Pulse Quality Evaluation 2022-2024

Lentil

Saskatchewan Food Industry Development Centre Inc.
2335 SCHUYLER STREET, SASKATOON, SASKATCHEWAN, S7M 5V1,
TEI: (306) 933-7555, FAX: (306) 933-7208

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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2022-24 Lentil Quality Evaluation

There were seventeen lentil varieties that remained in the regional variety trials from 2022 to 2024. Samples acquired in 2022, 2023, and 2024 were harvested from 6, 5, and 5 locations, respectively. **Table A** provides detailed information about the samples.

Table A. Description of lentils tested for the Pulse Quality Program from 2022 to 2024.

Type	Variety	2022 Site	2023 Site	2024 Site	Region
Large green	CDC Greenstar CDC Lima				**Northwestern NW**
Small green	CDC 6964 CDC Kermit CDC Jimini	Rosthern St Brieux	Rosthern St Brieux	St Brieux	**Northeastern NE**
Large red	CDC Sublime CDC Monarch	Scott			**West-Central WC**
Medium red	CDC Imu			Clavet	**East-Central EC**
Small red	CDC 6928 CDC 6956 CDC Impulse CDC Maxim CDC Nimble CDC Proclaim CDC Redmoon	Elrose Moose Jaw Swift Current	Elrose	Elrose Swift Current	**Southwestern SW**
	CDC Simmie		Avonlea Redvers	Redvers	**Southeastern SE**
Extra small red	CDC Imani				
Number of Samples		**306**	**255**	**255**	

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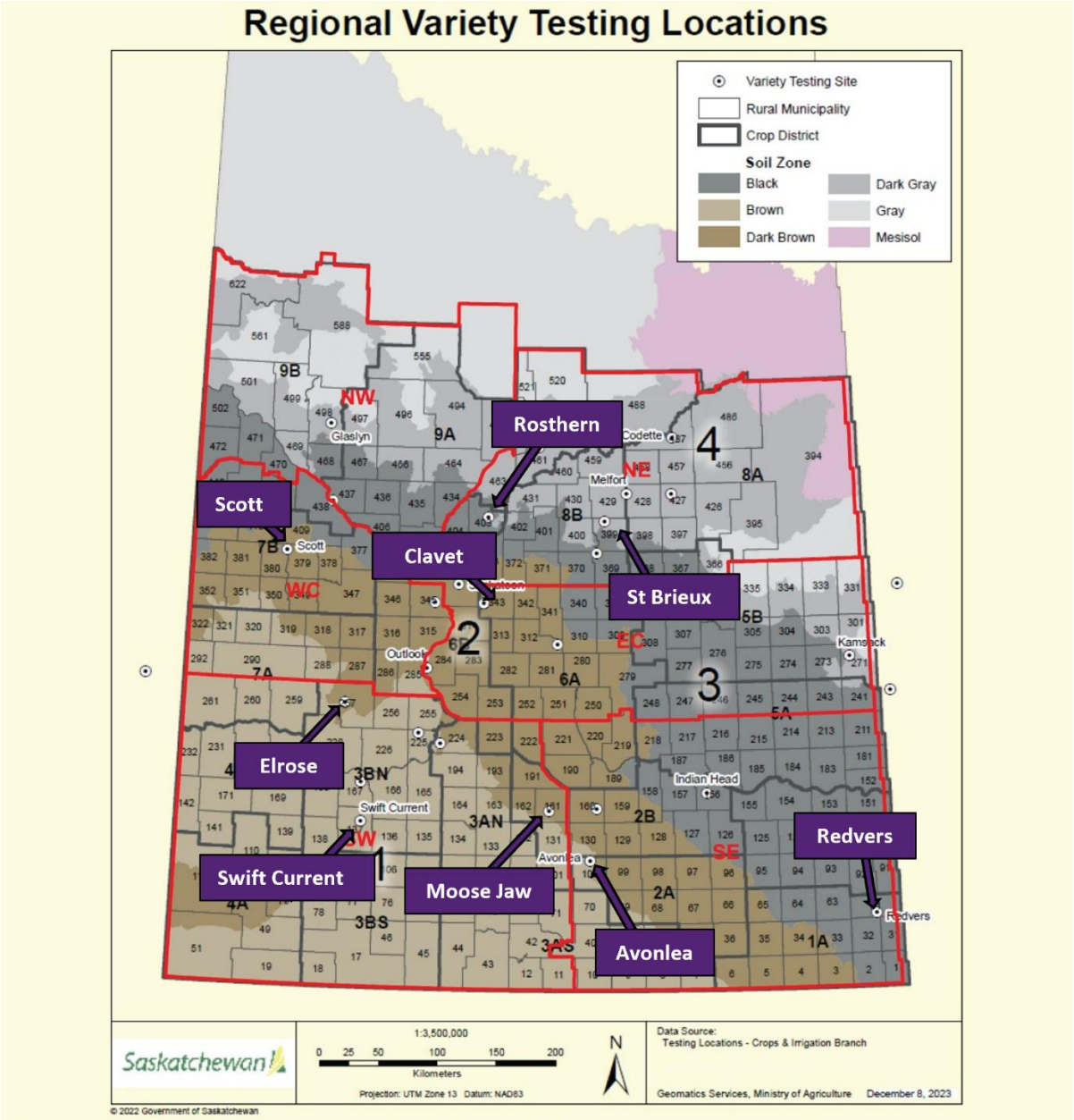

The cropland of Saskatchewan has been divided into four areas based roughly on agro-climatic conditions. Crop yields can vary from area to area. In choosing a variety, producers will want to consider the yield data in combination with marketing and agronomic factors.

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 lentil quality testing during 2022 to 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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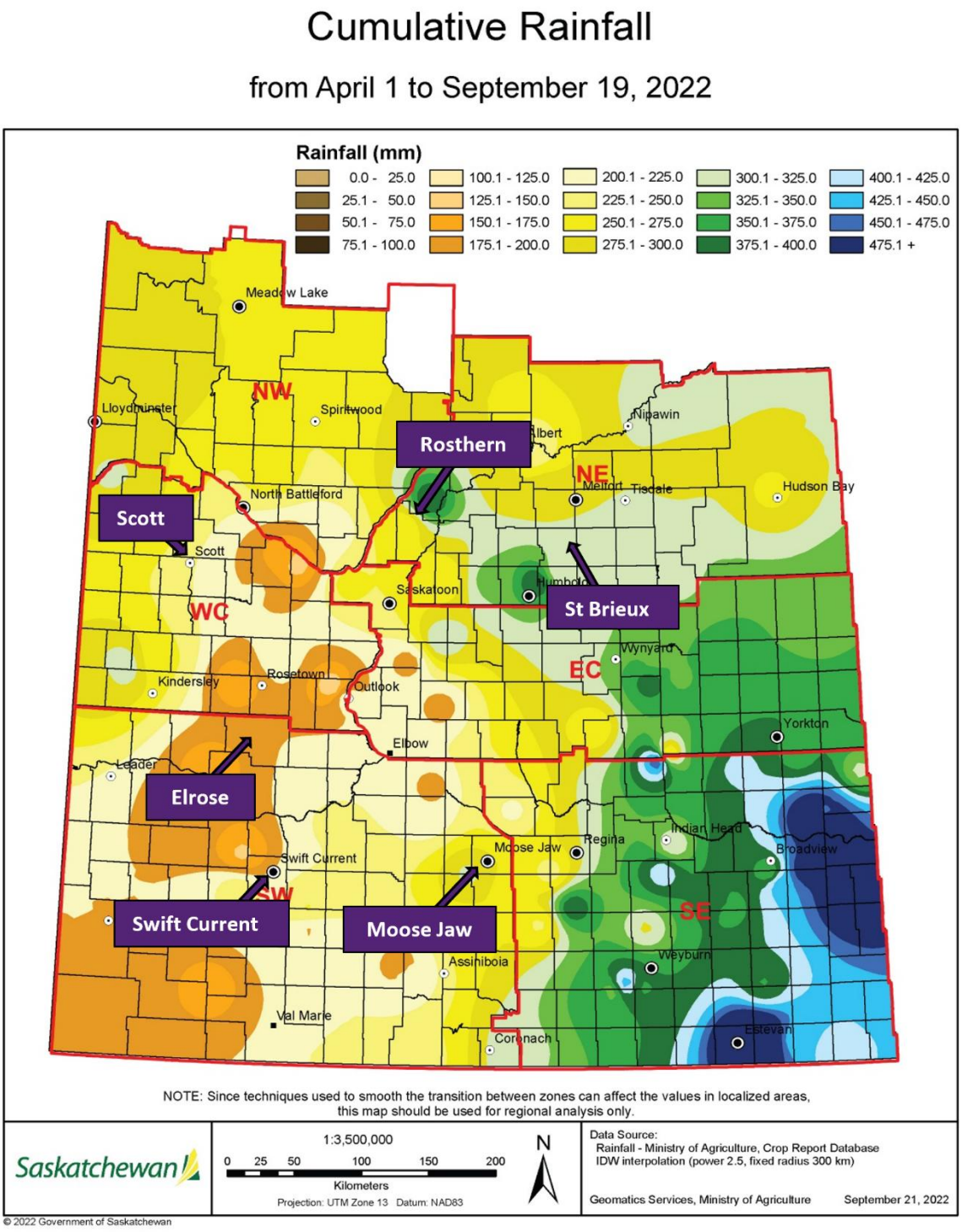

Figure B. Locations for lentil quality testing and cumulative rainfall from April 1 to September 19, 2022. Figure was modified from material provided by the Saskatchewan Ministry of Agriculture.

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Cumulative Rainfall

from April 1 to September 18, 2023

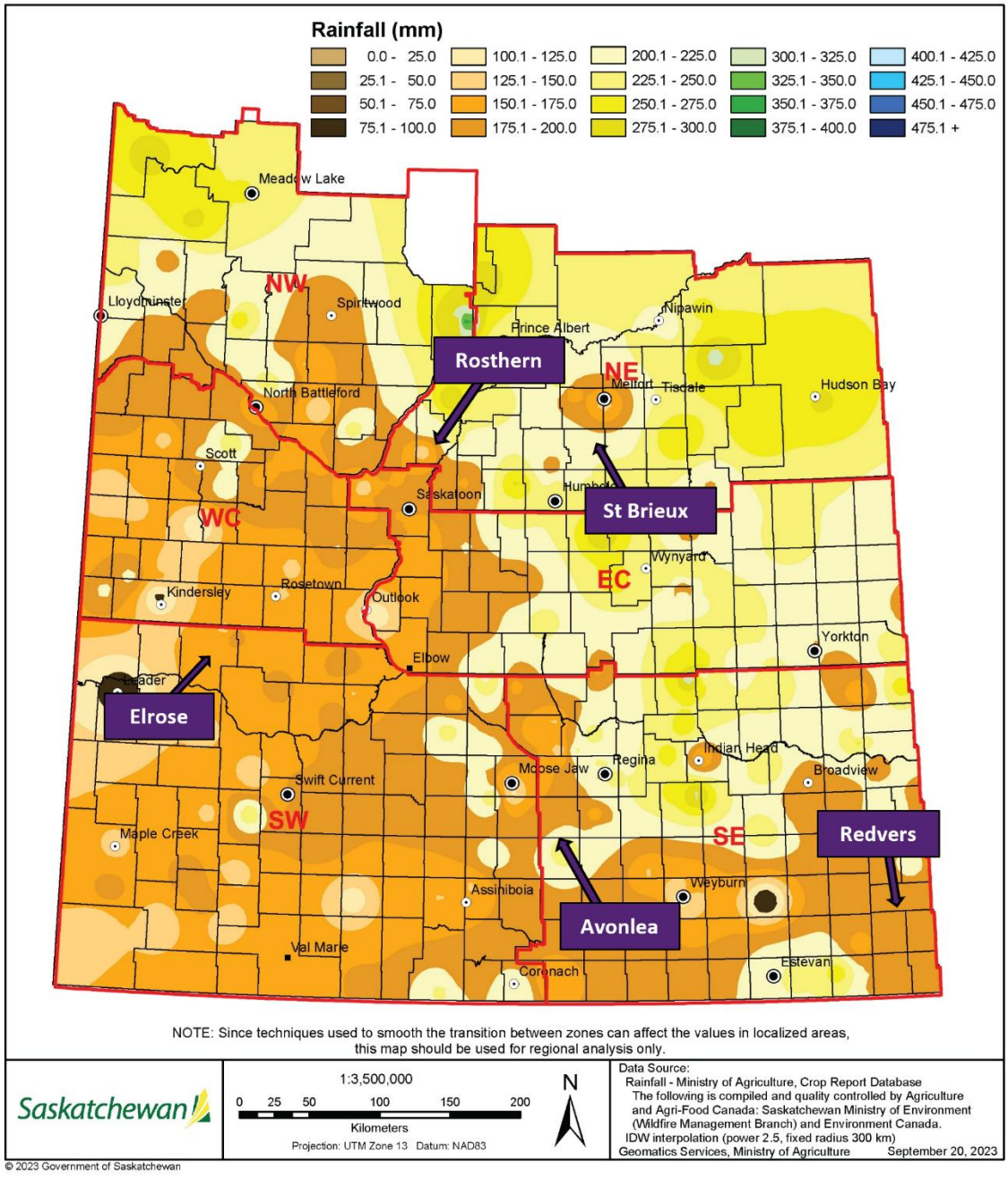

Figure C. Locations for lentil quality testing and cumulative rainfall from April 1 to September 18, 2023. Figure was modified from material provided by the Saskatchewan Ministry of Agriculture.

