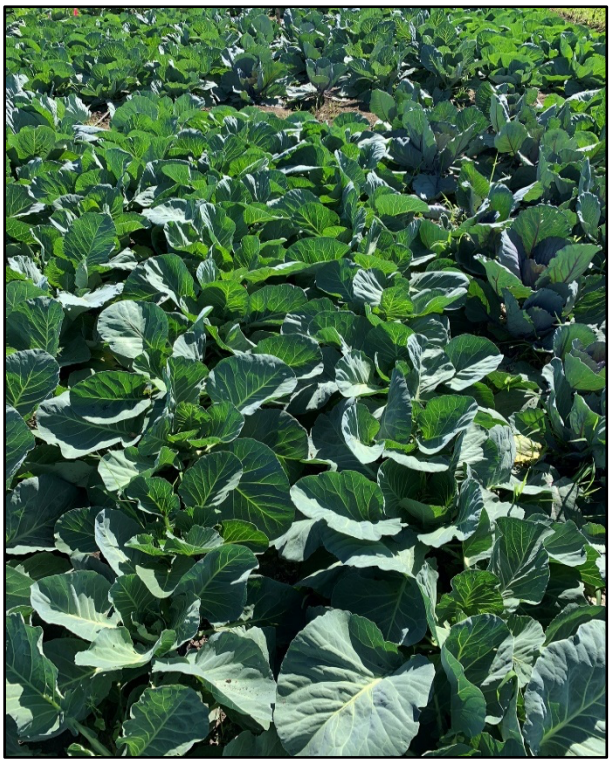

Project Identification

1. **Project Title:** New Cabbage Cultivars for Processing in SK
2. **Project Number:** 20220502
3. **Producer Group Sponsoring the Project:** Saskatchewan Vegetable Growers Association (SVGA)
4. **Project Location:** Saskatchewan Conservation Learning Centre, Prince Albert
   Legal Land Location: SW-20-46-26-W2 RM 461
5. **Project Start and End Dates:** March 2023 to February 2024
6. **Project Contact Person and Contact Details**
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Objectives and Rationale

7. **Project Objectives**

The purpose of this project was to provide a demonstration for local producers of the potential of growing large cabbage cultivars for processing. This project is also intended to identify cabbage cultivars that have resistance to sclerotinia and large cabbage cultivars that are resistant to splitting.

8. Project Rationale

This project was a repetition of ADOPT #20211040, which was conducted in summer of 2022. Industry was extremely interested in this demo and the additional site year, with improved disease ratings and modifications to selected cultivars. New vegetable cultivars become available every year for producers to grow, but these cultivars are bred and grown in climates with pests and diseases different from those in Saskatchewan. Producers in SK require sustainable cultivars that can be grown under SK conditions and perform on the SK market.

Saskatchewan's climate and soils are well suited for growing brassicas. The province has abundant processing market opportunities for locally grown cabbage. Current cabbage products being processed in SK include sauerkraut, kimchee, and coleslaw. The companies purchasing processing cabbage prefer larger heads as this requires less coring, but local producers typically grow smaller varieties for the fresh market. Growing larger varieties is an advantage to producers as the companies buy cabbage based on weight. The issue with growing large heads of cabbage is that they are very dense and tend to split at maturity. Some cultivars are resistant to splitting and thus would provide producers with desirable processing cabbage heads.

The increasing incidence of sclerotinia in cabbage fields has producers searching for ways to reduce the risk of such fungal infections. ADOPT 20170358, Control Options for Sclerotinia in Cabbage found some fungicides help lessen the prevalence of sclerotinia in cabbage, but no products completely eliminate the problem. This fungal infection is responsible for serious in field losses, which progressively gets worse in storage where major breakdowns occur. Some cultivars are more resistant to sclerotinia than others. With a reduced risk in sclerotinia, producers will opt to grow the more resistant cultivars.

Methodology and Results

9. Methodology

This trial was set up as a randomized complete block design with six replicates (Fig. 1). The treatments consisted of 11 different cultivars of cabbage (Table 1). These 11 cultivars consist of a selection of early, mid, and late season cabbages; including one red cultivar and one flat head cultivar. Six of the 11 cultivars were grown in the 2022 ADOPT #20211040 cultivar demo.

The trial site was rototilled prior to transplanting. Fertilizer was broadcast and incorporated and applied based on soil test results (Table 3) and recommendations provided by Agvise. Nitrogen, phosphorous, and sulfur were spread at rates of 182 kg N/ha (46-0-0-0), 180 kg P_2O_5/ha (11-52-0), and 22 kg S /ha (21-0-0-24), respectively (formulations used).

