2023 Pulse Quality Evaluation

Dry Bean

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., thousand kernel weight, amount of damage, seed size, and seed hardness), nutritional composition (i.e., ash, moisture, and protein content), milling, and colour. 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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2023 Dry Bean Quality

A total of **105** dry bean samples harvested in **2023** were evaluated. There were **5** varieties, and three replicates of each variety were cultivated in each location. Samples were acquired from **7** locations, including Melfort, Outlook, Redvers, Riverhurst, Rosthern, Saskatoon, and Swan River, MB. Three replicates of each variety were cultivated in each location. **Table A** and **Figure A** provide the samples' information and locations in detail.

Figure B provides the cumulative rainfall from April 1 to October 16, 2023. Overall, there was more rainfall in the southeast, east-central, northeast, and northwest regions than in the southwest and west-central regions. According to the 2023 Crop Reports by the Ministry of Agriculture, seeding started in early May due to cool weather and excess moisture in April, and seeding was wrapped up in the beginning of June. During the growing season, warm temperatures have accelerated crop development in the majority of the province, especially the southwest and west-central regions, and harvest began in these regions at the end of July.

Table A. Description of 2023 dry bean samples tested for the Pulse Quality Program. Varieties also present in 2022 are shown in black, and new varieties that entered in 2023 are shown in red.

Crop	Type	Variety	Site	Number of samples
Dry bean	Black	CDC Blackstrap	Melfort Outlook Redvers Riverhurst Rosthern Saskatoon Swan River, MB	105
	Navy	AAC Shock CDC Whitetrack Blast		
	Yellow	CDC Sunburst		

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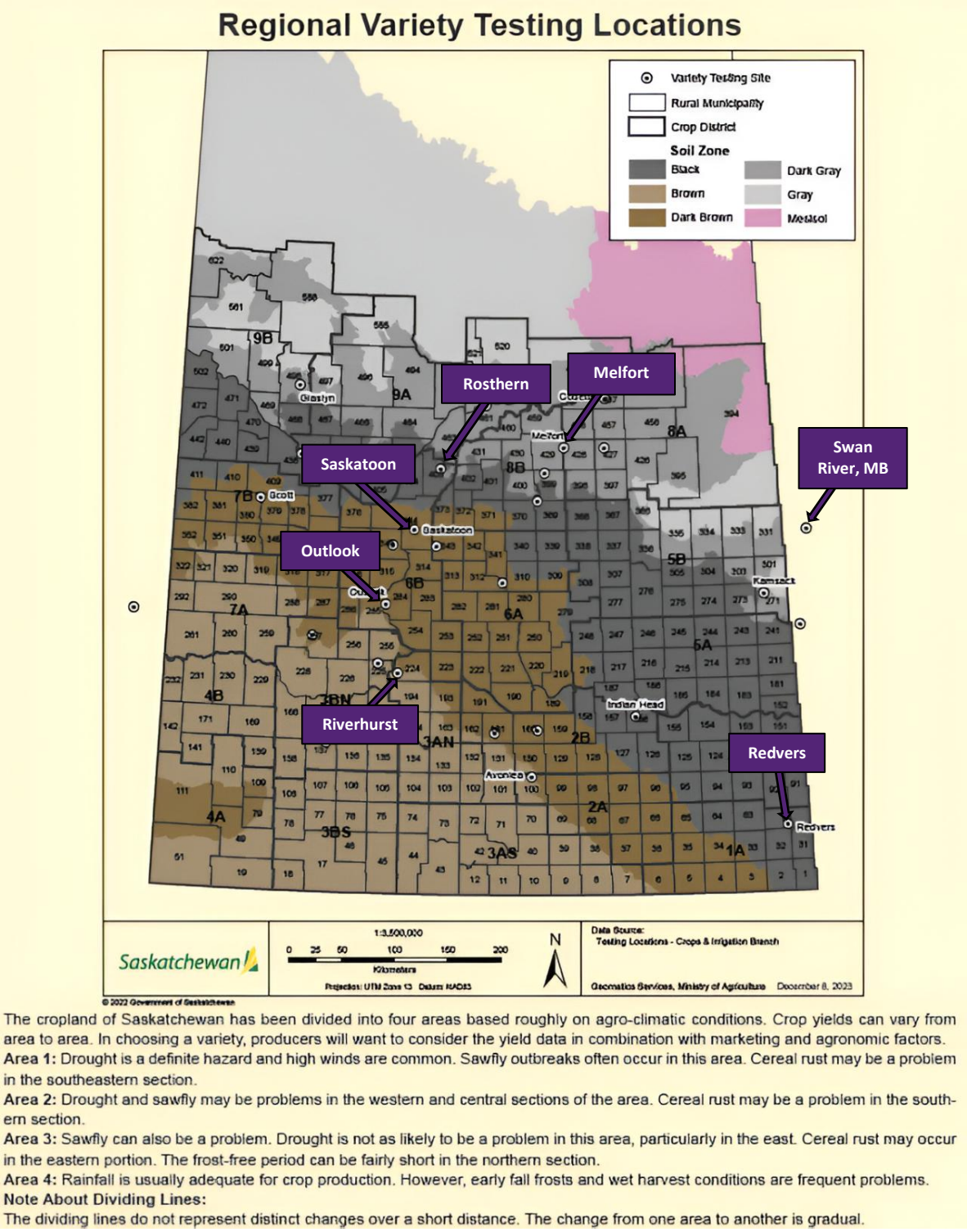

The cropland of Saskatchewan has been divided into four areas based roughly on agro-climatic conditions. Crop yields can vary from area to area. In choosing a variety, producers will want to consider the yield data in combination with marketing and agronomic factors.

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 dry bean quality testing in 2023 and the corresponding soil zones. Figure was modified from material provided by the Saskatchewan Ministry of Agriculture.

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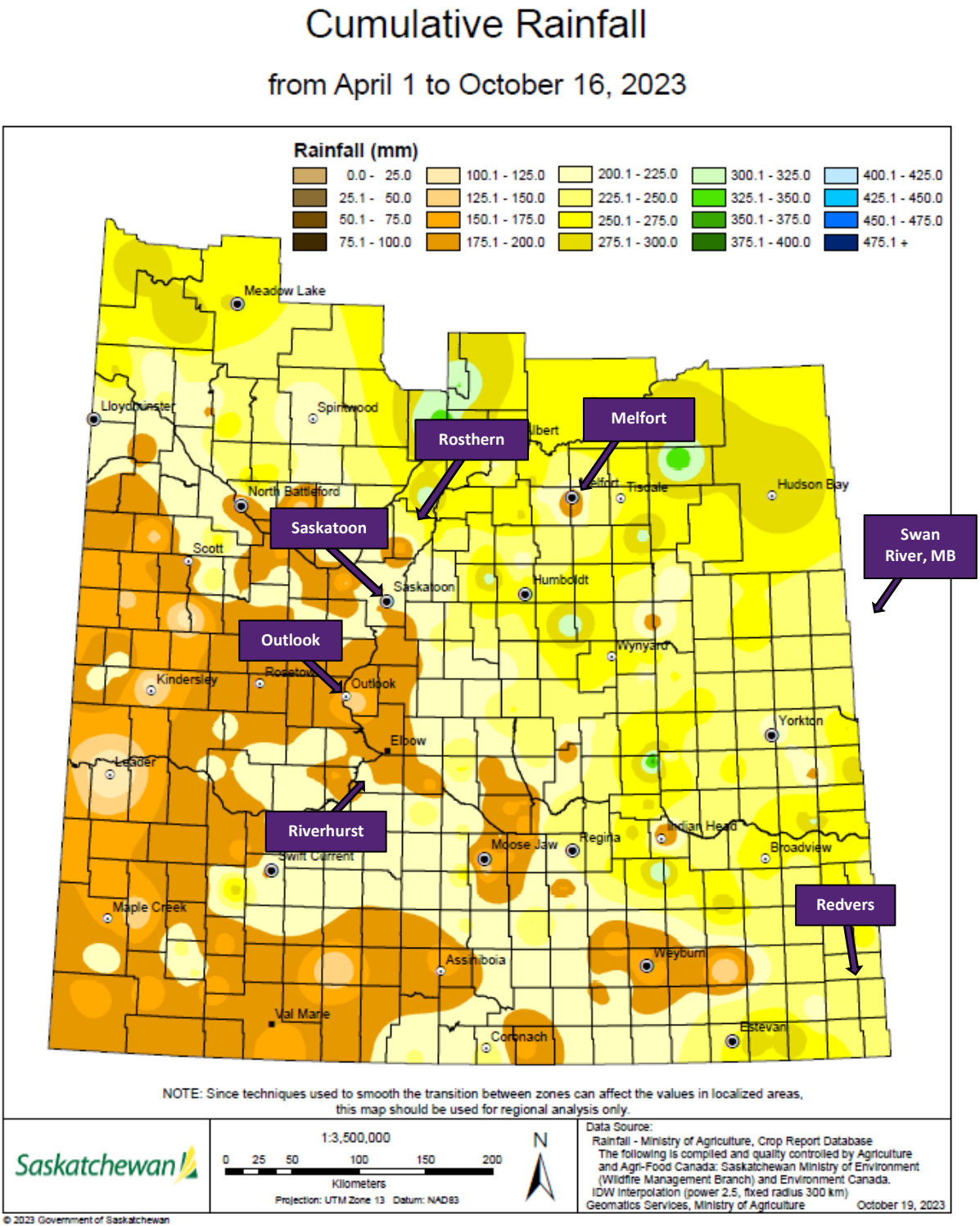

Figure B. Locations for dry bean quality testing and cumulative rainfall from April 1 to October 16, 2023. Figure was modified from material provided by the Saskatchewan Ministry of Agriculture.

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SASKATCHEWAN pulse Growers

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This report includes twelve subsections for the results of the following quality parameters:

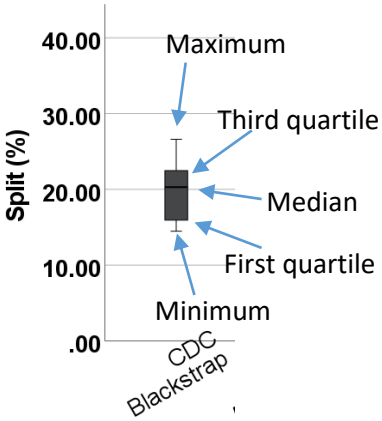
1. Yield
2. Thousand kernel weight (TKW)
3. Seed size: length, width, thickness
4. Split amount
5. Other damage
6. Hardness of whole seed
7. Ash content
8. Protein content
9. Protein productivity
10. Colour (*L*, a*,* and *b**)

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 first 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 values 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, other damage, ash, protein, protein productivity, and colour for each bean type by location and for navy bean by variety. A two-way analysis of variance (ANOVA) was conducted to determine the effects of variety, location, and their interaction on each parameter for navy beans. The Pearson Product Moment Correlation was performed to measure the correlation between quality parameters.