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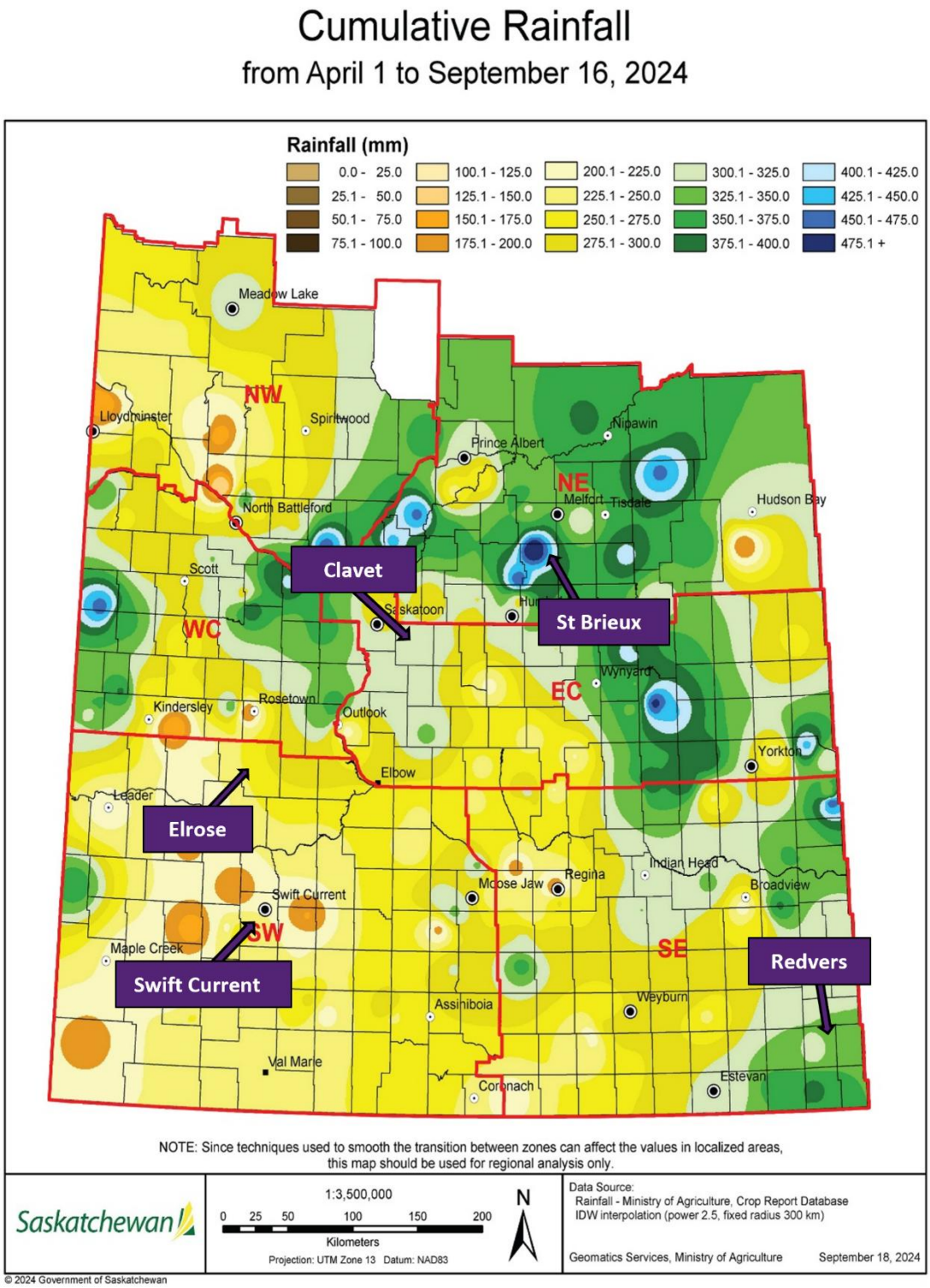

Figure D. Crop regions, locations for lentil quality testing, and cumulative rainfall from April 1 to September 16, 2024. Figure was modified from material provided by the Saskatchewan Ministry of Agriculture.

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

1. Yield
2. Thousand kernel weight (TKW)
3. Seed size distribution
4. Peeled + split + broken seeds
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 plot and a mean bar graph are first provided in each section to compare the overall yearly performance. The **Box and Whisker** plot shows the full dataset of each year, 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) are provided.

Additionally, the **mean** value of each variety over three years is provided to show the variety performance.

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 by variety and by year.

The Pearson Correlation was performed to measure the correlation between quality parameters (**Table B**).

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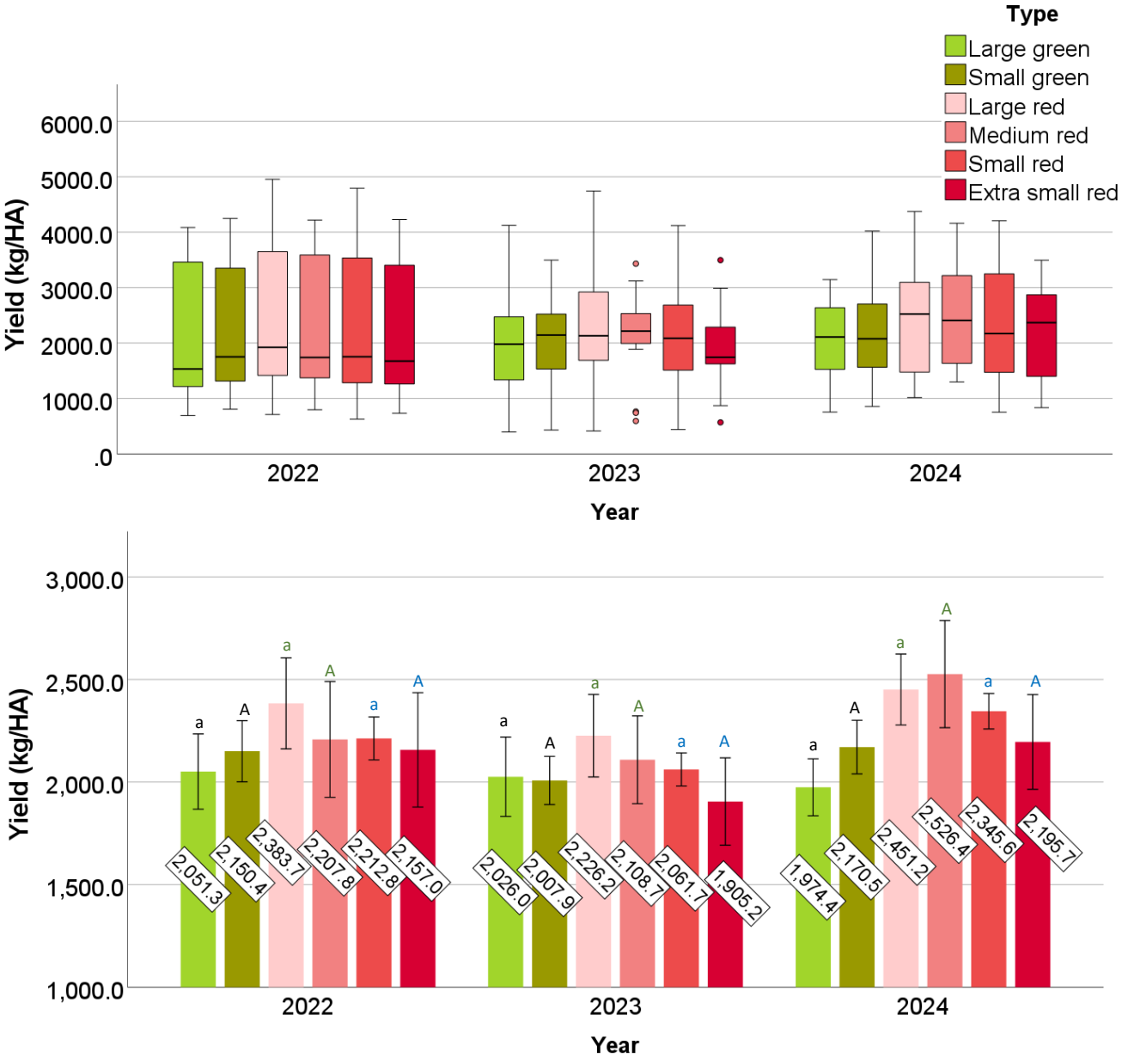
1. Yield

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

Results: Figure 1.1. Box plots (top) and mean yields (bottom) of lentils in 2022, 2023, and 2024.



- Lower variability in yield was observed among the 2024 samples.

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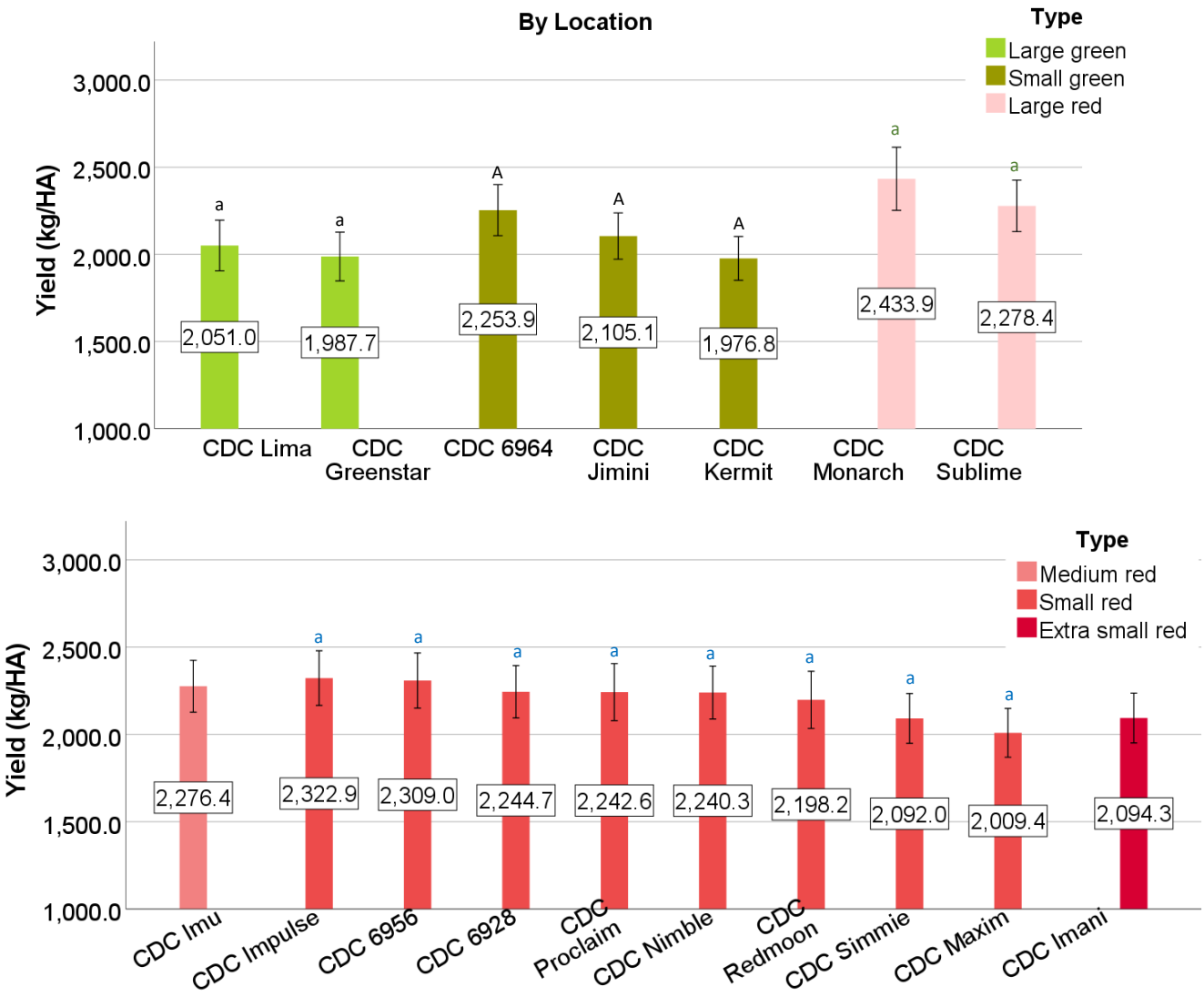
Figure 1.2. Mean yield of each lentil variety based on trials conducted from 2022 to 2024. Each bar represents mean ± one standard error.



- No significant differences in yield were observed among varieties across the three years.

Note: Small letters in black indicated significant differences (p<0.05) by large green. Capital letters in black indicated significant differences (p<0.05) by small green. Small letters in green indicated significant differences (p<0.05) by large red. Capital letters in green indicated significant differences (p<0.05) by medium red. Small letters in blue indicated significant differences (p<0.05) by small red. Capital letters in blue indicated significant differences (p<0.05) by extra small red.

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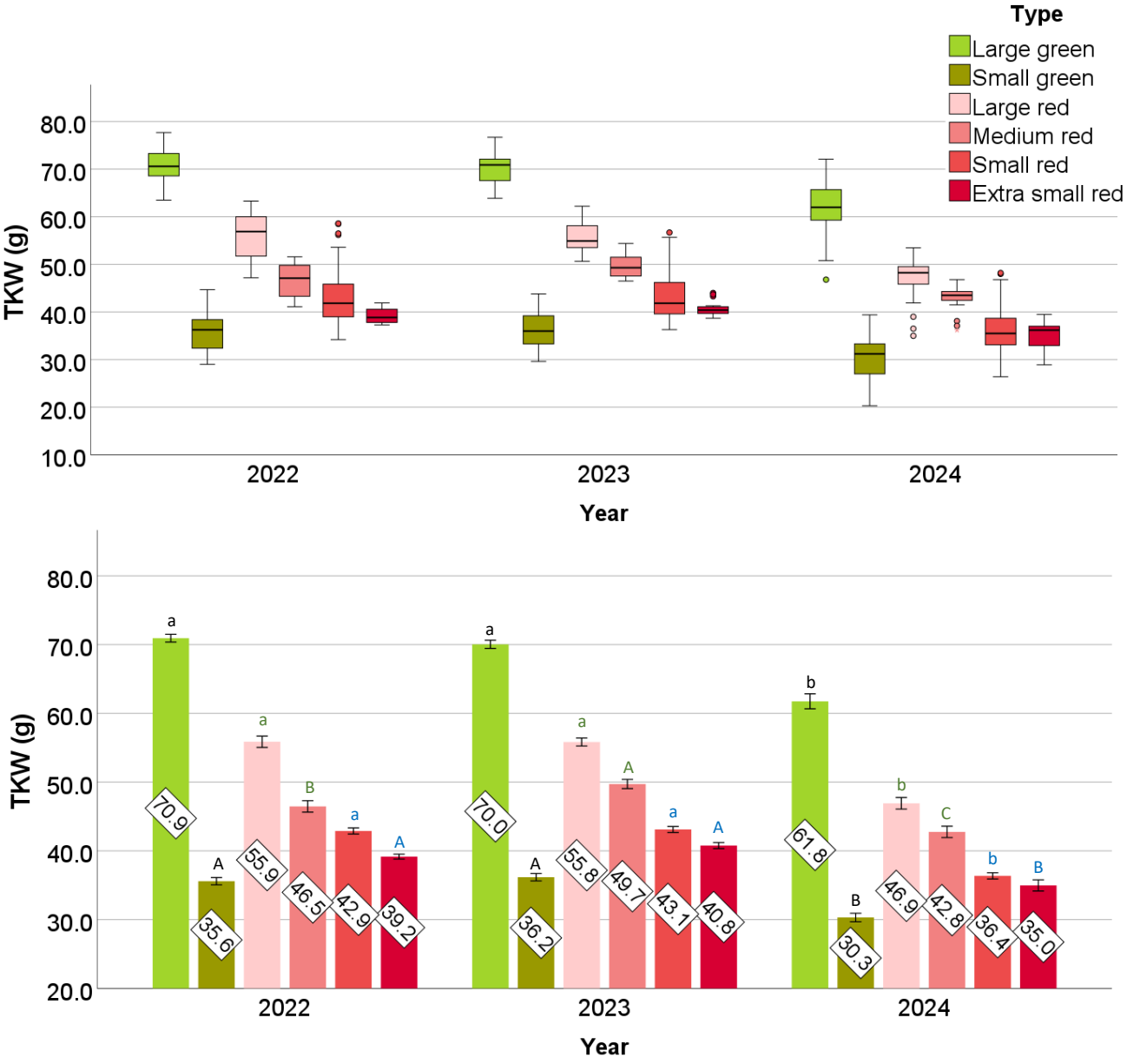
2. Thousand Kernel Weight (TKW)

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 TKW was reported.