Cabbage transplants were started indoors on April 20, 2023 and transplanted outside on May 31, 2023. Rows were 6 m in length and 75 cm apart. There were 15 plants per row with 40 cm in row spacing. Drip irrigation was installed for every row and cabbage was irrigated with city water when required.

Figure 1. Cabbage cultivar trial layout on July 14, 2023 near Prince Albert Saskatchewan.

Plots were monitored for pests and disease. Poast Ultra was applied on June 8 at a rate of 1.1L/ha to control grassy weeds. Plots were kept weed free by hand weeding or the use of a mini gas-powered rototiller. Cabbage worm control began on July 6, 2023 with an application of Coragen @250mL/ha. Pounce was applied at a rate of 180 mL/ha on August 4 and 21 to maintain control of insect pressure. Disease symptoms were recorded for each plant during harvest. No disease control was implemented in order to compare potential disease resistance across cultivars. Electric fencing was installed in September due to late season deer pressure. Some yield results were affected by deer grazing.

Cabbage harvest occurred from August 11 to October 12. A plot was harvested when the cultivar reached maturity. It is possible the later harvested varieties had not reached full maturity, but the growing season had ended. During harvest, cabbage plants were rated for presence of alternaria black spot, downy mildew, sclerotinia white mold, and black rot. Detailed description of scale used is attached in the appendix. Each cabbage plant was also rated on the area affected by disease (1=root/soil, 2=stem/lower leaves, 3=head, 4=whole plant). After disease ratings, each plant was cleaned, weighed, circumference measured, observed for splitting, and additional notes made, such as presence of multiple heads, pest damage, and marketability. Cabbage plants that had multiple heads present at time of harvest were analyzed for disease pressure but not weight and circumference. These heads were often too small to be marketable. Other criteria that resulted in a cabbage being labelled as unmarketable included pest damage by deer or insects, disease, splitting, and loose or soft heads.

Table 1. Cabbage cultivars used in the "New Cabbage Cultivars for Processing in SK" trial.

Trt #	Cultivar*	Expected Size	Disease Tolerance
1	**Xtreme Vantage**	2.7 kg	HR to Fusarium yellows, strong tolerance to tip burn and IR to Black rot
2	Promise	3-4.5 kg	HR to Fusarium yellows
3	**Grand Vantage**	2.3-2.7 kg	HR to Fusarium yellows and tip burn
4	**Multikeeper**	2.7-3.6 kg	Good tolerance to tip burn and splitting. IR to Fusarium, black rot and thrip
5	Copenhagen Market	0.9-1.4 kg	
6	**Acclaim**	5.9 in	HR Fusarium yellows
7	Expectation	2-2.3 kg	Tolerance to fusarium yellows, thrips and tip burn
8	**Bronco**	0.9-2.3 kg	R fusarium yellows
9	**Cheers**	2.3 kg	HR fusarium yellows and I to black rot
10	Cairo Hybrid	1.4 – 2.7 kg	HR: Fusarium / IR: black spot, tip burn
11	Gunma	1.8 – 3.6 kg	Resists fusarium yellows, tip burn

*Bolded cultivars were also grown in 2022. Expected size and disease tolerance was recorded from seed companies. HR=high resistance, IR=intermediate resistance, R=resistant

Data analysis was completed by ANOVA using Statistix 10 software. Any non-parametric data was analyzed using the Kruskal-Wallis test. Post-hoc tests used were LSD for parametric data and Dunn's multiple comparisons test for non-parametric data at the p=0.05 level unless otherwise indicated. Co-efficient of variation (CV) is reported along with p-values.

10. Results

Weather

The growing season of 2023 was drier than the long-term average (Table 2) and was very smoky from Canadian wildfires. The first light frost occurred on September 20 (-0.3°C). 'Acclaim', 'Cheers', 'Copenhagen Market', and 'Xtreme Vantage' were the only cabbage cultivars harvested prior to any frost. The first heavy frost occurred October 6 (-2.6°C). 'Promise', 'Bronco', 'Expectation', and 'Multikeeper' were harvested October 6-12th following the frost. Cabbage plants have some frost tolerance and all cultivars were harvested before continuous and/or deep-freezing temperatures. Complete monthly weather summaries can be viewed/downloaded at src.sk.ca/download-weather-summaries.

Table 2. Weather conditions from 2023 growing season at the CLC, near Prince Albert SK from onsite SRC weather station.

Year	May	June	July	August	September	October	Average/Total
				--- Mean Temperature (°C) ---			
2023	14.4	18.8	16.6	17.1	13.9	3.5	14.1
2012-2021	17.1	16.2	18.7	17.1	11.6	3.1	14.0
				--- Precipitation (mm) ---			
2023	22.8	52.8	40.8	51.2	3.8	26.9	198.3
2012-2021	38.3	77.6	75	43	28.3	20	282.2
				--- Growing Degree Days (base 5°C) ---			
2023	289.9	412.7	359.2	373.9	266.5	60.1	1762.3
2012-2021	199.3	334.8	423.4	374.8	202.6	37.4	1572.3

Table 3. May 2023 soil test results.