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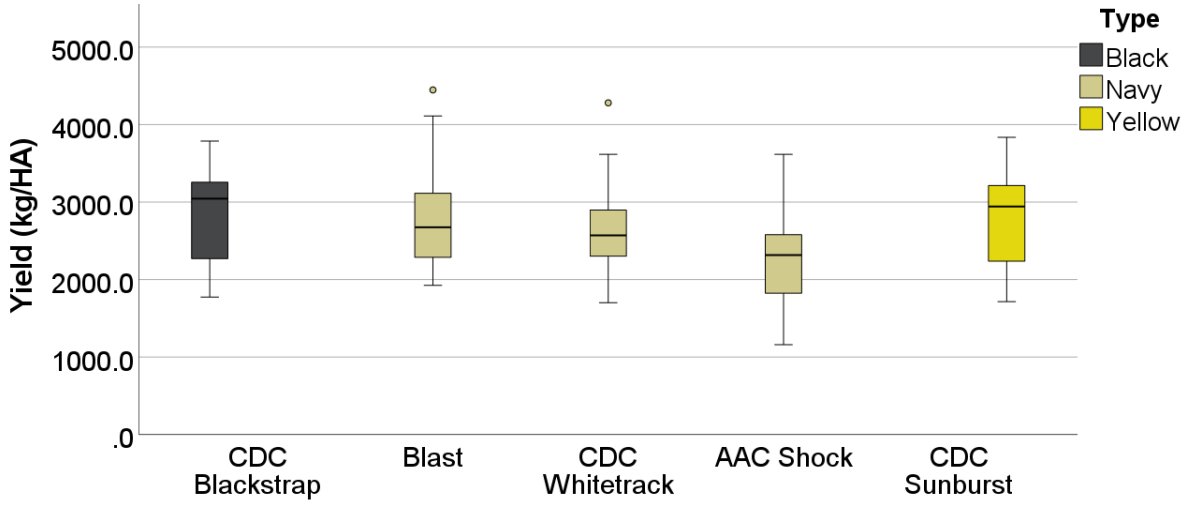
2023 Dry Bean Quality

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. Box and Whisker plot of dry beans for yield in 2023. Results by type were reported from highest to lowest.



- A large variation in yield was observed in all varieties.

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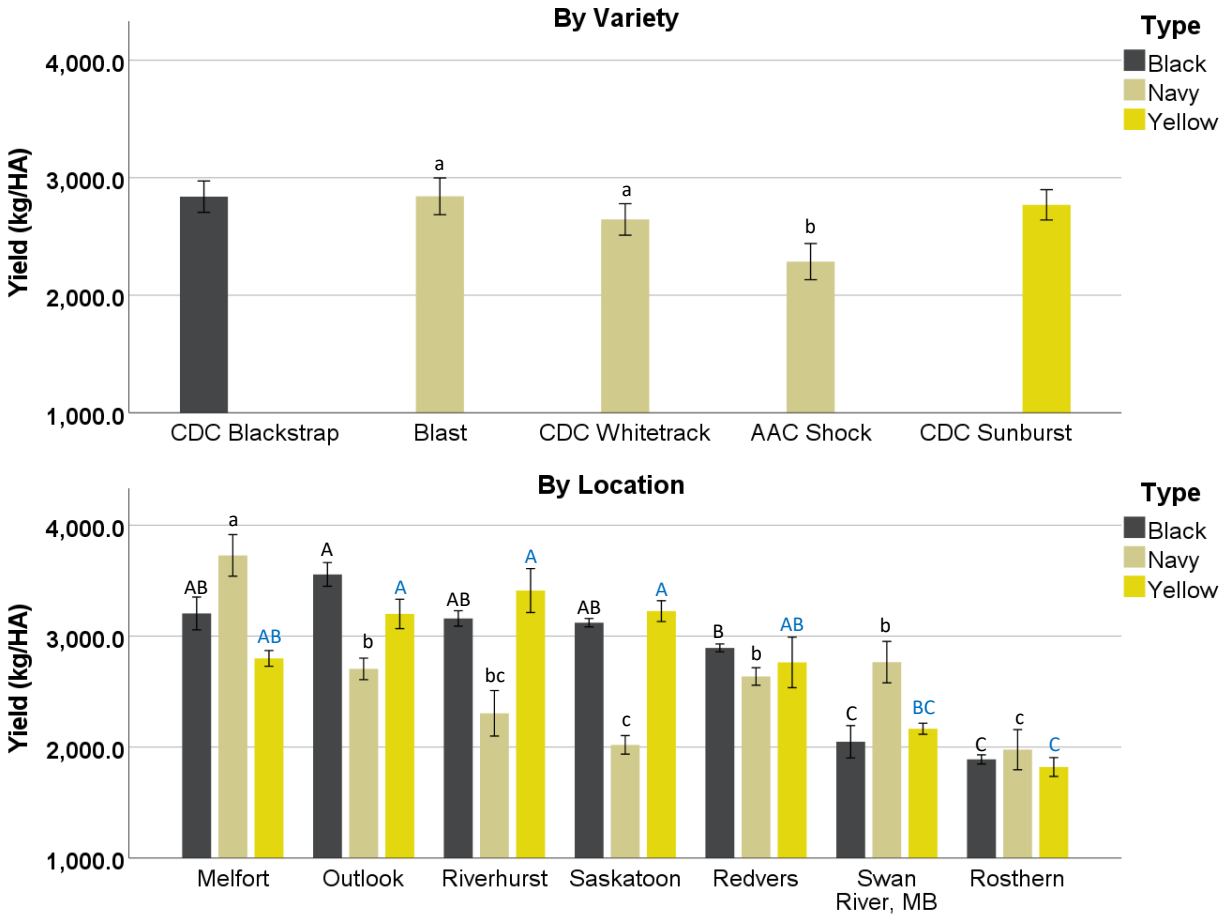
Figure 1.2. Mean yield of 2023 dry beans by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

By Variety:

- **Navy:** AAC Shock yielded 400 kg/HA less than CDC Whitetrack.
- CDC Blackstarp (black) and CDC Sunset (yellow) had yields comparable to Blast and CDC Whitetrack.

By Location:

- Navy: Yields in Melfort (highest) were over 1800 kg/HA higher than in Rosthern and Saskatoon (lowest).
- Black: Yields in Oulook (highest) were over 1500 kg/HA higher than in Rosthern and Swan River (lowest).
- Yellow: Yields in Riverhurst, Saskatoon, Oulook (highest) were 1400 kg/HA higher than in Rosthern (lowest).

Table 1. Effects of variety and location.

	Navy
Variety	***
Location	***
Variety x Location	**

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

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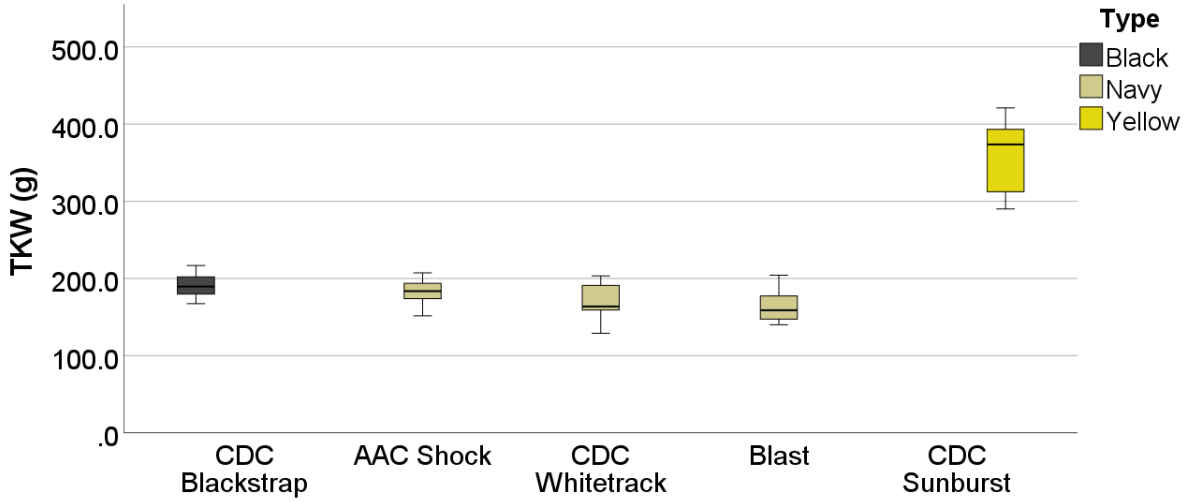
2. Thousand Kernel Weight

Method: Seed weight is an important parameter to indicate seed size and yield production. This test was conducted by weighing 300 seeds with duplicated measurements per sample, and the 1000 seed weight (TKW) was reported.

Results: Figure 2.1. Box and Whisker plot of dry beans for TKW in 2023. Results by type were reported from highest to lowest.



- Yellow had the highest TKW but showed significant variability.
- CDC Blackstrap (black) was similar to AAC Shock (Navy).

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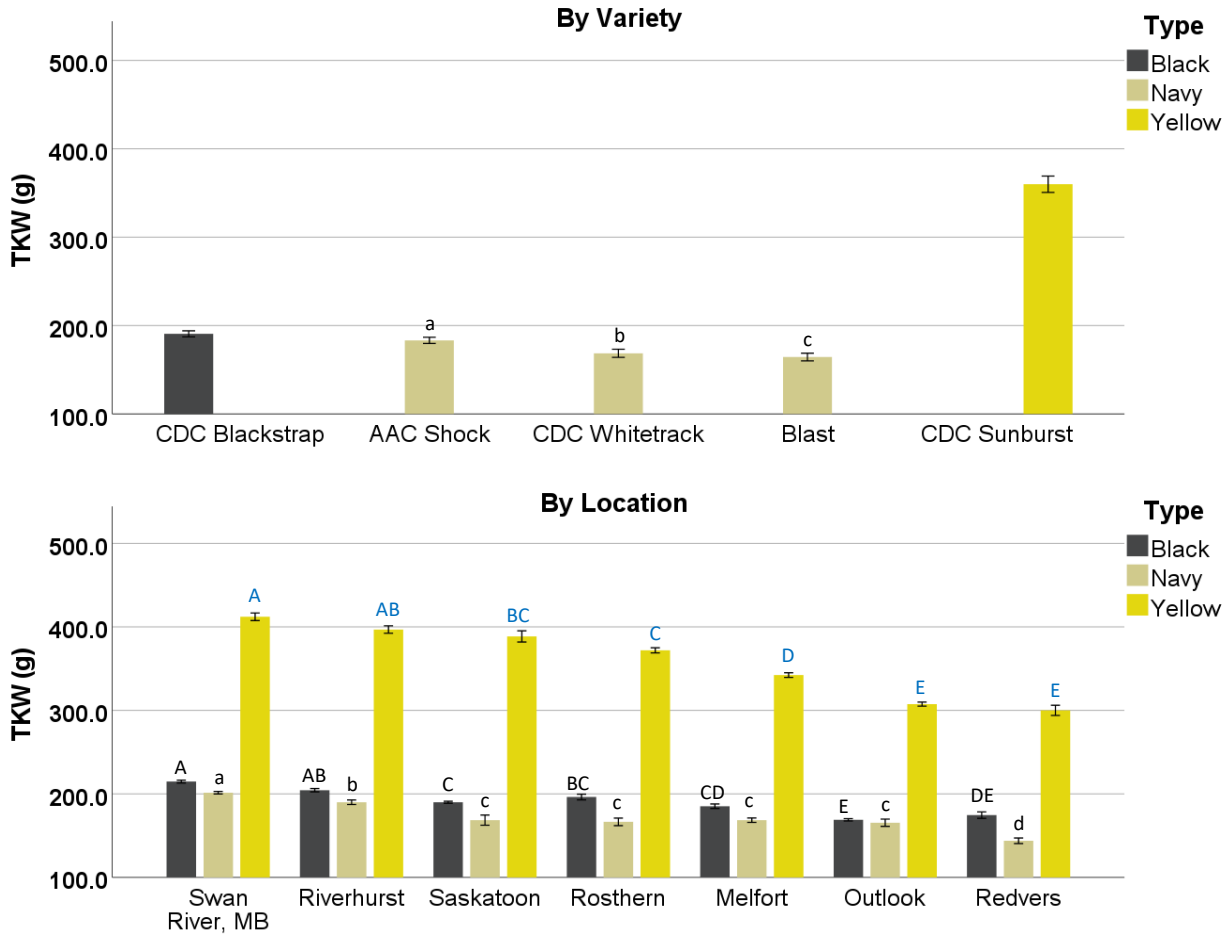
Figure 2.2. Mean TKW of 2023 dry beans by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

By Variety:

- CDC Sunset was 170 g higher than all other beans.
- **Navy:** AAC Shock (highest) was 20 g higher than Blast (lowest).

