2024 Pulse Quality Evaluation

Pea

Saskatchewan Food Industry Development Centre Inc.
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Pulse Quality Program—*Mission*

The Pulse Quality Program launched in spring 2022 with a partnership between Saskatchewan Pulse Growers and the Saskatchewan Food Industry Development Centre with the mission to add in best management practices for pulses grown in Western Canada and to help the development of pulse-based ingredients/products in the food industry.

The program aims to develop a comprehensive database of composition, functionality, and nutrition for pulses that provides information to growers, agronomists, breeders, buyers, and end users to make more informed choices. This program implements a genotype by environment (G x E) evaluation of quality parameters of peas, faba beans, lentils, chickpeas, and dry beans.

Phase 1 of the program analyzes up to 3000 samples annually from regional variety trials. The main focus of parameters includes seed quality (i.e., 1000 seed weight, amount of damage, seed size, and seed hardness), nutritional composition (i.e., ash, moisture, and protein content), and physical properties (i.e., colour, particle size, and Hausner ratio). The generated data are compared across pulse varieties, locations, and years. Additional parameters will be considered in future years in Phase 2 and Phase 3.

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2024 Pea Quality Evaluation

A total of **1170** pea samples were harvested in **2024.** The samples were acquired from **thirteen locations** x **thirty varieties**, with three replicates per variety per location. Varieties consist of five varieties of green peas, twenty-one varieties of yellow peas, and two varieties of maple peas. **Table A** provides the samples' information in detail.

Table A. Description of 2024 pea samples tested for the Pulse Quality Program.

Crop	Type	Variety		Site	Number of samples
Pea	Green	CDC Forest	CDC Rider	Avonlea	1170
		CDC Huskie	CDC Spruce	Codette	
	Yellow	AAC Beyond	CDC Tollefson	Glaslyn	
		AAC Julius	CS ProStar	Lucky Lake	
		Caphorn	PS Boost	Osler	
		CDC 5791	AAC Aberdeen	Outlook	
		CDC 5845	AAC McMurphy	Redvers	
		CDC Amarillo	AAC Planet	Roblin, MB	
		CDC Boundless	6020-11	Saskatoon (Sutherland)	
		CDC Citrine	6242-1	Scott	
		CDC Engage	AAC Harrison	St Brieux	
		CDC Hickie	CDC 6482-4	Swan River, MB	
		CDC Inca	CDC Canuck	Swift Current	
		CDC Lewochko	EP6381		
		CDC Spectrum	EP8971		

Note:

- Twenty varieties that existed in 2022, 2023, and 2024 are shown in black.
- Three varieties present in both 2023 and 2024 are shown in blue.
- Seven new varieties entered in 2024, shown in red.

The thirteen sampling locations for 2024 pea trials and their corresponding crop regions (i.e., southeast, southwest, east-central, west-central, northeast, and northwest) are shown in **Figure A** and **Figure B**. **Figure A** also illustrates the soil zones across the province, while **Figure B** presents the cumulative rainfall during the 2024 growing season.

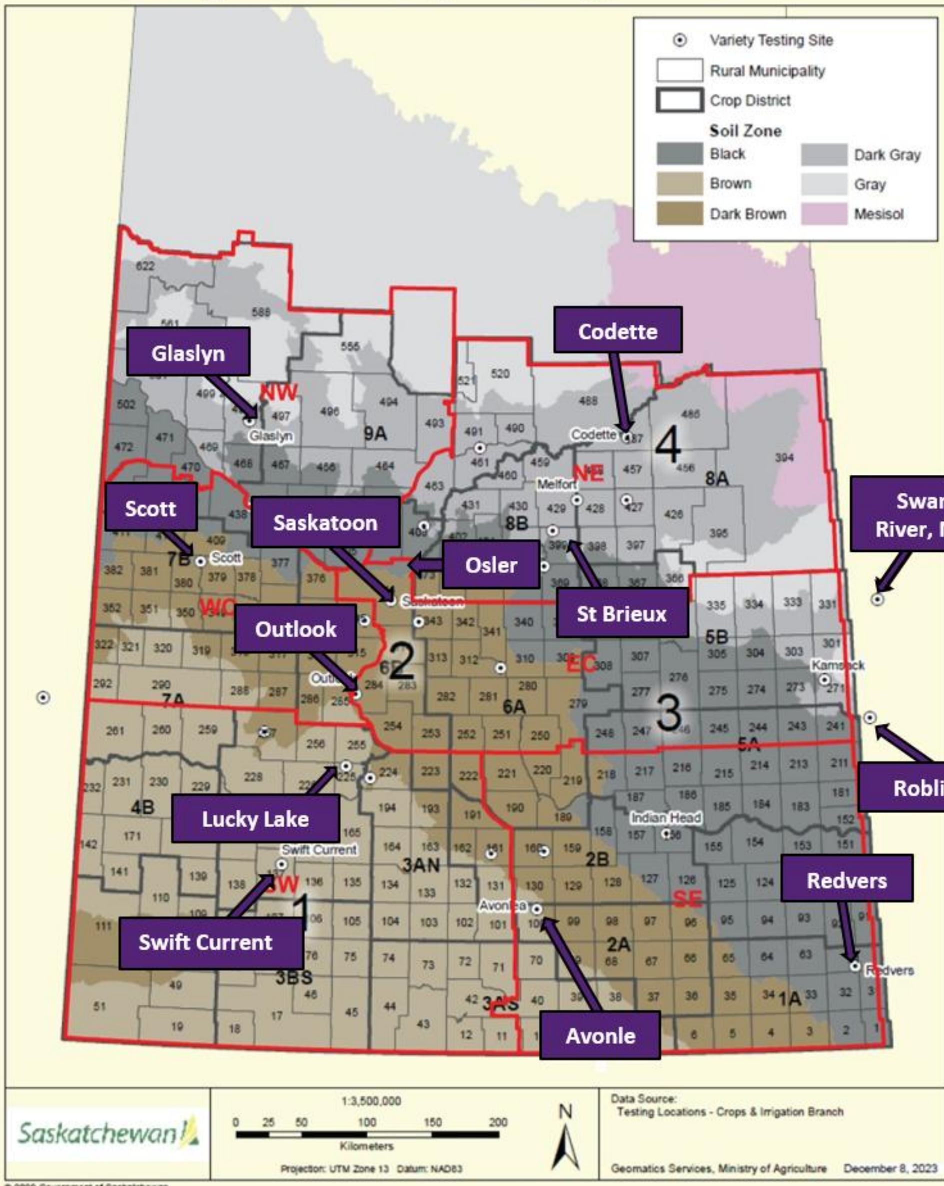
According to the 2024 Crop Reports by the Ministry of Agriculture, adequate rainfall in May improved topsoil moisture conditions across the province. However, subsequent moisture and cooler temperatures delayed seeding. Seeding progress has been fastest in the southwest and southeast, while the central and northeast regions have experienced slower progress due to higher spring snowfall accumulations. Provincially, seeding of field peas is nearly complete by the end of May.

In June, cooler temperatures and excessive moisture further delayed overall crop development. By July and early August, reduced precipitation and rising temperatures depleted topsoil moisture reserves in many regions, accelerating crop advancement and maturity. The development of crops in the southern and western regions was further ahead while the central and northern regions fell behind.

Pea harvest began in early August in southwest and southeast regions and continued throughout the province over the following two weeks. Harvest was completed by early September, reflecting variable yields across the province.

Crop yields vary across the province, with some producers reporting higher-than-expected yields, while others—particularly in areas most affected by heat and drought—are seeing below-average yields.

Regional Variety Testing Locations



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The cropland of Saskatchewan has been divided into four areas based roughly on agro-climatic conditions. Crop yields can vary from area to area. In choosing a variety, producers will want to consider the yield data in combination with marketing and agronomic factors.

Area 1: Drought is a definite hazard and high winds are common. Sawfly outbreaks often occur in this area. Cereal rust may be a problem in the southeastern section.

Area 2: Drought and sawfly may be problems in the western and central sections of the area. Cereal rust may be a problem in the southern section.

Area 3: Sawfly can also be a problem. Drought is not as likely to be a problem in this area, particularly in the east. Cereal rust may occur in the eastern portion. The frost-free period can be fairly short in the northern section.

Area 4: Rainfall is usually adequate for crop production. However, early fall frosts and wet harvest conditions are frequent problems.

Note About Dividing Lines:

The dividing lines do not represent distinct changes over a short distance. The change from one area to another is gradual.

Figure A. Locations for pea quality testing in 2024, along with the corresponding soil zones and crop regions. Figure was modified from material provided by the Saskatchewan Ministry of Agriculture.

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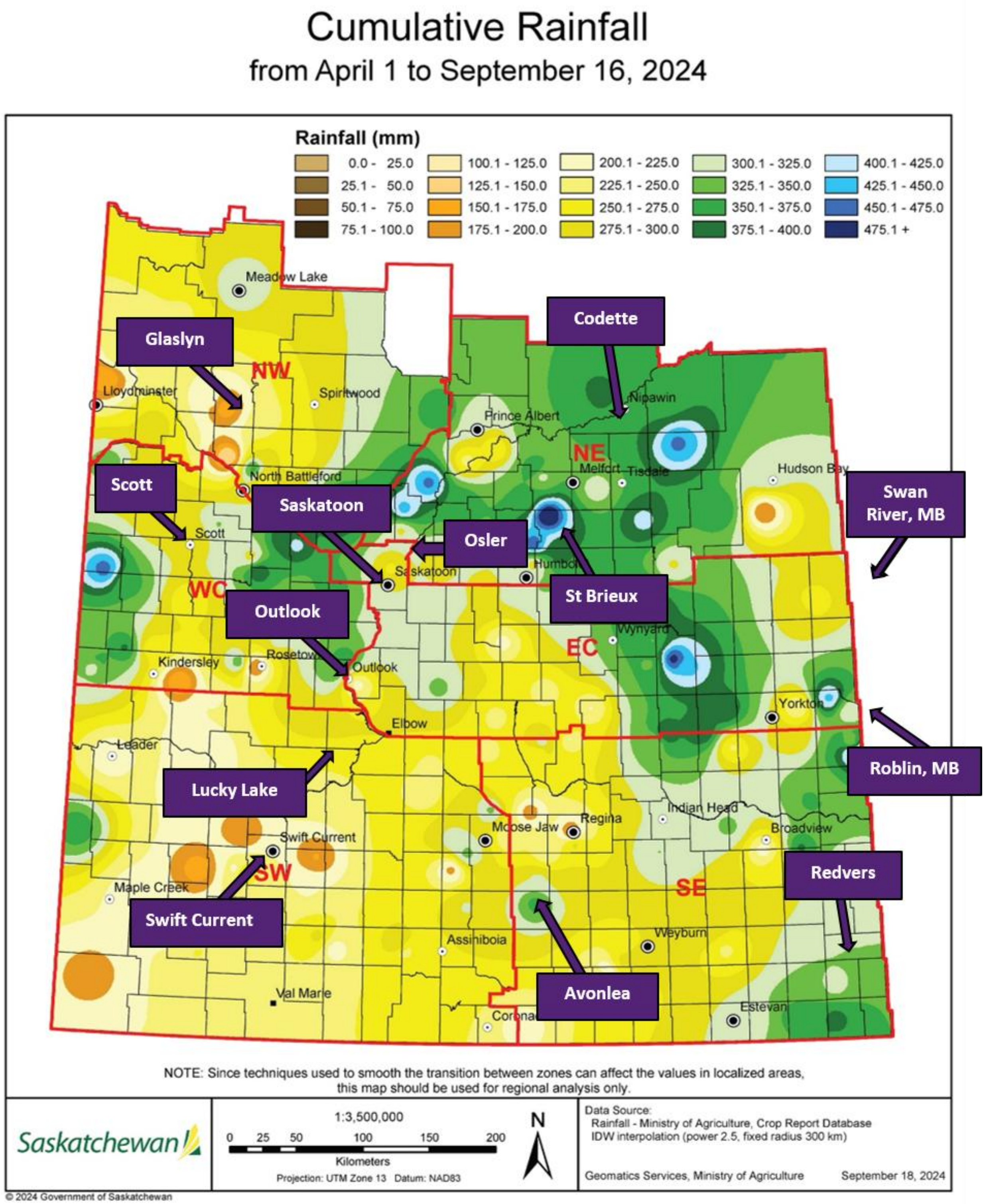


Figure B. Crop regions, locations for pea quality testing, and cumulative rainfall from April 1 to September 16, 2024. Figure was modified from material provided by the Saskatchewan Ministry of Agriculture.

This report includes three sections: **1)** green pea varieties and **2)** yellow pea varieties. Each section includes twelve subsections for the results of the following quality parameters:

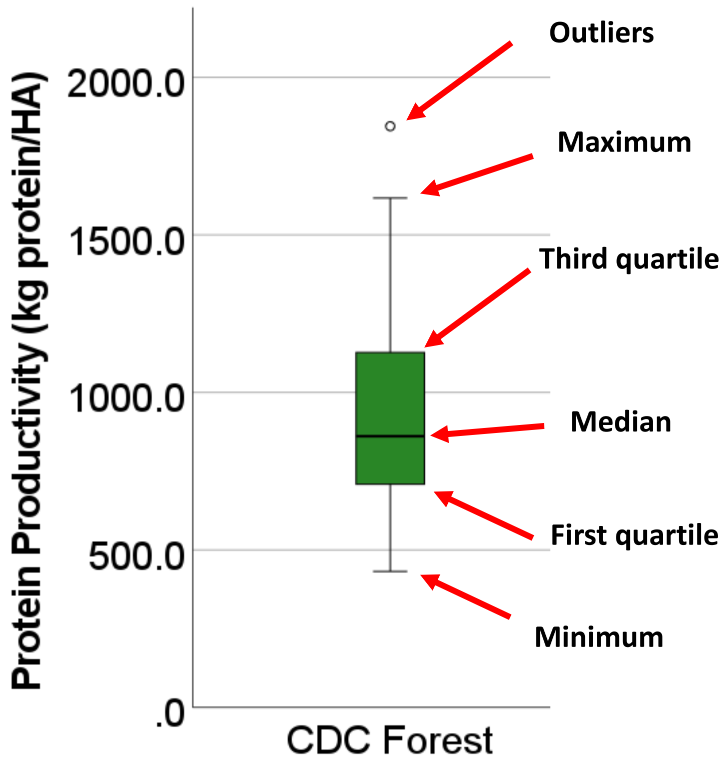
1. Yield
2. Thousand kernel weight (TKW)
3. Seed size distribution
4. Split
5. Seed coat breakage (SCB)
6. Bleaching (green peas) or Immature/ Greenness (yellow peas)
7. Other damage
8. Hardness of whole seed
9. Ash content
10. Protein content
11. Protein productivity
12. Colour (*L**, *a**, and *b**)

The **method** used to evaluate each quality parameter is provided at the beginning of each subsection.

For the **results**, a **Box and Whisker** plot is provided to show the full dataset of each variety, where the minimum, median, maximum, first quartile (the median of the lower half of the dataset), and third quartile (the median of the upper half of the dataset).

In addition, a **Bar** graph is included to provide the mean value by variety to show the variety performance and by location to show how the locations differed.

Furthermore, the effects of variety, location, and variety x location on the characteristic are given in a **table**.



For **statistics**, a one-way analysis of variance (ANOVA) along with a post-hoc Tukey test (SPSS, Chicago, IL, USA) was performed to identify the differences in the quality parameters, including yield, TKW, seed size, seed hardness, split + cracked seed coat, other damage, protein, protein productivity, ash, Hausner ratio, colour, and particle size, by variety and by location.

A two-way analysis of variance (ANOVA) was conducted to determine the effects of variety, location, and their interaction on each parameter. The Pearson Product Moment Correlation was performed to measure the correlation between quality parameters.

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1) 2024 Green Pea Quality

1. Yield

Method: Yield refers to how much crops are produced and how efficiently land is used to produce food or agricultural commodities. The yield of each variety from each location is provided as kilogram per hectare (kg/HA).

Results: Figure 1.1.1. Box and Whisker plot of green peas for yield in 2024.

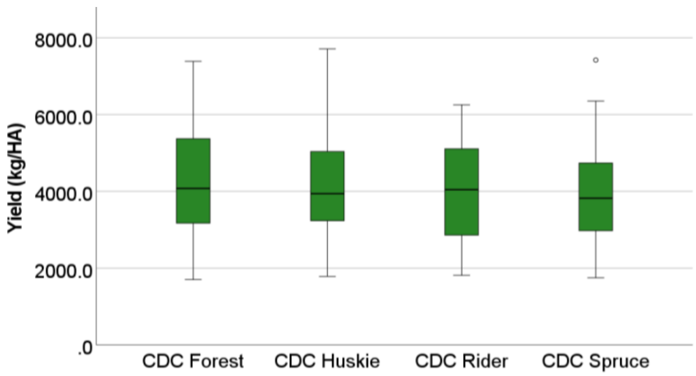
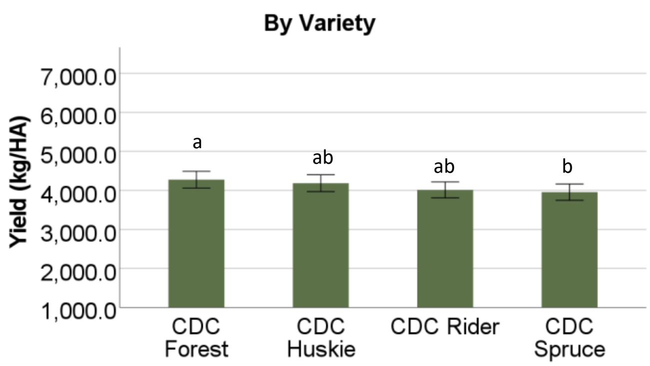


Table 1.1. Effects of variety and location.

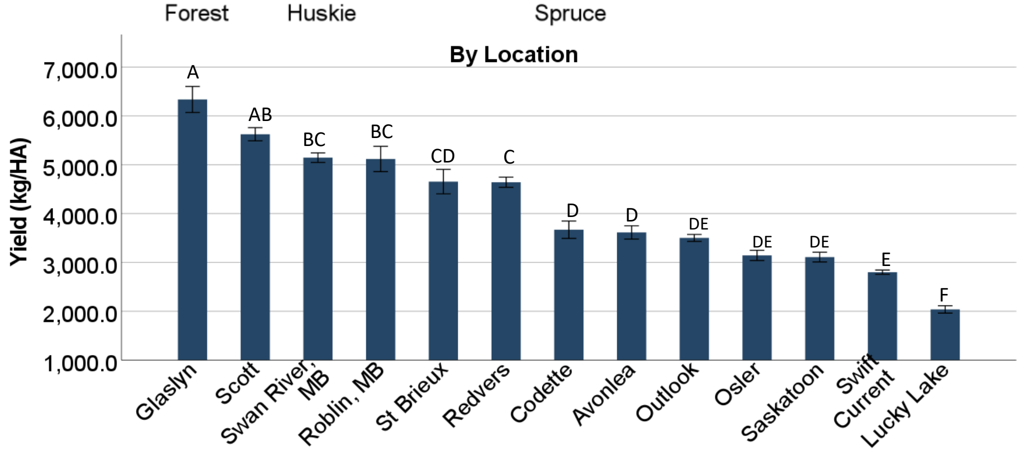
	Sig.
Variety	*
Location	***
Variety x Location	*NS*

****p<0.001; **p<0.01; *p<0.05; NS not significant.*

Figure 1.1.2. Mean yield of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



By Location: The location effect played a significant role. Yields in Glaslyn was three times as high as in Lucky Lake. Lucky Lake and Swift Current were reported to have lower rainfall and higher temperature during the growing seasons.



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

2. Thousand Kernel Weight (TKW)

Method: Seed weight is important to indicate seed size and yield production. This test was conducted by weighing 300 seeds with duplicated measurements per sample. TKW was reported.

Results: Figure 1.2.1. Box and Whisker plot of green peas for TKW in 2024.