Depth (cm)	**N** (lb/ac)	**P** (ppm)	**K** (ppm)	**S** (lb/ac)	**OM** (%)	**pH**	**Salts** (mmho/cm)
0-15	32	16	272	30	6.1	5.9	0.28
15-30	34			18		6.5	0.3
0-30	66						

Plant Counts and Harvest Timing

Four cabbage cultivars, 'Bronco', 'Cheers', 'Expectation', and 'Gunma' had all cabbage plants survive transplanting up until harvest (Table 6). Most cabbage cultivars had 90% survivability. 'Copenhagen Market' had the greatest plant loss prior to harvest. All plants present at time of harvest were rated for disease. Plants removed and not included in remaining data analysis included plants with multiple small heads, heads that were too rotten due to disease, or plants that had not formed a compact head. Multiple heads per plant likely resulted due to windy conditions immediately after transplanting causing excessive plant whipping, which damaged the growing point. The odd multi-headed cabbage produced a marketable sized head. While 'Bronco' had 100% survivability, 14% of 'Bronco' cabbages were not included in the yield data due to many small multi-headed cabbage plants.

There was a large range of maturity across the cabbage cultivars. Harvest occurred from August 11 – October 12, 2023. The whole plot was harvested when most heads were mature, but due to uneven maturity, some heads would be very large and at risk of splitting, while other heads were small. 'Copenhagen Market' was the earliest maturing cabbage cultivar, followed by 'Cheers' and 'Acclaim' ($p < 0.0001$). 'Promise' was the latest harvested cabbage, and could have been harvested at least 1 week earlier, but was delayed due to poor weather and seasonal staff shortages. Many cabbages were harvested later than their expected days to harvest.

Table 4. Days to harvest for cabbage cultivars grown near Prince Albert, Saskatchewan in 2023.

Variety	Days to harvest*	
	Actual	Expected
Acclaim	102 f	75
Bronco	128 b	90
Cairo Hybrid	116 cd	85
Cheers	101 fg	80
Copenhagen Market	88 g	70
Expectation	128 b	108
Xtreme Vantage	105 ef	75
Grand Vantage	120 c	85
Gunma	114 de	110
Multikeeper	128 b	86
Promise	134 a	110
P value	<0.0001	-
CV	13	-

*Days to harvest is calculated from date of transplanting. Expected days to maturity were provided by seed companies. Different letters indicate significance at p=0.05.

Cabbage yields

Overall total yields and mean head weights were lower than anticipated (Table 5, Fig. 2-3) and similar to 2022 results. Bronco (1.6 kg) and Copenhagen Market (1.1 kg) were the only two varieties that had mean yields reach the estimated size advertised by seed suppliers of 0.9-2.3 kg and 0.9-1.4 kg (Table 1). However, there was a wide range of head weight (Fig. 2) indicating cabbages can perform better under more ideal growing conditions. 'Promise' had the greatest mean head weight of 1.8 kg ($p<0.0001$) and total yield 50.4 Mg/ha ($p=0.0002$). 'Promise' also had one of the largest circumferences (50.5 cm). 'Gunma' performed similar to 'Promise', but had a greater circumference of 11 cm. 'Gunma' is a unique cultivar compared to the other cultivars as it is a flat head cabbage. Other cultivars that performed well for size and yield included 'Multikeeper', 'Bronco', 'Cheers', and 'Acclaim'. 'Cairo Hybrid' was the smallest and lowest yielding cultivar. It was also the only red cultivar included in the demo. 'Copenhagen Market' was the lowest yielding green cabbage; however, this is to be expected as this cultivar expected size is the smallest of all cultivars included in the demo.

Table 5. Mean circumference and yield results of 11 different cabbage cultivars grown near Prince Albert, SK in 2023.

Cultivar	N	Circumference (cm)	Yield (kg/head)	Total Yield (Mg/ha) *
Acclaim	83	47.0 cde	1.4 bc	42.5 ab
Bronco	81	48.8 bcd	1.6 ab	48.9 ab
Cairo Hybrid	77	40.2 f	0.9 d	26.9 c
Cheers	82	49.3 bc	1.4 bc	44.0 ab
Copenhagen Market	69	44.7 de	1.1 d	26.9 c
Expectation	81	44.6 ef	1.2 cd	39.9 ab
Xtreme Vantage	80	47.5 cde	1.4 bc	42.2 ab
Grand Vantage	69	46.9 cde	1.5 bc	38.1 b
Gunma	89	61.6 a	1.5 bc	49.1 a
Multikeeper	73	49.5 bc	1.6 ab	43.4 ab
Promise	75	50.5 b	1.8 a	50.4 a
P-value		<0.0001	<0.0001	0.0002
CV		17	39	28