Results: Figure 2.1. Box plots (top) and mean TKWs (bottom) of lentils in 2022, 2023, and 2024.



- The TKW in 2024 was significantly lower than in 2022 and 2023 for all lentil types.

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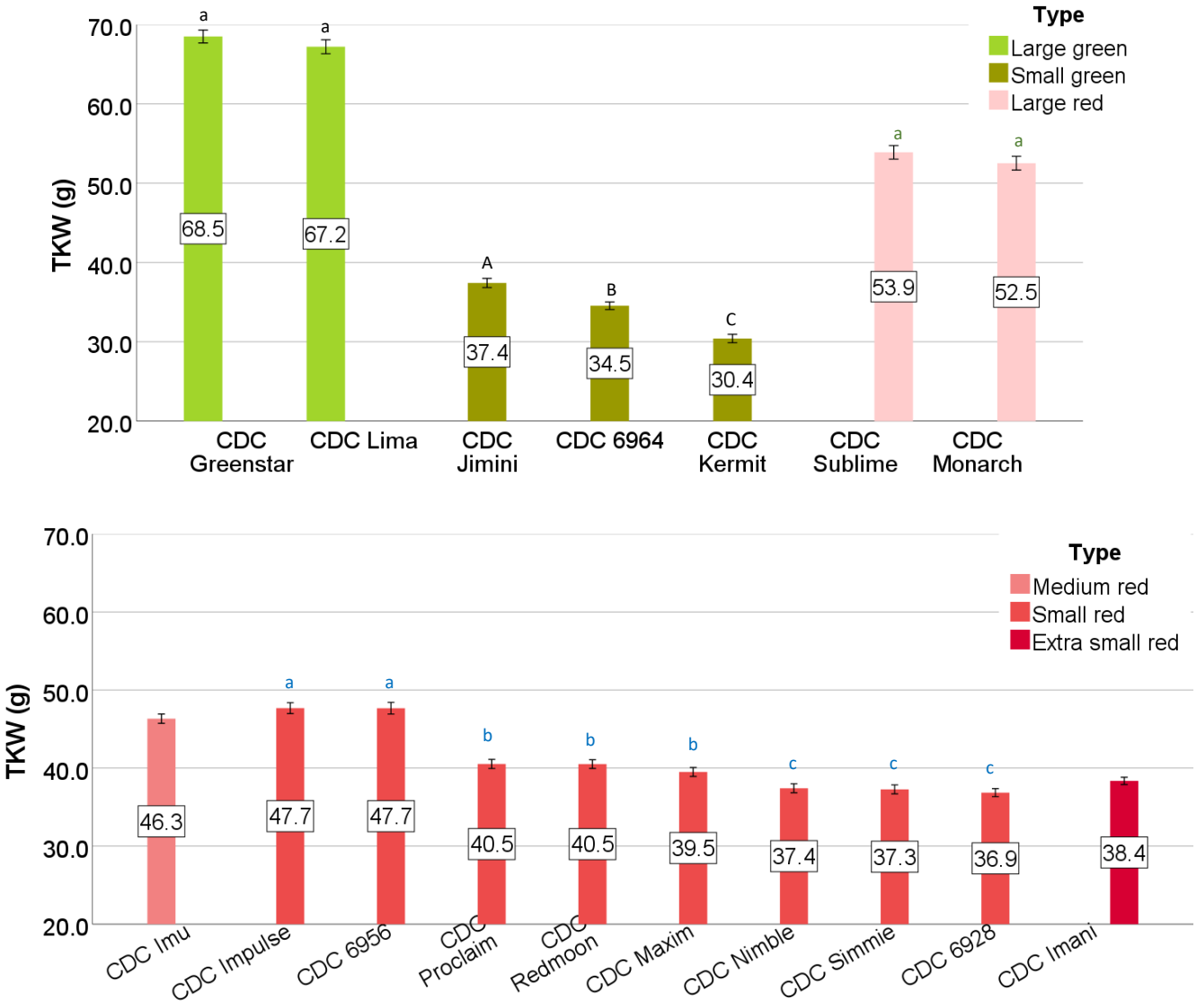
Figure 2.2. Mean TKW of each lentil variety based on trials from 2022 to 2024. Each bar represents mean ± one standard error.



- CDC Kermit (small green) had the lowest TKW among all varieites, while CDC Greenstar and CDC Lima (large green) had the highest.
- The TKWs of CDC Impulse and CDC 6956 (small red) were significantly higher than those of all other small red lentils.

Note: Small letters in black indicated significant differences (p<0.05) by large green. Capital letters in black indicated significant differences (p<0.05) by small green. Small letters in green indicated significant differences (p<0.05) by large red. Capital letters in green indicated significant differences (p<0.05) by medium red. Small letters in blue indicated significant differences (p<0.05) by small red. Capital letters in blue indicated significant differences (p<0.05) by extra small red.

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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 lentils:

a. #18R: 7.14 mm
b. #16R: 6.35 mm
c. #14R: 5.56 mm
d. #12R: 4.76 mm
e. #10R: 3.97 mm

Results: Table 3.1. Seed size distribution (%) of each lentil variety based on trials from 2022 to 2024. Data represent mean ± one standard deviation.

Type	Variety	> 7.14 mm (%)	> 6.35 mm (%)	> 5.56 mm (%)	> 4.76 mm (%)	> 3.97 mm (%)	Below 3.97 mm (%)
Large green	CDC Greenstar	2.2 ± 2.1^{a}	60.5 ± 13.7^{a}	31.4 ± 11.7^{b}	4.1 ± 3.4^{b}	1.2 ± 0.9^{a}	1.3 ± 1.9^{a}
	CDC Lima	0.1 ± 0.2^{b}	36.9 ± 11.4^{b}	53.7 ± 8.0^{a}	7.2 ± 4.6^{a}	1.0 ± 0.8^{a}	1.1 ± 1.0^{a}
Small green	CDC Jimini	0.0 ± 0.0	0.0 ± 0.0^{A}	0.2 ± 0.2^{A}	43.9 ± 14.7^{A}	52.5 ± 13.1^{B}	3.4 ± 2.5^{B}
	CDC 6964	0.0 ± 0.0	0.0 ± 0.0^{A}	0.1 ± 0.2^{AB}	41.7 ± 15.7^{A}	54.8 ± 13.9^{B}	3.4 ± 2.7^{B}
	CDC Kermit	0.0 ± 0.0	0.0 ± 0.0^{A}	0.0 ± 0.1^{B}	11.7 ± 7.4^{B}	76.7 ± 7.0^{A}	11.6 ± 8.9^{A}
Large red	CDC Sublime	0.0 ± 0.0^{a}	2.8 ± 2.0^{a}	63.9 ± 11.6^{a}	29.9 ± 11.4^{b}	2.4 ± 2.0^{a}	1.0 ± 1.0^{a}
	CDC Monarch	0.0 ± 0.0^{a}	0.4 ± 0.7^{b}	52.6 ± 16.5^{b}	42.8 ± 14.7^{a}	3.1 ± 3.3^{a}	1.0 ± 0.9^{a}
M red	CDC Imu	0.0 ± 0.0	0.0 ± 0.0	10.9 ± 6.1	72.2 ± 4.9	15.5 ± 8.1	1.3 ± 0.9
Small red	CDC Impulse	0.0 ± 0.0	0.2 ± 0.3^{a}	40.4 ± 14.2^{a}	53.1 ± 11.5^{c}	5.4 ± 4.2^{d}	0.9 ± 0.6^{d}
	CDC 6956	0.0 ± 0.0	0.0 ± 0.0^{b}	11.4 ± 6.6^{b}	73.5 ± 7.3^{a}	13.3 ± 8.2^{c}	1.3 ± 0.9^{d}
	CDC Proclaim	0.0 ± 0.0	0.0 ± 0.0^{b}	1.1 ± 1.2^{c}	71.1 ± 15.2^{ab}	26.3 ± 14.9^{b}	1.5 ± 1.3^{cd}
	CDC Maxim	0.0 ± 0.0	0.0 ± 0.0^{b}	2.6 ± 2.4^{c}	66.1 ± 13.1^{b}	29.6 ± 14.1^{b}	1.7 ± 1.4^{bcd}
	CDC Simmie	0.0 ± 0.0	0.0 ± 0.0^{b}	0.8 ± 1.0^{c}	56.8 ± 18.0^{c}	39.9 ± 17.1^{a}	2.5 ± 2.5^{ab}
	CDC 6928	0.0 ± 0.0	0.0 ± 0.0^{b}	1.5 ± 1.5^{c}	54.5 ± 13.9^{c}	41.0 ± 13.6^{a}	3.0 ± 1.8^{a}
	CDC Redmoon	0.0 ± 0.0	0.0 ± 0.0^{b}	0.6 ± 0.8^{c}	54.3 ± 15.2^{c}	42.7 ± 14.8^{a}	2.4 ± 1.6^{abc}
	CDC Nimble	0.0 ± 0.0	0.0 ± 0.0^{b}	0.4 ± 0.5^{c}	52.2 ± 17.6^{c}	44.4 ± 16.7^{a}	3.0 ± 2.1^{a}
XS red	CDC Imani	0.0 ± 0.0	0.0 ± 0.0	0.3 ± 0.7	50.1 ± 14.0	47.2 ± 13.2	2.4±1.5

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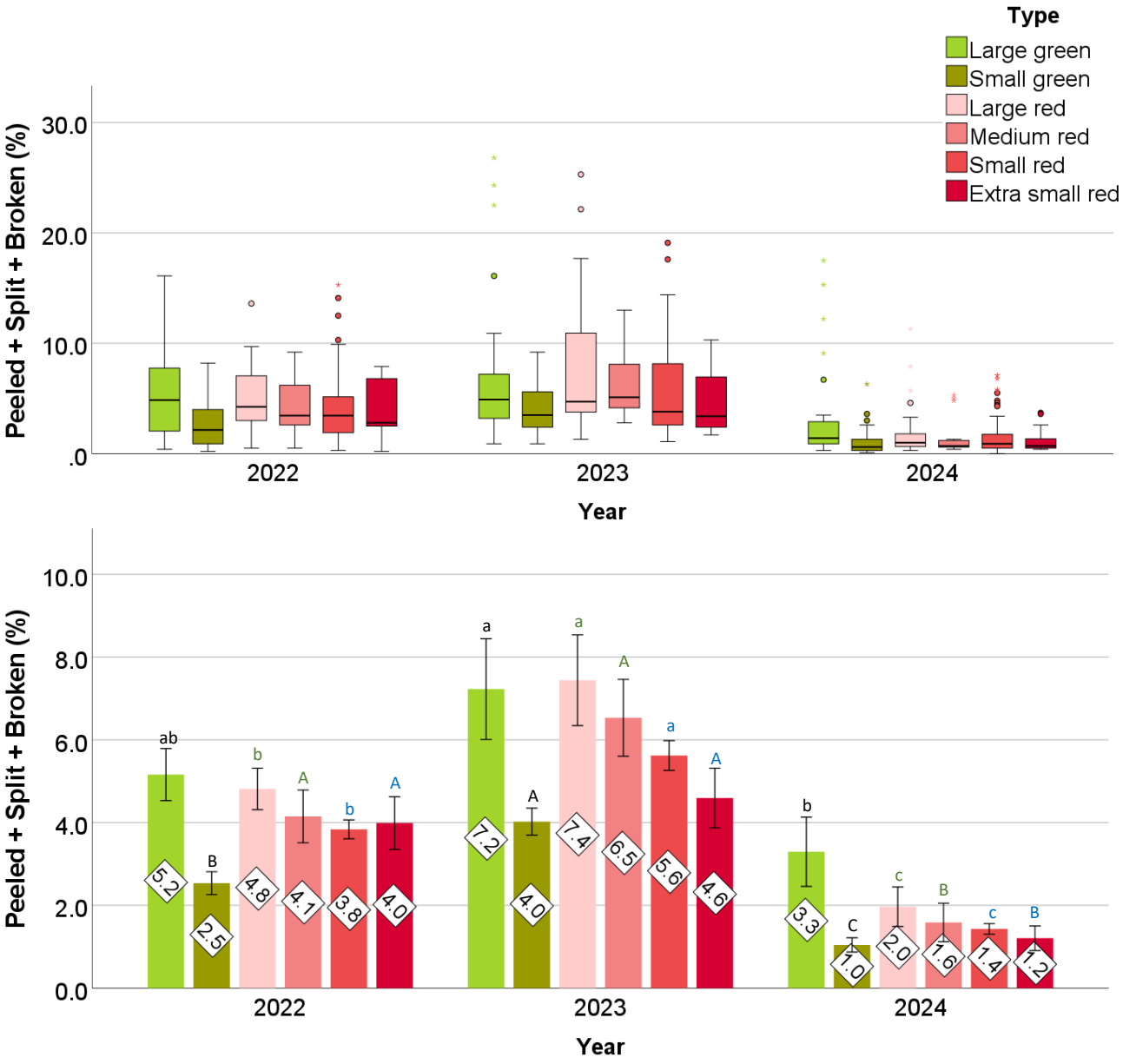
4. Split