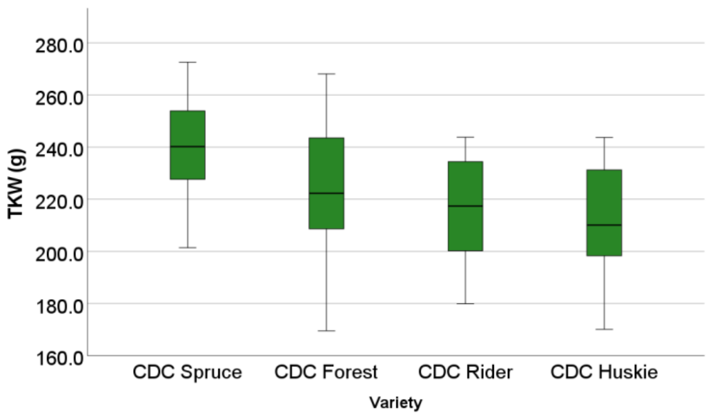
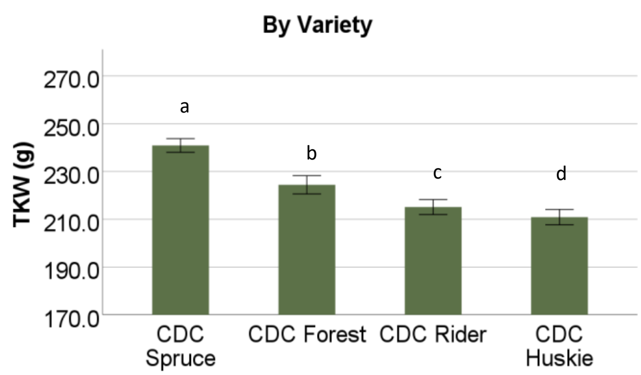


Table 1.2. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

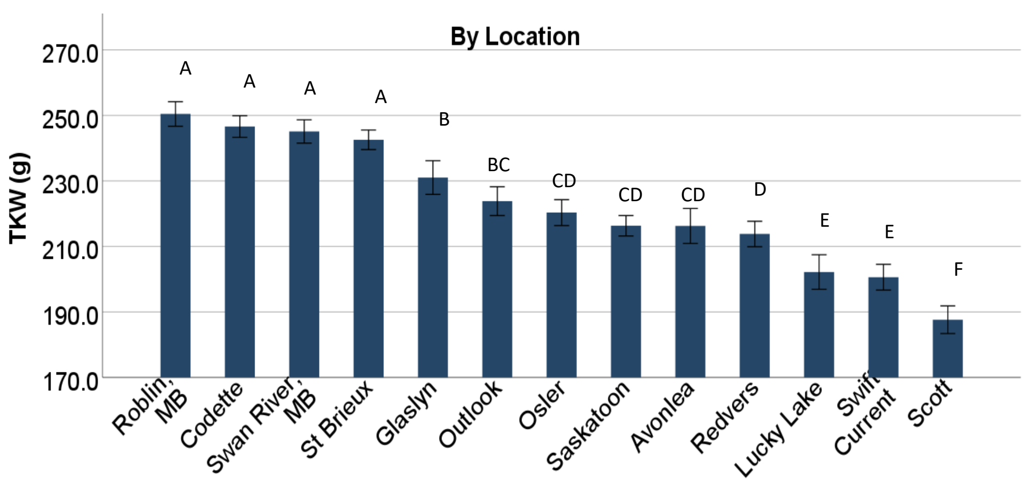
Figure 1.2.2. Mean TKW of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



By Variety: A difference of 30 g was determined from the largest to the smallest.

By Location: A difference of 63 g was determined from the highest to the lowest.

A positive trend between yield and TKW was oberserved (r=.263, p<0.01).



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

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3. Seed Size Distribution

Method: 250 g of seeds were placed on a series of round-hole opening sieves. The weight of seeds retained on each sieve was determined and reported as % of seeds retained. Duplicated measurements were performed.

Sieves used for 2024 green pea varieties:

a. #20R: 7.94 mm
b. #18R: 7.14 mm
c. #16R: 6.35 mm
d. #14R: 5.56 mm

Results: Table 1.3. Seed size distribution (%) of each 2024 green pea variety. Data represent mean ± one standard deviation.

Variety	> 7.94 mm (%)	> 7.14 mm (%)	> 6.35 mm (%)	> 5.56 mm (%)	Below 5.56 mm (%)
CDC Spruce	1.5 ± 1.8[a]	30.1 ± 14.9[a]	62.0 ± 13.8[b]	6.0 ± 4.4[d]	0.3 ± 0.3[c]
CDC Forest	1.1 ± 1.6[a]	24.4 ± 17.8[b]	61.0 ± 14.0[b]	12.8 ± 11.9[c]	0.7 ± 0.8[b]
CDC Rider	0.6 ± 0.7[b]	14.8 ± 12.3[c]	67.2 ± 9.2[a]	16.6 ± 12.3[b]	0.8 ± 0.7[b]
CDC Huskie	0.4 ± 0.5[b]	13.8 ± 12.1[c]	63.3 ± 9.5[b]	21.3 ± 14.4[a]	1.2 ± 1.2[a]

Note: Means within a column followed by different lowercase letters are significantly different ($p<0.05$).

- The majority of green peas had a seed size between 6.4 mm to 7.9 mm.
- Seed size distribution results corresponded to TKW, with CDC Spruce having the highest weight (pg. 9) and the most seeds greater than 7.14 mm.
- In contrast, CDC Huskie had the lowest TKW (pg. 8) and the fewest seeds retained on the #20 and #18 sieves but more on the #16 and #14 sieves.

4. Split

Method: 100 grams of each sample was used for evaluation, and damaged seeds were selected by hand. Results included splits, cracks, partially missing hull, and partially missing cotyledon.

Results: Figure 1.4.1. Box and Whisker plot of green peas for split in 2024.

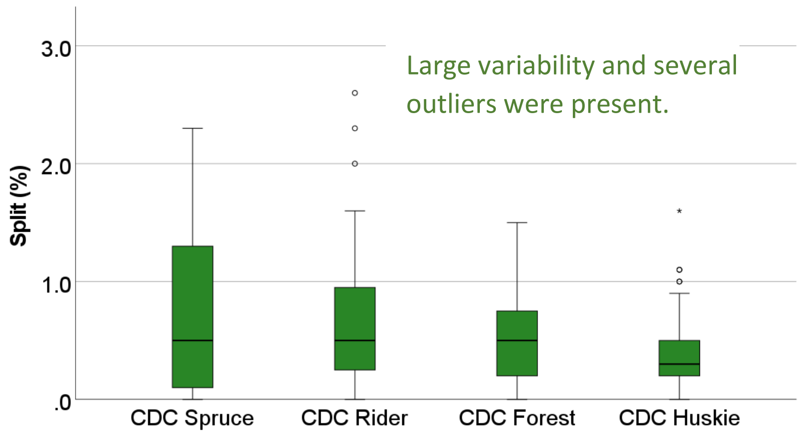
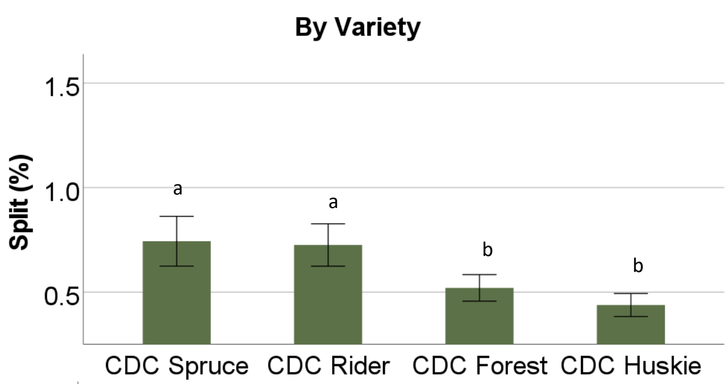


Table 1.4. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

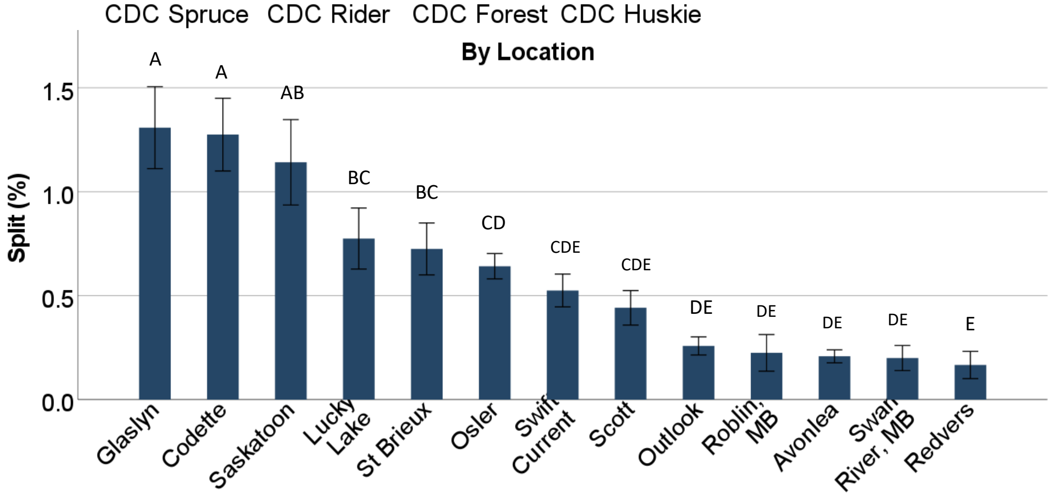
*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

Figure 1.4.2. Mean split of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



By Variety: Only a 0.3% of difference was determined from the largest to the smallest.

By Location: A 1.2% difference was determined from the lowest to the highest.



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

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5. Seed Coat Breakage (SCB)

Method: 100 grams of each sample was used for evaluation, and seeds with seed coat damage were selected by hand. Seed coat breakage occurs during harvesting and handling, reducing seed quality. It is recommended to combine peas at around 18-20% moisture content to reduce the risk of seed cracking or peeling. Using lower speeds with the combine and auger is also preferred (Saskatchewan Pulse Growers, 2024[1]).

Results: Figure 1.5.1. Box and Whisker plot of green peas with SCB in 2024.

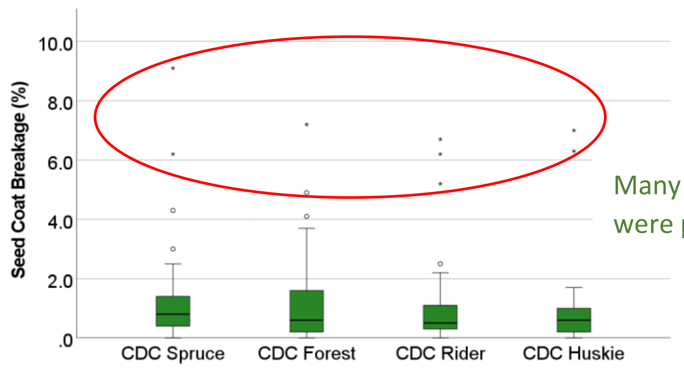
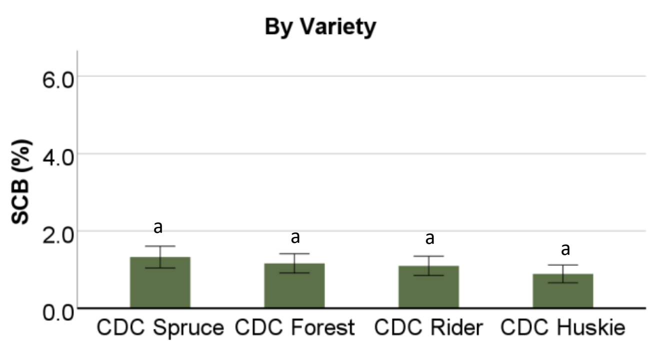


Table 1.5. Effects of variety and location.

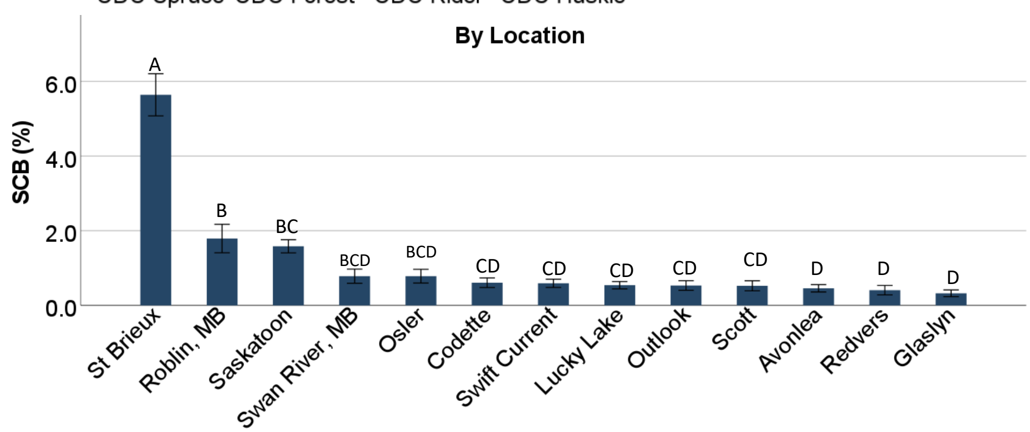
	Sig.
Variety	*NS*
Location	*****
Variety x Location	*NS*

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

Figure 1.5.2. Mean SCB of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



By Location: Location significantly affected the seed coat damage, indicated that seed handling during harvest and post-harvest process played a role.



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

[1] Saskatchewan Pulse Growers. 2024. Accessed June 03, 2024. https://saskpulse.com/resources/pea-harvest-management/

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6. Bleaching

Method: 100 grams of each sample was used for evaluation, and bleached seeds were selected by hand. Green peas are bleached when one-eight or more of the surface of the cotyledon has a distinct yellow color. Bleached green peas in general do not affect seed quality but the appearance, thereby reducing the market price. Bleaching occurs when the chlorophyll is enzymatically degraded under a combination of bright sunlight and moisture. Choosing varieties that have better tolerance to bleaching is a good idea to minimize bleaching. In addition, it is also recommended to harvest green peas as soon as possible to reduce the time of green peas in the field.

Results: Figure 1.6.1. Box and Whisker plot of bleached green peas in 2024.

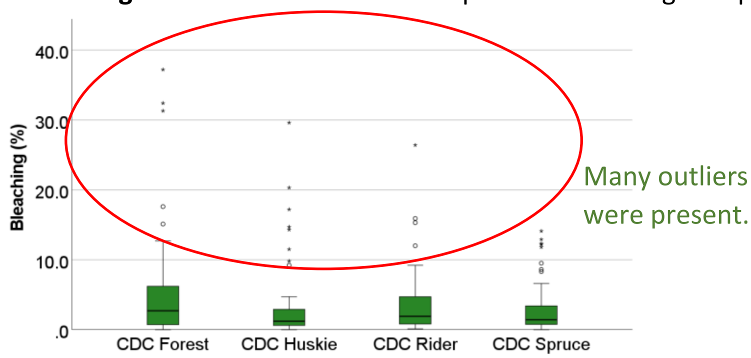
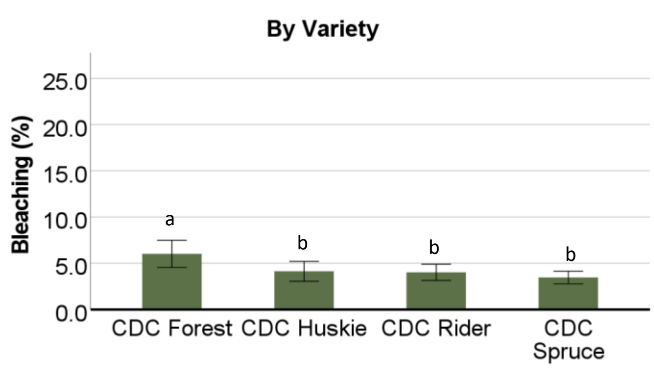


Table 1.6. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

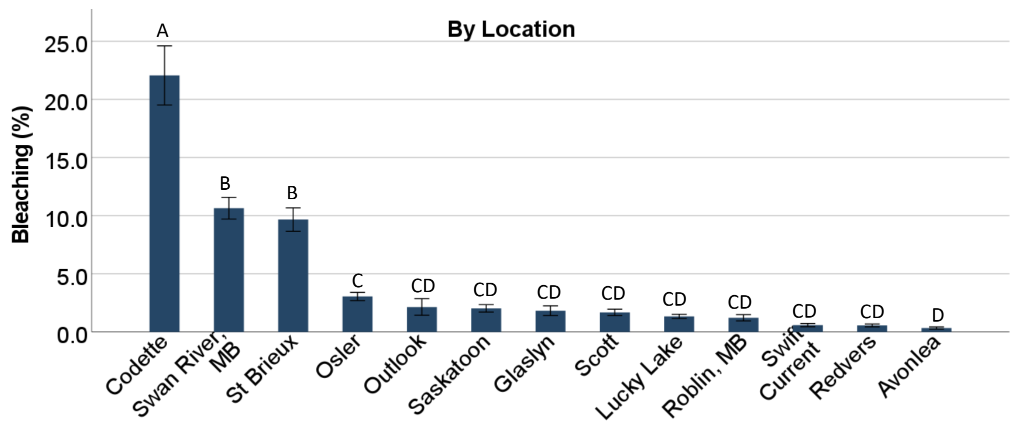
*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

Figure 1.6.2. Mean of 2024 bleached green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



By Variety: CDC Forest had the higher bleaching level.

By Location: Codette and St Brieux (NE) and Swan River had extreme high bleaching level.



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

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7. Other Damage

Method: 100 grams of each sample was used for evaluation, and damaged seeds were selected by hand. Other damage included pink, sprouting, shrivelled, heated, frost, and insect damage.

Results: Figure 1.7.1. Box and Whisker plot of green peas for other damage in 2024.

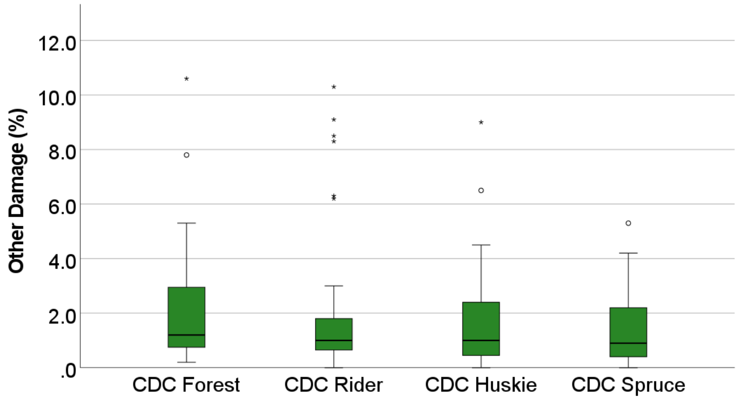
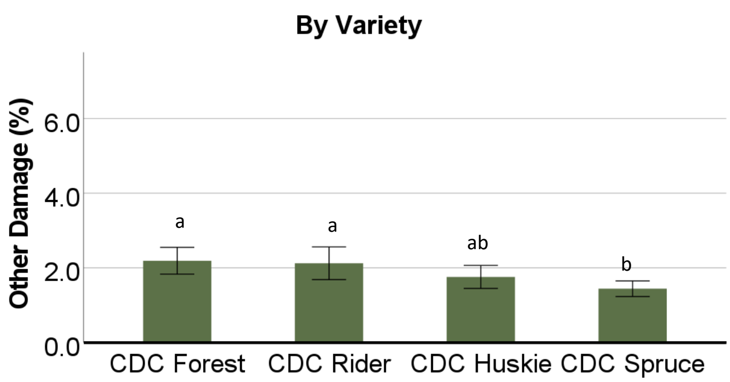


Table 1.7. Effects of variety and location.

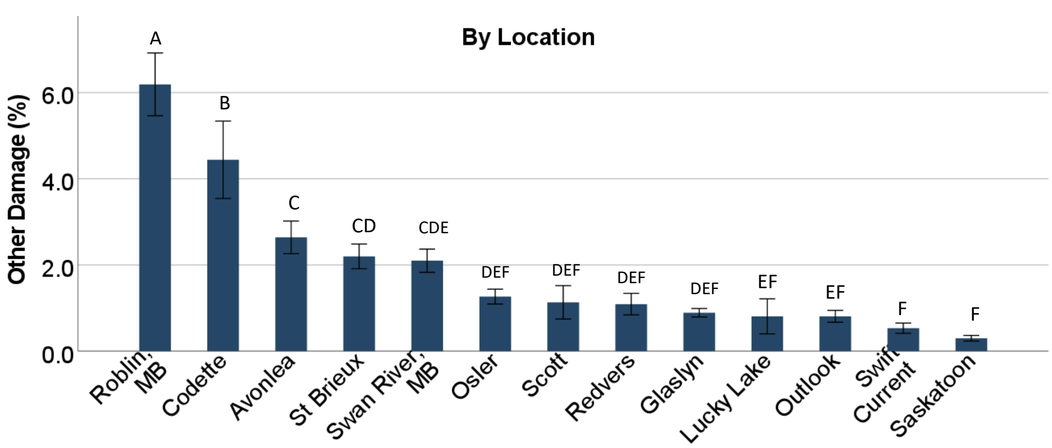
	Sig.
Variety	**
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

Figure 1.7.2. Mean of other damage for 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



By Location: A high level of sprouting seeds and water damage was found in Roblin, and frost damage was observed in Codette (data not shown).



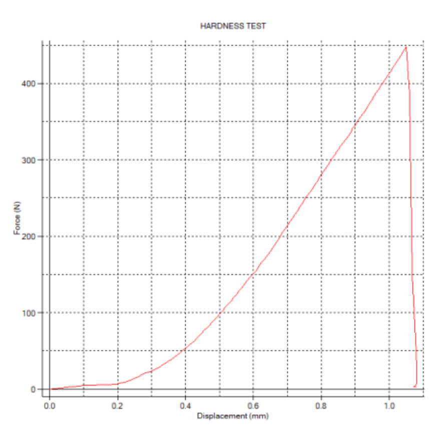
Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

8. Hardness of Whole Seed

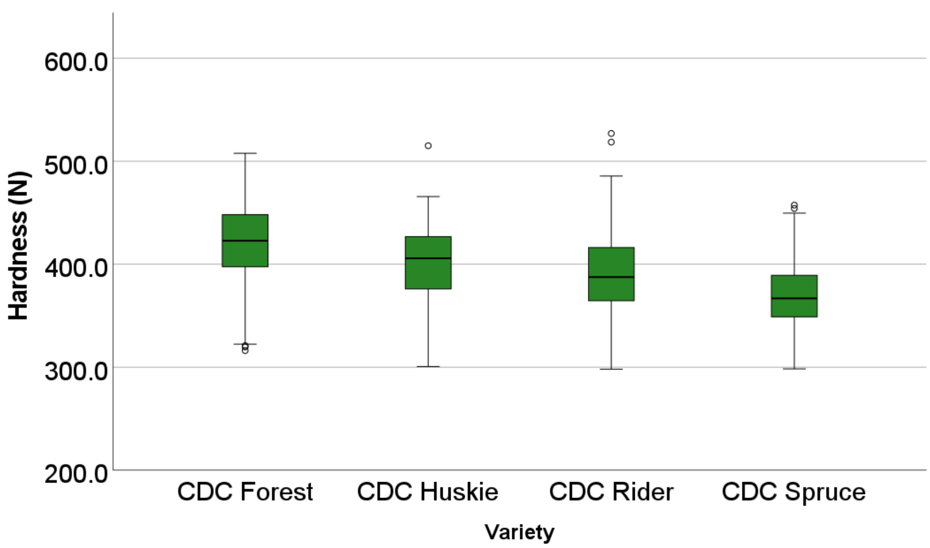
Method: Seed hardness is an important parameter to indicate milling yield and cooking quality. Seed hardness is affected by seed size, shape, density, composition, etc.