*For total yield, n=6 for each cultivar. 1.0 ton/acre = 2.24 Mg/ha. 1.0 Mg/ha = 1.0 tonnes/ha. 1 kg = 2.21 lb. Different letters indicate significance at P<0.05

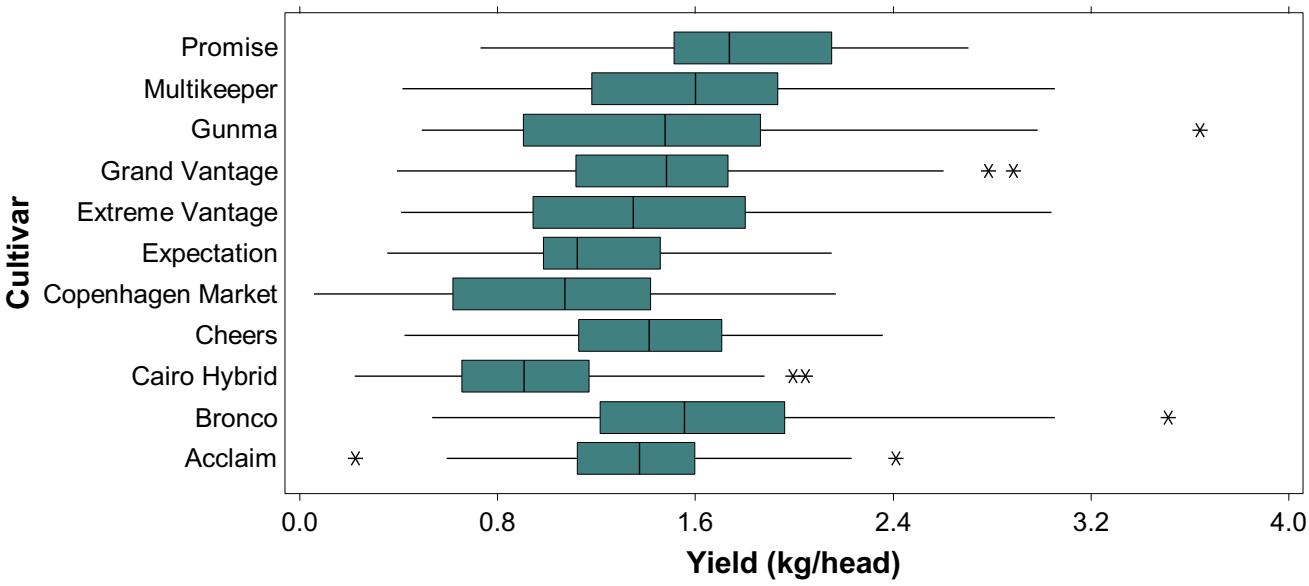

Figure 2. Range of cabbage head weights documented for 11 different cabbage cultivars grown near Prince Albert, SK in 2023.