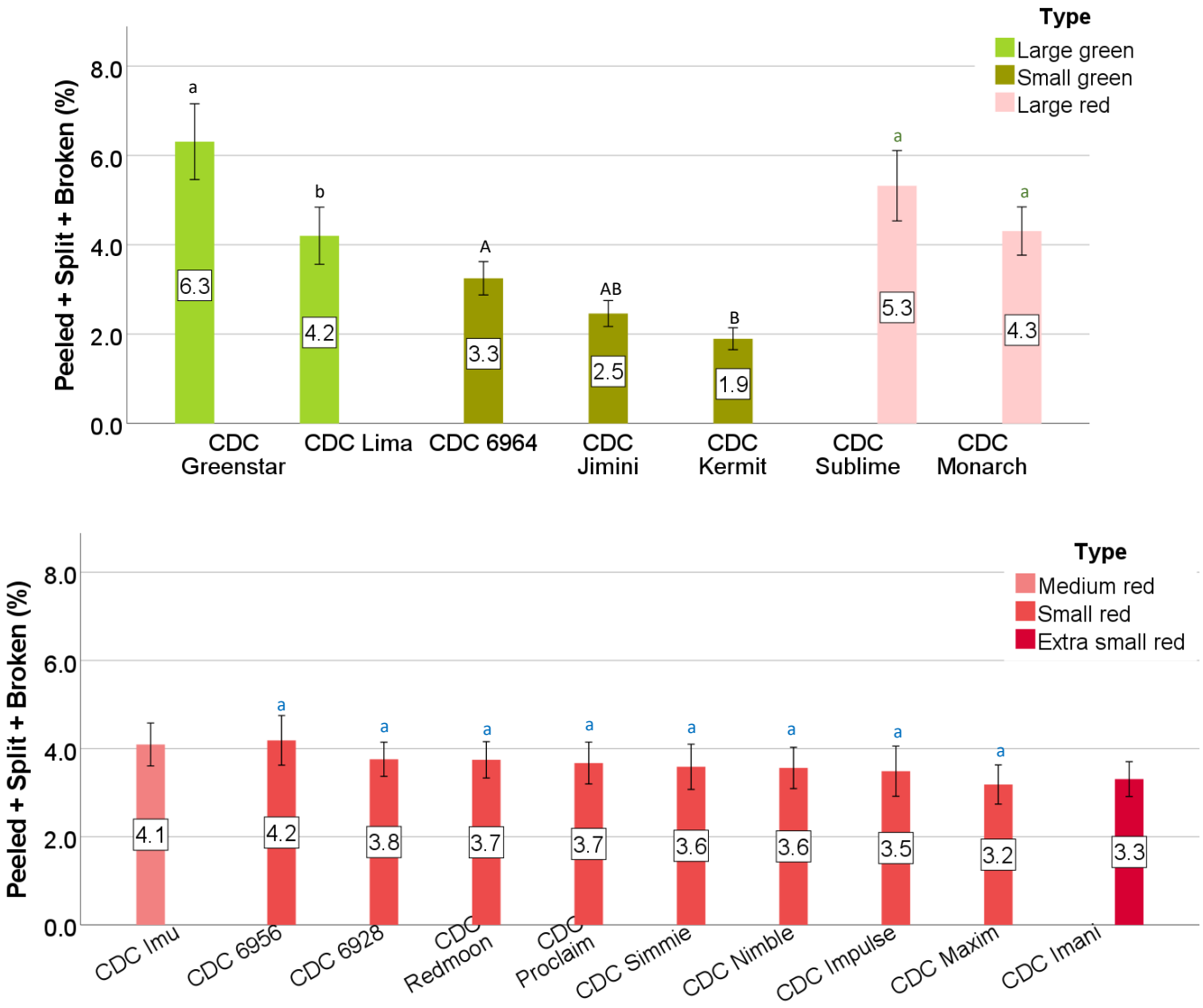
Method: 50 grams of each sample was used for evaluation, and damaged seeds were selected by hand. Results included splits, cracks, seed coat damage, partially missing hull, and partially missing cotyledon.

Results: Figure 4.1. Box plots (top) and mean (bottom) splits of lentils in 2022, 2023, and 2024.



- Overall, few splits were observed in lentils in 2024.
- Outliers and extreme outliers were observed in all years.

Figure 4.2. Mean split of each lentil variety based on trials from 2022 to 2024. Each bar represents mean ± one standard error.



- Split was found to be positively correlated with TKW (r=0.34; p<0.01) (**Table B**).

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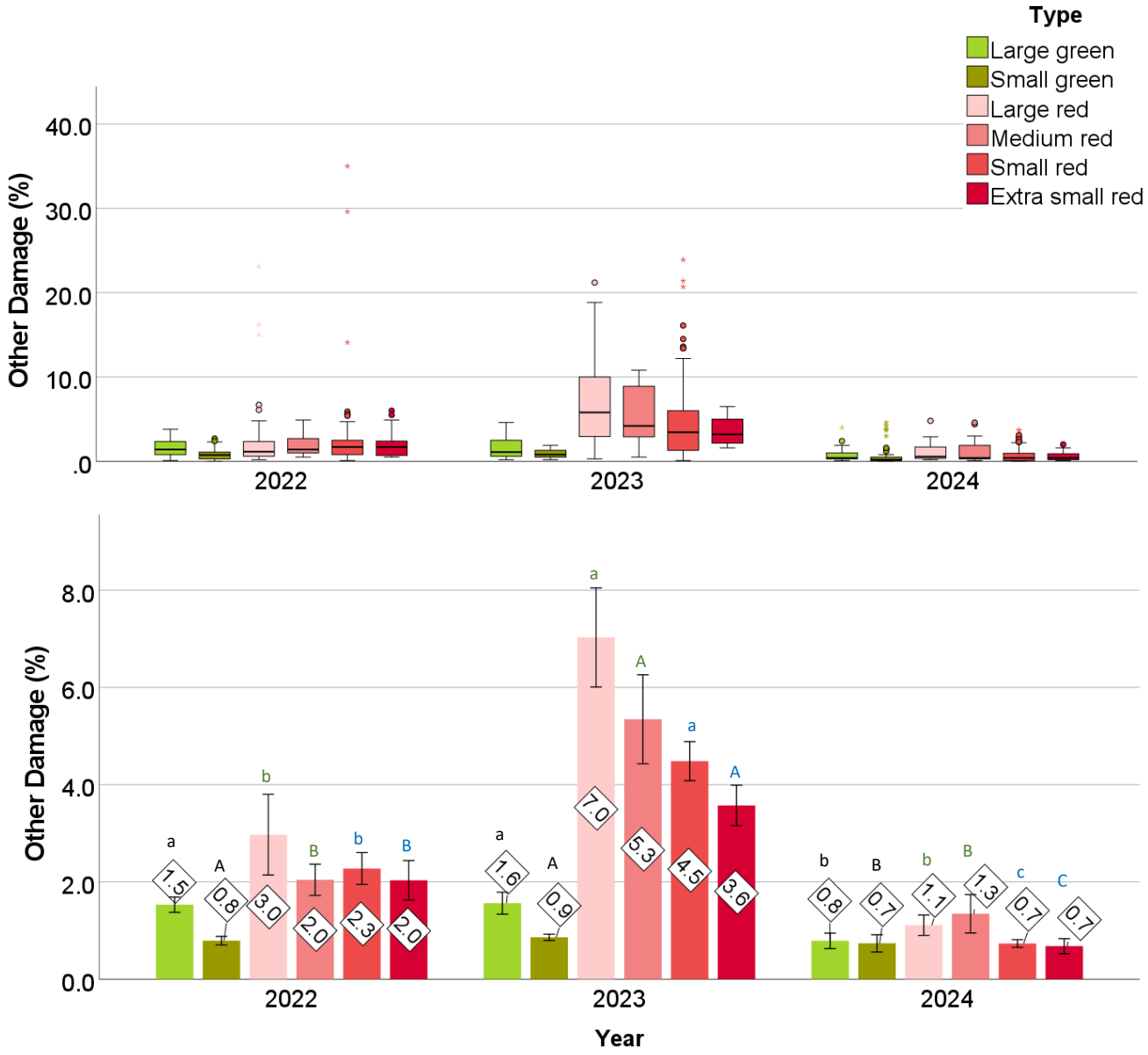
5. Other Damage

Method: 50 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 plots (top) and mean other damage (bottom) of lentils in 2022, 2023, and 2024.



- Other damage in red lentils was significantly higher in 2023. More details can be found in the 2023 Pulse Quality Evaluation – Lentil report.

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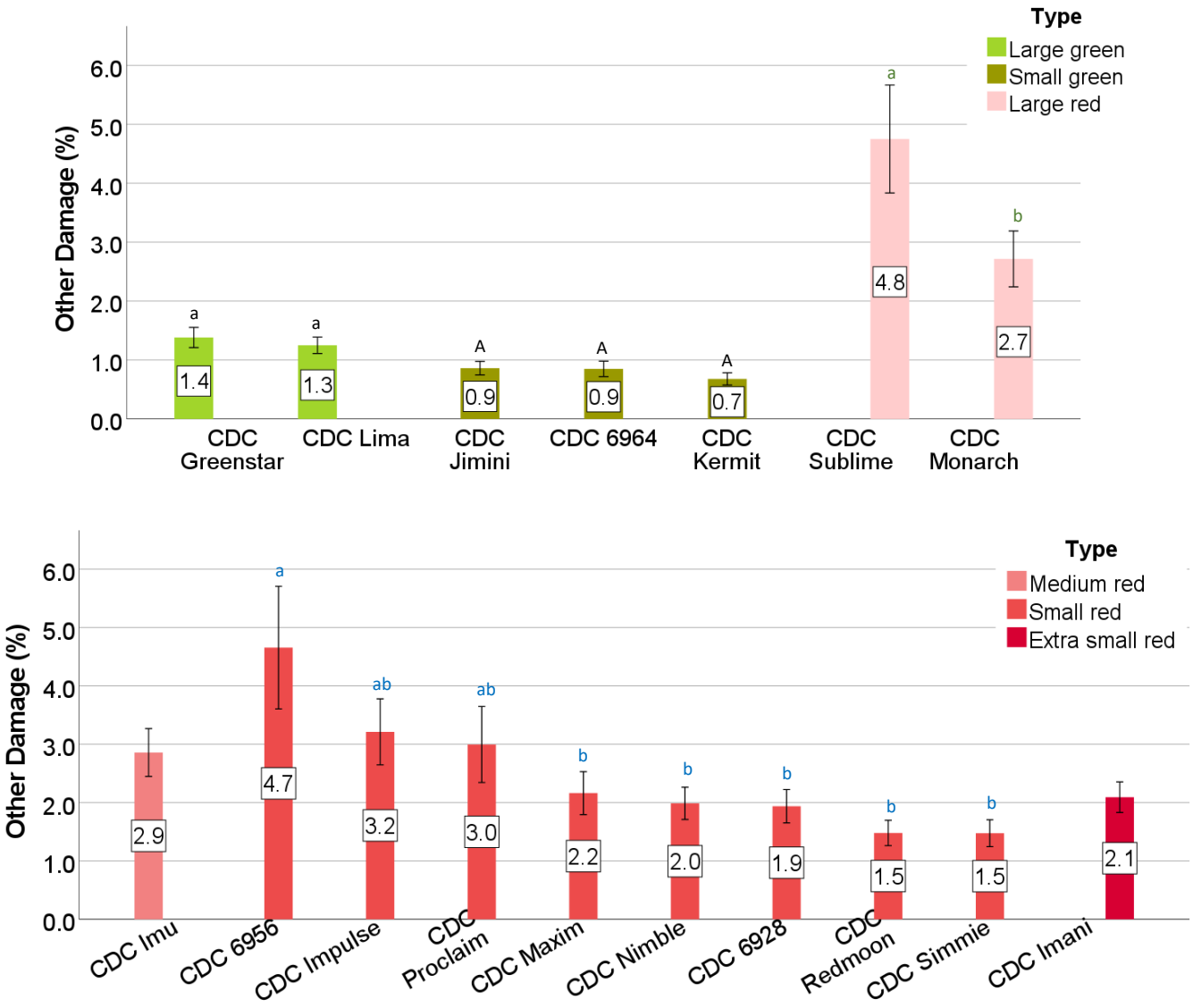
Figure 5.2. Mean other damage of each lentil variety based on trials from 2022 to 2024. Each bar represents mean ± one standard error.



- Red lentils had a higher level of other damage due to wrinkles (data not shown); it is positively correlated with TKW (r=0.20; p<0.01),

Note: Small letters in black indicated significant differences (p<0.05) by large green. Capital letters in black indicated significant differences (p<0.05) by small green. Small letters in green indicated significant differences (p<0.05) by large red. Capital letters in green indicated significant differences (p<0.05) by medium red. Small letters in blue indicated significant differences (p<0.05) by small red. Capital letters in blue indicated significant differences (p<0.05) by extra small red.

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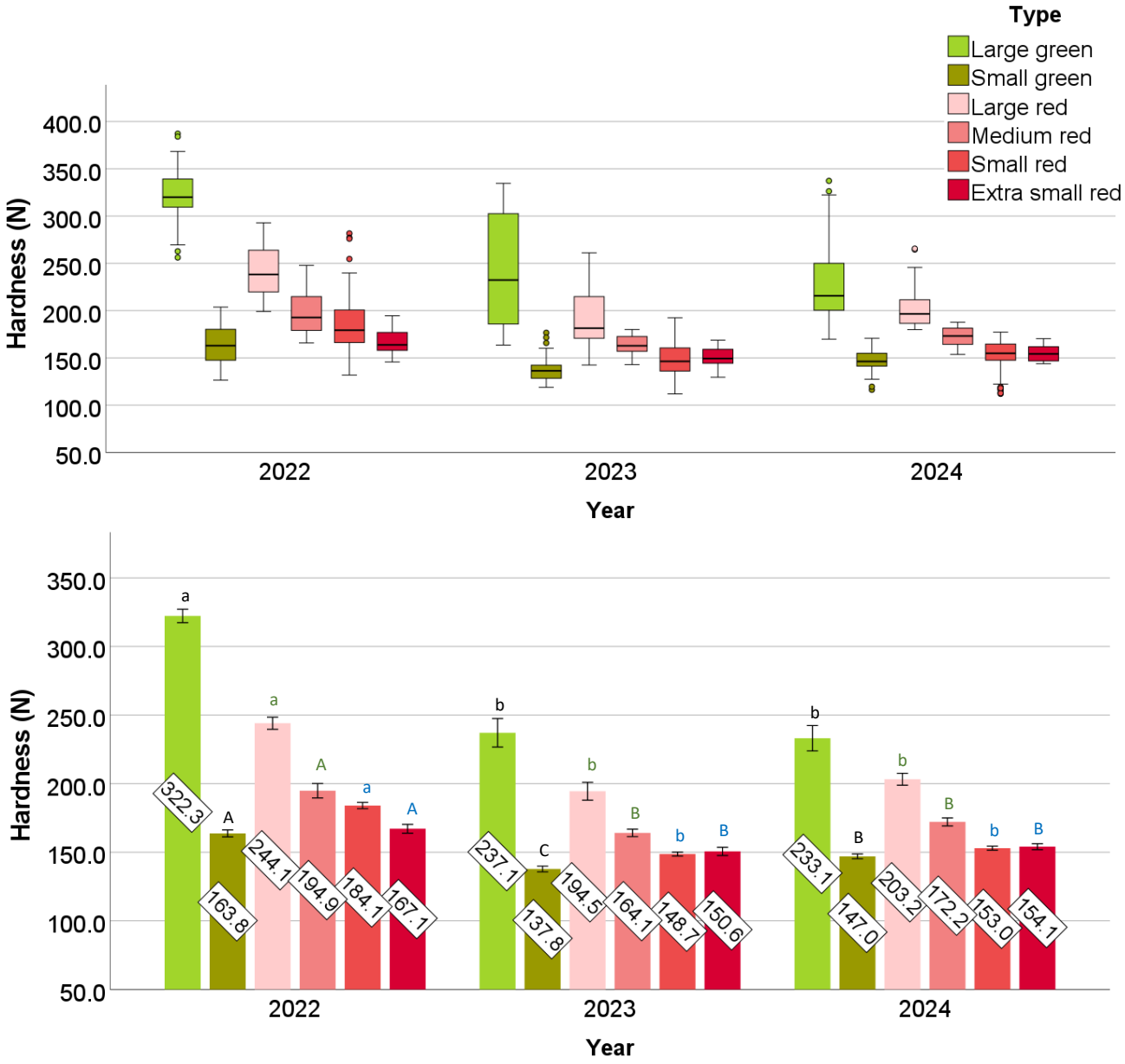
6. Hardness of Whole Seed

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 mean peak force (N) of 10 seeds was reported.

