty	3.30	1.66	15.43	53.96 BCD
10	Boreal blizzard	3.53	0.48	1.95	51.22 CDE
11	Blue banana	2.42	0.03	0.06	55.20 BCD
12	Happy giant	2.19	0.05	0.19	54.90 BCD
13	Blue diamond	3.06	0.33	1.45	50.85 CDE
14	Blue Jewel	3.72	1.92	10.59	56.80 BC
15	Blue moose	2.84	0.11	0.05	66.48 A
16	Evie	3.25	0.00	0.00	55.83 BCD
17	Larissa	3.95	0.00	0.18	48.17 DEF
18	Rebecca	2.83	0.13	0.79	27.03 H
19	Sveta	2.97	0.33	4.28	54.81 BCD
20	Kawai	3.05	1.58	9.79	52.41 CDE
	P value	<0.0005	<0.0005	<0.0005	<0.0005

Counts of dead plants throughout the growing season by treatment and the end of season % survival can be found in Table 10 below. A plant was described as dead during the survey when it was missing or completely brown and leafless. The number of dead plants occasionally decreased throughout the growing season when a dead-looking plant sprouted leaves or when a new shoot grew. July 2 survival data was omitted due to inconsistencies in data collection

methods on this survey date. There were no visible trends in the number of dead plants in each treatment throughout the growing season. End of season percent survival was high in all treatments.

Table 10. Percent survival and count of dead plants by treatment throughout the growing season.

Row	Treatment	Number of Dead Plants				End of Season
		May 27	June 2	August 13	Sep 22	% Survival
1	Black Plastic	3	5	1	4	95
2	White Plastic	3	3	3	3	96
3	Red Mulch	6	6	6	6	93
4	Landscape Fabric	6	6	6	6	93
5	Control	6	7	6	6	93
6	2x Granular Fert	2	2	2	2	98
7	3x Granular Fert	6	6	6	6	93
8	4x Fertigation	7	7	8	7	91
9	6x Fertigation	5	5	6	6	93
10	7x Fertigation	8	7	7	7	91
11	1 drip 2x	7	7	7	7	91
12	1 drip 3x	2	2	2	2	98
13	2 drip 2x	3	3	3	3	96
14	2 drip 3x	3	4	4	4	95
15	Tensiometer	3	2	4	4	95
16	Natural Mulch	9	9	6	6	93
	Mean	4.94	5.06	4.81	4.94	93.83
	Std. Deviation	2.24	2.17	2.10	1.77	2.21

A summary of the number of dead plants of each variety of haskap, and the end of season percent survival, can be found in Table 11 below. Honeybee had a high mortality, with only 56% of the plants surviving at the end of the season. The number of dead plants of the Honeybee variety did not increase throughout the growing season, meaning mortality occurred over the winter or after planting in 2019. Percent survival was high for most other varieties, though slightly lower at 84% and 86% for Blue banana and Boreal beauty, respectively.

Table 11. Count of deceased plants by variety throughout the growing season.

	Variety	Number of Dead Plants				End of Season
		May 27	June 2	August 13	Sep 22	% Survival
1	Honeybee	28	27	28	28	56
2	Tundra	1	1	1	1	98
3	Blue treasure	1	1	1	0	100
4	Indigo treat	1	1	0	0	100
5	Indigo yum	2	1	2	2	97
6	Indigo gem	0	0	0	0	100
7	Aurora	5	5	5	5	92
8	Boreal beast	3	3	4	4	94
9	Boreal beauty	9	10	8	9	86
10	Boreal blizzard	1	1	1	1	98
11	Blue banana	9	10	8	10	84
12	Happy giant	6	8	7	7	89
13	Blue diamond	1	1	1	1	98
14	Blue Jewel	0	0	0	0	100
15	Blue moose	1	1	1	1	98
16	Evie	0	0	0	0	100
17	Larissa	6	6	6	6	91
18	Rebecca	0	0	0	0	100
19	Sveta	2	2	2	2	97
20	Kawai	3	3	2	2	97
	Mean	3.95	4.05	3.85	3.95	93.83
	Std. Deviation	6.34	6.30	6.32	6.47	10.11

A summary of growth characteristics by treatment can be found in Table 12 below. Growth characteristics of each plant were recorded in late summer. Plant growth was described as either horizontal (prostrate) or vertical. Plant fullness was recorded as either bushy or leggy/spindly. The natural mulch treatment had the highest proportion of plants displaying prostrate growth of all treatments. The red mulch treatment had the lowest proportion of plants growing horizontally. The 2 drip 2x treatment had the highest proportion of leggy plants of all treatments. This high proportion of leggy plants in this treatment could indicate that growth conditions in this treatment were too perfect, leading to rapid, spindly growth. 6x fertigation and 2 drip 3x had the lowest proportion of leggy plants.