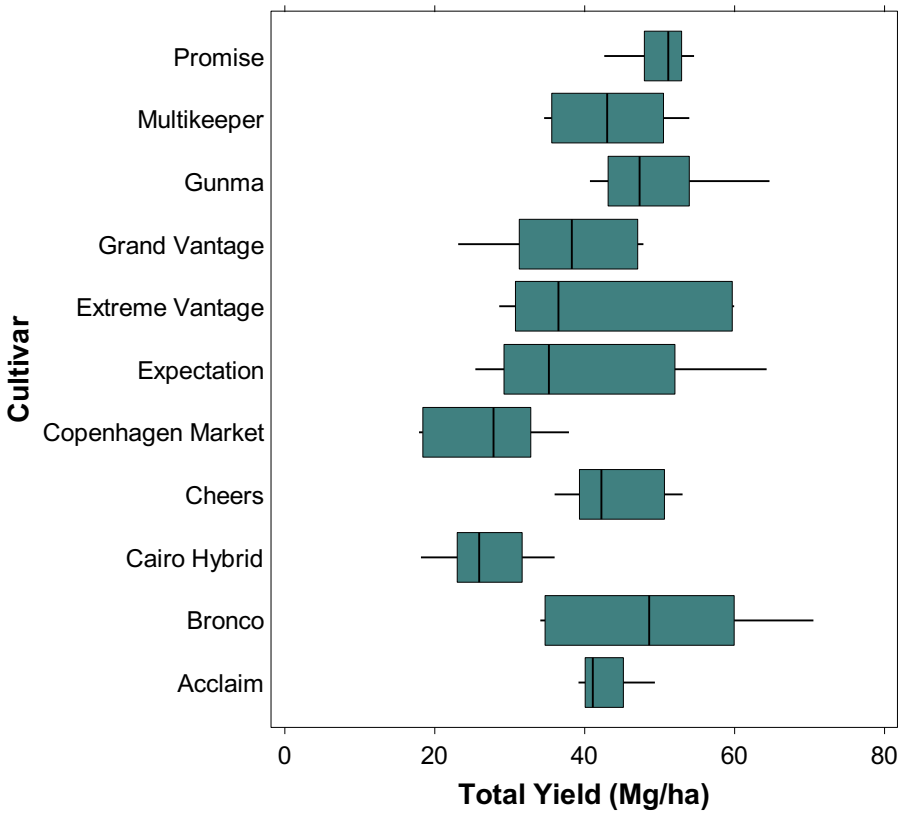

Figure 3. Range of total cabbage yield for 11 different cabbage cultivars grown near Prince Albert, SK in 2023. Total yield includes unmarketable cabbages.

Marketability

Likely due to smaller than anticipated cabbage head size, splitting was not common. However, there were cultivars that exhibited greater splitting such as 'Acclaim' (31%), 'Copenhagen Market' (30%), and 'Grand Vantage' (18%) (Table 6). In 2022, 'Cheers' had a high incidence of splitting within one rep (57%), but there was minimal splitting of 3% in 2023. It appeared that splitting was more common when the harvester cut the stem too close to the head of the cabbage during cleaning. As a result, cultivars showing higher incidence of splitting may be a result of harvester error. Splitting was also more evident in the cultivars that had shorter days to maturity. 'Acclaim', 'Cheers', and 'Expectation' had the greatest proportion of cabbage heads deemed to be marketable compared to the other cultivars. 'Gunma', 'Grand Vantage', and 'Copenhagen Market' had 50% or less cabbage heads deemed as unmarketable (Table 6).

Table 6. Comparison of survival and marketability of 11 different cabbage cultivars grown near Prince Albert, SK in 2023. Harvested cabbages are % of cabbages that survived transplanting. Measurable indicates of the harvested counts, the % that were large enough or of good quality to collect yield, splitting and circumference data on. Split is the % of cabbages that showed signs of splitting at harvest. Marketable are cabbages that were of suitable quality for market. Cabbages deemed not measurable included those that produced multiple small heads, were too small or not developed enough, and excessively diseased.

Cultivar	Harvested	Measurable	Split	Marketable
		%		
Acclaim	98	98	31	83
Bronco	100	86	2	68
Cairo Hybrid	90	86	0	71
Cheers	100	100	3	80
Copenhagen Market	79	79	30	50
Expectation	100	90	0	81
Xtreme Vantage	93	92	8	66
Grand Vantage	88	83	18	48
Gunma	100	100	4	44
Multi-keeper	91	83	10	64
Promise	96	86	0	74

Disease

Similar to 2022, as the growing season progressed disease became more evident. More detailed disease observations and data collection occurred for the 2023 trial. With each individual disease, a maximum rating of 5 was possible, for a total cumulative possible ranking of 20. 'Grand Vantage', 'Gunma', 'Multikeeper', and 'Bronco' showed the greatest plant area affected by disease, while 'Acclaim', 'Copenhagen Market', and 'Cairo Hybrid' had the least plant area affected by disease. Downy mildew and black rot had the lowest prevalence of all diseases rated with all values < 1 (Table 7). Cumulative disease was most severe for 'Gunma', 'Grand Vantage', and 'Promise' (Fig. 4). For downy mildew, 5/11 cabbage cultivars showed no symptoms. 'Cairo Hybrid' and 'Cheers' had no presence of black rot. While low (<1) 'Gunma' and 'Promise' had the greatest presence of black rot ($p<0.0001$). Both these cultivars disease package does not list black rot. Alternaria black spot was present in all cultivars; 'Grand Vantage' was the most susceptible (rating 2.4) and 'Multikeeper' (rating 0.5) the least susceptible ($P<0.0001$). The disease of greatest concern was sclerotinia. 'Gunma', 'Multikeeper', and 'Promise' had the greatest sclerotinia ratings ($p<0.0001$). 'Multikeeper' and 'Promise' were later maturing cultivars that had more time for disease to progress. Five cultivars showed some resistance to sclerotinia with ratings ≤0.5; these cultivars included 'Acclaim', 'Cairo hybrid', 'Copenhagen Market', 'Expectation', and 'Xtreme Vantage'. All these cultivars, with the exception of 'Expectation', were earlier maturing cultivars.

Table 7. Disease observations of 11 different cabbage cultivars grown near Prince Albert, SK in 2023.