Results: Figure 6.1. Box plots (top) and mean hardness (bottom) of lentils in 2022, 2023, and 2024.



- Hardness in 2022 was higher, but hardness in 2023 and 2024 was similar.

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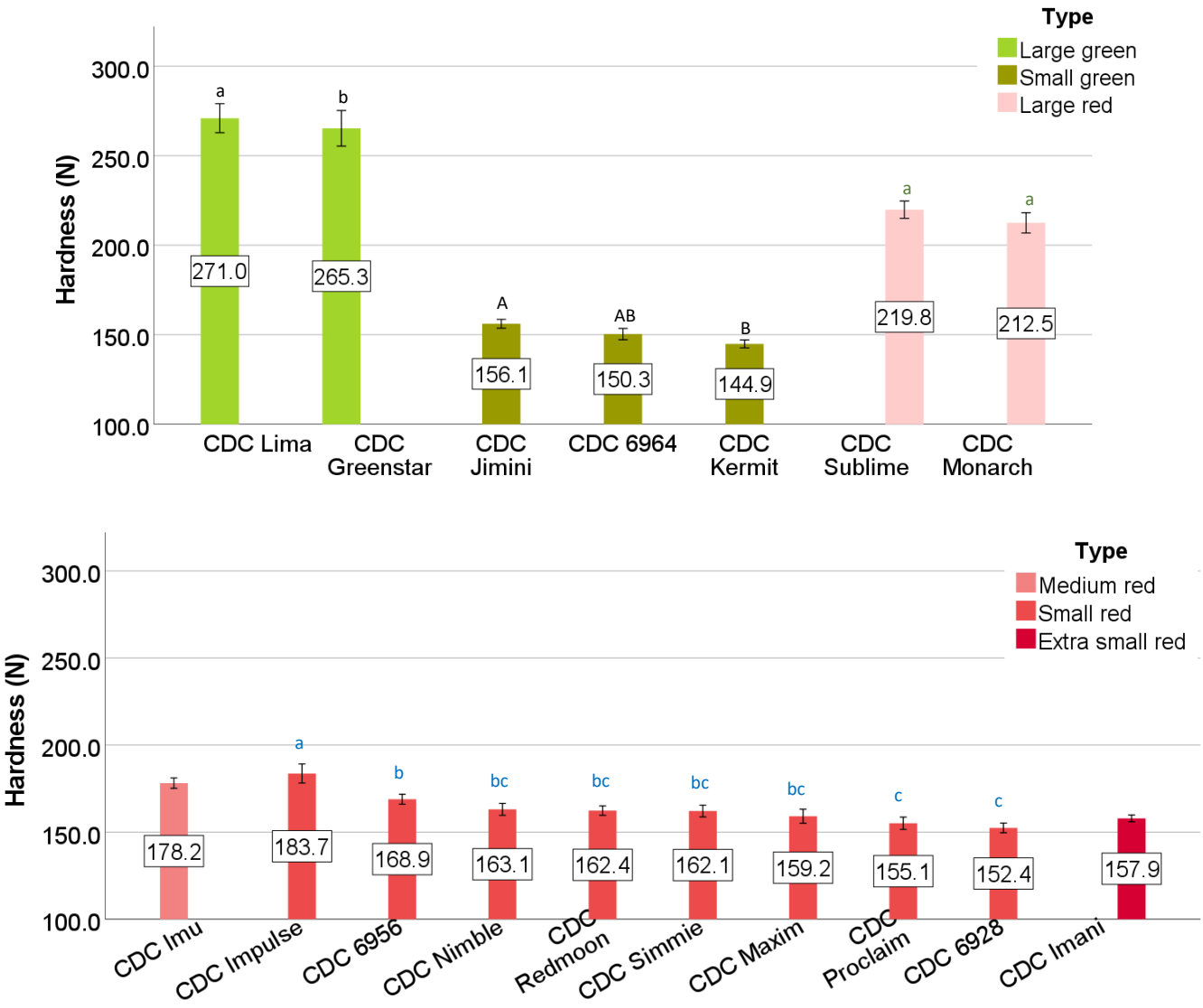
Figure 6.2. Mean hardness of each lentil variety based on trials from 2022 to 2024. Each bar represents mean ± one standard error.



- Hardness was positively correlated with TKW (r=0.76; p<0.01) (**Table B**).

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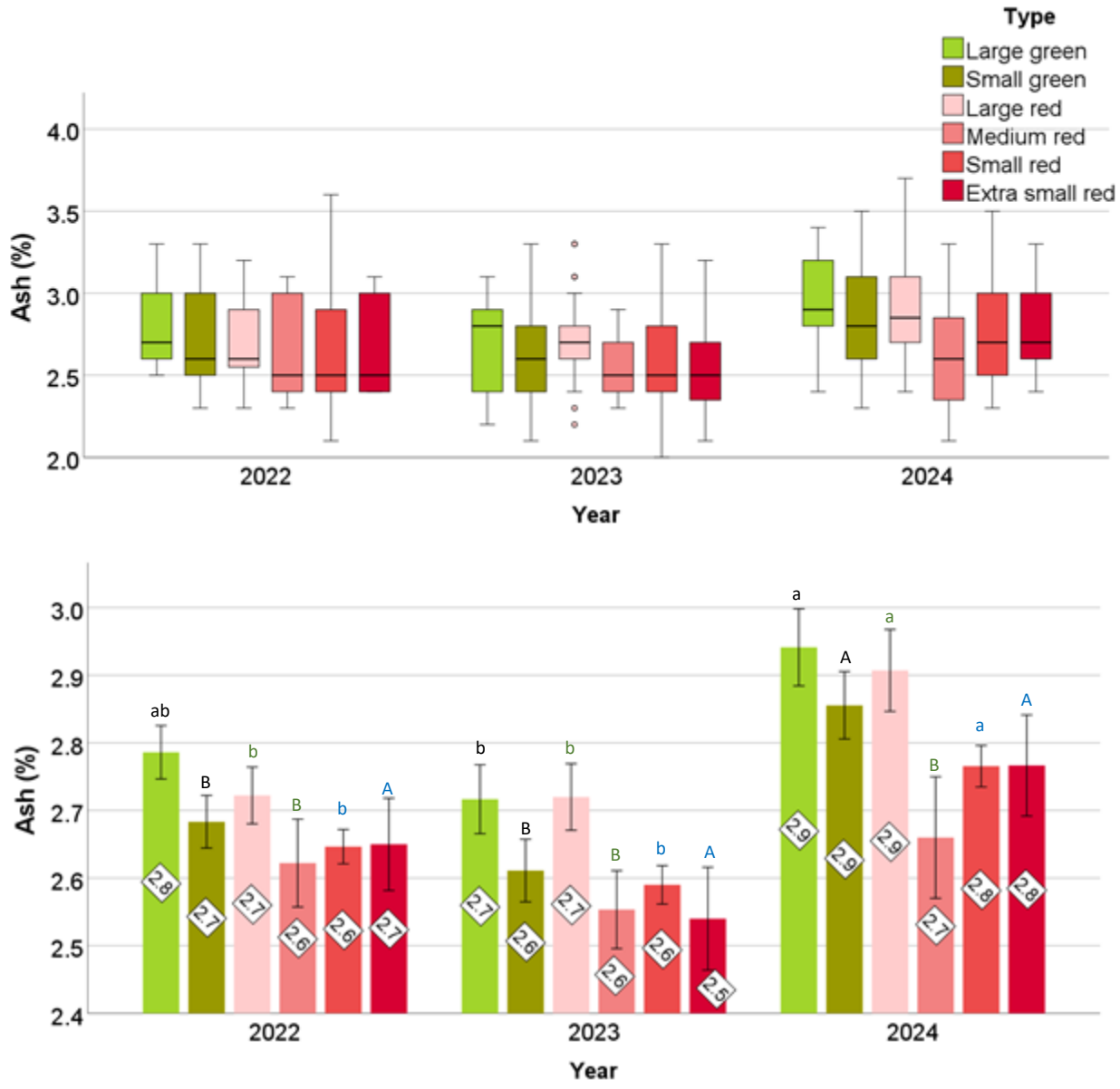
7. Ash Content

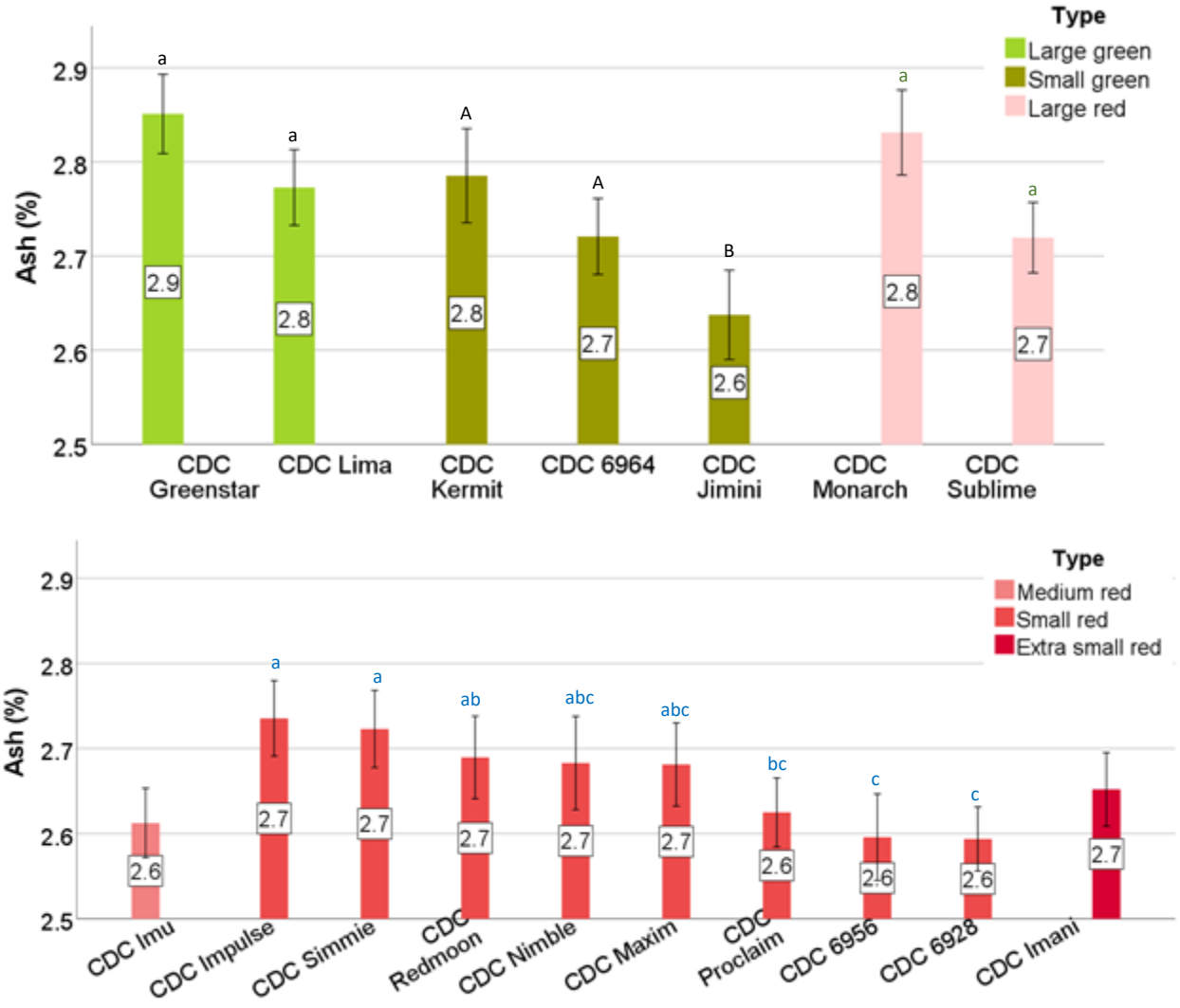
Method: Ash content (%) was determined using AACC 08-01.01[1] with modification. Samples were heated at 560°C till they turned white. Duplicated measurements were performed for each sample, and the average was reported on a dry basis (d.b.).

Results: Figure 7.1. Box plots (top) and mean ash contents (bottom) of lentils in 2022, 2023, and 2024.



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

Figure 7.2. Mean ash content of each lentil variety based on trials from 2022 to 2024. Each bar represents mean ± one standard error.



- The ash content in 2024 was significantly higher than in 2022 and 2023.