By Location:

- TKW was highest in Swan River across all sample, while the lowest TKW was found in Redvers and Outlook.

Table 2. Effects of variety and location.

	Navy
Variety	***
Location	***
Variety x Location	***

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

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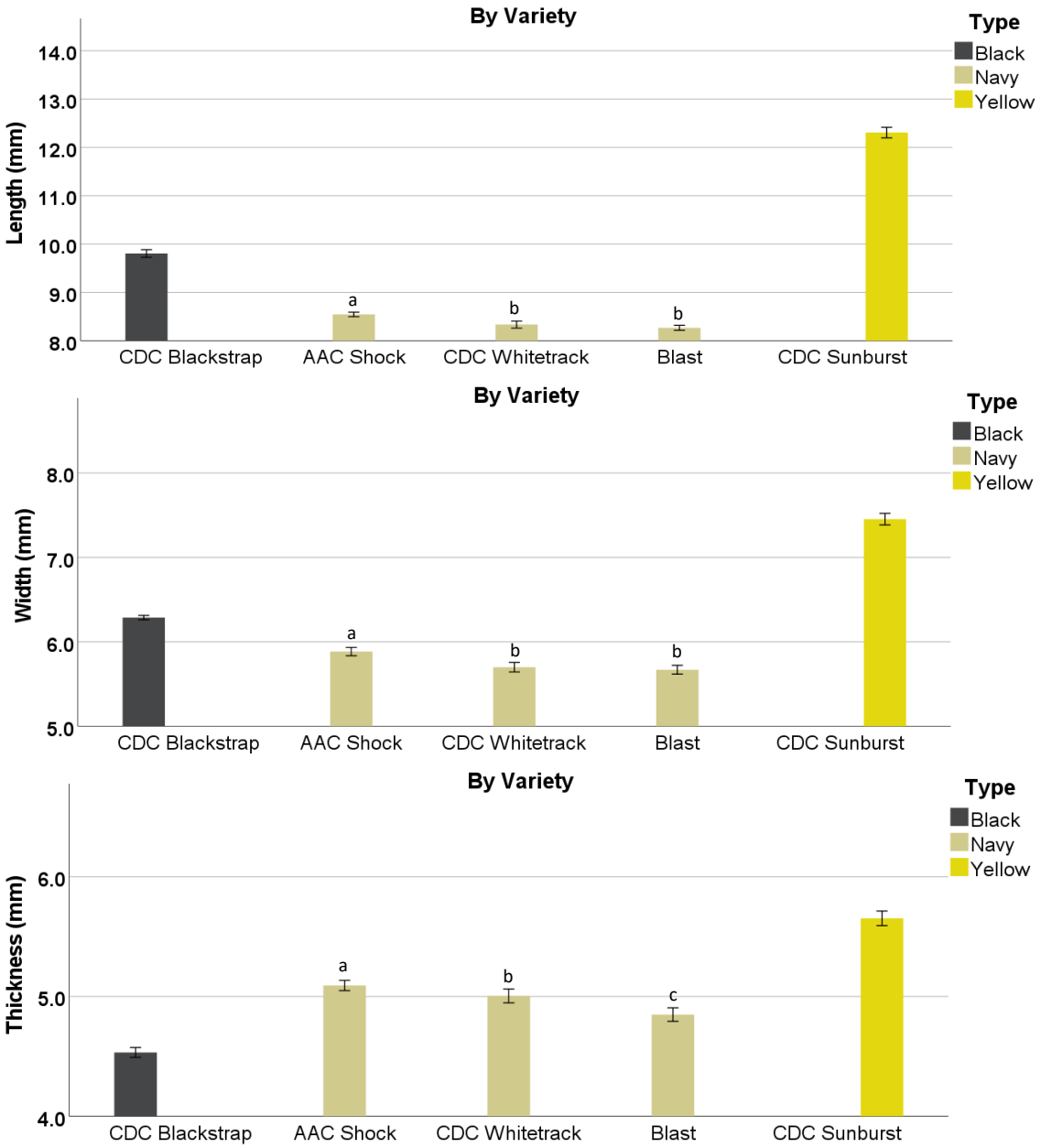
3. Seed Size

Method: The length, width, and thickness (mm) of the faba bean seed were measured with a caliper. The mean of twenty seeds was reported.

Figure 3.1. Mean length (mm), width (mm), thickness (mm) of 2023 dry beans by variety.



- CDC Sunset (yellow) had the largest length, width, and thickness across the five bean samples.
- CDC Blackstrap (black) had the smallest thickness.
- The navy beans had the shortest length.

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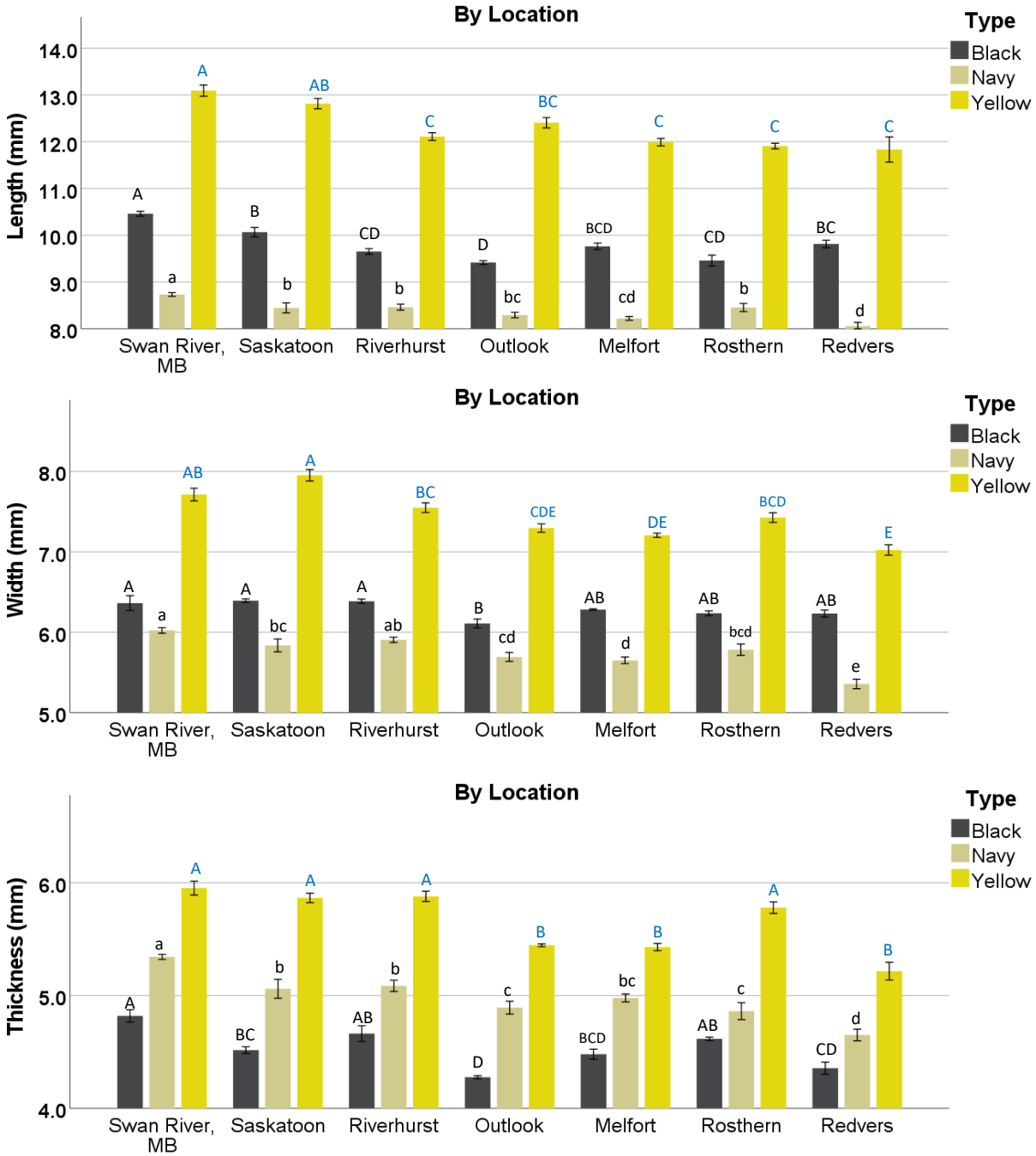
Figure 3.2. Mean length (mm), width (mm), thickness (mm) of 2023 dry beans by location.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

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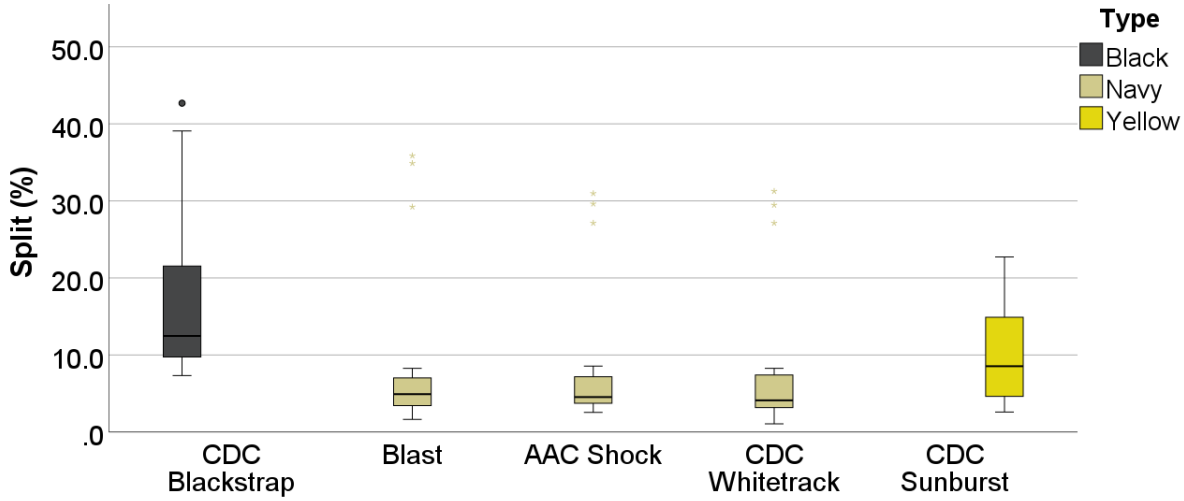
4. Split

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

Results: Figure 4.1. The Box and Whisker plot of dry beans for the split in 2023. Results by type were reported from highest to lowest.