Cultivar	Alternaria Black Spot	Downy Mildew	Sclerotinia White Mold	Black Rot	Plant Affected Area
			(0-5)		
Acclaim	1.0 cde	0.5 ab	0.3 d	0.3 ab	1.7 e
Bronco	1.1 cd	0.0 c	1.4 c	0.4 ab	2.7 ab
Cairo Hybrid	1.4 bc	0.5 ab	0.1 d	0.0 b	1.8 de
Cheers	0.7 de	0.5 ab	1.6 c	0.0 b	2.6 bc
Copenhagen Market	0.9 cde	0.5 ab	0.3 d	0.2 ab	1.9 e
Expectation	1.3 bc	0.0 c	0.5 d	0.2 ab	2.1 cd
Xtreme Vantage	1.2 cd	0.6 a	0.4 d	0.3 ab	2.3 c
Grand Vantage	2.4 a	0.0 c	1.5 c	0.2 ab	3.1 a
Gunma	0.9 cde	0.2 bc	3.1 a	0.6 a	2.9 ab
Multikeeper	0.5 e	0.0 c	2.8 ab	0.2 ab	2.9 ab
Promise	1.8 ab	0.0 c	2.1 bc	0.6 a	2.6 bc
P-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
CV	94	254	119	293	36

*Plant affected area was rated as 1=root/soil, 2=stem/lower leaves, 3=head, 4=whole plant

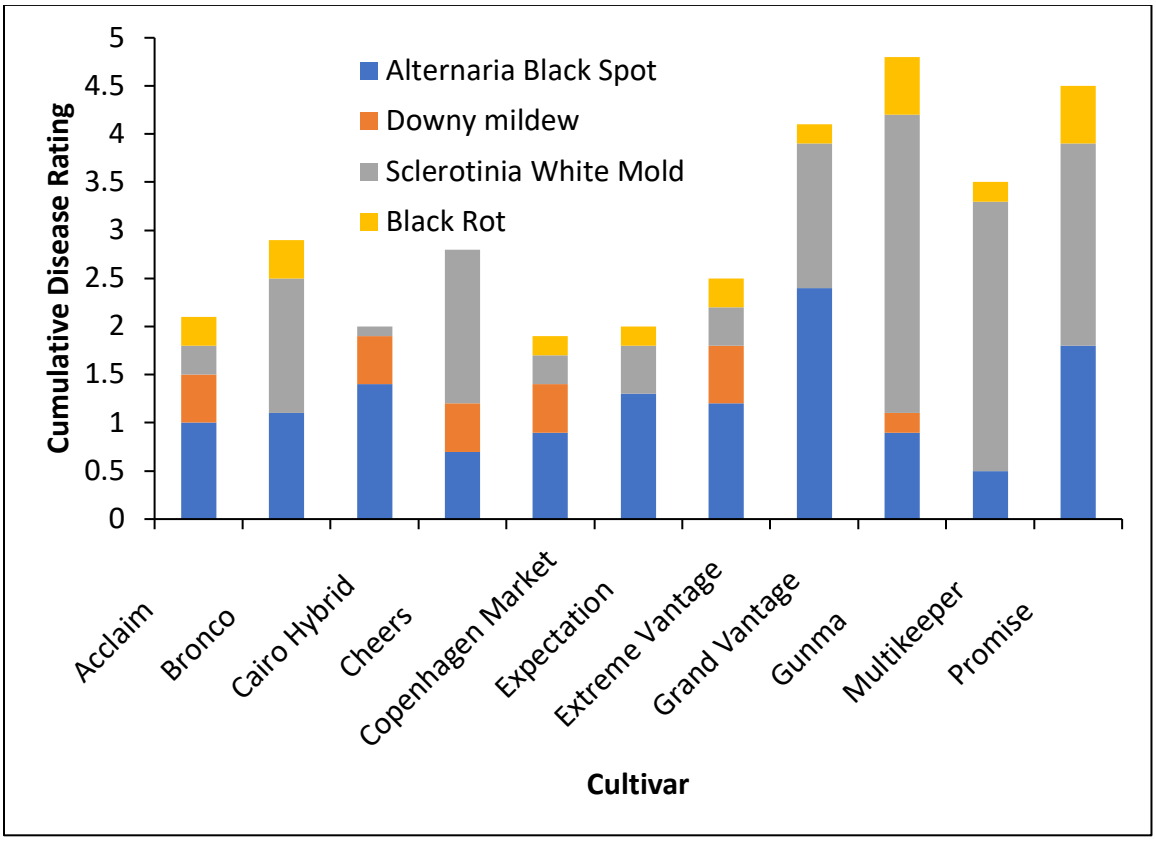

Figure 4. Cumulative disease ratings for 11 cabbage cultivars grown near Prince Albert, SK in 2023. Each disease was ranked 0-5. A maximum cumulative disease rating of 20 is possible.