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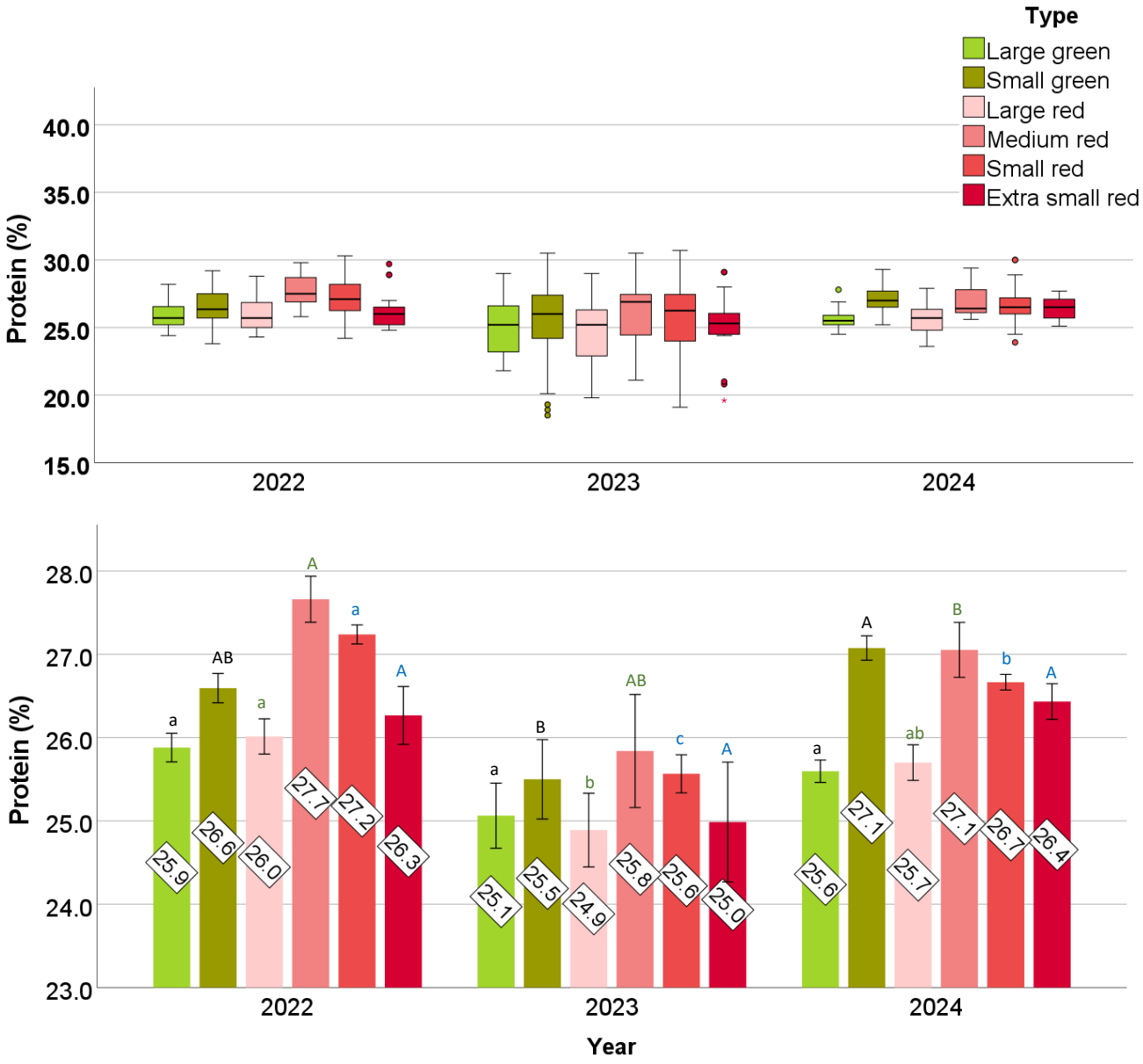
8. Protein Content

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 plots (top) and mean proteins (bottom) of lentils in 2022, 2023 and 2024.



[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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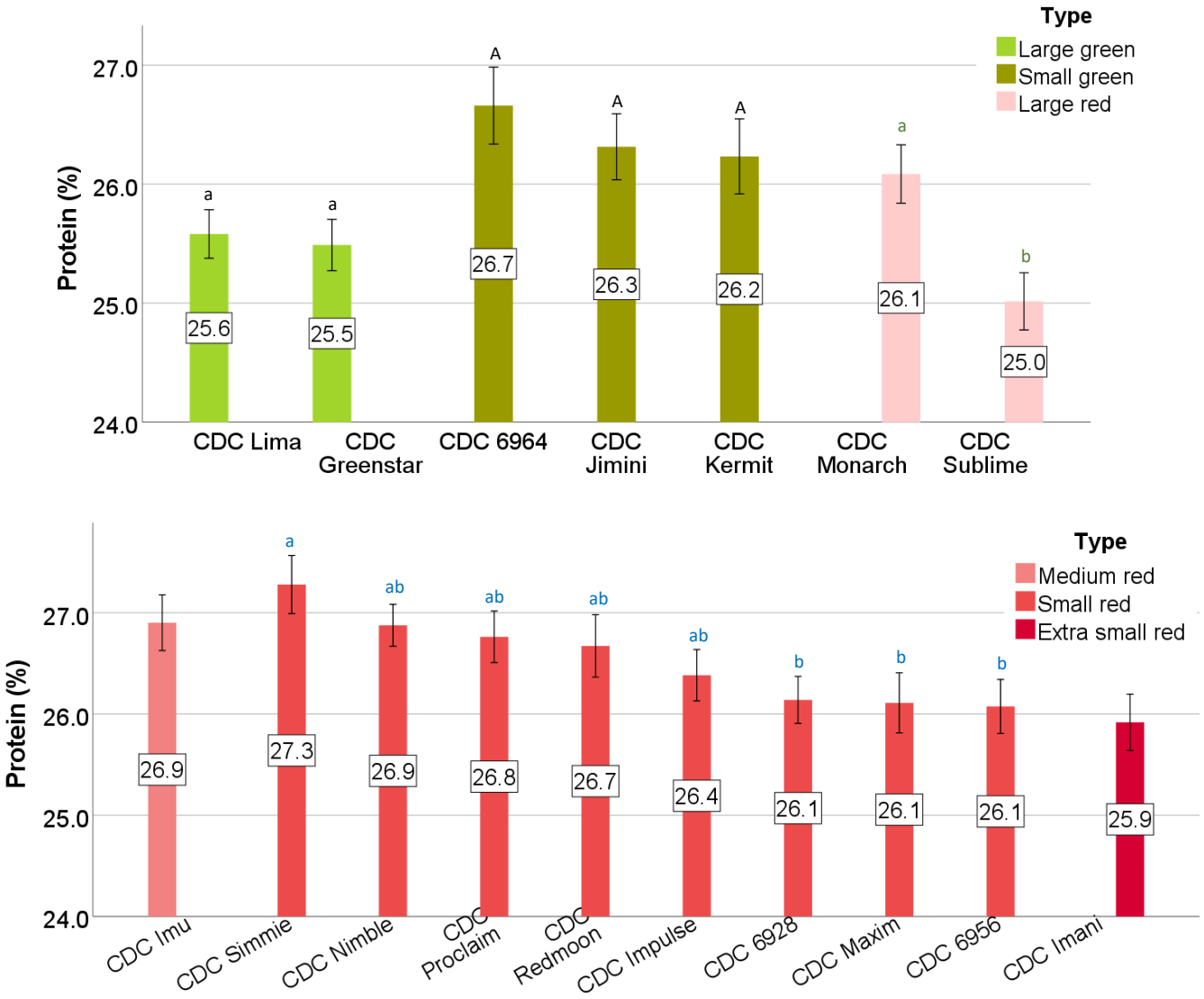
Figure 8.2. Mean protein content of each lentil variety based on trials from 2022 to 2024. Each bar represents mean ± one standard error.



- Larger variability in protein was observed in the 2023 lentils.
- Protein was negatively correlated with other damage (r=-0.16; p<0.01) and yield (r=-0.21; p<0.01) (**Table B**).

Note: Small letters in black indicated significant differences (p<0.05) by large green. Capital letters in black indicated significant differences (p<0.05) by small green. Small letters in green indicated significant differences (p<0.05) by large red. Capital letters in green indicated significant differences (p<0.05) by medium red. Small letters in blue indicated significant differences (p<0.05) by small red. Capital letters in blue indicated significant differences (p<0.05) by extra small red.

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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 plots (top) and mean protein productivity (bottom) of lentils in 2022, 2023 and 2024.

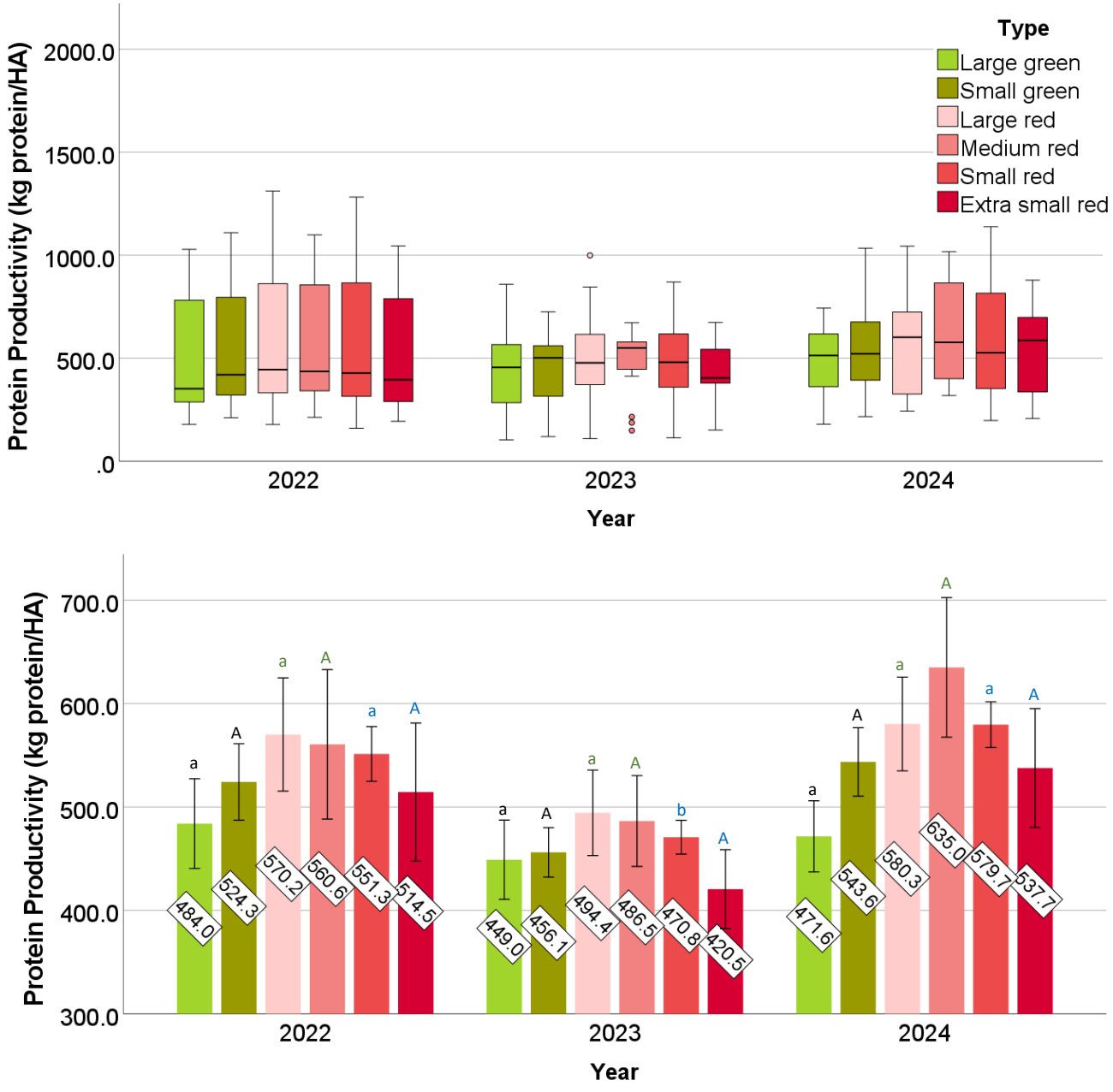

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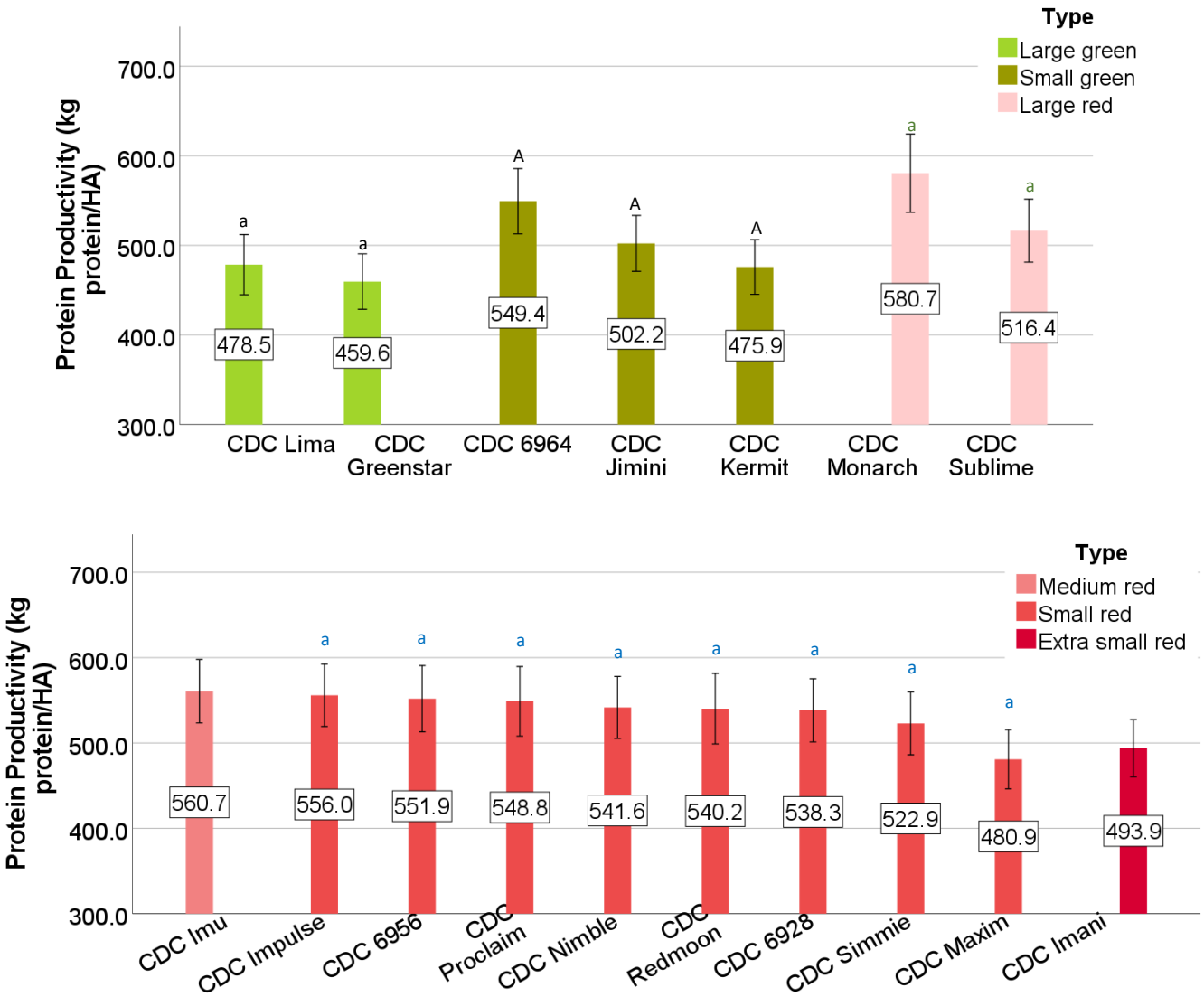
Figure 9.2. Mean protein productivity of each lentil variety based on trials from 2022 to 2024. Each bar represents mean ± one standard error.