Seed hardness was determined by measuring the force of breaking a seed using a texture analyzer (TMS-Pro, Food Technology Corporation, USA) equipped with a 2500 N load cell with a modified method from Karami et al. (2017) and Lovas-Kiss (2020)[2].

In brief, a seed was placed under the 10 mm cylinder probe that was lowered with a speed of 50 mm/min. The forces to lower the probe till a seed was broken were monitored. The mean peak force (N) of 10 seeds was reported.



Results: Figure 1.8.1. Box and Whisker plot of green pea hardness in 2024.



- Several outliers were present.
- CDC Spruce had the smallest variability across locations.

[2] Karami, S., Sabzalian, M. R., Rahimmalek, M., Saeidi, G., & Ghasemi, S. (2017). Interaction of seed coat color and seed hardness: An effective relationship which can be exploited to enhance resistance to the safflower fly (Acanthiophilus helianthi) in Carthamus spp. Crop Protection, 98, 267-275.

Lovas‐Kiss, Á., Vincze, O., Kleyheeg, E., Sramkó, G., Laczkó, L., Fekete, R., ... & Green, A. J. (2020). Seed mass, hardness, and phylogeny explain the potential for endozoochory by granivorous waterbirds. Ecology and Evolution, 10(3), 1413-1424.

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Figure 1.8.2. Mean hardness of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.

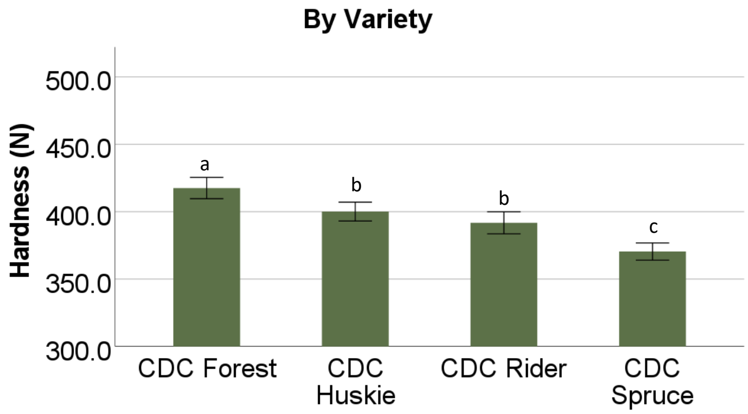
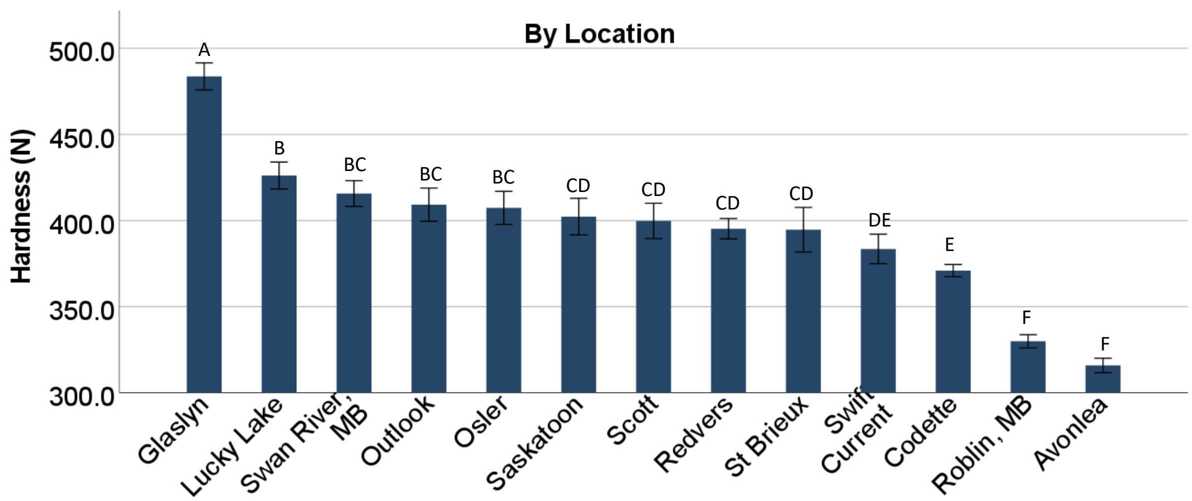


Table 1.8. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

By Variety:

- A difference of 47 N was observed from highest to lowest.
- CDC Forest > CDC Huskie = CDC Rider > CDC Spruce.

By Location:

- Except for the extreme high of Glaslyn and the lowest three locations, hardness for other locations ranged from 380 N to 420 N.

A negative trend between moisture and hardness was observed (r=-0.597; p<0.01).

9. Ash Content

Method: Ash content (%) was determined using AACC 08-01.01[3] with modification. Samples were heated at 560°C till they turned white. Duplicated measurements were performed for each sample, and the average was reported on a dry basis (d.b.).

Results: Figure 1.9.1. Box and Whisker plot of green peas for ash content in 2024.

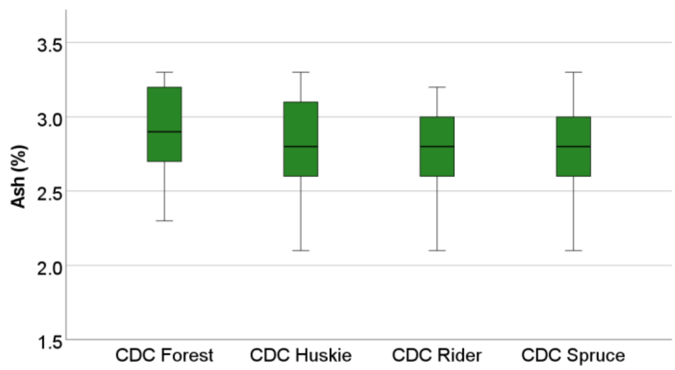
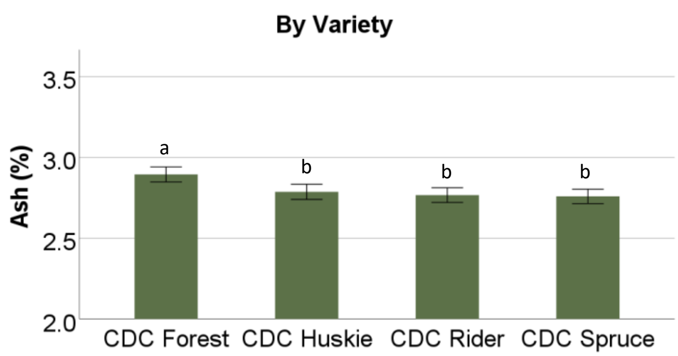


Table 1.9. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	*

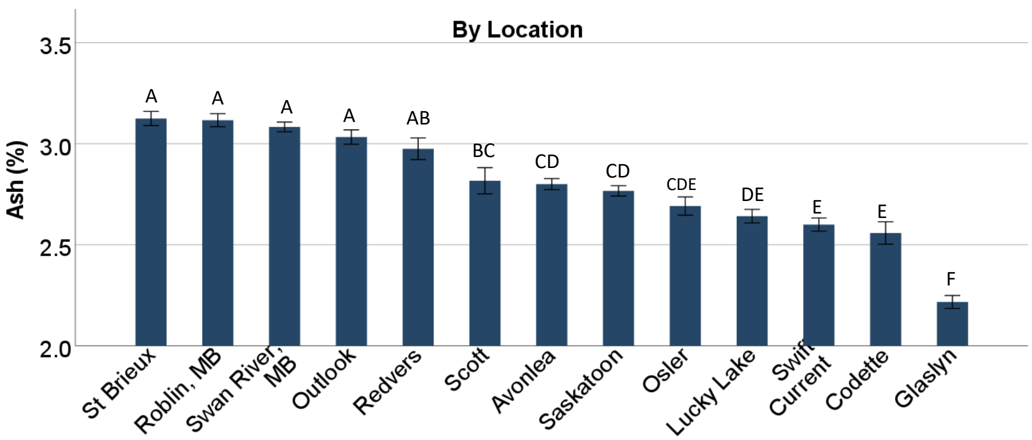
*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

Figure 1.9.2. Mean ash content of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



By Variety: Only a 0.1% difference was determined between the four varieties.

By Location: A 0.9% difference was determined from the highest (St Brieux) to the lowest (Glaslyn).



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

[3] AACC (1999). American Association of Cereal Chemists International. Approved methods of analysis (11th ed.). The Saint Pauls Association: Saint Paul, MN.

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10. Protein Content

Method: The protein content (%) of each flour was determined through AACC 46-30[2] using the combustion method through a Rapid N Exceed (Elementar, USA). Duplicated measurements were performed for each sample, and the average was reported on a dry basis (d.b.).

Results: Figure 1.10.1. Box and Whisker plot of green peas for protein content in 2024.

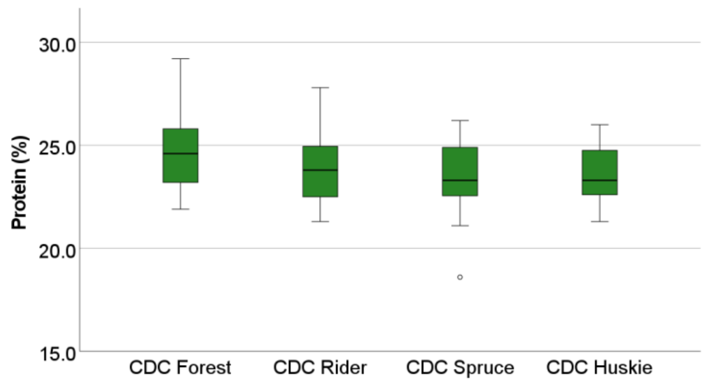
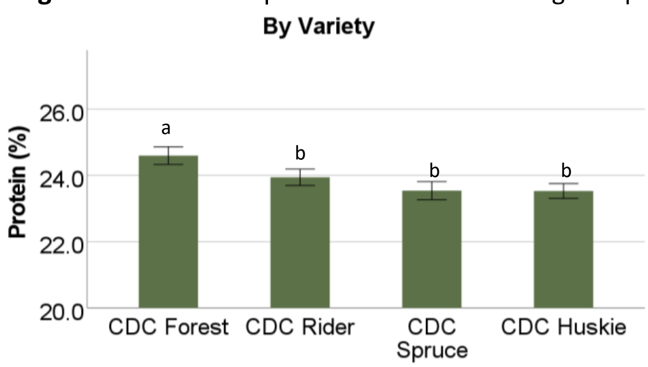


Table 1.10. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	*NS*

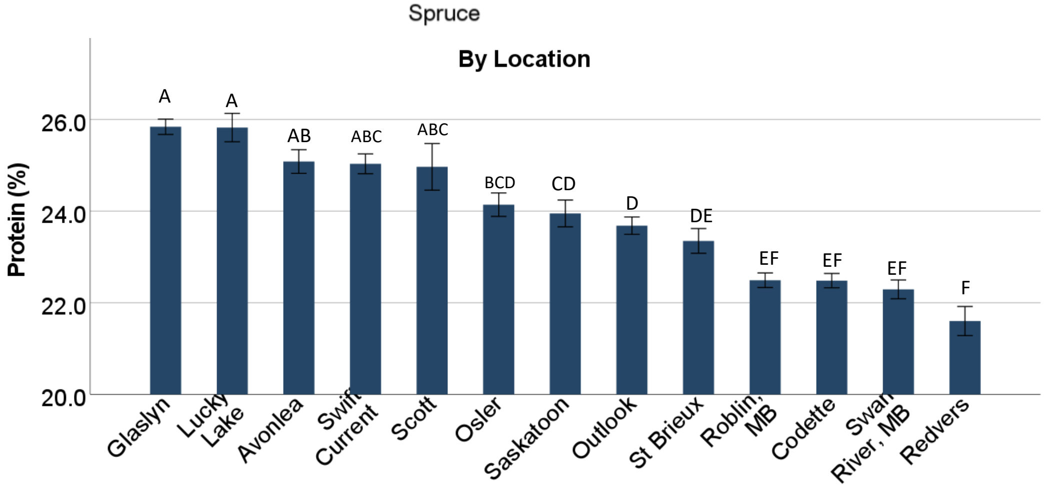
*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

Figure 1.10.2. Mean protein content of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



By Variety: About 1% of difference was determined from the highest to the lowest.

By Location: A difference of 4% was determined from the highest to the lowest.



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

[2] AACC (1999). American Association of Cereal Chemists International. Approved methods of analysis (11th ed.). The Saint Pauls Association: Saint Paul, MN.

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11. Protein Productivity

Method: Protein productivity (kg protein/HA), which is calculated using yield (kg/HA) multiplied by protein content (%), refers to the amount of protein produced per unit of land. It evaluates how much protein is being harvested from a given area.

Results: Figure 1.11.1. Box and Whisker plot of green peas for protein productivity in 2024.

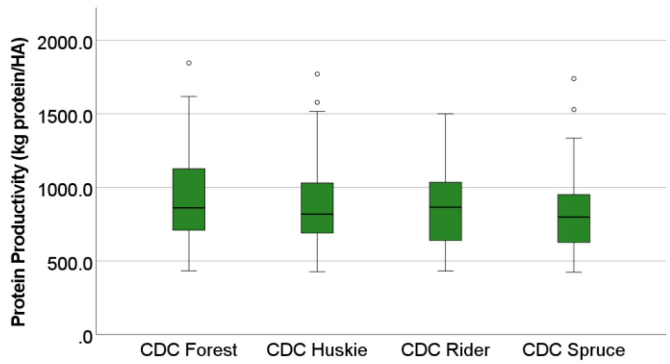
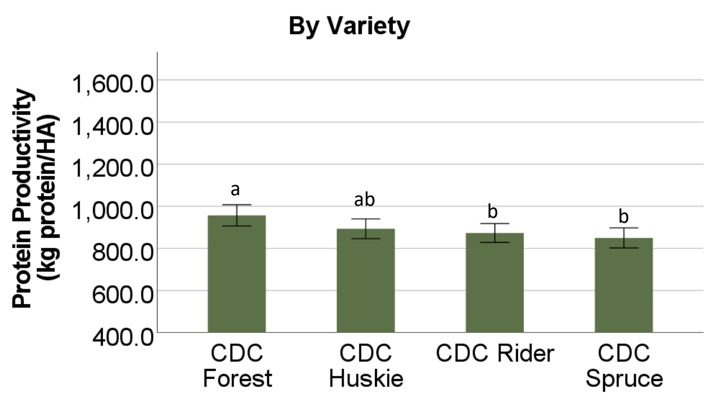


Table 1.11. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	*NS*

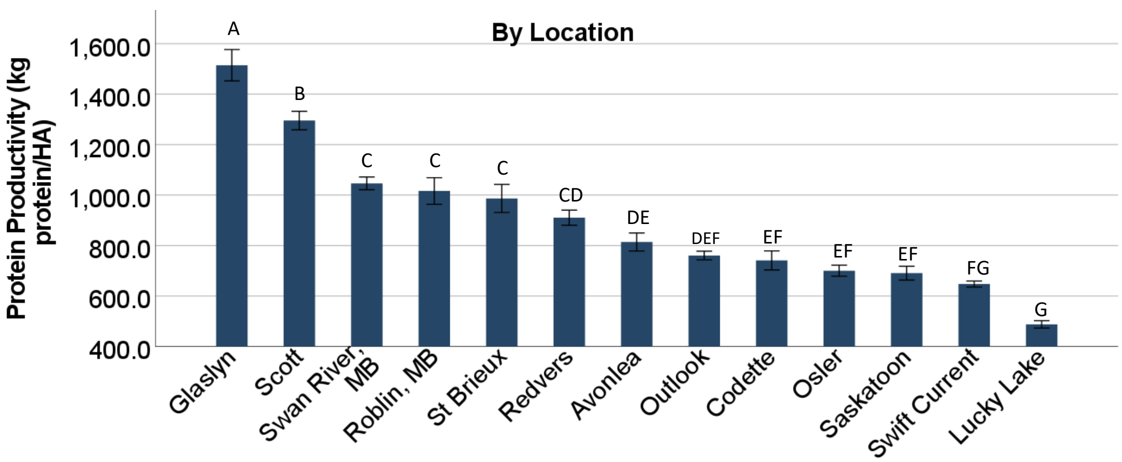
*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

Figure 1.11.2. Mean protein productivity of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



By Variety: A 107 kg protein/HA difference was determined from the highest to the lowest.

By Location: Glaslyn had the highest yield and protein content, contributing to the highest protein productivity. In contrast, Lucky Lake had the lowest protein productivity due to its very low yield.



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

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12. Colour

Method: The absolute colour of each flour was determined using the Konica Minolta CR-400 Chroma meter, where *L*, a*,* and *b** values were reported.

- ***L* (lightness):*** white (100) to black (0)
- ***a*:*** red (+) to green (-)
- ***b*:*** yellow (+) to blue (-)

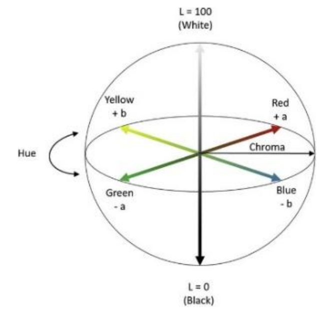


Figure 1.12.1. The CIELAB color spacediagram[4].

a) ***L* (lightness):*** white (100) to black (0)

Results: Figure 1.12.2. Box and Whisker plot of green peas for *L** values in 2024.

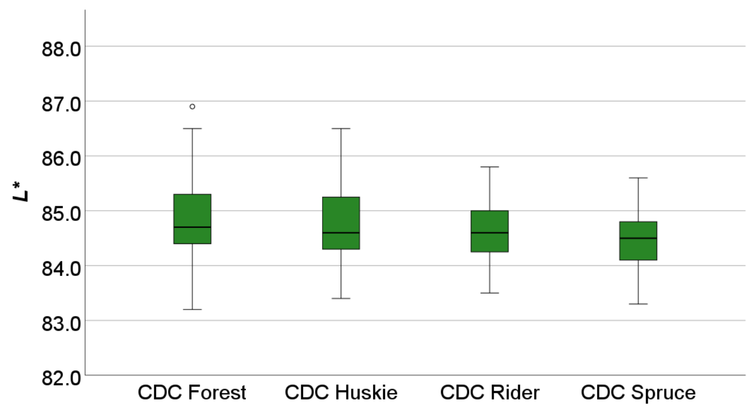


Figure 1.12.3. Mean *L** values of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.

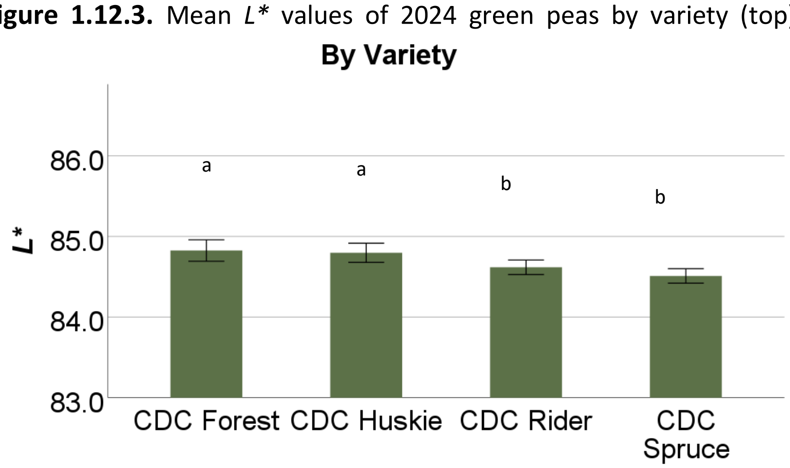
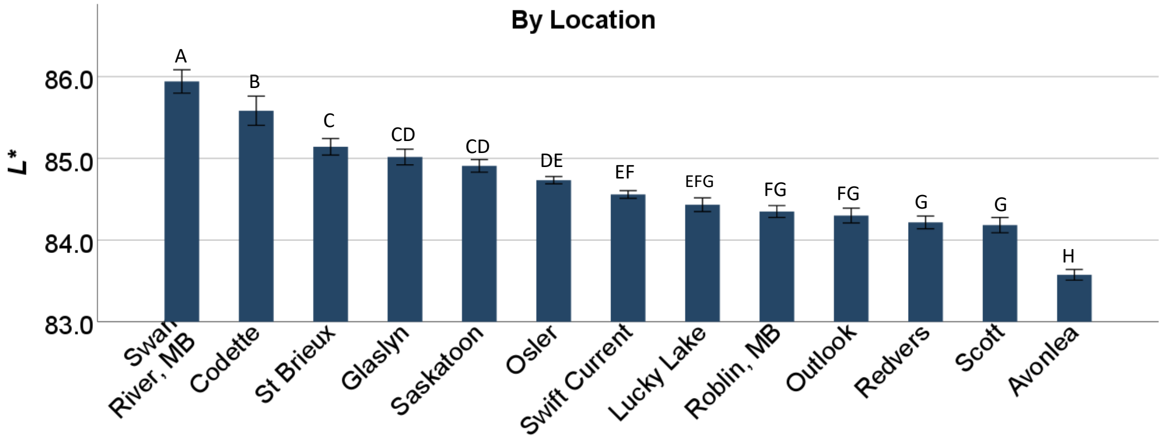


Table 1.12.1. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

[4] Ly, B. C. K., Dyer, E. B., Feig, J. L., Chien, A. L., & Del Bino, S. (2020). Research techniques made simple: cutaneous colorimetry: a reliable technique for objective skin color measurement. *Journal of Investigative Dermatology*, *140*(1), 3-12.