- CDC Blackstrap (black) had highest split level.
- Navy beans in general had lower split.

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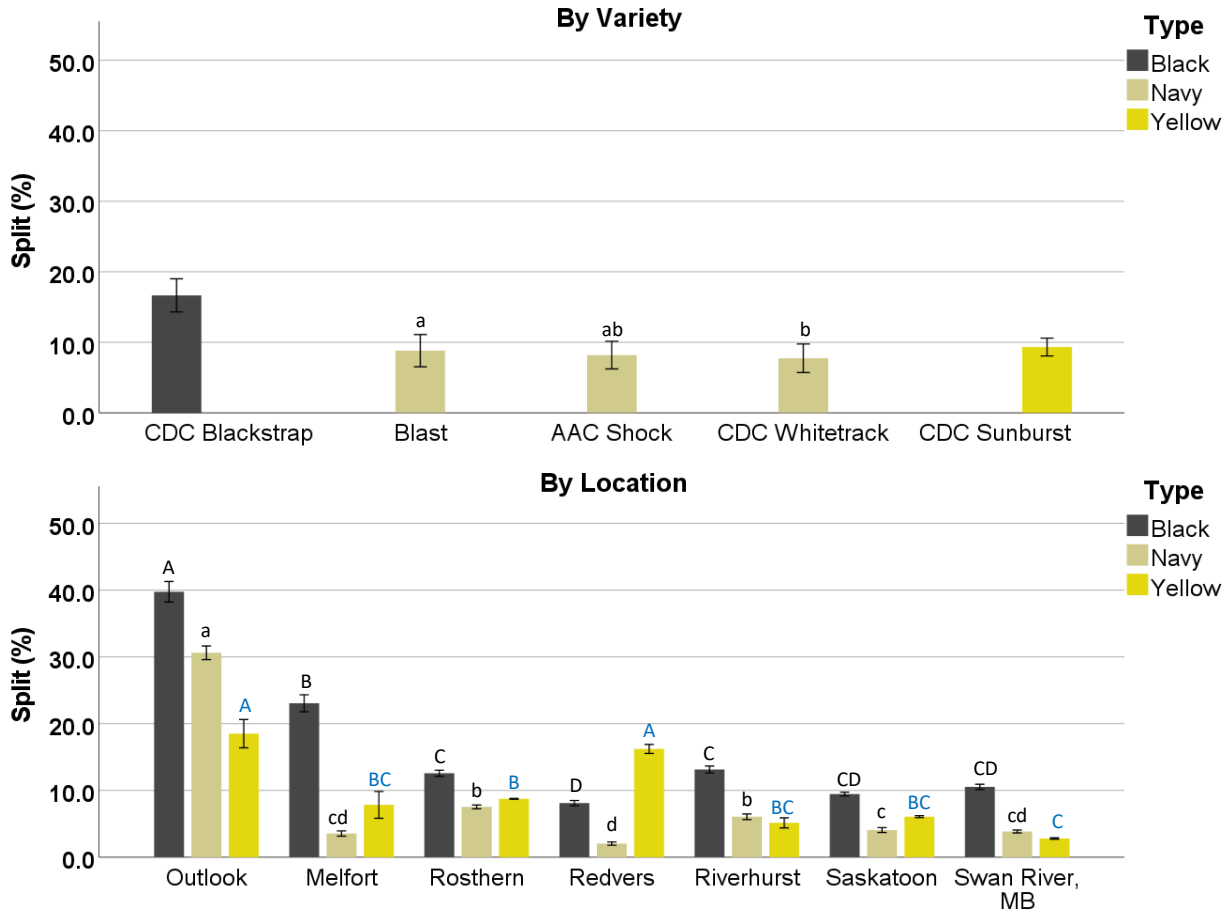
Figure 4.2. Mean split of 2023 dry beans by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

By Variety:

- The split level of CDC Blackstrap was double that of the other bean samples.

By Location:

- Location had a significant impact on split levels. The amount of split for all bean types was extremely high in Outlook.

Table 4. Effects of variety and location.

	Navy
Variety	*
Location	***
Variety x Location	*NS*

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

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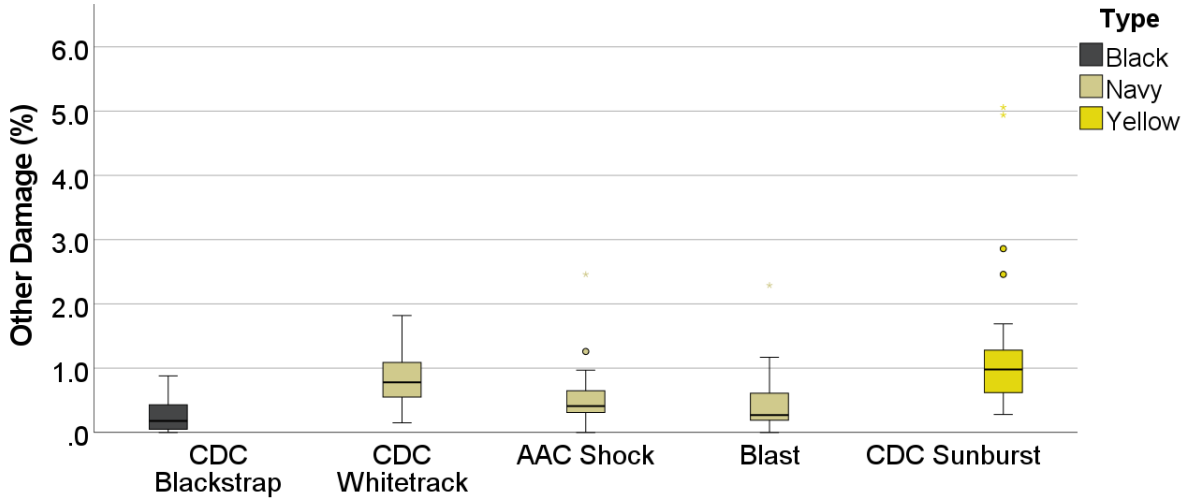
5. Other Damage

Method: 100 grams of each sample was used for evaluation, and damaged seeds were selected by hand. Other damage included sprouting, distinct immaturity, distinct deterioration or discolouration by weather or disease, insect damage, heat damage, and any other damage that affects appearance.

Results: Figure 5.1. Box and Whisker plot of dry beans for other damage in 2023. Results by type were reported from highest to lowest.



- Some extreme values were noted.

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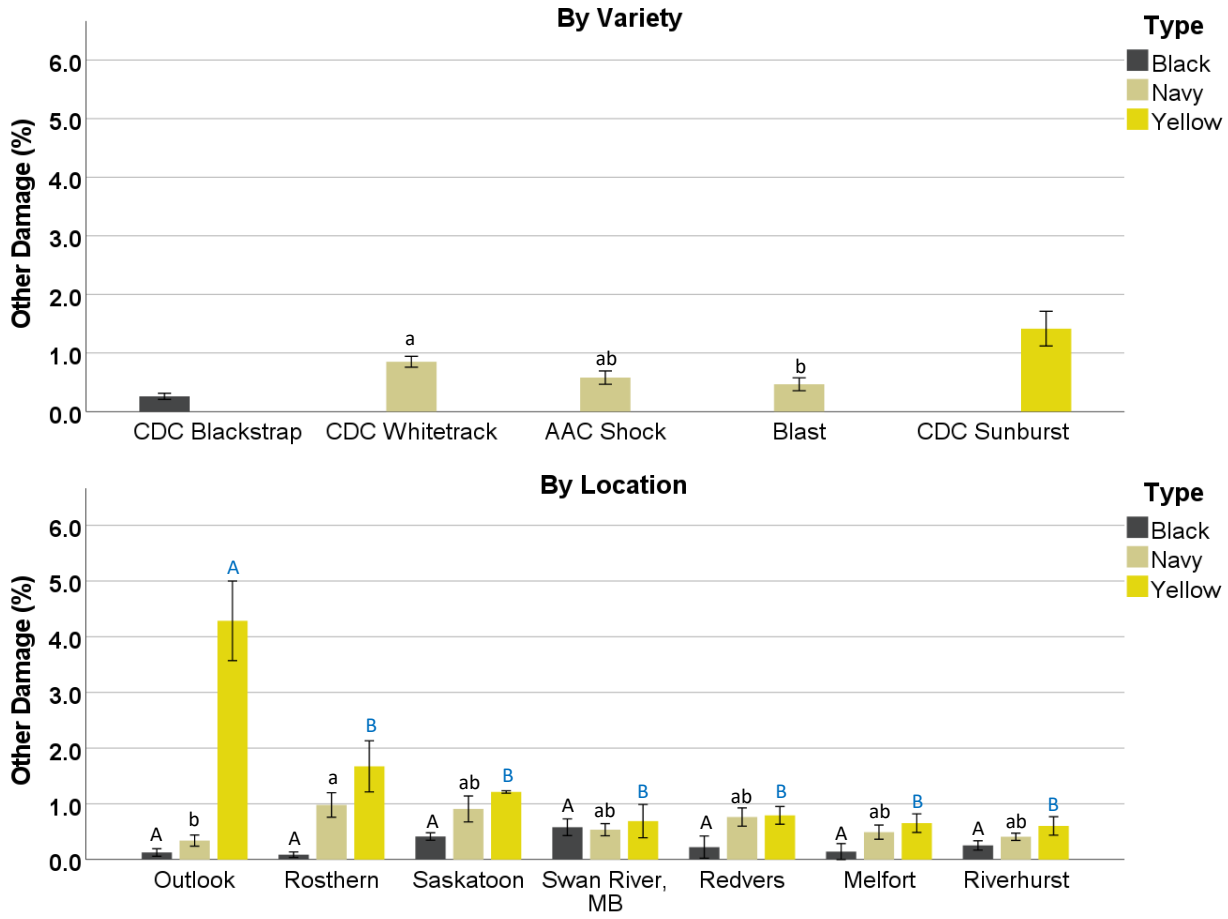
Figure 5.2. Mean other damage of 2023 dry beans by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

By Variety:

- The mean of other damage for CDC Sunset was 1.4%, while other damage for the other samples were below 1%.

By Location:

- A significant amount of CDC Sunset (yellow) was dsicolourated in Outlook.

Table 5. Effects of variety and location.