- Protein productivity was positively correlated with yield (r=0.98; p<0.01) (**Table B**).

Note: Small letters in black indicated significant differences (p<0.05) by large green. Capital letters in black indicated significant differences (p<0.05) by small green. Small letters in green indicated significant differences (p<0.05) by large red. Capital letters in green indicated significant differences (p<0.05) by medium red. Small letters in blue indicated significant differences (p<0.05) by small red. Capital letters in blue indicated significant differences (p<0.05) by extra small red.

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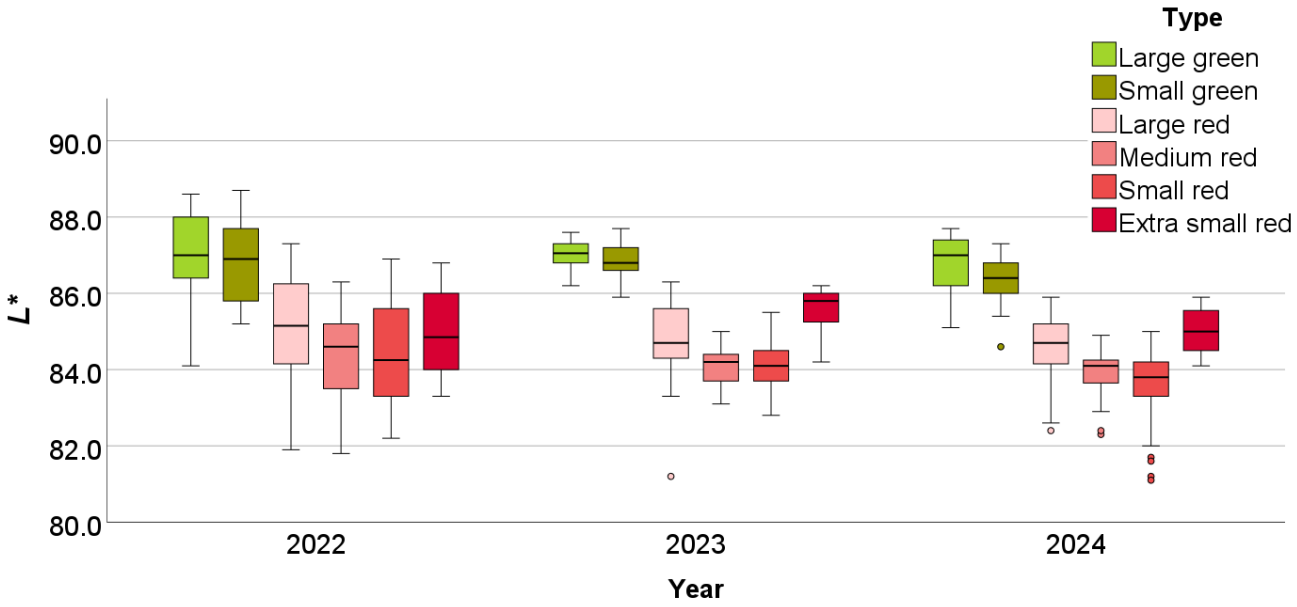
10. Colour

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.

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

Results: Figure 10.1. Box plots (top) and mean *L** (bottom) of lentils in 2022, 2023, and 2024.



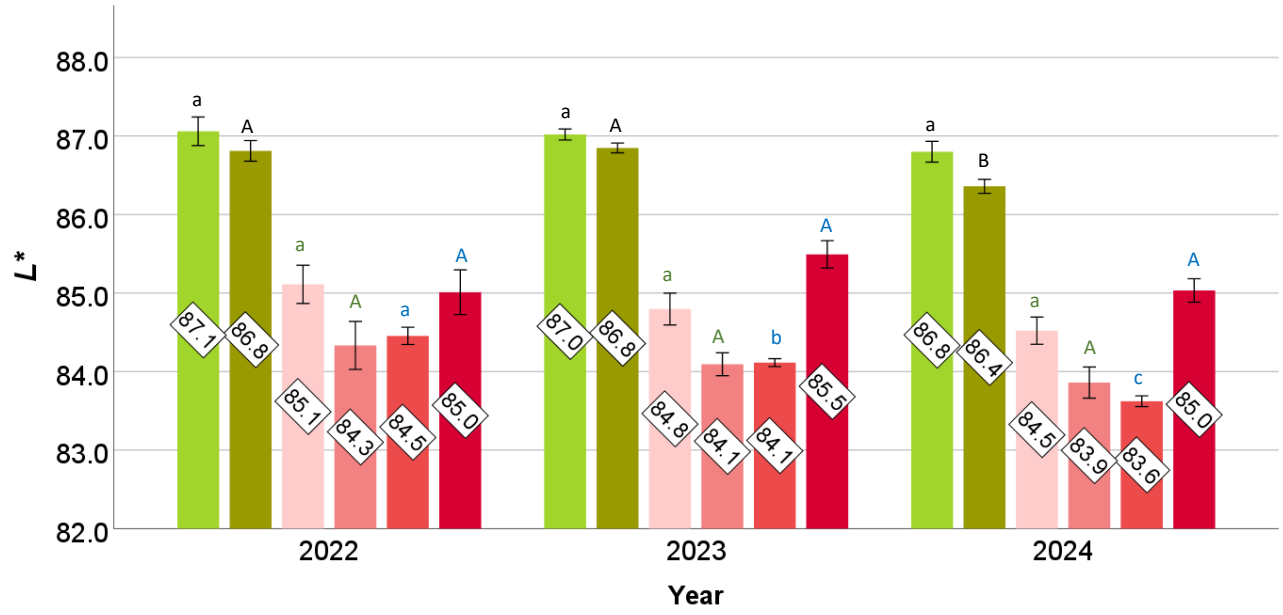


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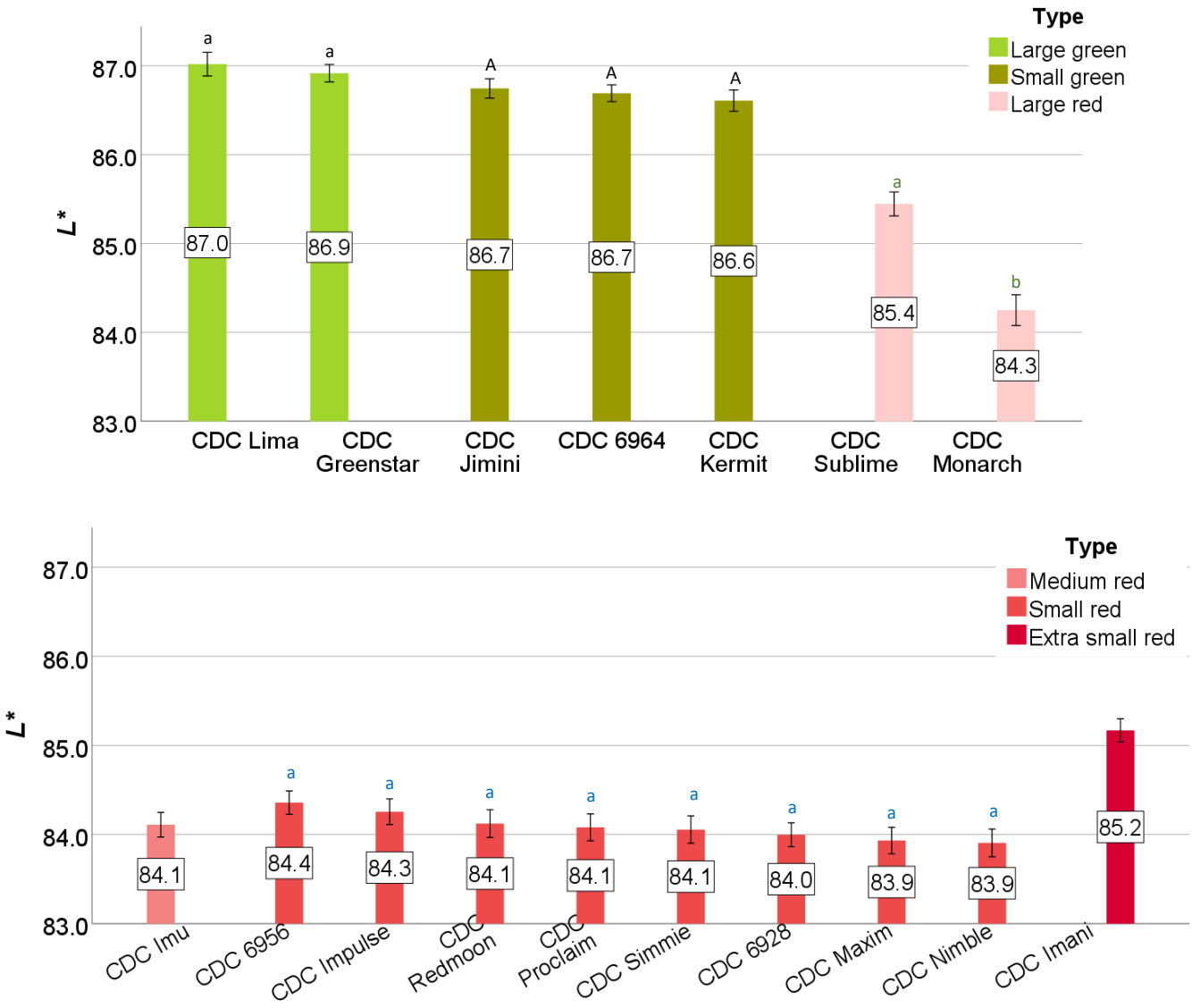
Figure 10.2. Mean *L** values of each lentil variety based on trials from 2022 to 2024. Each bar represents mean ± one standard error.



- The lightness of green lentils was significantly higher than that of red lentils.
- **Large red:** CDC Sublime had a greater lightness, which could be attributed to its lighter seed coat color.

Note: Small letters in black indicated significant differences (p<0.05) by large green. Capital letters in black indicated significant differences (p<0.05) by small green. Small letters in green indicated significant differences (p<0.05) by large red. Capital letters in green indicated significant differences (p<0.05) by medium red. Small letters in blue indicated significant differences (p<0.05) by small red. Capital letters in blue indicated significant differences (p<0.05) by extra small red.

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

Results: Figure 10.3. Box plots (top) and mean *a** values (bottom) of lentils in 2022, 2023, and 2024.