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

b) ***a*:*** red (+) to green (-)

Figure 1.12.4. Box and Whisker plot of 2024 green peas for *a** values in 2024.

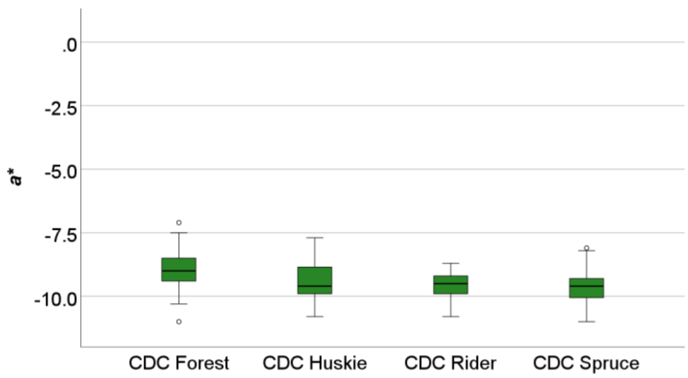


Figure 1.12.5. Mean *a** values of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.

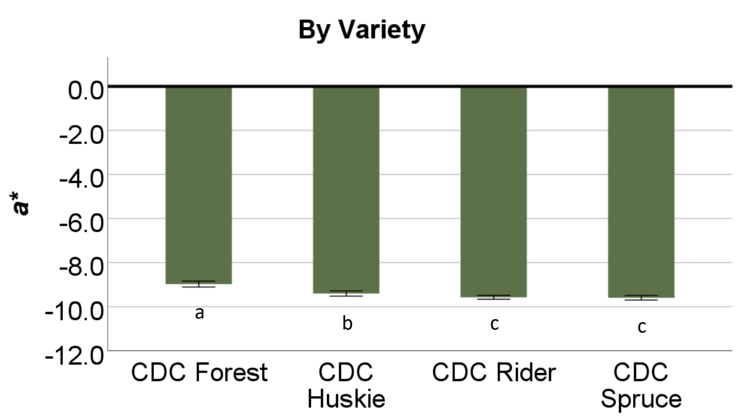
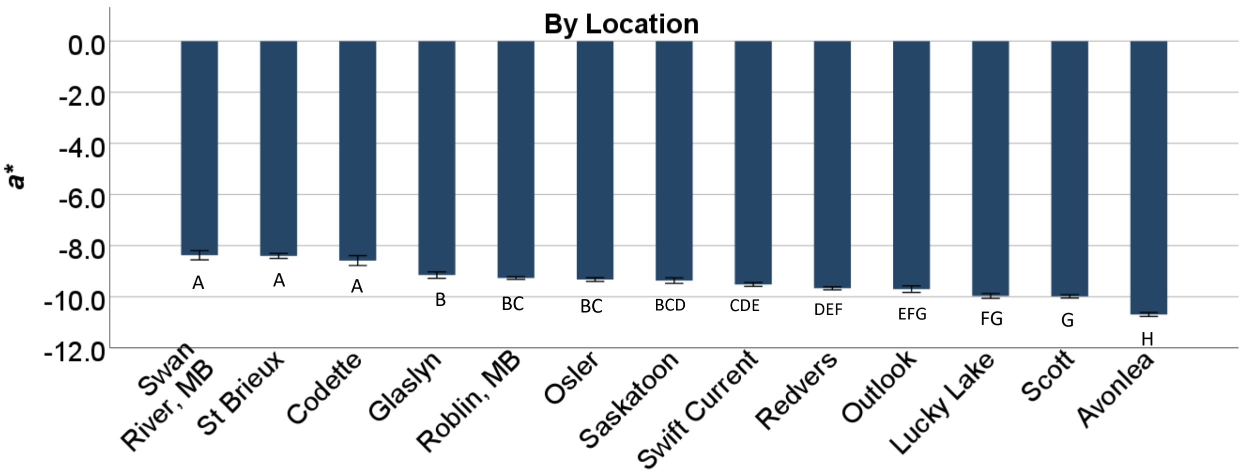


Table 1.12.2. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

- **By Variety:** CDC Forest had the least greenness. One reason may be that Forest is susceptible to bleaching.

c) ***b*:*** yellow (+) to blue (-)

Figure 1.12.6. Box and Whisker plot of 2024 green peas for *b** values in 2024.

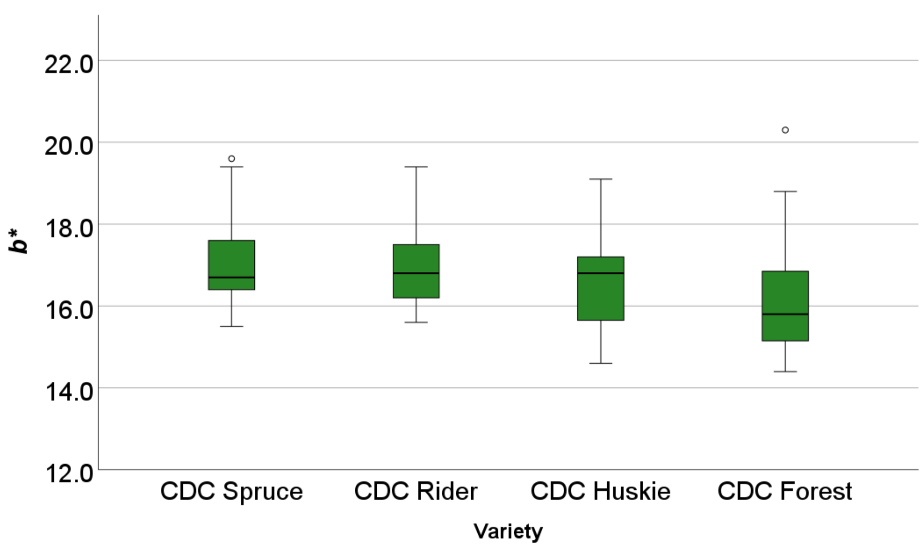


Figure 1.12.7. Mean *b** values of 2024 green peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.

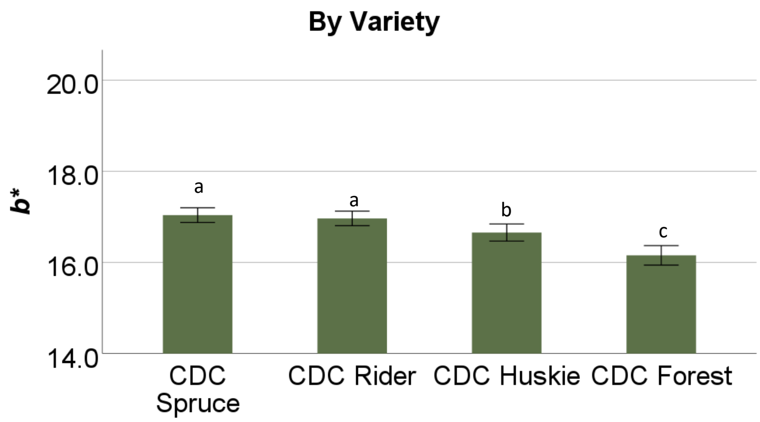
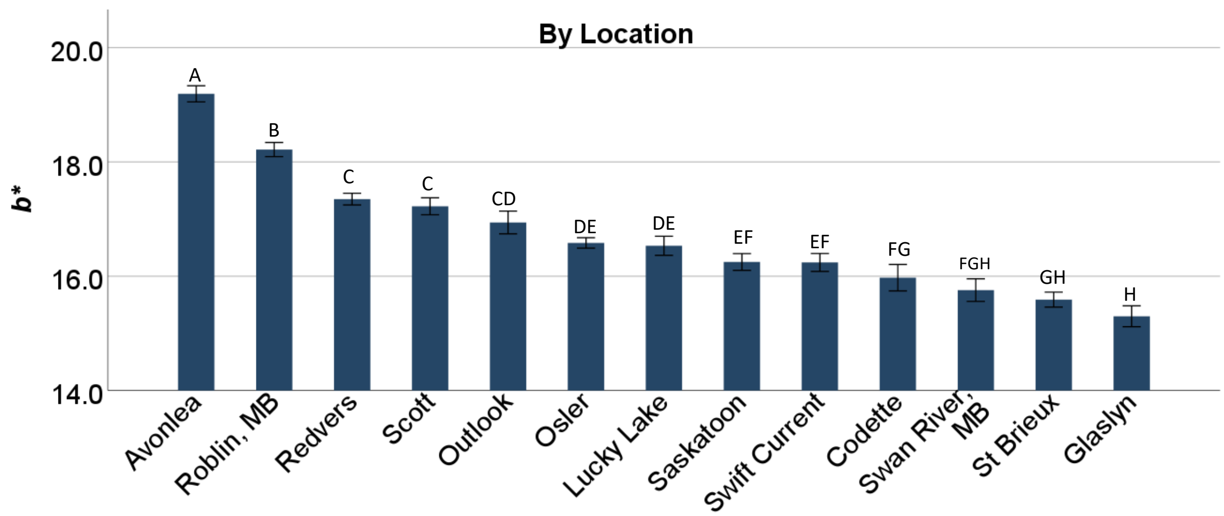


Table 1.12.3. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	**

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*



Note: Small and capital letters indicated significant differences (p<0.05) by variety and location, respectively.

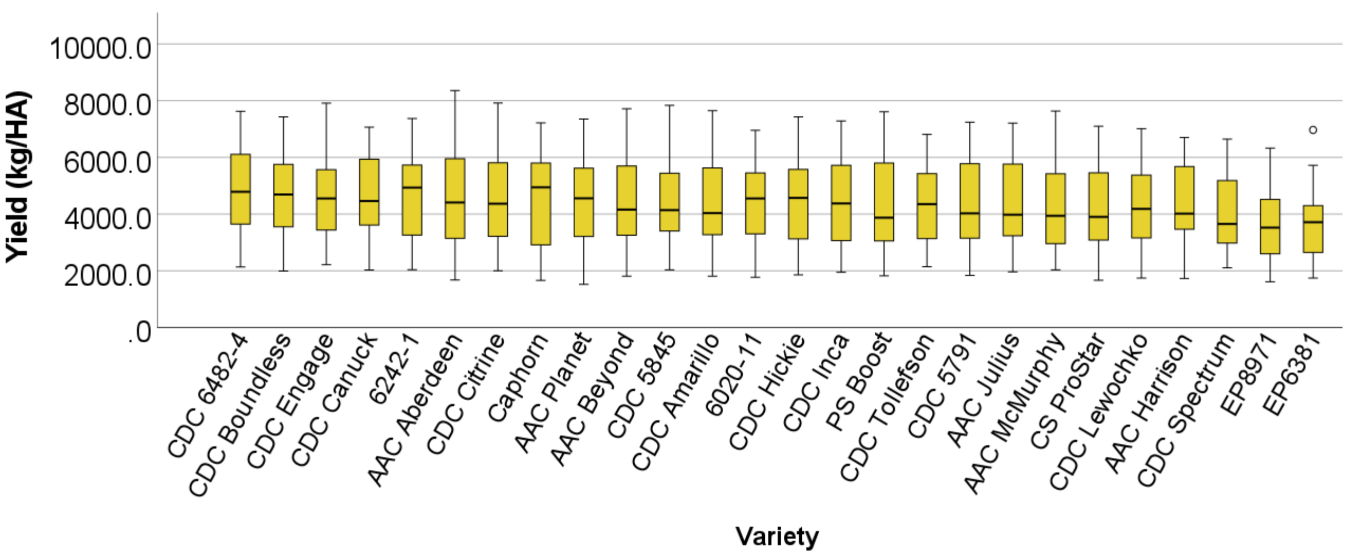
- **By Variety:** The difference from the highest to the lowest was 1.9 units.
- **By Location:** The difference from the highest to the lowest was 4 units.

2) 2024 Yellow Pea Quality

1. Yield

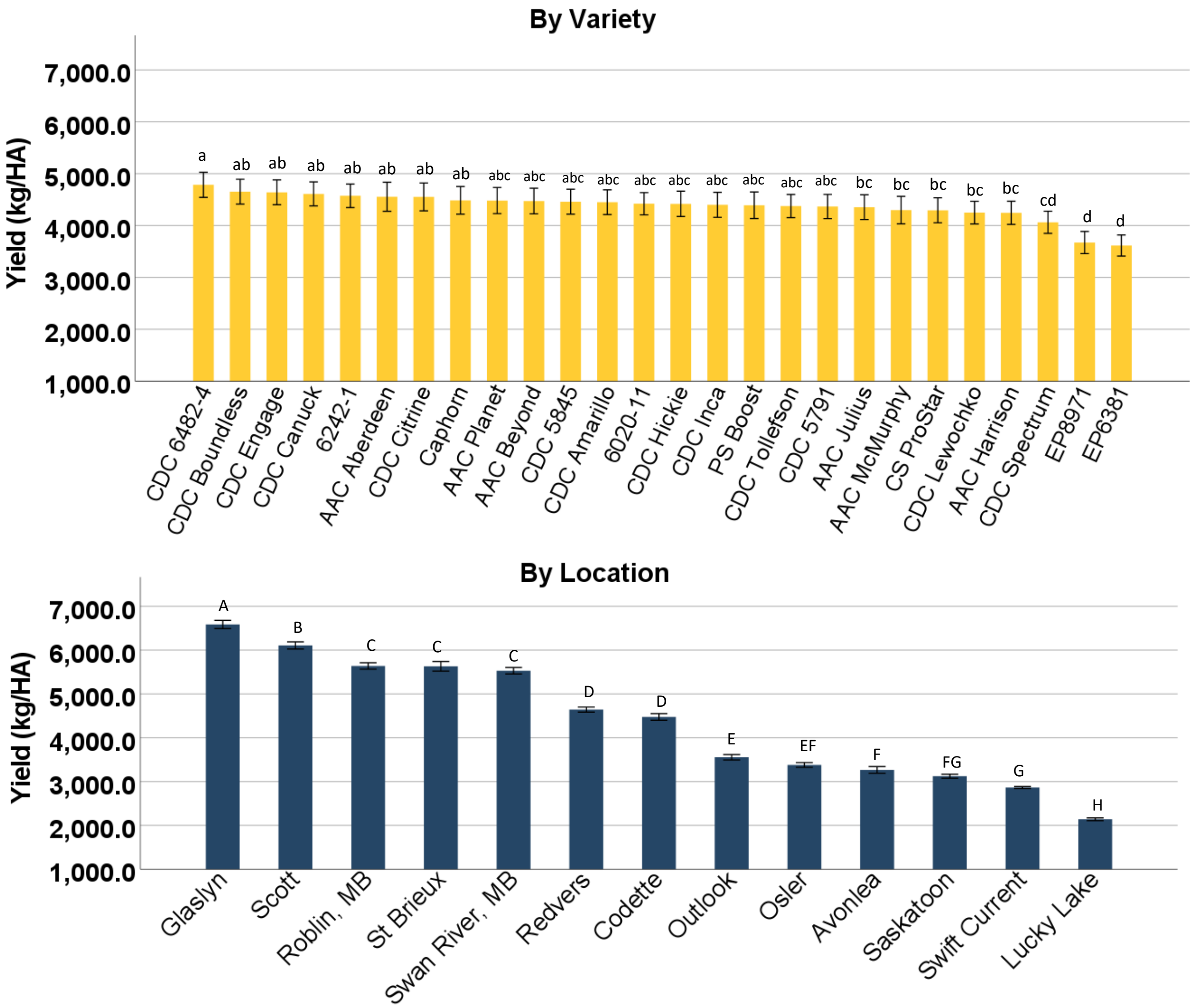
Method: Yield refers to how much crops are produced and how efficiently land is used to produce food or agricultural commodities. The yield of each variety from each location is provided as kilogram per hectare (kg/HA).

Results: Figure 2.1.1. Box and Whisker plot of yellow peas for yield in 2024.



- All varieties had large variability.

Figure 2.1.2. Mean yield of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** A difference of 1170 kg/HA was determined from the highest to the lowest.
- **By Location:** The location effect played a significant role. The yield in Glaslyn was over three times that of Lucky Lake.

Table 2.1. Effects of variety and location.

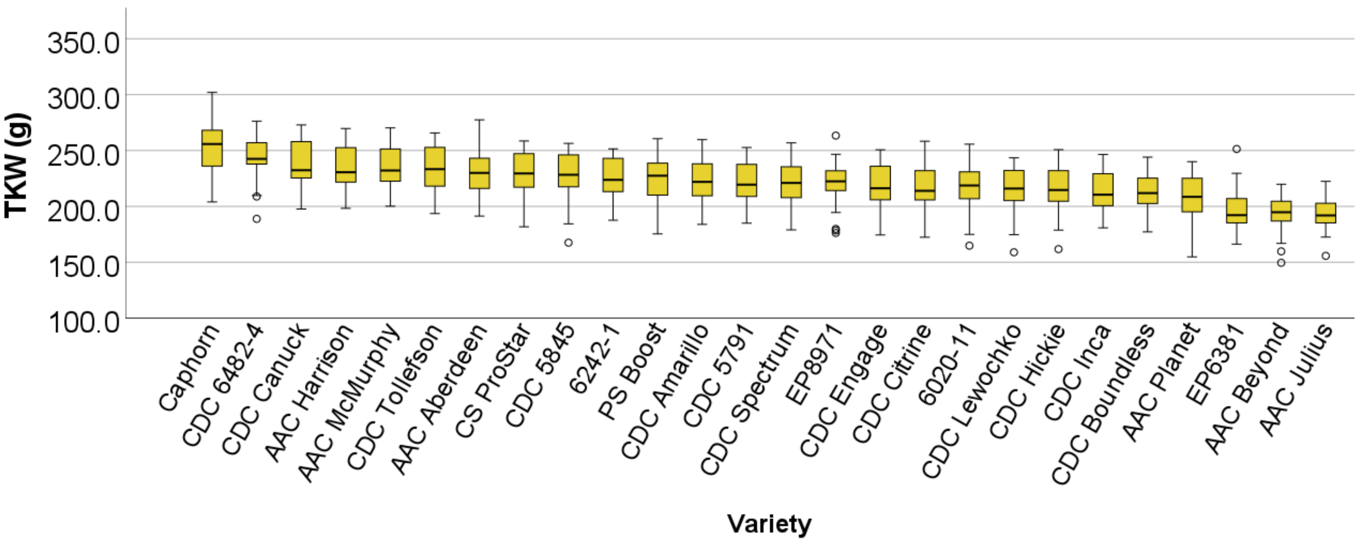
	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

2. TKW

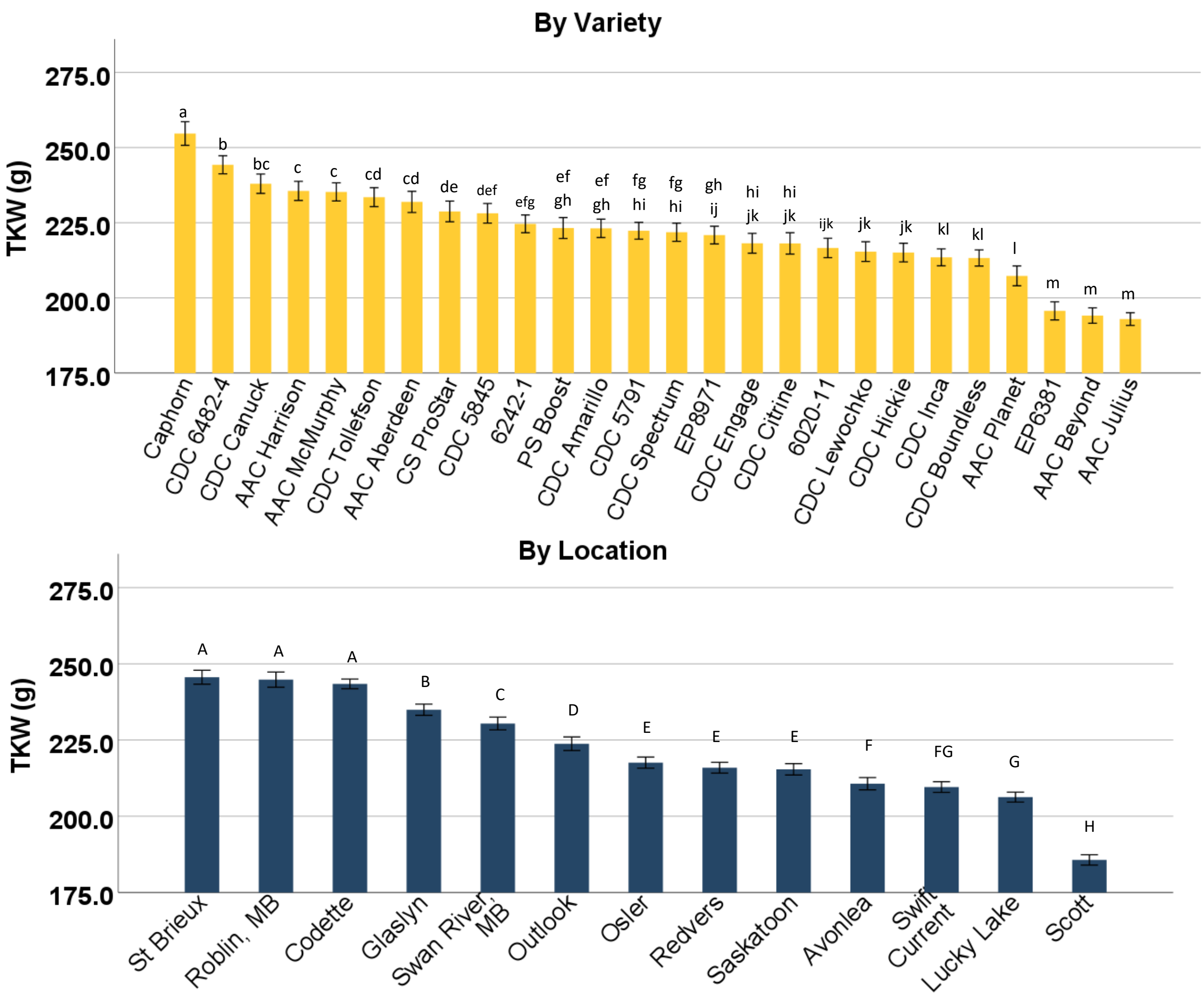
Method: This test was conducted by weighing 300 seeds with duplicated measurements per sample, and TKW was reported.