Table 12. Proportion of plants displaying different growth characteristics by treatment.

Row	Treatment	Proportion of Plants Displaying Certain Growth Characteristics			
		% Horizontal	% Vertical	% Bushy	% Leggy
1	Black Plastic	16	84	76	24
2	White Plastic	22	78	65	35
3	Red Mulch	11	89	68	32
4	Landscape Fabric	18	82	72	28
5	Control	12	88	72	28
6	2x Granular Fert	19	81	78	22
7	3x Granular Fert	18	82	68	32
8	4x Fertigation	26	74	77	23
9	6x Fertigation	23	77	82	18
10	7x Fertigation	14	86	81	19
11	1 drip 2x	21	79	52	48
12	1 drip 3x	26	74	51	49
13	2 drip 2x	23	77	49	51
14	2 drip 3x	21	79	82	18
15	Tensiometer	21	79	70	30
16	Natural Mulch	31	69	78	22
	Mean	20.04	79.96	70.01	29.99
	Std. Deviation	5.38	5.38	10.86	10.86

A summary of growth characteristics by haskap variety can be found below in Table 13. Indigo yum, Indigo gem and Rebecca all displayed primarily prostrate growth. Tundra and Larissa also had a high number of plants growing horizontally. Blue moose had the highest proportion of plants displaying leggy growth of all tested varieties. Evie, Blue diamond, Happy giant and Tundra all had primarily leggy plants. Boreal blizzard was the only variety with 100% bushy plants.

Table 13. Proportion of plants displaying different growth characteristics by variety.

	Variety	Proportion of Plants Displaying Certain Growth Characteristics			
		% Horizontal	% Vertical	% Bushy	% Leggy
1	Honeybee	0	100	83	17
2	Tundra	51	49	48	52
3	Blue treasure	8	92	70	30
4	Indigo treat	0	100	95	5
5	Indigo yum	90	10	69	31
6	Indigo gem	88	13	81	19
7	Aurora	0	100	56	44
8	Boreal beast	5	95	68	32
9	Boreal beauty	0	100	98	2
10	Boreal blizzard	0	100	100	0
11	Blue banana	0	100	54	46
12	Happy giant	0	100	46	54
13	Blue diamond	0	100	35	65
14	Blue Jewel	0	100	98	2
15	Blue moose	0	100	13	87
16	Evie	0	100	31	69
17	Larissa	45	55	93	7
18	Rebecca	98	2	80	20
19	Sveta	0	100	98	2
20	Kawai	0	100	87	13
	Mean	19.23	80.77	70.23	29.77
	Std. Deviation	34.63	34.63	25.91	25.91

The proportion of plants in each treatment flowering at each survey date can be found in Table 14 below. The 2x granular fertilizer treatment had the highest proportion of flowering plants in any treatment on May 27, with 70% of the plants flowering. The control had the lowest proportion of flowering plants of any treatment on May 27. In the mulch block, the black plastic and landscape fabric treatments had the highest proportion of flowering plants on May 27. Flowering in the white mulch and natural mulch treatments was delayed and instead reached a peak on August 13. In the fertilizer block, flowering in the granular fertilizer treatments peaked on May 27. Flowering in the fertigation treatments was delayed, peaking on August 13. In the irrigation treatment block, flowering peaked on August 13 for all treatments except 2 drip 3x.

Table 14. Proportion of flowering plants throughout the growing season by treatment.

Row	Treatment	Proportion of Plants Flowering		
		% Flowering on May 27	% Flowering on June 2	% Flowering on August 13
1	Black Plastic	64	21	19
2	White Plastic	7	0	23
3	Red Mulch	37	12	16
4	Landscape Fabric	61	18	15
5	Control	3	0	7
6	2x Granular Fert	70	26	17
7	3x Granular Fert	32	22	16
8	4x Fertigation	18	14	31
9	6x Fertigation	29	9	34
10	7x Fertigation	20	4	34
11	1 drip 2x	33	14	51
12	1 drip 3x	42	17	44
13	2 drip 2x	20	10	36
14	2 drip 3x	35	17	32
15	Tensiometer	20	15	18
16	Natural Mulch	8	1	20
	Mean	16.69	12.51	25.79
	Std. Deviation	8.85	7.87	11.90

The proportion of plants flowering for each variety at each survey date is described in Table 15. Indigo gem had the highest proportion of flowering plants of all varieties on May 27. Flowering for Boreal beauty, Sveta and Kawai peaked on June 2. Peak flowering was delayed until August 13 for several varieties, including Honeybee, Tundra, Blue treasure, Indigo treat, Boreal beast, all Russian varieties, Evie and Sveta. Flowering was very low in all Polish varieties throughout the growing season.