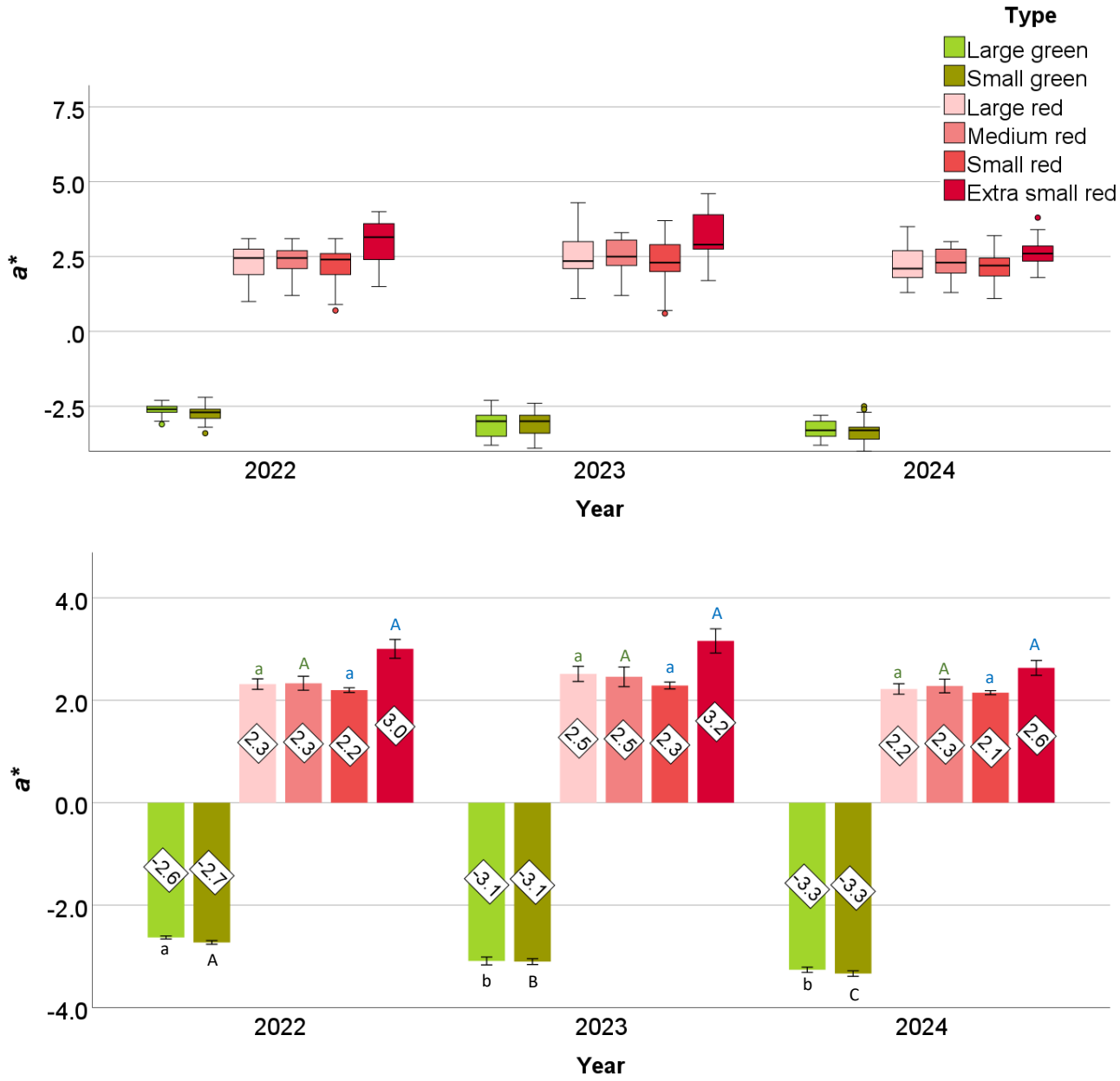


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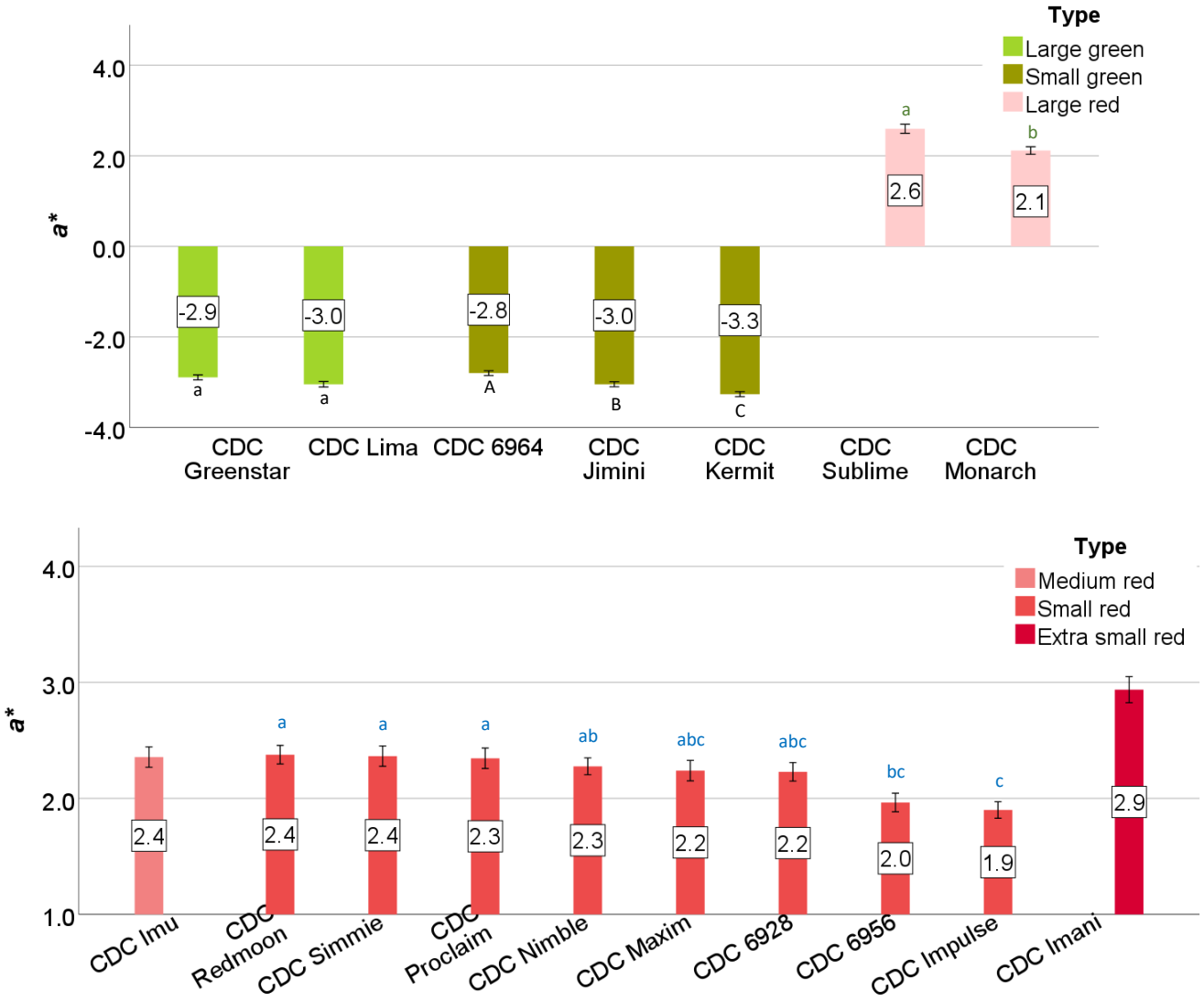
Figure 10.4. Mean *a** values of each lentil variety based on trials from 2022 to 2024. Each bar represents mean ± one standard error.



- CDC Imani (extra small red) exhibited the greatest redness among all red lentils.
- The *a** values were negatively correlated with *L** values (r= -.76; p<0.01).

Note: Small letters in black indicated significant differences (p<0.05) by large green. Capital letters in black indicated significant differences (p<0.05) by small green. Small letters in green indicated significant differences (p<0.05) by large red. Capital letters in green indicated significant differences (p<0.05) by medium red. Small letters in blue indicated significant differences (p<0.05) by small red. Capital letters in blue indicated significant differences (p<0.05) by extra small red.

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

Results: Figure 10.5. Box plots (top) and mean *b** values (bottom) of lentils in 2022, 2023, and 2024.

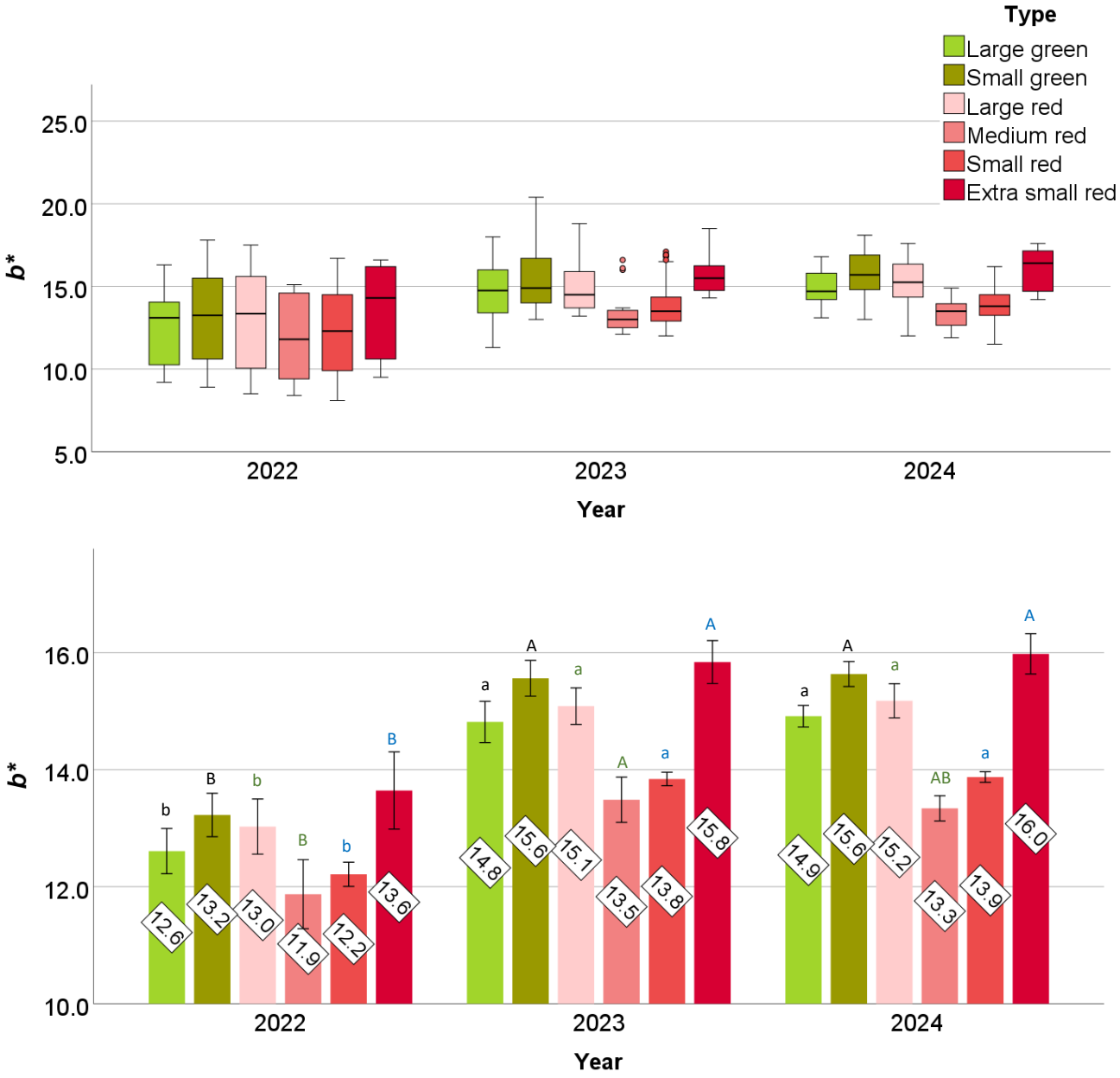

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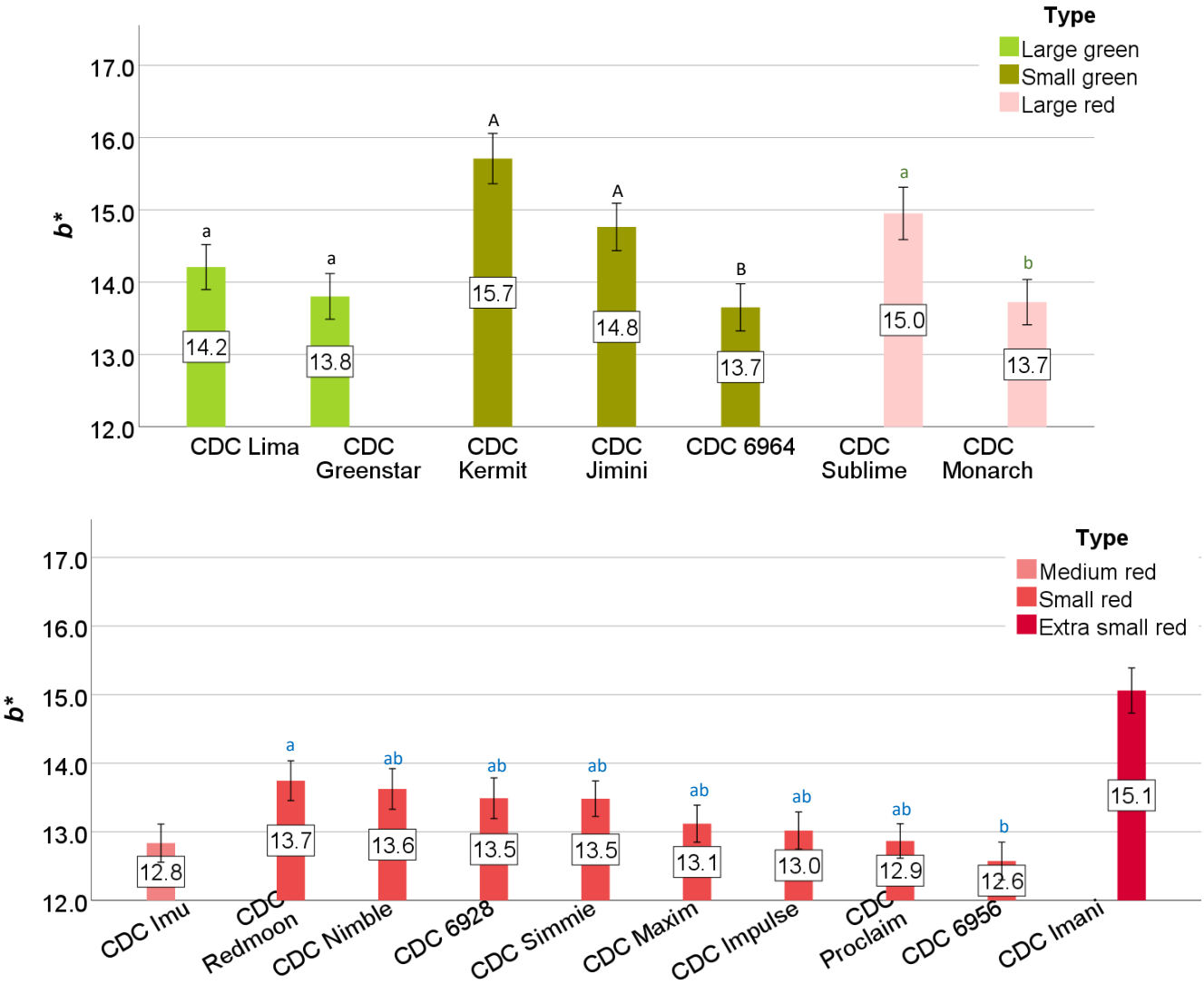
Figure 10.6. Mean *b** values of each lentil variety based on trials from 2022 to 2024. Each bar represents mean ± one standard error.



Note: Small letters in black indicated significant differences (p<0.05) by large green. Capital letters in black indicated significant differences (p<0.05) by small green. Small letters in green indicated significant differences (p<0.05) by large red. Capital letters in green indicated significant differences (p<0.05) by medium red. Small letters in blue indicated significant differences (p<0.05) by small red. Capital letters in blue indicated significant differences (p<0.05) by extra small red.

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TEI: (306) 933-7555, FAX: (306) 933-7208

Table B. Correlation coefficients between quality attributes based on trials from 2022 to 2024.

	Yield	TKW	Split	Other Damage	Hardness	Moisture	Ash	Protein	Protein Productivity	*L**	*a**	*b**
Yield	1											
TKW	*NS*	1										
Split	-.31**	.34**	1									
Other Damage	*NS*	.20**	.47**	1								
Hardness	.11**	**.76****	*NS*	*NS*	1							
Moisture	*NS*	.23**	.25**	.13**	*NS*	1						
Ash	.20**	*NS*	*NS*	*NS*	.08*	-.29**	1					
Protein	-.21**	-.17**	.09**	-.16**	-.09**	*NS*	-.22**	1				
Protein Productivity	**.98****	*NS*	-.31**	*NS*	.10**	*NS*	.18**	*NS*	1			
L*	.29**	.31**	*NS*	-.09*	0.39**	*NS*	*NS*	-.17**	.28**	1		
a*	*NS*	-.16**	*NS*	.20**	-.22**	*NS*	-.21**	.11**	*NS*	**-.76****	1	
b*	**-.52****	-.16**	*NS*	-.19**	-.28*	*NS*	*NS*	*NS*	**-.55****	-.22**	-.11**	1

**Pearson correlations coefficients significant at P<0.05; ** Pearson correlations coefficients significant at p<0.01; NS not significant; na not applied.*

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Contact information:

Project Manager
Lindsay (Yingxin) Wang, Ph.D.

Manager, Food Crop Quality
Saskatchewan Food Industry Development Centre Inc. (Food Centre)
2335 Schuyler Street, Saskatoon, SK, S7M 5V1, Canada
Direct: (306) 964-1819
E-mail: lwang@foodcentre.sk.ca

Project Advisor
Mehmet Tulbek, Ph.D.

President
Saskatchewan Food Industry Development Centre Inc. (Food Centre)
2335 Schuyler Street, Saskatoon, SK, S7M 5V1, Canada
Direct: (306) 933-7175
Fax: (306) 933-7208
Main office: (306) 933-7555
E-mail: mtulbek@foodcentre.sk.ca