Results: Figure 2.2.1. Box and Whisker plot of yellow peas for TKW in 2024.



- Caphorn had the largest TKW, followed by CDC 6482-4.
- AAC Beyond and AAC Julius had the smallest TKW.
- Several outliers were present.

Figure 2.2.2. Mean TKW of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

Both variety and location had significant effects on TKW.

- **By Variety:** A difference of 62 g was determined from the largest (Carphorn) to the smallest (AAC Beyond, Julius and EP6381).
- **By Location:** A difference of 60 g was determined from the largest (St Brieux) to the smallest (Scott).

A positive trend between yield and TKW is observed (r=0.296; p<0.01).

Table 2.2. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

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3. Seed Size Distribution

Method: 250 g of seeds were placed on a series of round-hole opening sieves. The weight of seeds retained on each sieve was determined and reported as % of seeds retained. Duplicated measurements were performed.

Sieves used for yellow pea varieties:

a. #20R: 7.94 mm
b. #18R: 7.14 mm
c. #16R: 6.35 mm
d. #14R: 5.56 mm

Results: Table 2.3. Seed size distribution (%) of each yellow pea variety in 2024. Data represent mean ± one standard deviation.

Variety	> 7.94 mm (%)	> 7.14 mm (%)	> 6.35 mm (%)	> 5.56 mm (%)	≤ 5.56 mm (%)
Caphorn	7.5 ± 7.8^{a}	44.4 ± 15.0^{a}	43.1 ± 17.7^{l}	4.5 ± 3.9^{n}	0.5 ± 0.4^{h}
CDC 6482-4	3.0 ± 2.7^{b}	38.5 ± 12.9^{b}	52.0 ± 11.5^{k}	6.1 ± 5.5^{mn}	0.4 ± 0.4^{h}
AAC McMurphy	1.0 ± 1.3^{fghi}	33.7 ± 18.0^{c}	57.3 ± 16.3^{hij}	7.3 ± 4.8^{lmn}	0.6 ± 0.5^{fgh}
AAC Aberdeen	1.7 ± 2.6^{cd}	29.3 ± 17.2^{d}	60.3 ± 16.9^{fg}	7.8 ± 5.6^{lmn}	0.8 ± 0.9^{efgh}
CDC Canuck	1.6 ± 1.6^{cdef}	27.2 ± 13.4^{de}	61.1 ± 10.5^{efgh}	9.5 ± 6.6^{klm}	0.5 ± 0.4^{h}
CDC Tollefson	1.7 ± 1.9^{cde}	26.1 ± 15.4^{def}	64.0 ± 13.9^{cdef}	7.8 ± 6.2^{lmn}	0.5 ± 0.4^{h}
EP8971	2.8 ± 3.3^{b}	25.3 ± 11.3^{ef}	54.0 ± 9.0^{jk}	16.2 ± 8.3^{defgh}	1.6 ± 1.2^{bcd}
CS ProStar	2.0 ± 3.0^{c}	24.2 ± 13.5^{ef}	61.8 ± 12.0^{efg}	11.2 ± 9.8^{ijkl}	0.8 ± 0.8^{efgh}
CDC 5845	1.1 ± 1.3^{efgh}	23.2 ± 13.3^{fg}	63.7 ± 12.0^{cdef}	11.2 ± 11.4^{ijkl}	0.8 ± 1.3^{efgh}
PS Boost	1.7 ± 2.4^{cde}	20.7 ± 14.8^{gh}	62.8 ± 14.3^{defg}	13.7 ± 12.2^{ghij}	1.1 ± 1.2^{defgh}
CDC 5791	0.9 ± 1.1^{ghij}	20.4 ± 11.3^{ghi}	62.9 ± 7.7^{defg}	14.8 ± 8.6^{efghij}	1.0 ± 1.0^{defgh}
6020-11	1.2 ± 1.3^{defg}	20.1 ± 11.6^{ghi}	62.5 ± 10.2^{efg}	15.2 ± 12.5^{efghi}	1.0 ± 1.5^{defgh}
AAC Harrison	0.3 ± 0.5^{jk}	18.0 ± 15.5^{hij}	70.0 ± 12.0^{a}	11.1 ± 8.3^{jkl}	0.7 ± 0.6^{efgh}
6242-1	0.6 ± 0.7^{hijk}	17.8 ± 12.4^{hij}	68.0 ± 8.6^{abc}	13.0 ± 9.5^{hijk}	0.6 ± 0.6^{gh}
CDC Amarillo	0.9 ± 1.2^{ghijk}	17.2 ± 13.8^{ij}	67.0 ± 12.2^{abcd}	14.3 ± 12.2^{fghij}	0.6 ± 0.6^{gh}
CDC Engage	0.8 ± 1.1^{ghijk}	17.4 ± 12.5^{hij}	64.0 ± 9.5^{cdef}	16.7 ± 12.7^{defgh}	1.0 ± 1.1^{defgh}
CDC Hickie	0.7 ± 0.9^{ghijk}	15.1 ± 11.4^{jk}	64.9 ± 11.0^{bcde}	18.0 ± 12.3^{cdef}	1.4 ± 1.8^{cdef}
CDC Spectrum	0.6 ± 0.8^{hijk}	13.1 ± 11.2^{kl}	67.4 ± 10.5^{abc}	17.6 ± 12.4^{cdefg}	1.3 ± 1.4^{cdefg}
CDC Lewochko	0.6 ± 0.7^{hijk}	13.7 ± 9.3^{kl}	64.7 ± 11.7^{bcdef}	19.7 ± 14.7^{cd}	1.3 ± 1.9^{cdefg}
CDC Inca	0.5 ± 0.7^{ijk}	12.6 ± 10.0^{kl}	69.7 ± 7.9^{a}	16.4 ± 9.9^{defgh}	0.8 ± 0.7^{efgh}
CDC Citrine	0.5 ± 0.8^{ijk}	11.8 ± 11.7^{kl}	65.1 ± 13.2^{bcde}	21.2 ± 14.9^{c}	1.4 ± 1.7^{cdef}
CDC Boundless	0.3 ± 0.3^{jk}	11.5 ± 8.1^{l}	68.5 ± 7.3^{ab}	18.7 ± 11.1^{cde}	0.9 ± 0.8^{defgh}
AAC Planet	0.5 ± 0.8^{hijk}	10.9 ± 10.3^{l}	67.6 ± 13.4^{abc}	19.6 ± 15.3^{cd}	1.4 ± 2.5^{bcde}
EP6381	0.6 ± 1.7^{hijk}	7.1 ± 8.2^{m}	54.3 ± 11.7^{jk}	35.4 ± 15.0^{ab}	2.6 ± 2.0^{a}
AAC Beyond	0.3 ± 0.5^{jk}	5.9 ± 5.3^{m}	59.0 ± 16.2^{ghi}	32.6 ± 17.2^{b}	2.1 ± 2.7^{ab}
AAC Julius	0.3 ± 0.4^{k}	5.1 ± 5.0^{m}	55.4 ± 13.6^{ijk}	37.3 ± 14.4^{a}	2.0 ± 2.1^{abc}

Note: Means within a column followed by different lowercase letters are significantly different (p<0.05).

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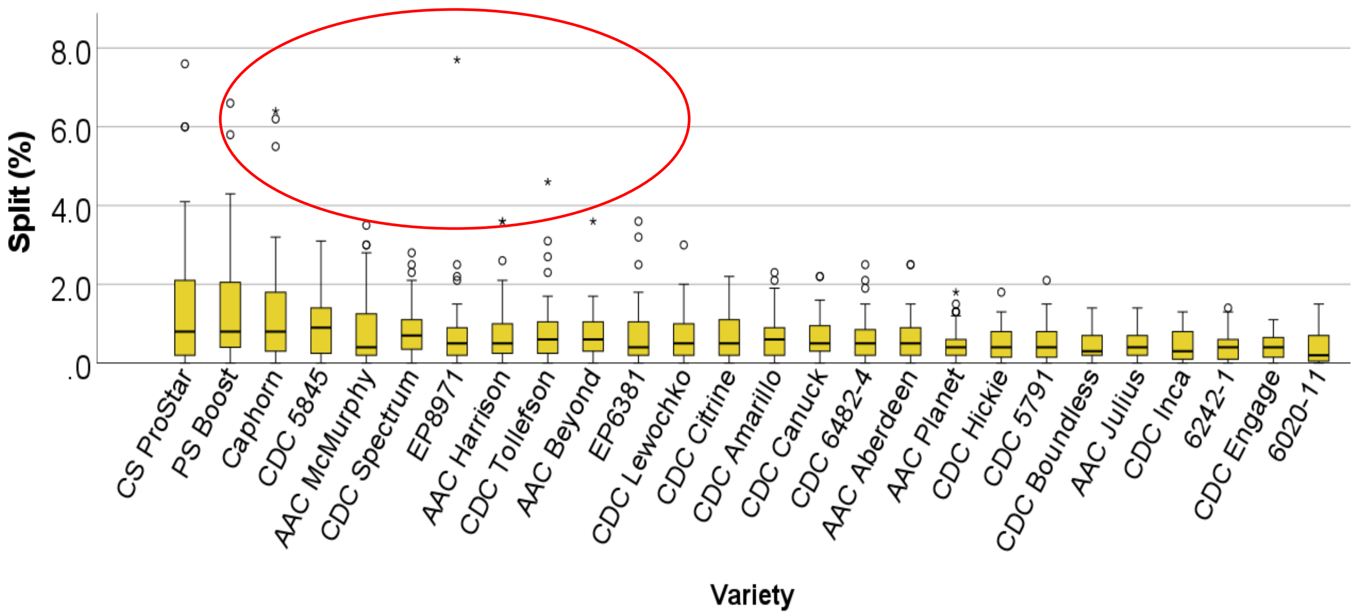
4. Split

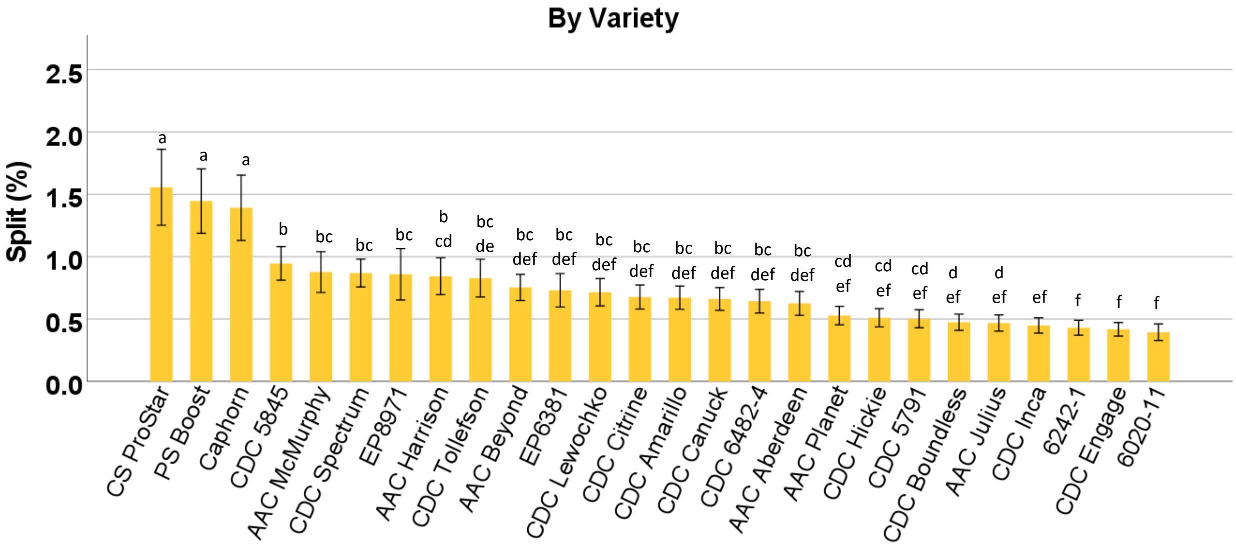
Method: 100 grams of each sample was used for evaluation, and damaged seeds were selected by hand. Results included splits, cracks, partially missing hull, and partially missing cotyledon.

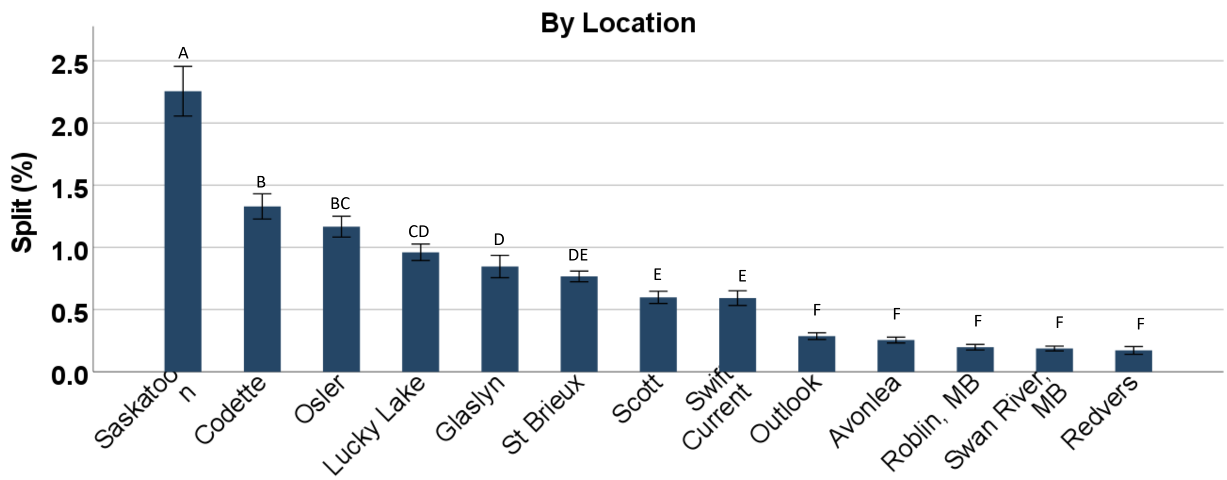
Results: Figure 2.4.1. Box and Whisker plot of yellow peas for split resulting from 13 locations in 2024.



- Several extreme outliers (*) were present.

Figure 2.4.2. Mean split of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.





Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** A 1.1% difference was determined from the largest to the smallest (lines 6242-1, 6020-11, and CDC Engage).

- **By Location:** A 2% difference was determined from the largest to the smallest.

Table 2.4. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

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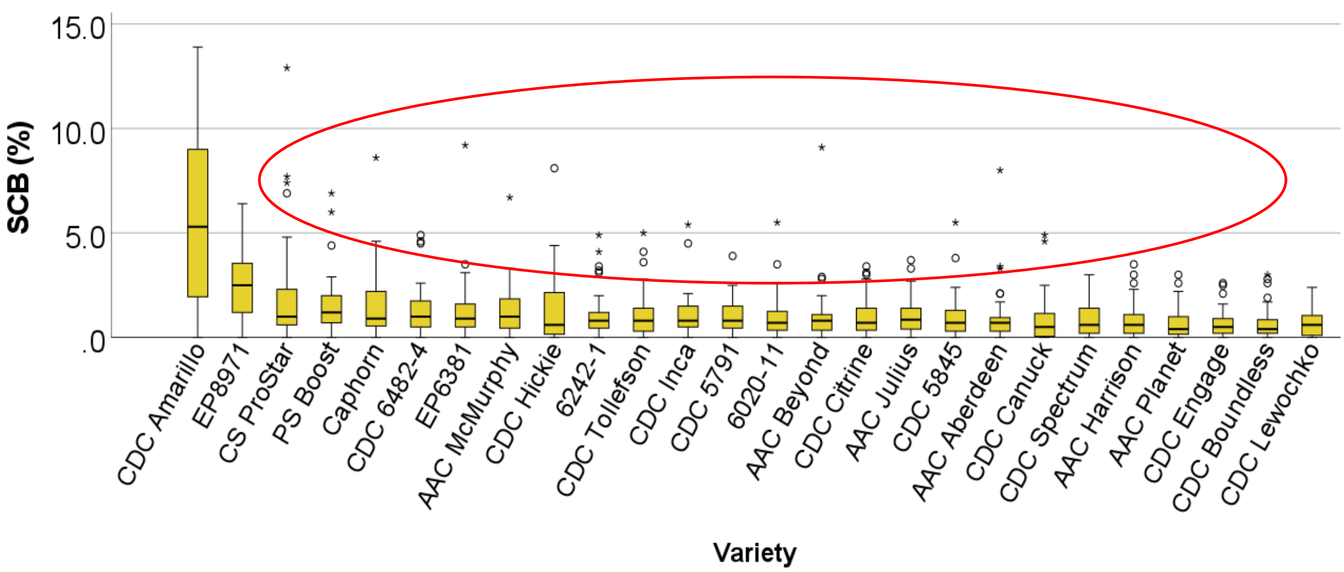
5. SCB

Method: 100 grams of each sample was used for evaluation, and seeds with seed coat damage were selected by hand. Seed coat breakage occurs during harvesting and handling, reducing seed quality. It is recommended to combine peas at around 18-20% moisture content to reduce the risk of seed cracking or peeling. Using lower speeds with the combine and auger is also preferred (Saskatchewan Pulse Growers, 2024[5]).

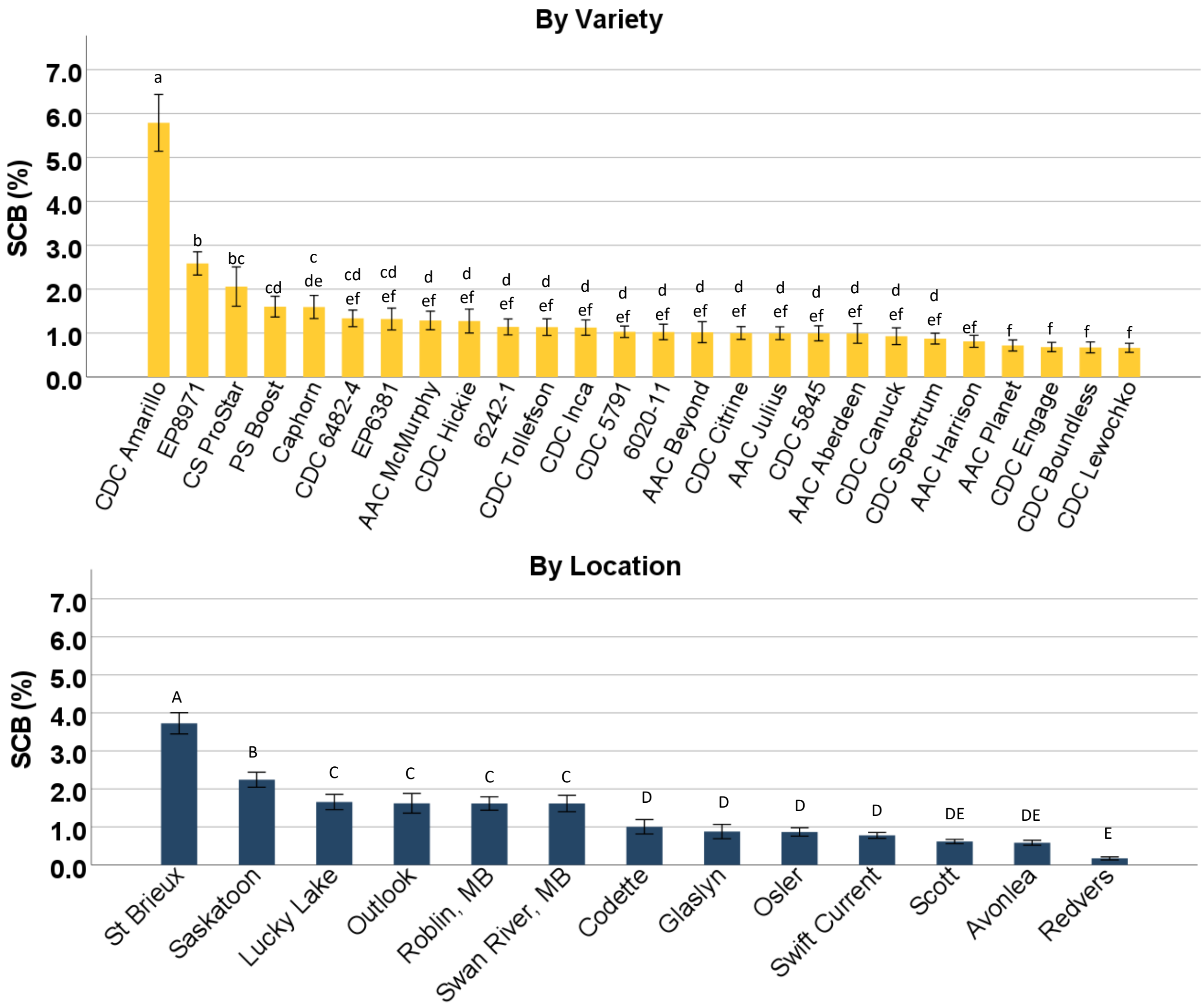
Results: Figure 2.5.1. Box and Whisker plot of yellow peas with SCB in 2024.