	Navy
Variety	*
Location	**
Variety x Location	*

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

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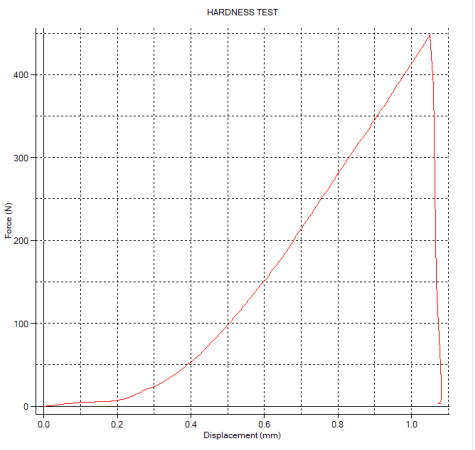
6. Hardness of Whole Seed

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



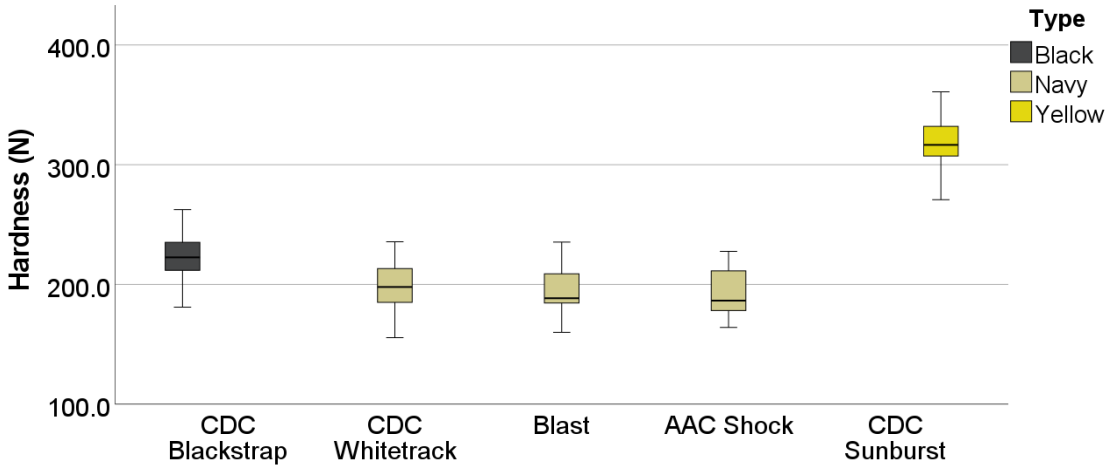
Method:

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)[1].

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 6.1. Box and Whisker plot of 2023 dry beans for seed hardness (N). Results were reported from highest to lowest.



- The yellow bean had the largest seed hardness, followed by the black type.

[1] 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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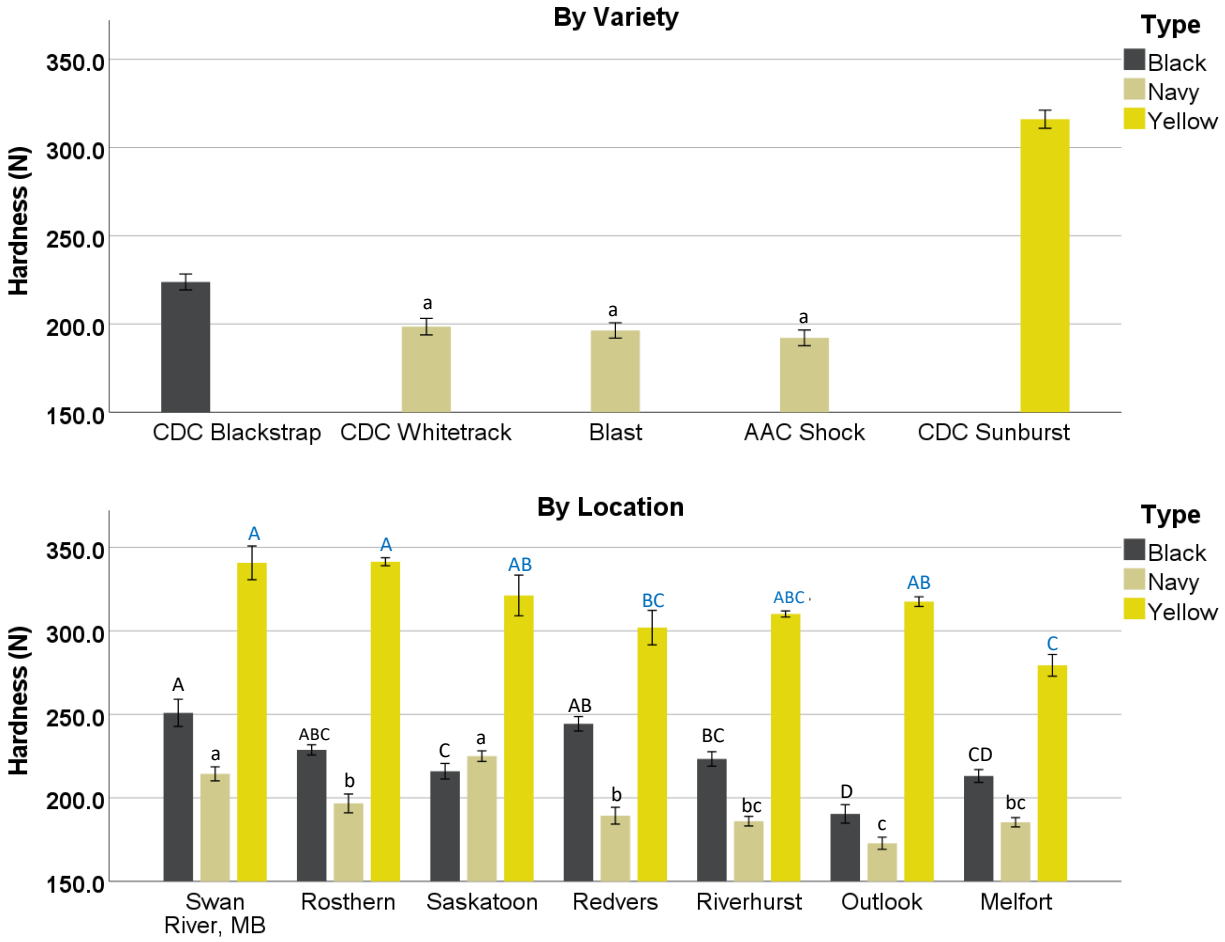
Figure 6.2. Mean hardness of 2023 dry beans by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

- Hardness for all navy beans was similar (p<0.05), but location effect played a role.
- A positive trend was observed between TKW and seed hardness (r=0.899, p<0.001).

Table 6. Effects of variety and location.

	Navy
Variety	*NS*
Location	***
Variety x Location	**

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

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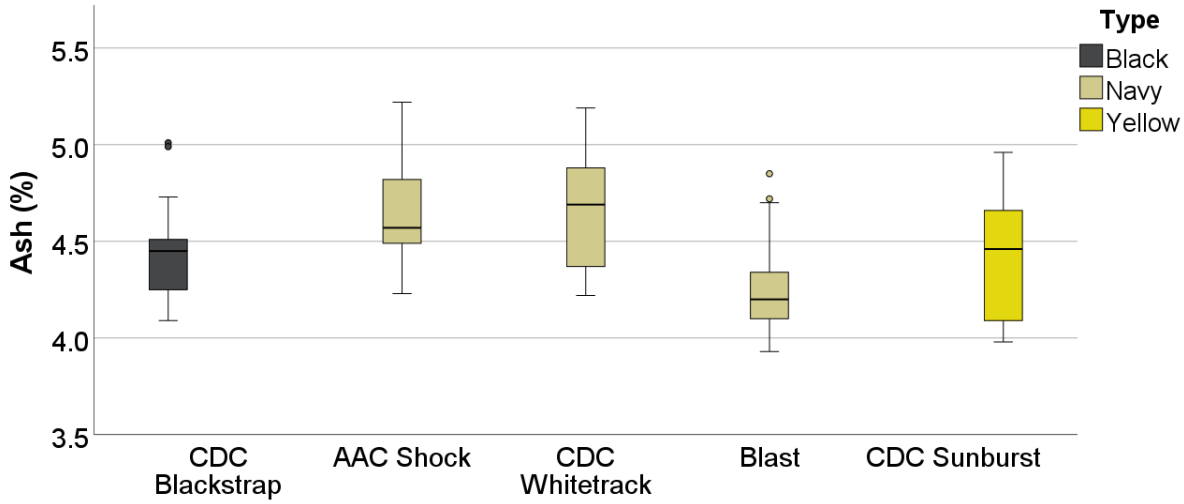
7. Ash Content

Method: Ash content (%) was determined using AACC 08-01.01[2] 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 7.1. Box and Whisker plot of dry beans for ash content (%) in 2023. Results by type were reported from highest to lowest.



[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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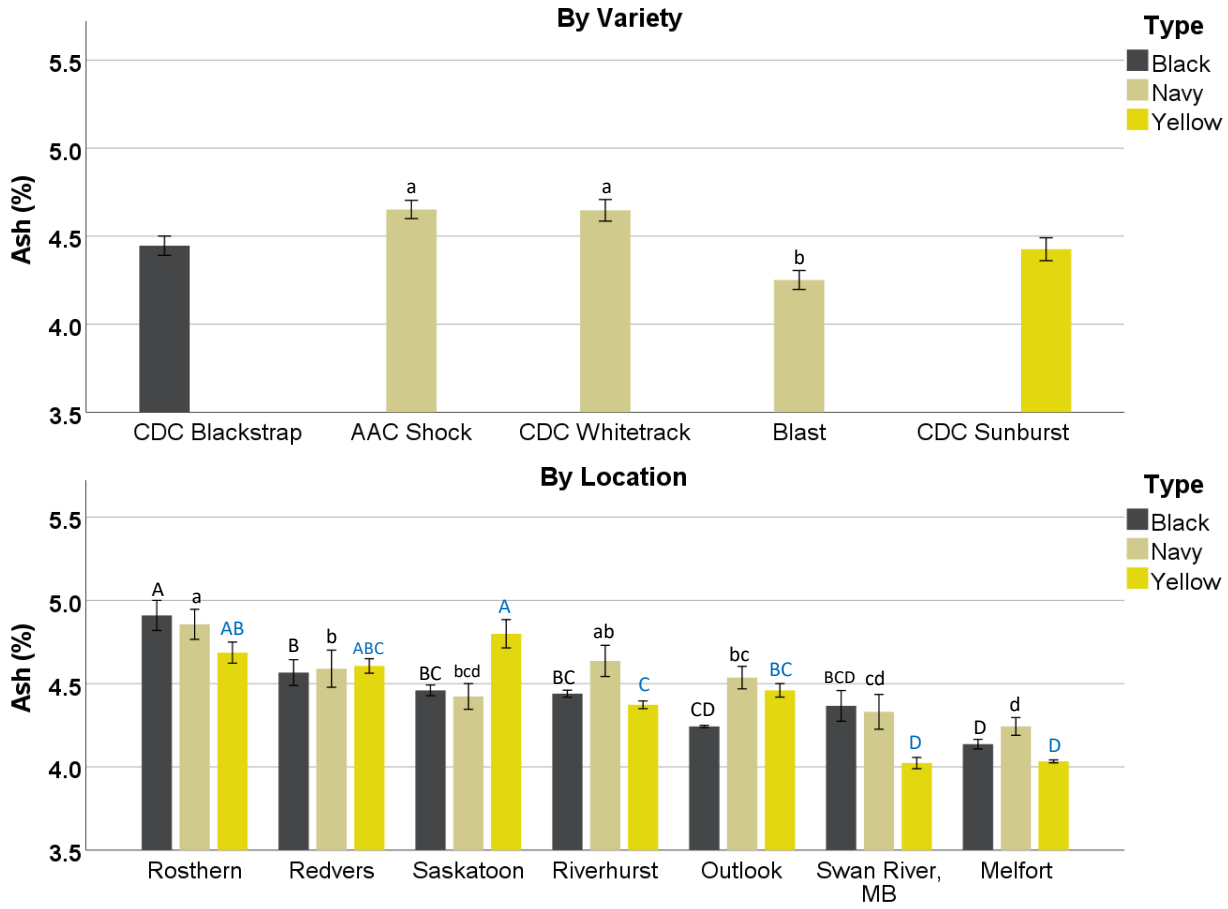
Figure 7.2. Mean ash of 2023 dry beans by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

By Variety:

- Ash levels for all bean varieties were above 4%.