Table 15. Proportion of flowering plants throughout the growing season by variety.

	Variety	Proportion of Plants Flowering		
		% Flowering on May 27	% Flowering on June 2	% Flowering on August 13
1	Honeybee	8	5	42
2	Tundra	10	3	40
3	Blue treasure	6	8	30
4	Indigo treat	21	5	63
5	Indigo yum	37	3	23
6	Indigo gem	77	31	23
7	Aurora	36	3	20
8	Boreal beast	36	30	73
9	Boreal beauty	45	50	0
10	Boreal blizzard	25	24	2
11	Blue banana	0	0	5
12	Happy giant	5	0	30
13	Blue diamond	16	0	21
14	Blue Jewel	42	14	67
15	Blue moose	6	2	10
16	Evie	2	0	6
17	Larissa	9	0	0
18	Rebecca	2	2	2
19	Sveta	15	26	18
20	Kawai	41	46	44
	Mean	21.89	12.57	25.85
	Std. Deviation	20.03	16.02	22.74

The proportion of plants by treatment producing ripe and/or green berries at the time of harvest and the proportion of plants still producing ripe berries after harvest, is described in Table 16. In the mulch block, the black plastic and red mulch treatments had the highest proportions of ripe berries on July 2. The landscape fabric treatment had the highest proportion of both ripe and unripe berries on July 2, as well as the highest proportion of plants with ripe berries on August 13. This indicates that peak berry production in the landscape fabric treatment was later than in the other mulch treatments. In the fertilizer treatment block, the highest proportion of plants producing ripe berries occurred in the granular fertilizer treatments and in the 4x and 7x fertigation treatments on August 13. In the irrigation treatment block, the single drip line irrigation treatments and the tensiometer row had the most plants with ripe berries on July 2. The double drip lines both had the most plants with ripe berries on August 13.

Table 16. Proportion of plants producing berries by treatment.

Row	Treatment	July 2			August 13
		% Plants with Blue Berries	% Plants with Green Berries	% Plants with Both Blue & Green Berries	% Plants with Blue Berries
1	Black Plastic	12	9	9	4
2	White Plastic	8	1	0	6
3	Red Mulch	11	5	7	7
4	Landscape Fabric	4	4	19	11
5	Control	0	0	1	0
6	2x Granular Fert	8	6	8	9
7	3x Granular Fert	8	3	3	11
8	4x Fertigation	3	0	1	11
9	6x Fertigation	8	4	4	7
10	7x Fertigation	5	1	4	12
11	1 drip 2x	10	4	5	14
12	1 drip 3x	14	3	9	5
13	2 drip 2x	4	3	3	10
14	2 drip 3x	8	3	10	11
15	Tensiometer	7	11	4	4
16	Natural Mulch	5	1	1	8
	Mean	7.02	3.57	5.44	8.10
	Std. Deviation	3.57	3.02	4.77	3.66

The proportion of plants for each variety producing ripe and/or unripe berries at the time of harvest, as well as the proportion of plants found to have ripe berries after harvest, is described in Table 17 below. Indigo yum and Indigo gem had the highest proportion of plants with ripe berries on July 2. Boreal beauty, Boreal blizzard and Kawai had the highest proportion of plants with unripe berries on July 2. Indigo gem and Blue jewel had the most plants with both ripe and unripe berries on July2. Indigo gem also had the highest proportion of plants with ripe berries on August 13.

Table 17. Proportion of plants producing berries by variety.

	Variety	July 2			August 13
		% Plants with Blue Berries	% Plants with Green Berries	% Plants with Both Blue & Green Berries	% Plants with Blue Berries
1	Honeybee	0	2	2	14
2	Tundra	10	0	0	14
3	Blue treasure	0	3	0	6
4	Indigo treat	8	0	8	9
5	Indigo yum	23	0	2	3
6	Indigo gem	48	0	20	36
7	Aurora	11	2	14	7
8	Boreal beast	7	8	13	15
9	Boreal beauty	0	20	7	0
10	Boreal blizzard	2	11	3	2
11	Blue banana	2	0	0	2
12	Happy giant	2	0	2	7
13	Blue diamond	8	0	0	11
14	Blue Jewel	11	0	22	27
15	Blue moose	3	0	2	0
16	Evie	0	0	0	2
17	Larissa	0	0	0	0
18	Rebecca	3	2	2	2
19	Sveta	0	5	2	2
20	Kawai	2	19	10	3
	Mean	6.89	3.62	5.36	8.04
	Std. Deviation	11.33	6.34	6.97	9.48

The date of plants beginning leaf loss or hardening off was recorded over a period of several weeks in the fall. A summary table of the proportion of plants beginning leaf loss by treatment is described in Table 18 below. Overall, rows 1-5 of the mulch treatment block was slower to begin leaf loss than the other treatment blocks. This could be due to the proximity of the mulch block to the shelterbelt. Within the mulch block, the natural mulch treatment was the earliest to begin leaf loss, and the control was the latest. In the fertilizer treatment block, the high-rate fertigation treatments began leaf loss more quickly than the granular or low-rate fertigation treatments. Finally, in the irrigation treatment block, the 2 drip 3x treatment began leaf loss the earliest, and the 2 drip 2x began leaf loss the latest.