- Outliers were present in alomost all varieties, and several extreme outliers were present.
- The seed coat damage of CDC Amarillo was much higher than all other varieties.

[5] Saskatchewan Pulse Growers. 2024. Accessed June 03, 2024. https://saskpulse.com/resources/pea-harvest-management/

Figure 2.5.2. Mean of SCB of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** CDC Amarillo had a mean of 5.8%, significantly higher than all other varieties. There were 10 varieties with SCB below 1%.

- **By Location:** A difference of 3.5% was determined from the highest (St Brieux) to the lowest (Redvers).

Table 2.5. Effects of variety and location.

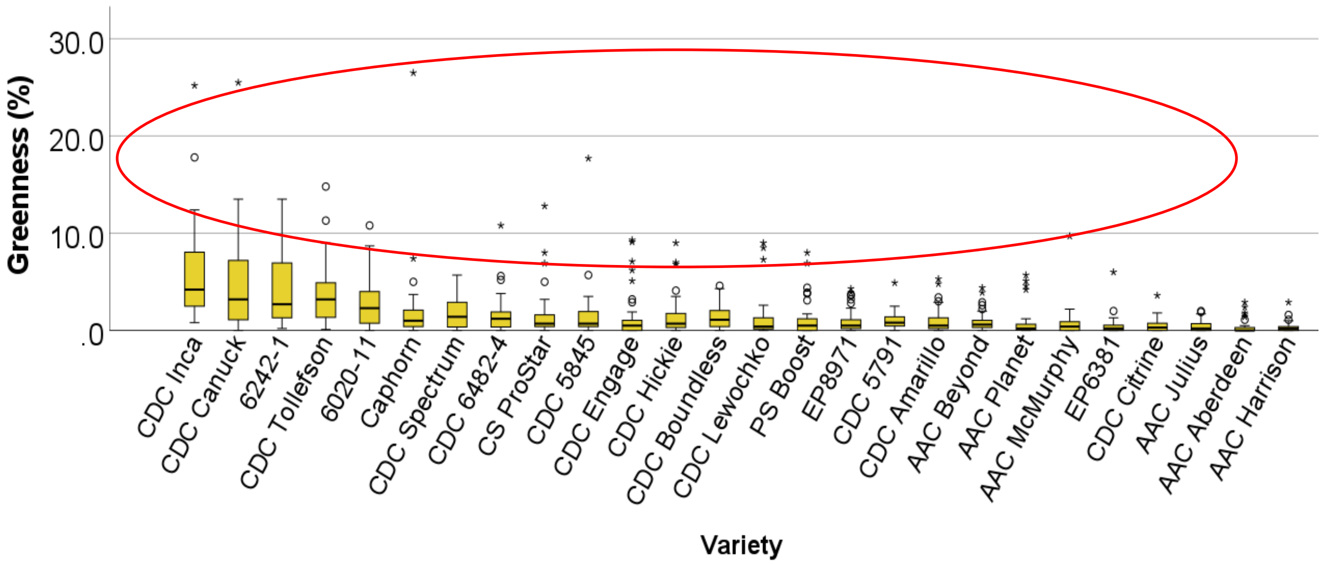
	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

6. Greenness

Method: 100 grams of each sample was used for evaluation. The results included yellow peas with distinct greenness due to immaturity or because certain varieties remain green even after reaching maturity.

Results: Figure 2.6.1. Box and Whisker plot of yellow peas for greenness in 2024.



- Outliers were present in all varieties, and several extreme outliers were present.
- CDC Inca, CDC Canuck, and line 6242-1 had the high levels of green seeds.

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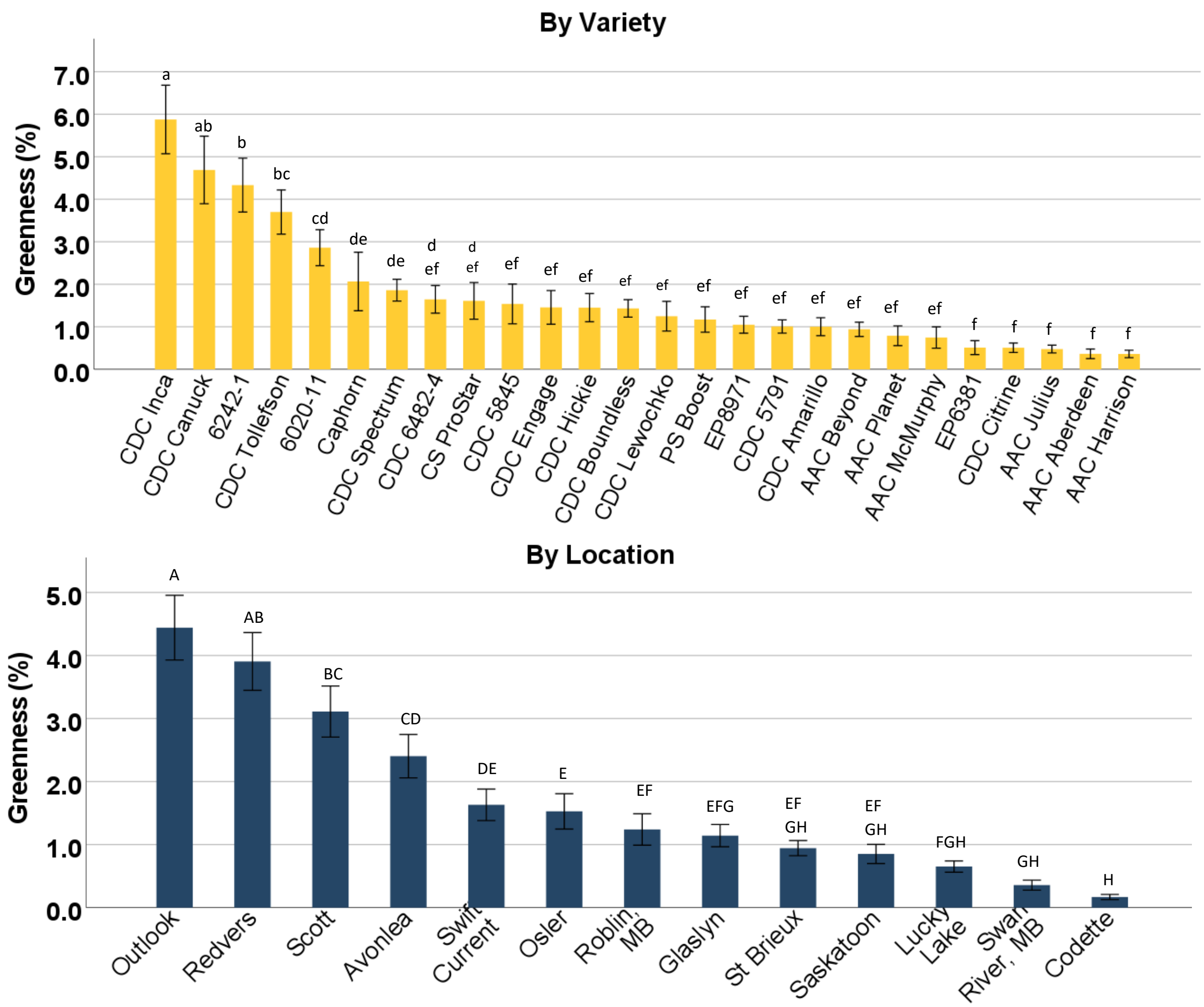
Figure 2.6.2. Mean of greenness of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** CDC Inca had the highest levels of green seeds, with the means of 5.9%, respectively. In contrast, eight varieties had greenness level below 1%.

- **By Location:** Location played a significant role. A difference of 4.2% was determined from the highest to the lowest.

Table 2.6. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

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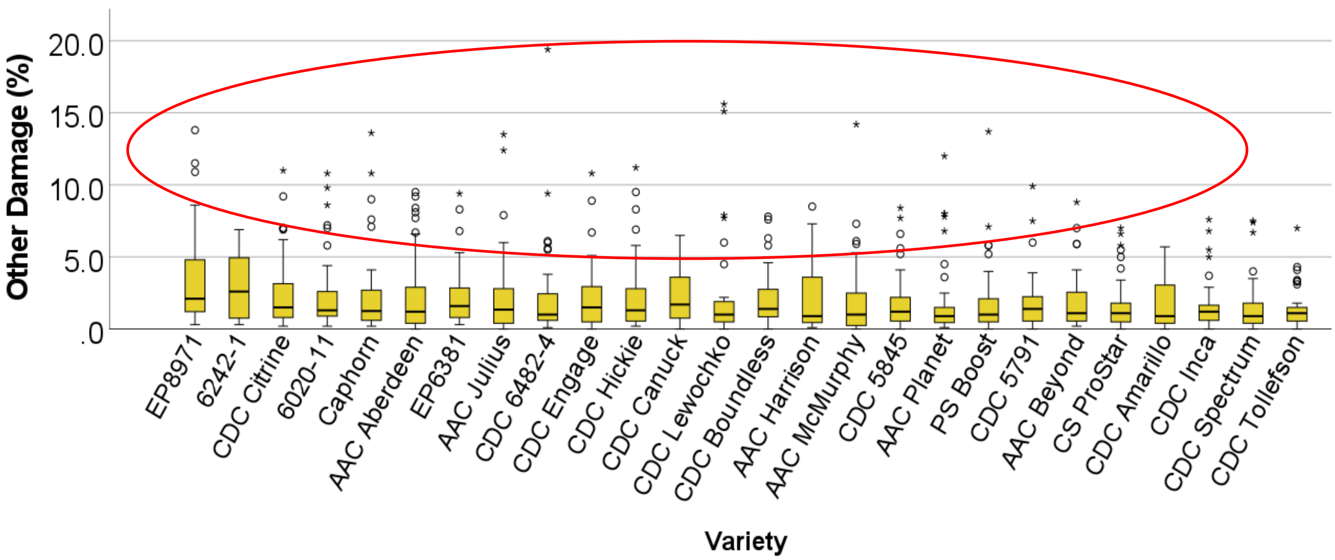
7. Other Damage

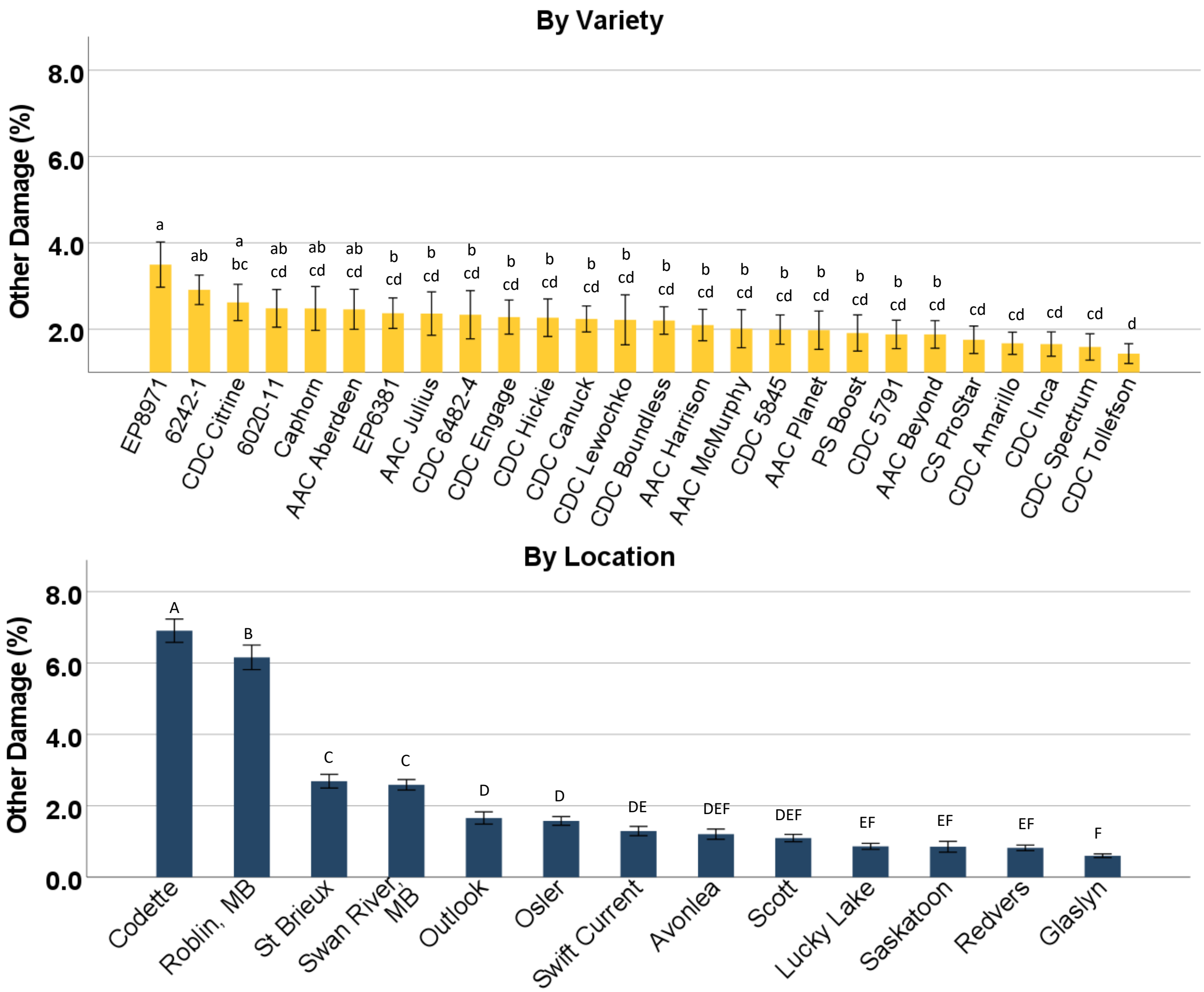
Method: 100 grams of each sample was used for evaluation, and damaged seeds were selected by hand. Other damage included pink, sprouted, shrivelled, heated, frost, and insect damage.

Results: Figure 2.7.1. Box and Whisker plot of yellow peas for other damage in 2024.



- Outliers were present in all varieties, and several extreme outliers were present.

Figure 2.7.2. Mean other damage of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** A difference of 2% was determined from the largest to the smallest.
- **By Location:** A high level of sprouting seeds and water damage was found in Roblin, and frost damage was observed in Codette (data not shown).

Table 2.7. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

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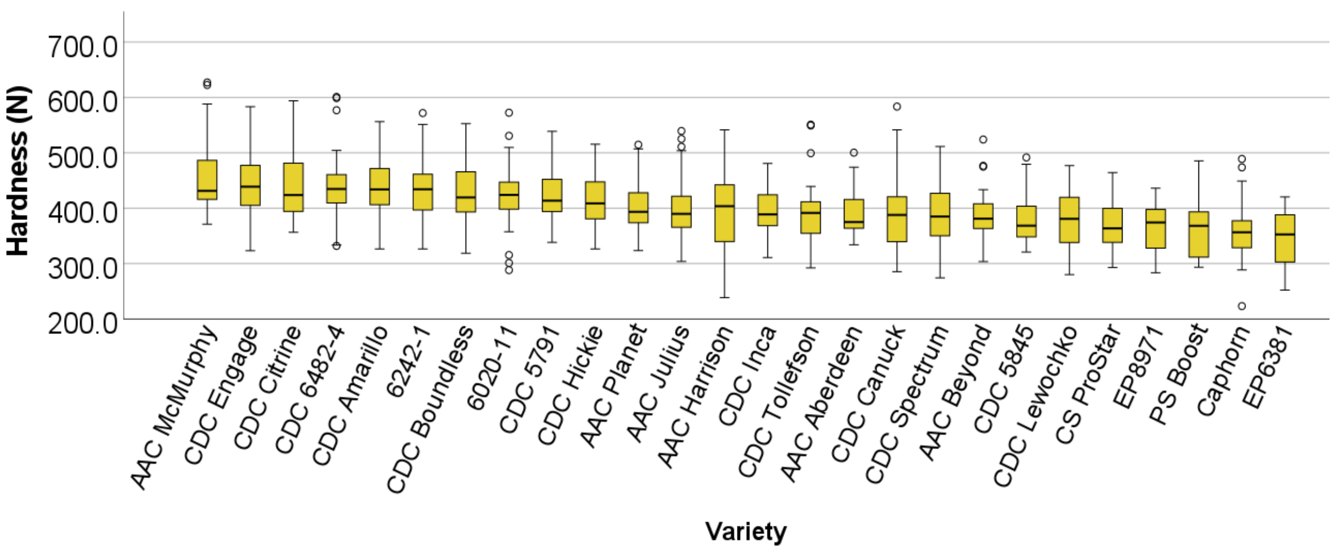
8. Hardness of Whole Seed

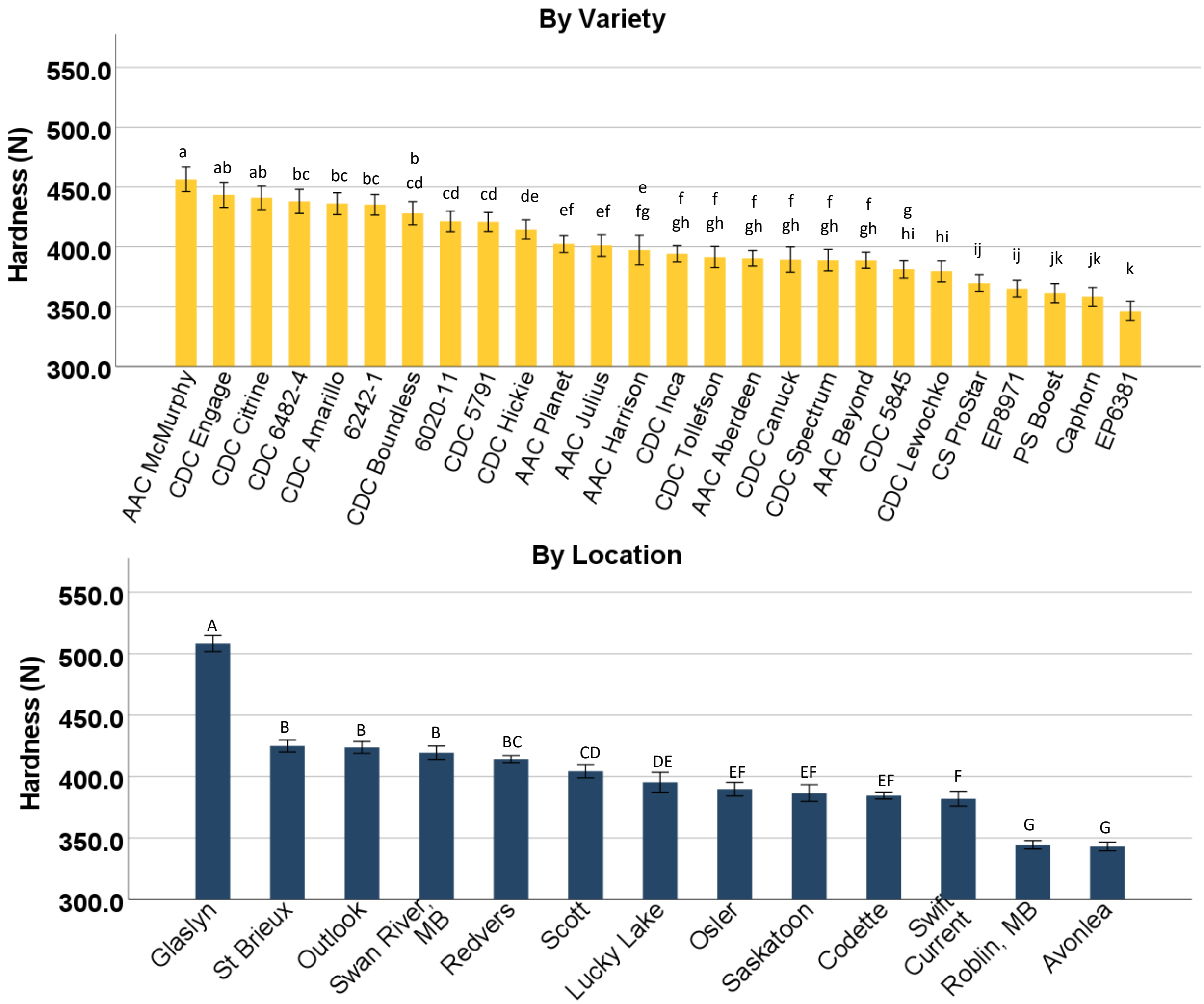
Method: Seed hardness is an important parameter to indicate milling yield and cooking quality. Seed hardness is affected by seed size, shape, density, composition, etc. Seed hardness was determined by measuring the force of breaking a seed using a texture analyzer (TMS-Pro, Food Technology Corporation, USA). The detailed procedure is outlined in the hardness section for green peas.