By Location:

- Location effect played a role. Seeds from Rosthern in general had a higher ash level, while Melfort was the lowest.

Table 7. Effects of variety and location.

	Navy
Variety	***
Location	***
Variety x Location	*

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

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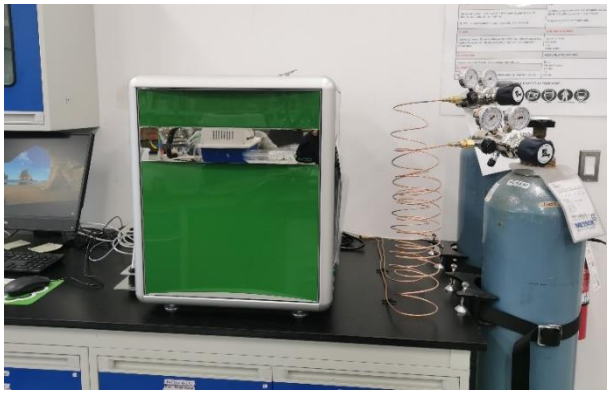
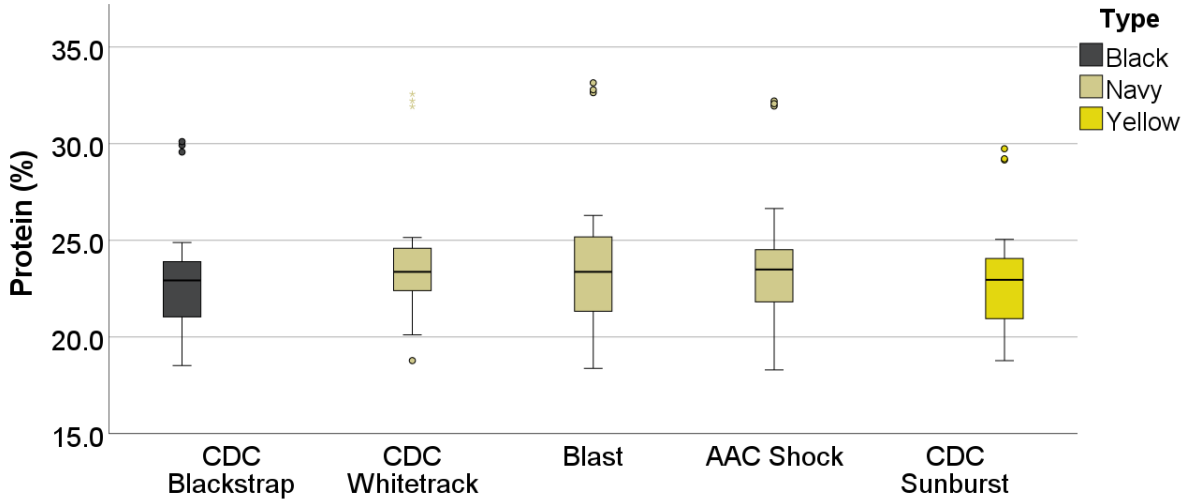
8. Protein Content

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 8.1. Box and Whisker plot of dry beans for protein content (%) in 2023. Results by type were reported from highest to lowest.



- Each bean type exhibited a few extreme high protein values.

[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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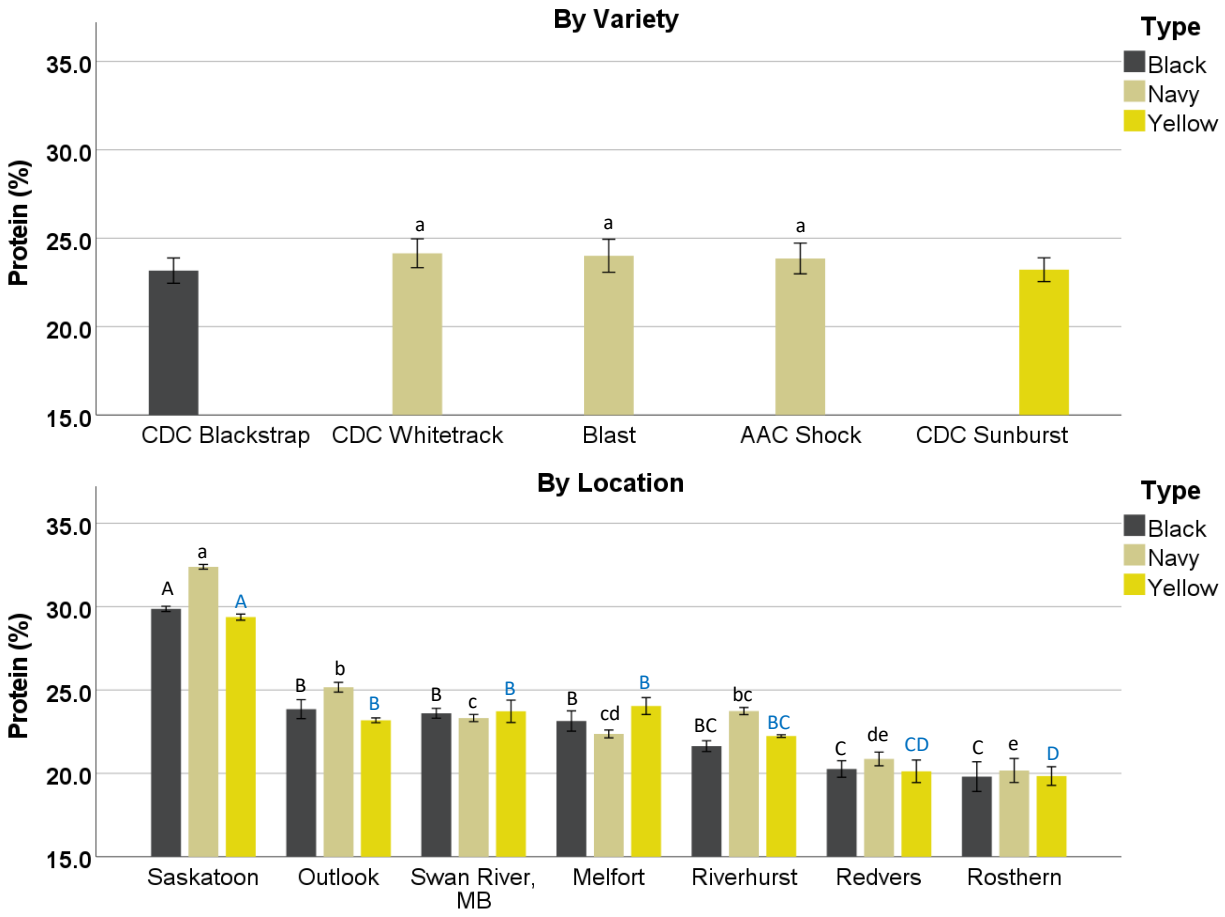
Figure 8.2. Mean protein of 2023 dry beans by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

By Variety:

- No statistical difference was observed between the navy types.

By Location:

- Protein from Saskatoon was 6-8% higher than Outlook, Swan River, Melfort, and Riverhurst, and about 10% higher than Redvers and Rosthern.
- The other three locations were similar.

Table 8. Effects of variety and location.

	Navy
Variety	*NS*
Location	***
Variety x Location	*NS*

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

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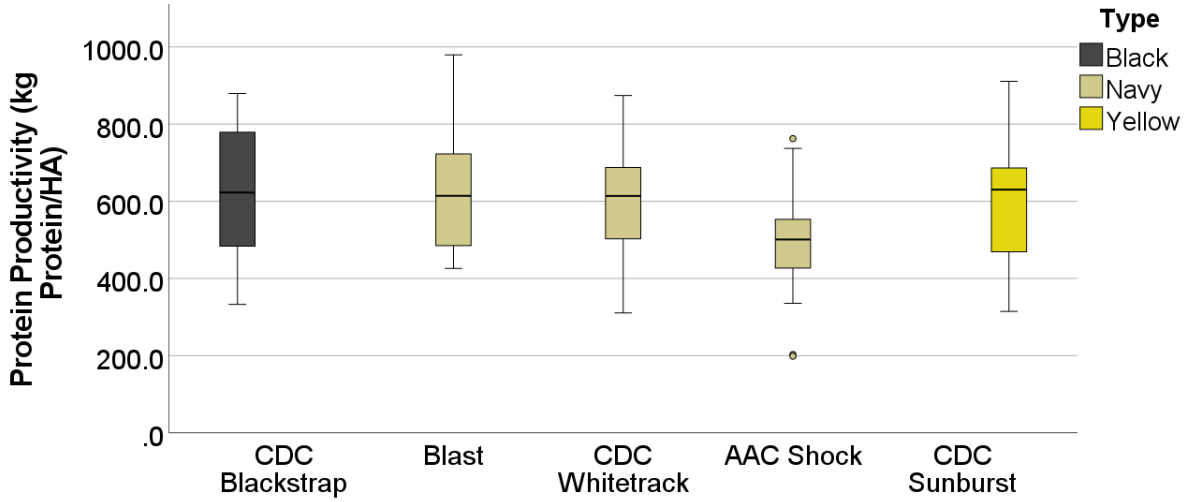
9. Protein Productivity

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 9.1. Box and Whisker plot of dry beans for protein productivity (kg Protein/HA) in 2023. Results by type were reported from highest to lowest.



- All bean samples exhibited significant variability.