Table 18. Proportion of plants beginning leaf loss/hardening off on the week of September 22, September 28, or October 2 by treatment.

Row	Treatment	Proportion of Plants Beginning Leaf Loss Each Week (%)		
		Sep. 22, 2020	Sep. 28, 2020	Oct. 2, 2020
1	Black Plastic	15	80	5
2	White Plastic	5	95	0
3	Red Mulch	5	95	0
4	Landscape Fabric	15	85	0
5	Control	0	100	0
6	2x Granular Fert	20	80	0
7	3x Granular Fert	25	75	0
8	4x Fertigation	20	80	0
9	6x Fertigation	30	70	0
10	7x Fertigation	30	70	0
11	1 drip 2x	30	70	0
12	1 drip 3x	20	80	0
13	2 drip 2x	10	90	0
14	2 drip 3x	50	50	0
15	Tensiometer	30	70	0
16	Natural Mulch	65	35	0
	Mean	23.13	76.56	0.31
	Std. Deviation	16.72	16.61	1.25

The proportion of plants beginning leaf loss by variety over several weeks is described in Table 19. Happy giant had the highest proportion of plants beginning leaf loss on September 22, with 81%. The majority of Blue banana and Blue moose plants also began leaf loss on September 22. All other varieties primarily began leaf loss on the week of September 28. A single plant of the Rebecca variety began leaf loss even later, on October 2.

Table 19. Proportion of plants beginning leaf loss/hardening off on the week of September 22, September 28, or October 2 by variety of haskap.

	Variety	Proportion of Plants Beginning Leaf Loss Each Week (%)		
		Sep. 22, 2020	Sep. 28, 2020	Oct. 2, 2020
1	Honeybee	13	88	0
2	Tundra	25	75	0
3	Blue treasure	0	100	0
4	Indigo treat	38	63	0
5	Indigo yum	13	88	0
6	Indigo gem	38	63	0
7	Aurora	31	69	0
8	Boreal beast	6	94	0
9	Boreal beauty	19	81	0
10	Boreal blizzard	0	100	0
11	Blue banana	50	50	0
12	Happy giant	81	19	0
13	Blue diamond	31	69	0
14	Blue Jewel	38	63	0
15	Blue moose	56	44	0
16	Evie	19	81	0
17	Larissa	6	94	0
18	Rebecca	0	94	6
19	Sveta	0	100	0
20	Kawai	0	100	0
	Mean	23.13	76.56	0.31
	Std. Deviation	22.31	22.02	1.40

The control, sierra red wood mulch and natural wood mulch required more labour than the other treatments, and it was higher maintenance because more mulch needed to be added to both wood mulch treatments. The landscape fabric treatment consistently required the least weeding throughout the growing season. Additionally, the wood mulch treatments required more hand weeding and whipper snipping than the other treatments. The control was the most time consuming to weed and often required extra weeding before any data collection to expose the plants.

11. Summary:

In the second year of the haskap agronomy trial, many varieties began flowering and producing berries. Vigour, survivability, growth characteristics, flowering and berry production was recorded throughout the growing season. Overall, the control treatment required the most

weeding, had the poorest vigour, shortest plants and lowest yields. The black plastic and landscape fabric treatments produced vigorous plants with good yields. The higher rate fertigation treatments resulted in vigorous plants, but this benefit did not translate to high yields. Trends in vigour and yield in the irrigation block were difficult to discern, perhaps due to good levels of precipitation in the 2020 growing season. Honeybee stood out as the variety with the poorest survivability, vigour and low yields. Indigo gem, Boreal beast and Boreal beauty were vigorous, high yielding, bushy plants. The haskap agronomy trial was featured in a YouTube video as part of the CLC's Virtual Field Day, reaching 27 viewers at the time of writing this report. This trial was also featured in a walking tour in lieu of the CLC's Annual Field Day in July of 2020. Approximately 10 people attended, including local producers and commodity group representatives. Walking tour attendance was restricted due to COVID-19.

11. Acknowledgements:

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