Results: Figure 2.8.1. Box and Whisker plot of yellow pea hardness in 2024.



- Variation was observed across all varieties, and several outliers were present.
- AAC McMurphy exhibited the largest hardness.

Figure 2.8.2. Mean hardness (N) of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** A 110 N difference was observed from the highest (AAC McMurphy) to the lowest (EP6381).
- **By Location:** A 165 N difference was observed from the highest (Glaslyn) to the lowest (Avonlea and Roblin).
- A positive trend between yellow pea hardness and seed weight was observed ($r = 0.112$, $p < 0.01$), while a negative trend with moisture was found ($r = -0.226$, $p < 0.01$).

Table 2.8. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

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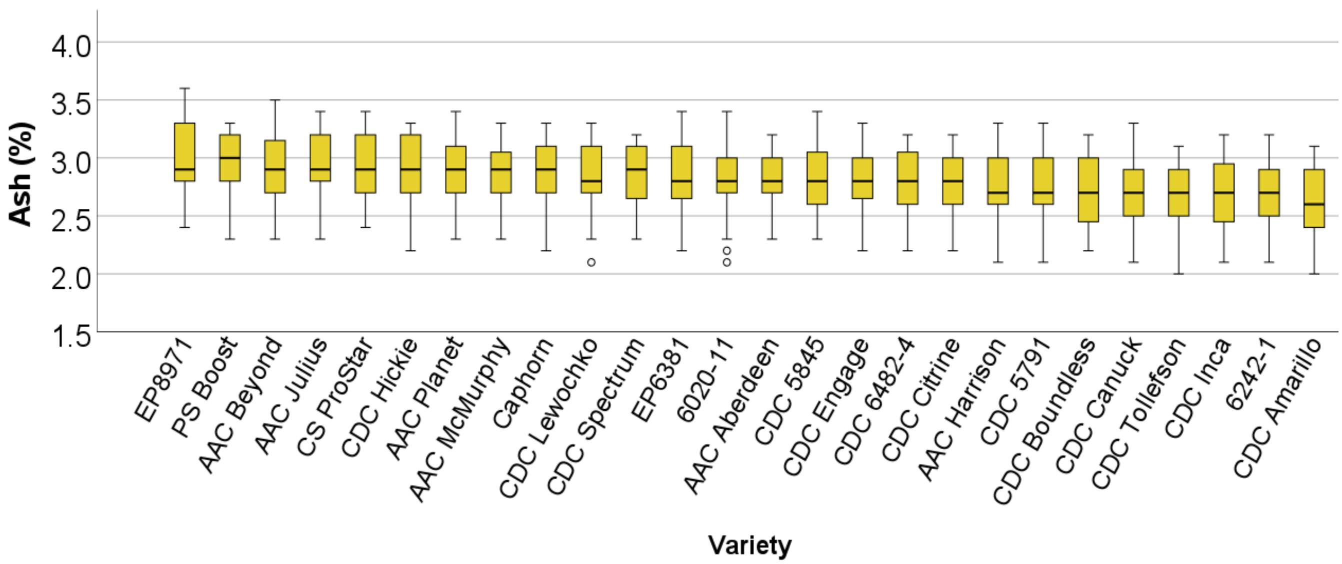
9. Ash Content

Method: Ash content (%) was determined using AACC 08-01.01[6] with modification. Samples were heated at 560°C till they turned white. Duplicated measurements were performed for each sample, and the average was reported on a dry basis (d.b.).

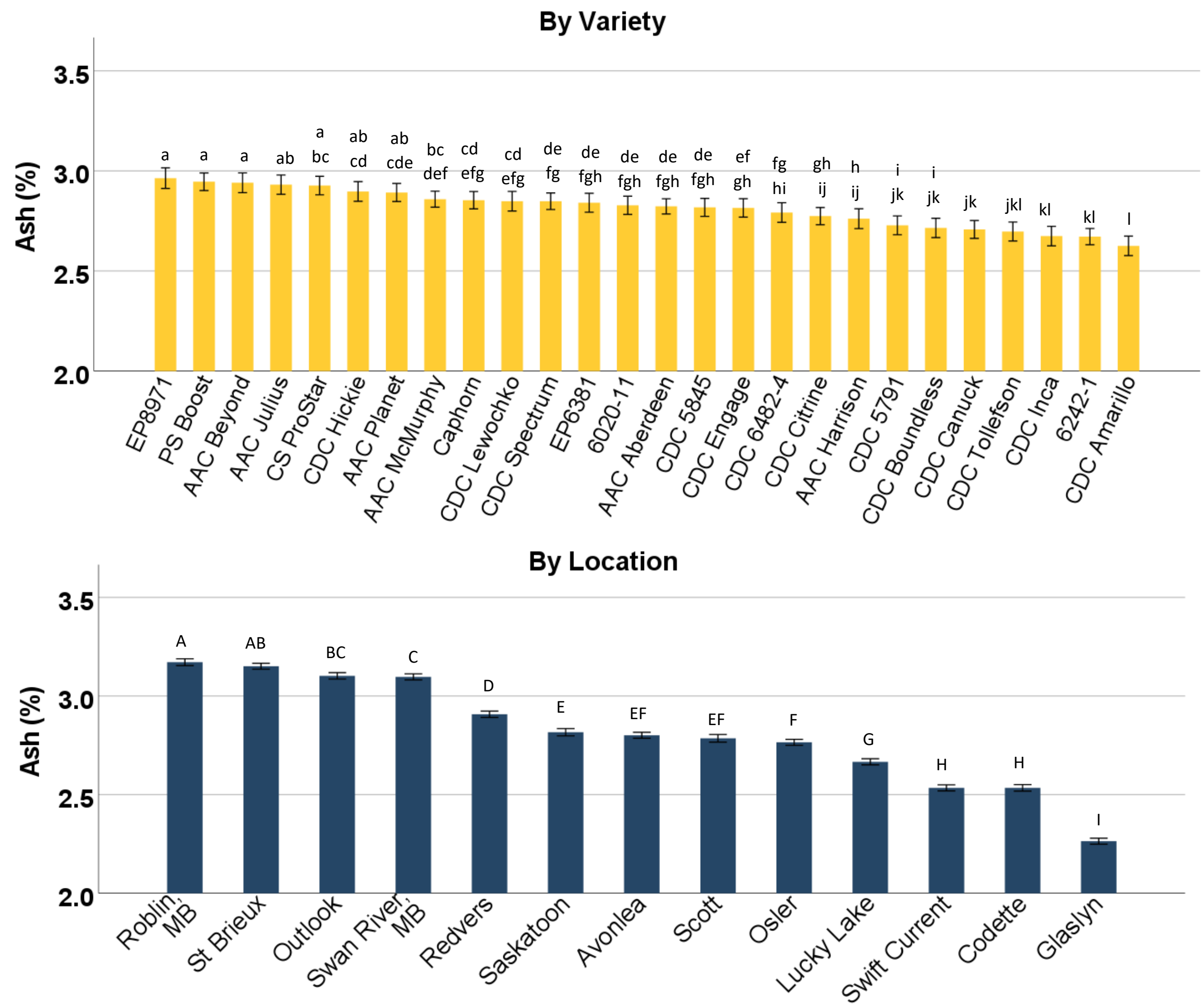
Results: Figure 2.9.1. Box and Whisker plot of yellow peas for ash content in 2024.



- CDC Amarillo had the lowest ash content among 21 varieties.

[6] AACC (1999). American Association of Cereal Chemists International. Approved methods of analysis (11th ed.). The Saint Pauls Association: Saint Paul, MN.

Figure 2.9.2. Mean ash content of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** The difference from highest to lowest was less than 0.3%.
- **By Location:** The difference from highest to lowest was 1%, where Roblin had the highest ash content of 3.3% on a dry basis.

Table 2.9. Effects of variety and location.

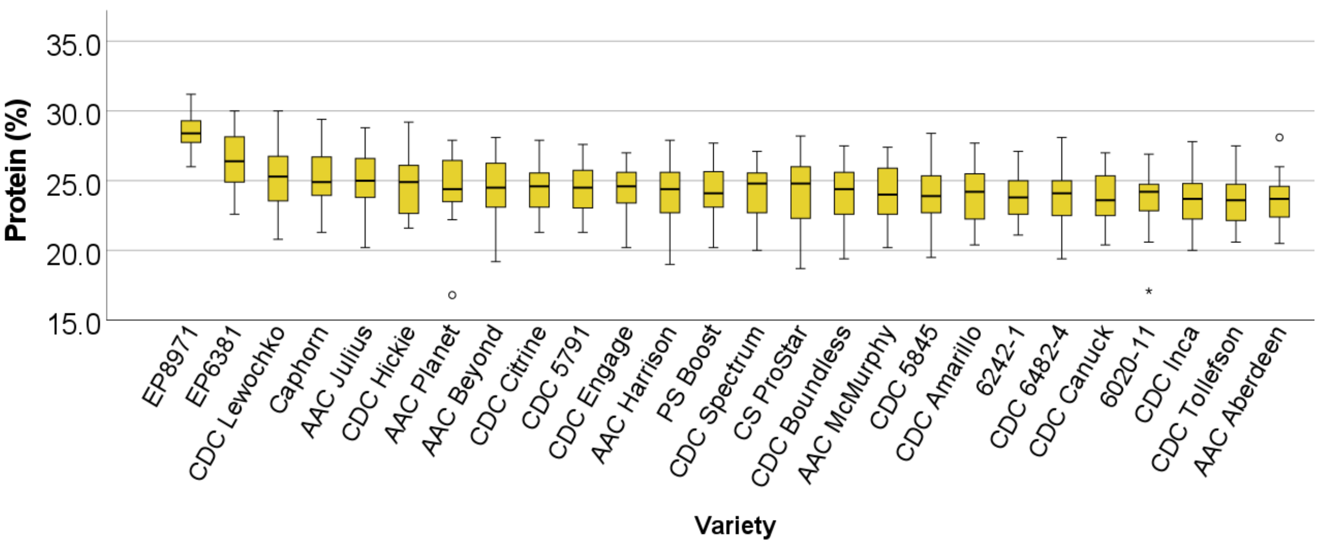
	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

10. Protein Content

Method: The protein content (%) of each flour was determined through AACC 46-30[2] using the combustion method through a Rapid N Exceed (Elementar, USA). Duplicated measurements were performed for each sample, and the average was reported on a dry basis (d.b.).

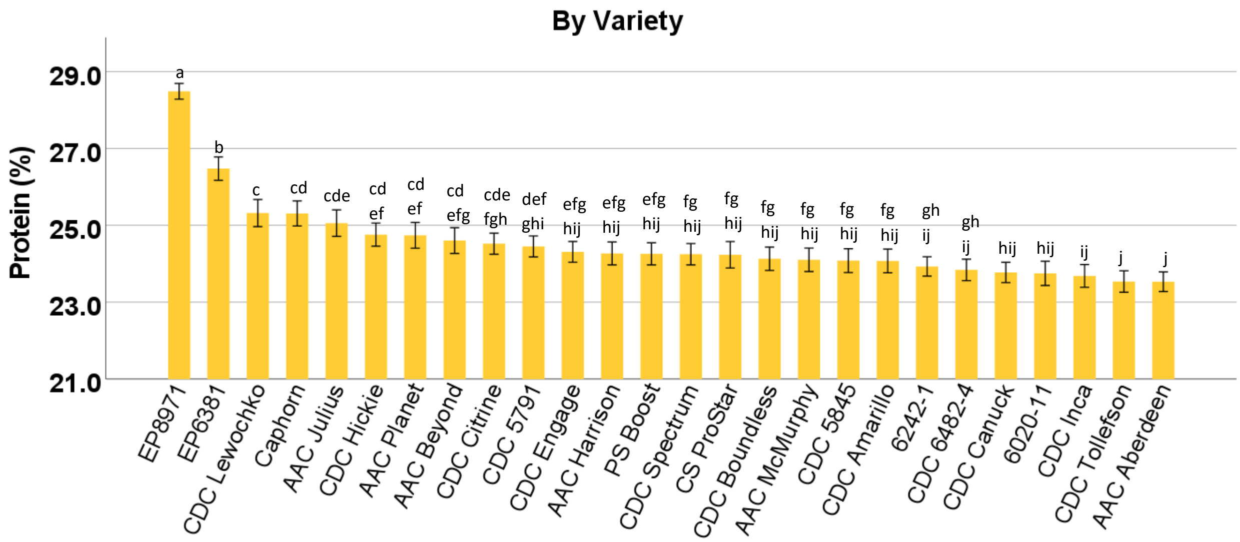
Results: Figure 2.10.1. Box and Whisker plot of yellow peas for protein content in 2024.

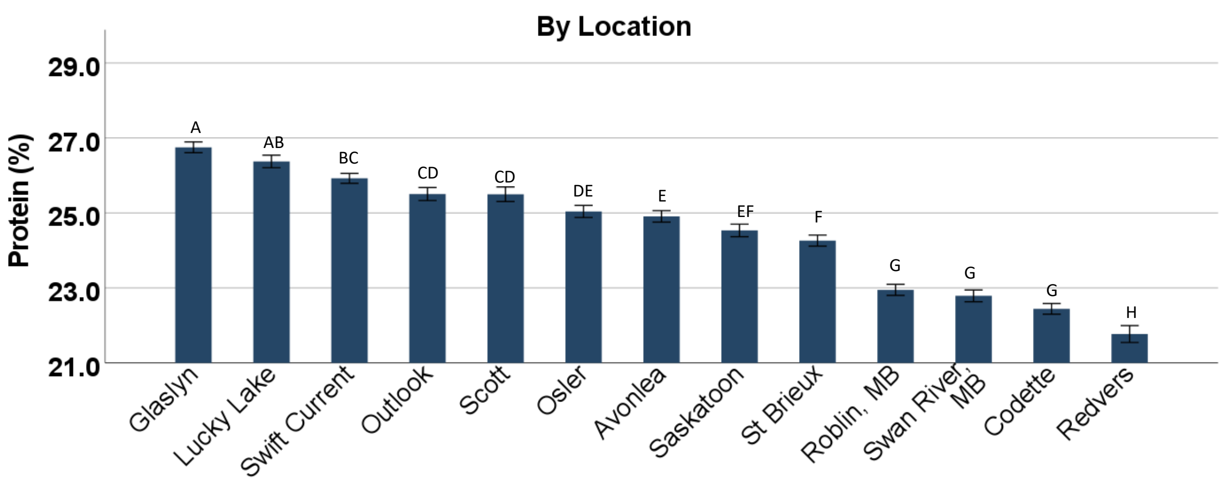


- EP8971 had the highest protein content.
- All other varieties showed large variability.

[2] AACC (1999). American Association of Cereal Chemists International. Approved methods of analysis (11th ed.). The Saint Pauls Association: Saint Paul, MN.

Figure 2.10.2. Mean protein content of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.





Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** Protein of EP8971 was 5% higher than the lowest.
- **By Location:** Location played a significant role in protein content, where a difference of 5% was determined from highest to lowest.

Table 2.10. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

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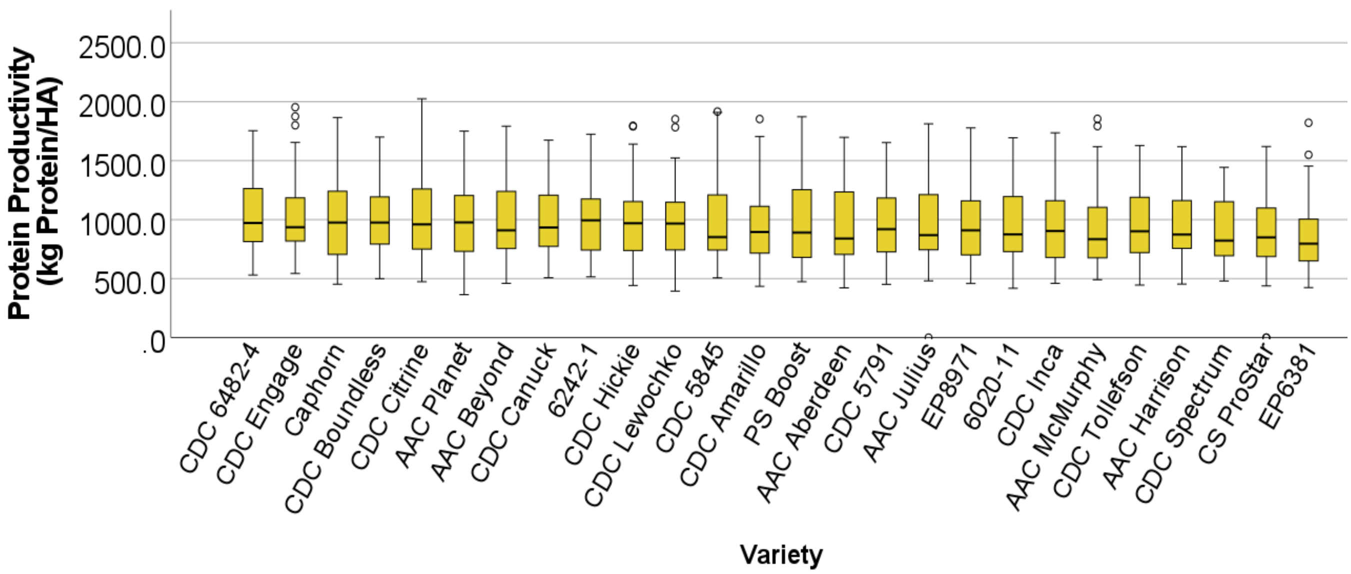
11. Protein Productivity

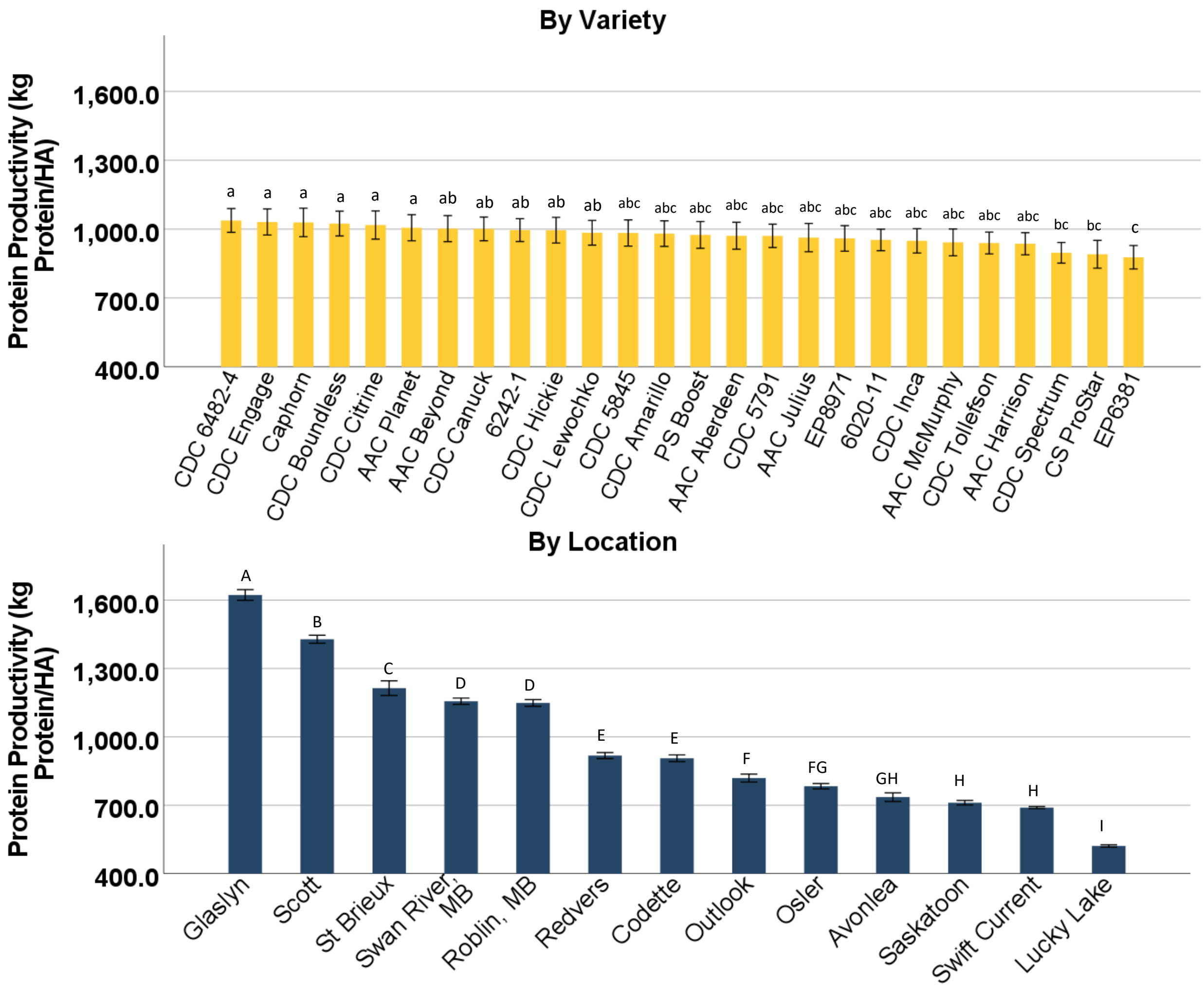
Method: Protein productivity (kg protein/HA), which is calculated using yield (kg/HA) multiplied by protein content (%), refers to the amount of protein produced per unit of land. It evaluates how much protein is being harvested from a given area.