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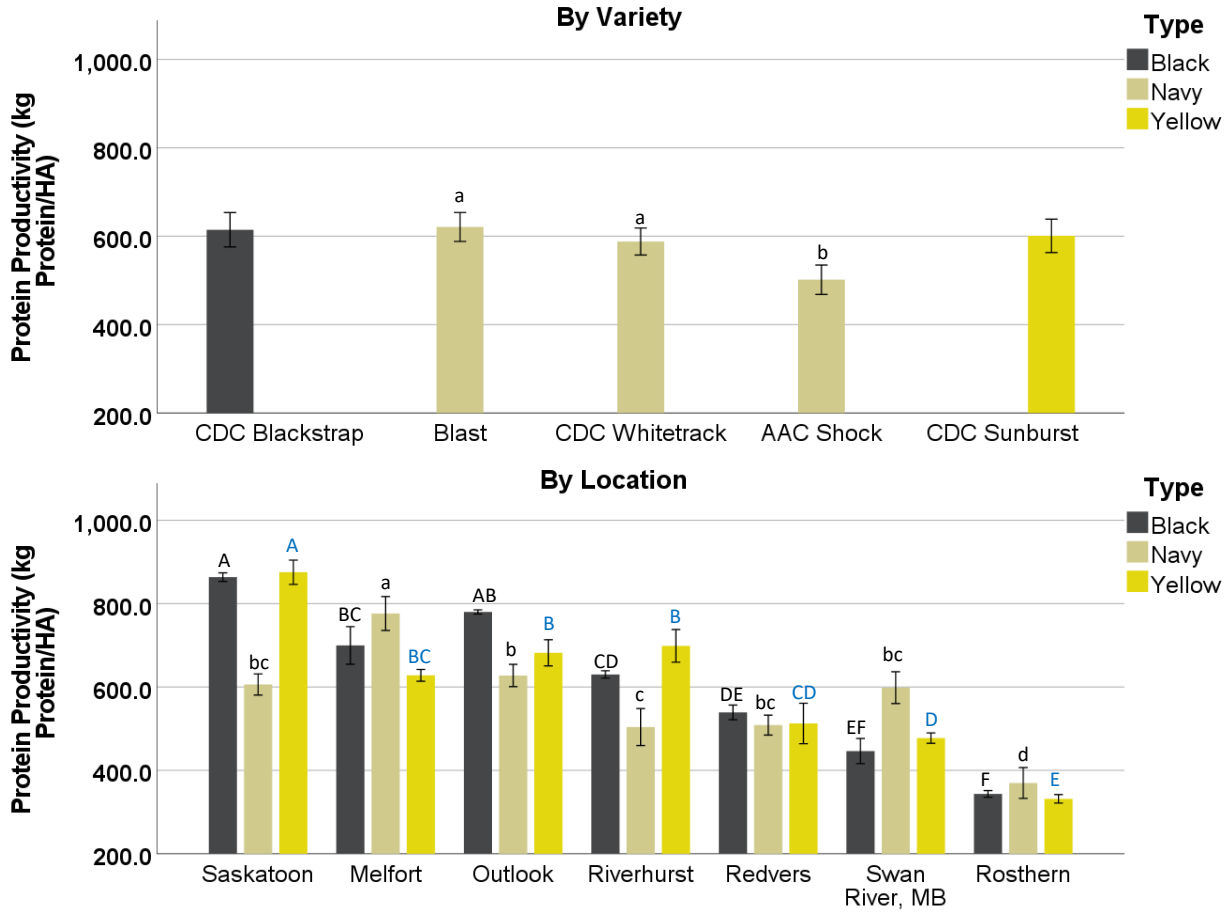
Figure 9.2. Mean protein productivity of 2023 dry beans by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

By Variety:

- AAC Shock had the lowest protein productivity due to its lowest yield (pg.7).

By Location:

- Rosthern had the lowest protein productivity due to its low yield and low protein content (pg. 7 & pg. 21).
- Black: Saskatoon was over twice as high as Rosthern.
- Navy: Melfort was 1.5 times higher than Rosthern.
- Yellow: Saskatoon was over twice as high as Rosthern.

Table 9. Effects of variety and location.

	Navy
Variety	***
Location	***
Variety x Location	*NS*

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

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10. 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. Three measurements were made for each sample, and the mean value was reported.

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

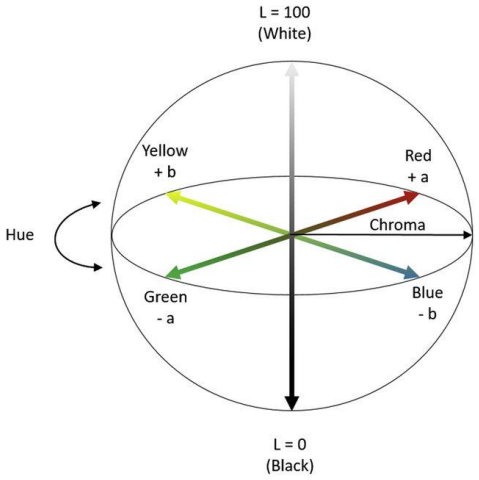
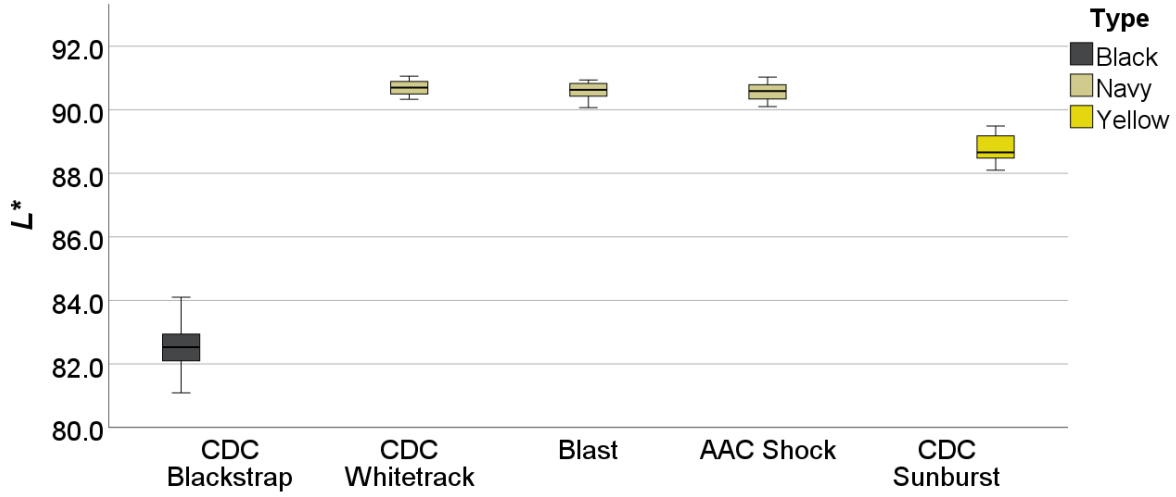


Figure 10.1. The CIELAB color spacediagram[3].

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

Results: Figure 10.2. Box and Whisker plot of dry beans for lightness resulting in 2023. Results by type were reported from highest to lowest.



[3] 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.

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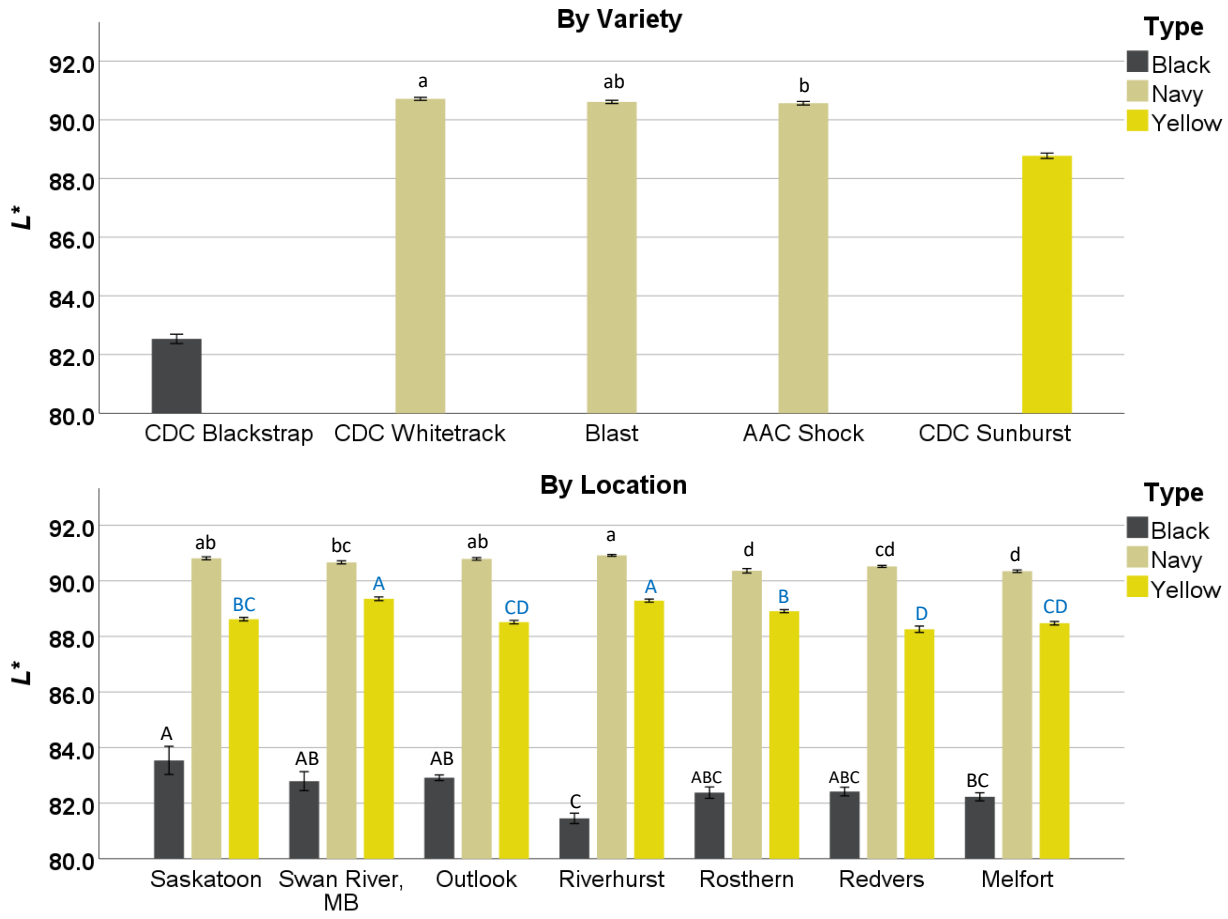
Figure 10.3. Mean lightness of 2023 dry beans by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

By Variety:

- CDC Blackstrap had the lowest lightness; in contrast, the navy type had higher lightness, likely related to their seed coat color.

By Location:

- Black: A 2-unit difference in lightness was found from highest (Saskatoon) to lowest (Riverhurst).
- Navy: Only a 0.6-unit of difference was found from highest (Riverhurst) to lowest (Melfort).
- Yellow: A 1-unit difference was found from highest (Swan River) to lowest (Redvers).

Table 10.1. Effects of variety and location.

	Navy
Variety	**
Location	***
Variety x Location	*NS*

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

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

Results: Figure 10.4. Box and Whisker plot of dry beans for *a** resulting in 2023. Results by type were reported from highest to lowest.