This cultivar trial is particularly useful and fills a gap of information for Saskatchewan growers. While the University of Saskatchewan previously conducted cultivar trials from 1989-2016 the recommendations are becoming outdated. Of the cultivars grown in this demo, the previous U of S cultivar recommendations suggest 'Cheers', 'Grand Vantage', and 'Copenhagen Market' as early season, 'Bronco' as a mid-season, and 'Multikeeper' as a late season cultivar. 'Cairo Hybrid' was listed as a recommended red cabbage cultivar (University of Saskatchewan, 2023). 'Cheers' and 'Multikeeper' were top performers in the 2022 CLC cabbage cultivar trial. The U of S suggests growers consider the North Dakota State University Gardener Cultivar Trials for recommendations as they share similar prairie climate and soils. None of the cultivars included in the most recent "Vegetable Cultivars for North Dakota: 2023" include the cultivars used in the CLC's 2022 and 2023 cultivar trials that were selected based on interest from local growers (Kalb, 2022). Norseco, a Quebec based seed company sells 6/11 of the cultivars tested at the CLC in 2023. Norseco has listed 'Bronco', 'Cairo Hybrid', and 'Grand Vantage' as "true value" cultivars. Also included in their catalogue were the cultivars 'Gunma', 'Xtreme Vantage', and 'Expectation' (Norseco, 2023). There is also limited data available on performance of many of the cultivars investigated at the CLC.

An older North Dakota trial identified 'Bronco' as a suitable cultivar for both the fresh and processing markets and 'Cheers' as a suitable cultivar for the processing market. These two cultivars must be longstanding cultivars as the study took place from 1993-1997 (Greenland et al., 2000). None of the other cultivars included in the CLC trial had been investigated in this older study.

11. Conclusions and Recommendations

This trial provided useful information of the performance of 11 different cabbage cultivars under challenging Saskatchewan growing conditions. When cultivars were ranked in order of best to worst for yield, sclerotinia resistance, splitting and marketability, there was no clear cultivar that was the best ranking for all categories (Appendix Table 1A). 'Copenhagen Market', an older heirloom cultivar, had the lowest plant stands, the greatest amount of splitting, was poor yielding, and had the lowest marketability. 'Gunma' had great survivability and was the preferred cabbage at a local farmers market due to its flat shape; however, it had the lowest marketable production and short-term storage was poor. The sole red cabbage variety, 'Cairo Hybrid', produced small heads, but had low disease pressure. These cultivars are likely more suited for small scale, fresh market production and are not well suited for commercial processing purposes.

'Promise' and 'Multikeeper' were higher yielders, but had greater presence of sclerotinia, while 'Bronco' and 'Grand Vantage' yielded well, and were middle ranking for disease. 'Expectation' yielded on the lower end, but had decent disease resistance and a high % of marketable heads. 'Acclaim' was mid range for yield, did exceptionally well against sclerotinia and had the greatest % of marketable heads. 'Acclaim' was ranked as the cultivar that had experienced the greatest amount of splitting, but cabbage head size was not conducive for accurately evaluating splitting in 2023. 'Cheers' performed similar to 'Acclaim' except 'Cheers' was more susceptible to sclerotinia and had less incidence of splitting. 'Acclaim' and 'Cheers' were overall top performers in both 2022 and 2023 trial years. 'Bronco' and 'Promise' have potential as high yielders, but higher sclerotinia ratings indicate these cultivars would likely benefit from fungicide applications. As this trial was to evaluate disease resistance across cultivars, disease control was not implemented, which likely affected yield and marketability. Growing

a more sclerotinia resistant cabbage cultivar combined with fungicide applications should help lessen the prevalence of sclerotinia, as no fungicide alone can completely eliminate the problem.

The additional year of data and the inclusion of additional reps was helpful for gaining a better understanding of how these cultivars perform and for better statistical power. It is not good practice to base recommendations off one single site year worth of data. While the cabbage trial was under drip irrigation in 2023, it was a relatively dry and smoky season that likely restricted growth. Max size recorded indicates there is a greater potential for these cultivars. Compared to the 2022 cultivar demo, the more in-depth observations and records of disease incidence in 2023 was beneficial to more accurately determine if certain cultivars appear to have better resistance than others.

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Supporting Information

12. Acknowledgments

The Conservation Learning Centre graciously acknowledged the Ministry's and the Saskatchewan Vegetable Growers Association support through signage directly in field.