Results: Figure 2.11.1. Box and Whisker plot of yellow peas for protein productivity in 2024.



- The spread of the protein content for all varieties was similar.
- Some outliers were present.

Figure 2.11.2. Mean protein productivity of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** EP6381 had the second highest protein content but the lowest protein productivity.
- **By Location:** The location effect played a significant role.
  - Glaslyn had the highest yield and protein content, contributing to the highest protein productivity.
  - In contrast, Lucky Lake had only one-third of Glaslyn's protein productivity due to its very low yield.

Table 2.11. Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	*

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

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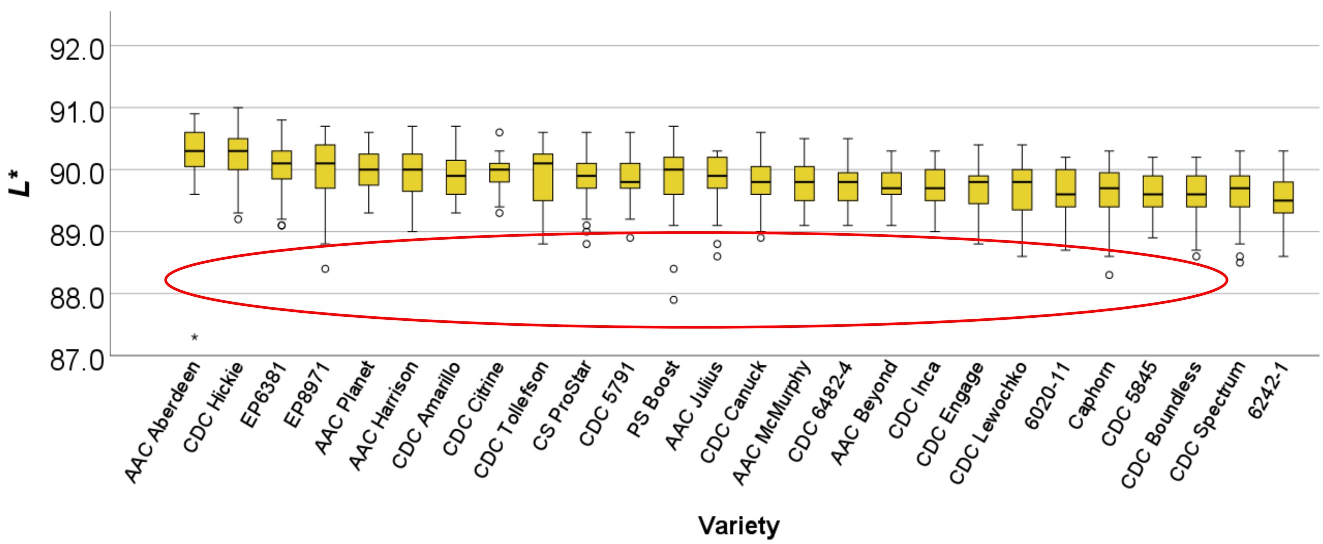
12. Colour

Method: The absolute colour of each flour was determined using the Konica Minolta CR-400 Chroma meter, where *L*, a*,* and *b** values were reported.

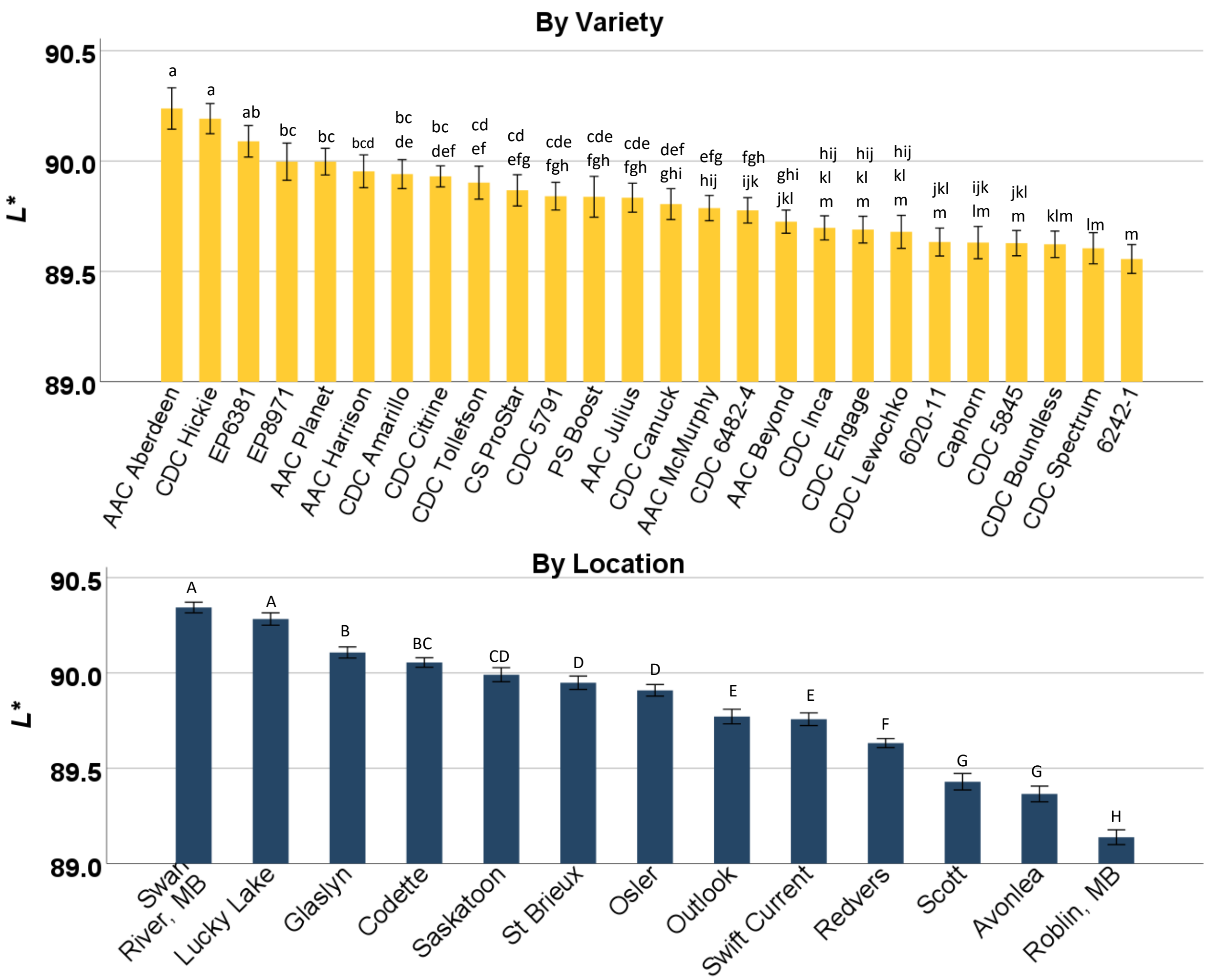
a) ***L* (lightness):*** white (100) to black (0)

Results: Figure 2.12.1. Box and Whisker plot of yellow peas for L* values in 2024.



- AAC Aberdeen had the greatest lightness, followed by CDC Hickie.
- In contrast, line 6242-1 had the least lightness.
- Several outliers were present.

Figure 2.12.2. Mean L* values of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** Only a 0.6 unit difference was determined from the highest (AAC Aberdeen) to the lowest (line 6242-1).
- **By Location:** A 1.2 unit difference was determined from the highest to the lowest.

Table 2.12.1 Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

b) ***a**:** red (+) to green (-)

Figure 2.12.3. Box and Whisker plot of yellow peas for *a** values in 2024.

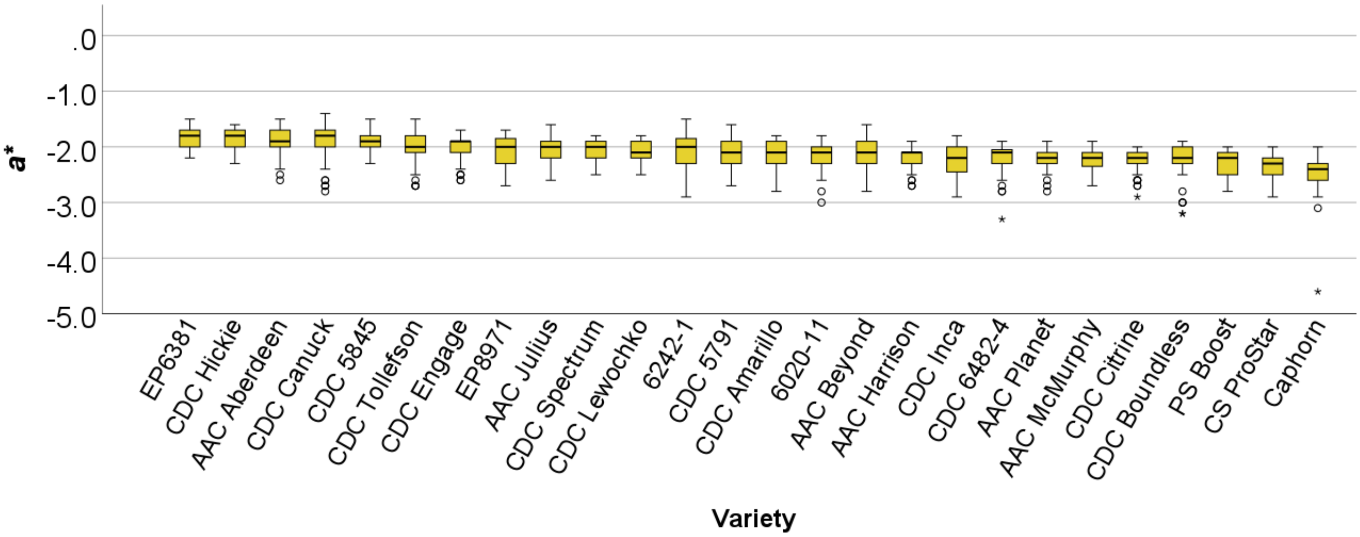
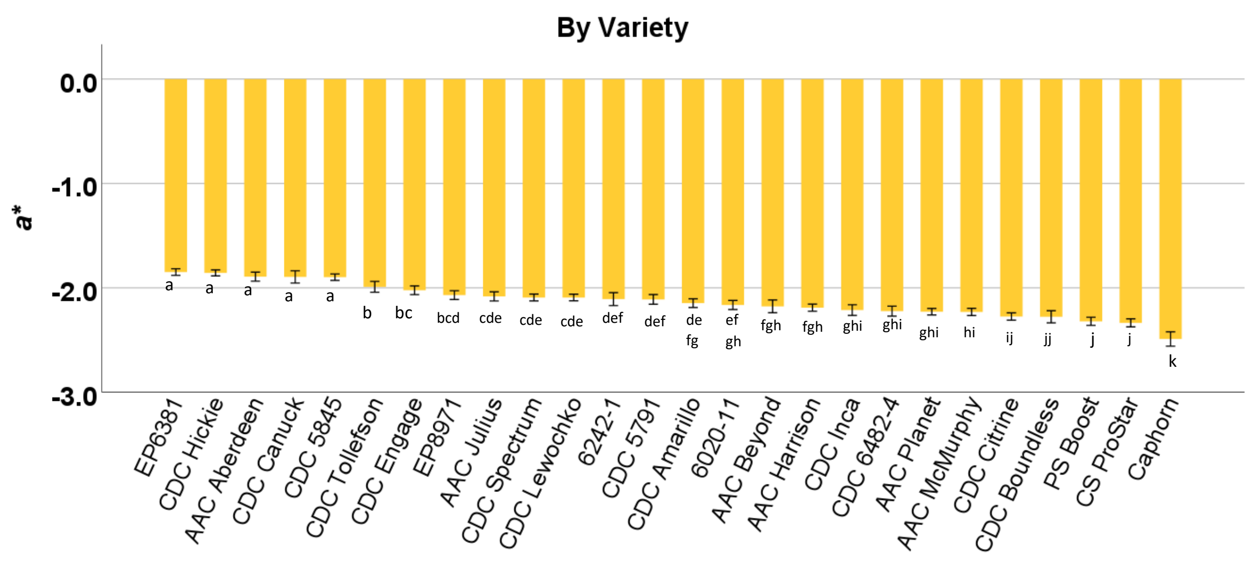


Figure 2.12.4. Mean *a** values of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



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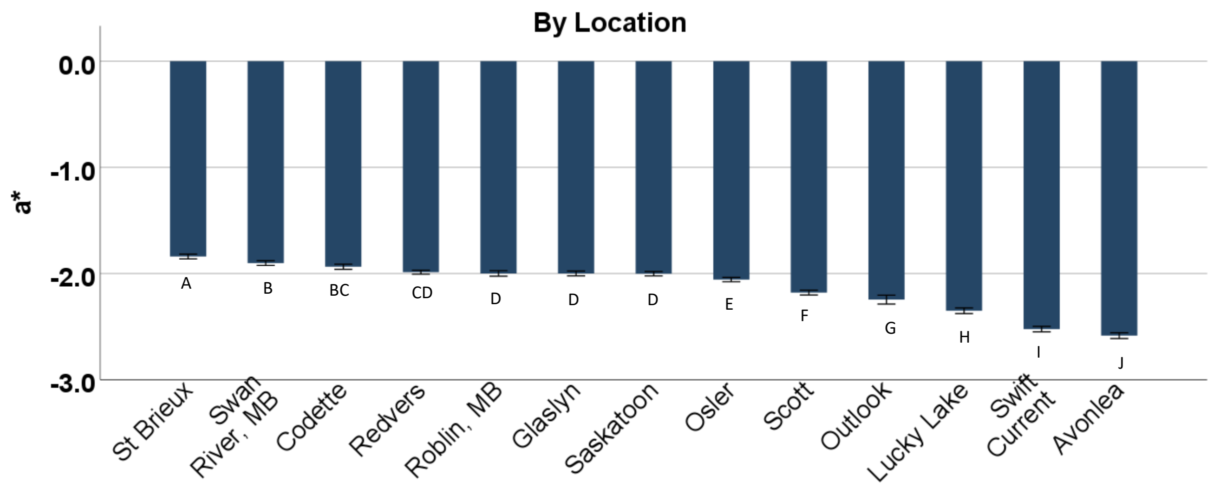


Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** a* values of all varieties ranged from -1.8 to -2.5.
- **By Location:** Only a 0.6 unit difference was determined from the highest to the lowest.
- A negative trend was observed between *a** value and greenness level (r=-0.237; p<0.01).

Table 2.12.2 Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

c) ***b*:*** yellow (+) to blue (-)

Figure 2.12.5 Box and Whisker plot of yellow peas for *b** values in 2024.

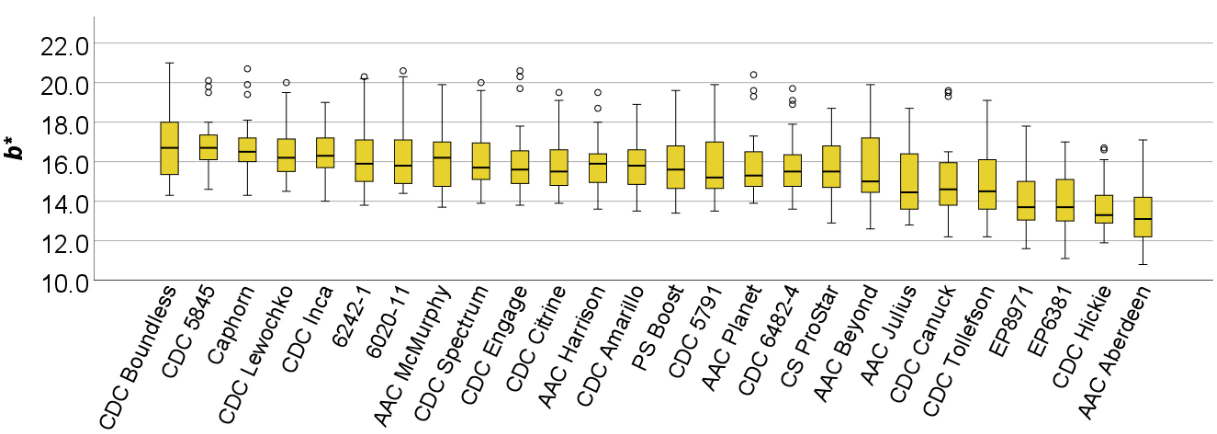
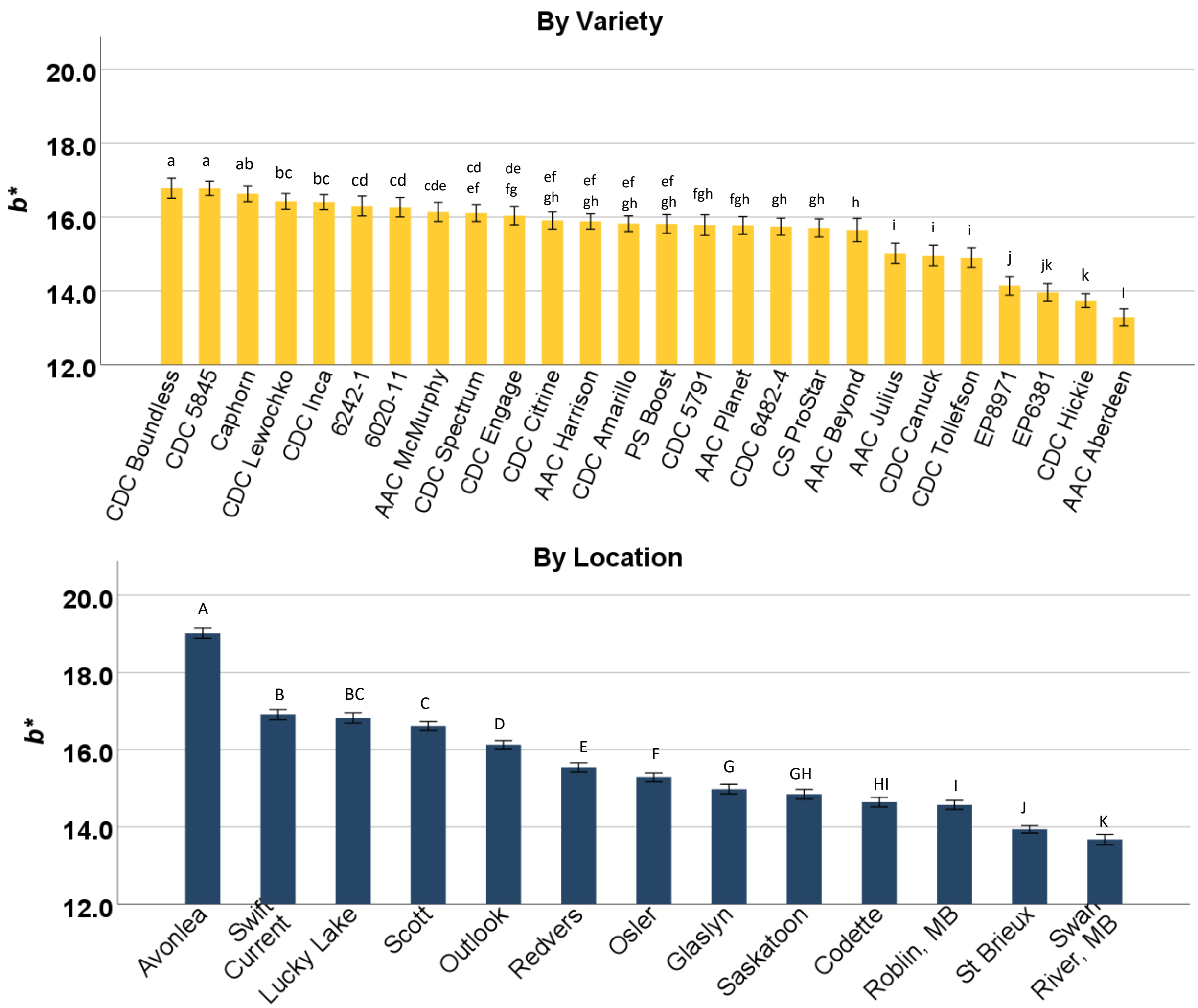


Figure 2.12.6. Mean *b** values of 2024 yellow peas by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Small letters indicated significant differences (p<0.05) by variety. Capital letters indicated significant differences (p<0.05) by location.

- **By Variety:** A difference of 3.5 units was determined from the stronest yellowness to the lowest.
- **By Location:** The *b** valules also varied between loations, where a difference of 5.3 units was determined from the stronest yellowness to the lowest.

Table 2.12.3 Effects of variety and location.

	Sig.
Variety	***
Location	***
Variety x Location	***

*Note: ***p<0.001; **p<0.01; *p<0.05; NS not significant.*

ACKNOWLEDGEMENTS

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