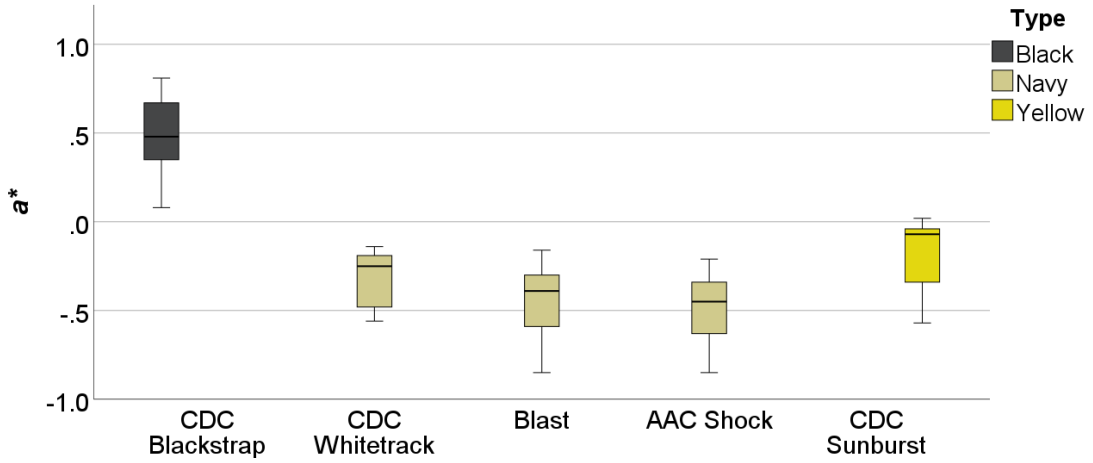
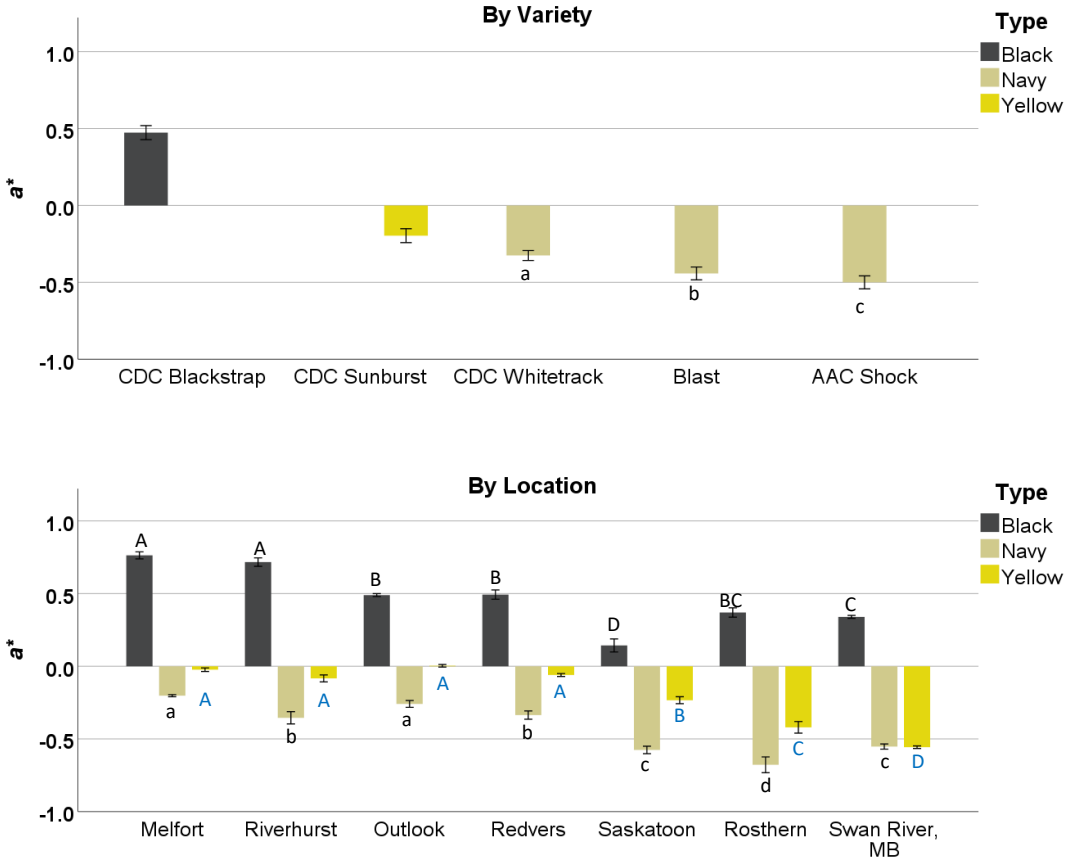


Figure 10.5.1. Mean *a** of 2023 dry beans by variety and by location. Each bar represents mean ± one standard error.



Note: <u>Capital letters in black</u> indicated significant differences (p<0.05) by black bean. <u>Small letters in black</u> indicated significant differences (p<0.05) by navy bean. <u>Capital letters in blue</u> indicated significant differences (p<0.05) by yellow bean.

By Variety:

- Overall, the *a** values of all samples were close to zero.

Location:

- The difference from highest to lowest for each seed type was less than 0.5 unit.

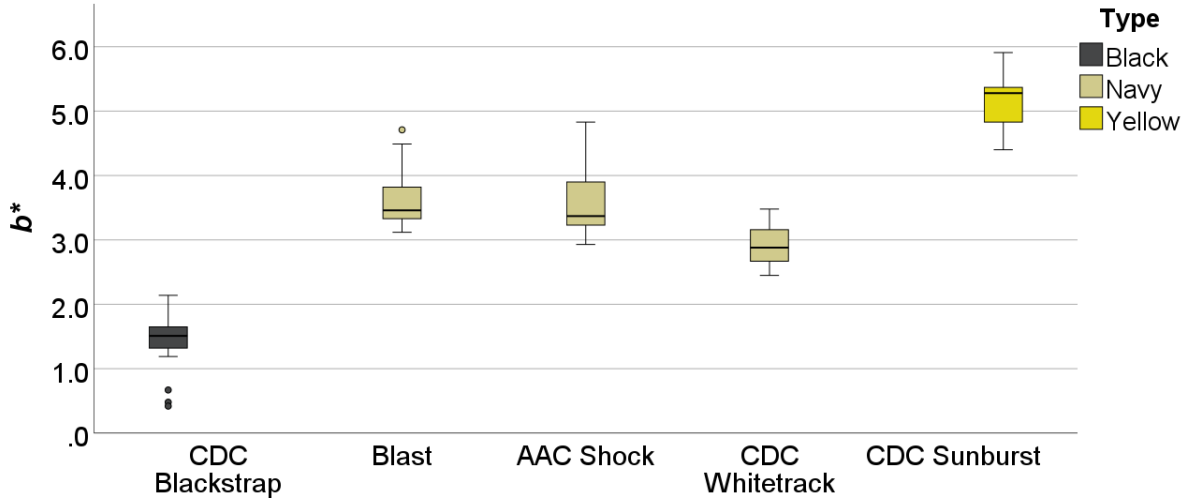
Table 10.2. Effects of variety and location.

	Navy
Variety	***
Location	***
Variety x Loca	***

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

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

Results: Figure 10.6. Box and Whisker plot of dry beans for *b** resulting in 2023. Results by type were reported from highest to lowest.



- CDC Blackstrap (Black) had the lowest *b** values.
- Overall, the *b** values for beans were low compared to those of other pulses.

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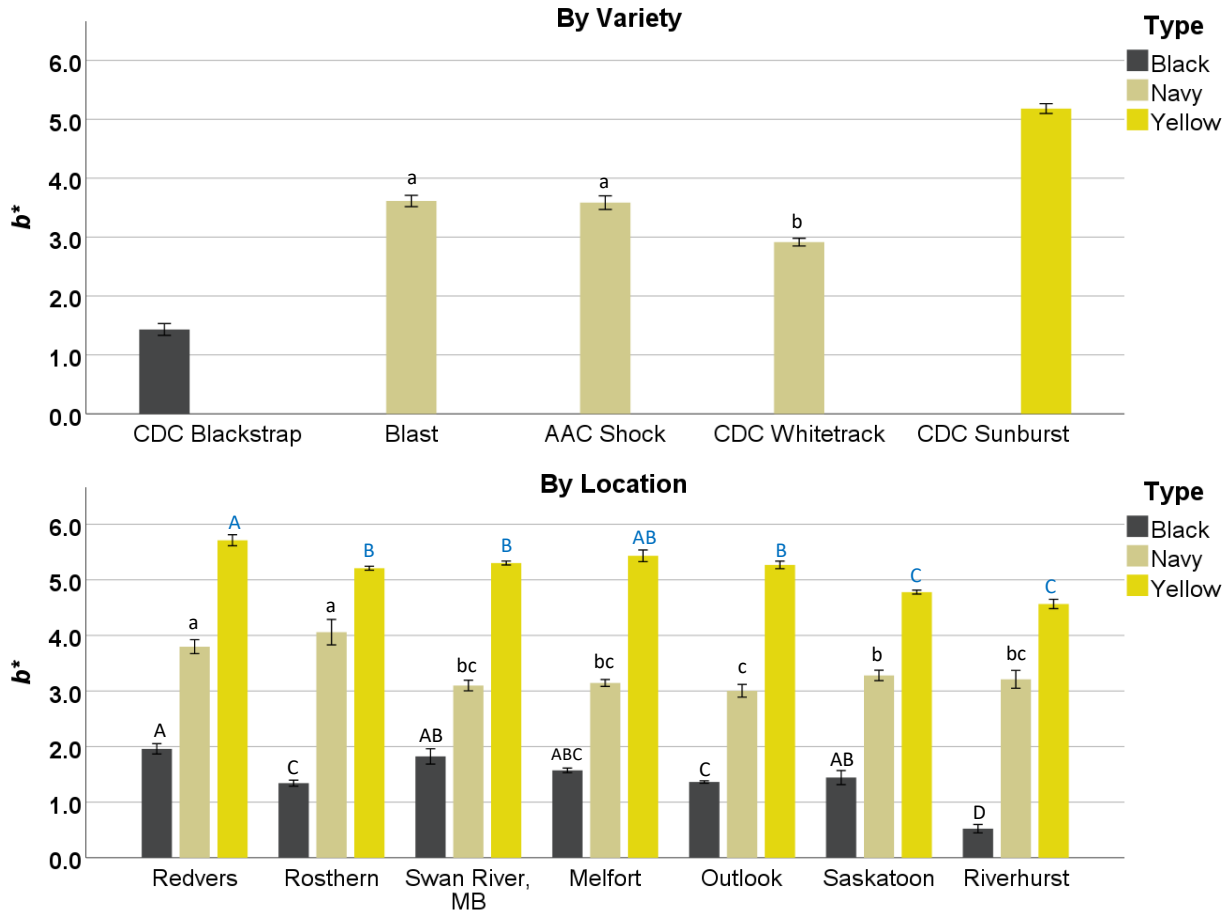
Figure 10.7. Mean *b** of 2023 dry beans by variety (top) and by location (bottom). Each bar represents mean ± one standard error.



Note: Capital letters in black indicated significant differences (p<0.05) by black bean. Small letters in black indicated significant differences (p<0.05) by navy bean. Capital letters in blue indicated significant differences (p<0.05) by yellow bean.

By Variety:

- CDC Sunburst had a higher yellowness due to the yellow seed coat.
- The *b** values remained low compared to other pulses due to the off-white cotyledon.

By Location:

- The difference from highest to lowest was about 1 unit for all bean types.

Table 10.3. Effects of variety and location.

	Navy
Variety	***
Location	***
Variety x Location	**

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

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