13. Abstract/Summary

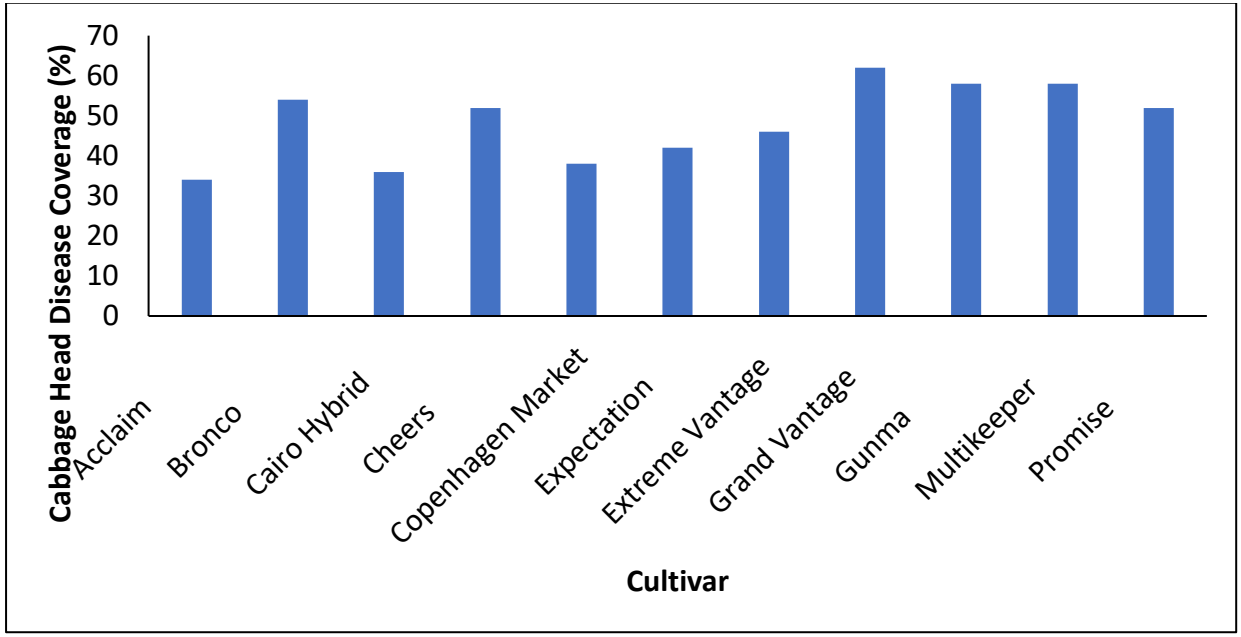
This trial evaluated 11 cabbage cultivars of interest to Saskatchewan vegetable growers and provides an additional year of data to complement ADOPT #20211040. The purpose was to identify suitable large headed cultivars for processing purposes. Ideal cultivars would be high yielding, and resistant to splitting and disease. Unfortunately, small cabbage head sizes were not conducive for splitting, but 'Acclaim' and 'Copenhagen Market' had the greatest incidence of splitting. Four different diseases were rated including 1. alternaria black spot, 2. downy mildew, 3. sclerotinia white mold and 4. black rot. Downy mildew and black rot had the lowest prevalence of all diseases rated with all values < 1 (scale 0-5). 'Grand Vantage' was most susceptible to alternaria black spot and 'Multikeeper' the least. The

disease of greatest concern was sclerotinia. ‘Gunma’, ‘Multikeeper’, and ‘Promise’ had the highest sclerotinia ratings. Five cultivars showed some resistance to sclerotinia with ratings ≤0.5; these cultivars included ‘Acclaim’, ‘Cairo Hybrid’, ‘Copenhagen Market’, ‘Expectation’, and ‘Xtreme Vantage’. All these cultivars, with the exception of ‘Expectation’, were earlier maturing cultivars. ‘Promise’, ‘Bronco’, and ‘Multikeeper’ were the highest yielding at 1.6-1.8 kg/head. ‘Copenhagen Market’ (1.1 kg/head) and ‘Cairo Hybrid’ (0.95 kg/head) were the lowest yielding. When cultivars were ranked in order of best to worst for yield, sclerotinia resistance, splitting, and marketability, there was no clear cultivar that was the best ranking across all categories. ‘Copenhagen Market’, ‘Gunma’, and ‘Cairo Hybrid’ are more appropriate for small scale, fresh market production and not well suited for commercial processing purposes. ‘Cheers’ and ‘Acclaim’ performed well in both 2022 and 2023. ‘Bronco’ and ‘Promise’ have good potential as high yielders, but higher sclerotinia ratings indicate these cultivars would likely benefit from fungicide applications. As this trial was to evaluate disease resistance across cultivars, disease control was not implemented and likely affected yield and marketability results. Growing a more sclerotinia resistant cabbage cultivar combined with fungicide applications should help lessen the prevalence of sclerotinia, as no fungicide alone can completely eliminate the problem.

Appendix:

Table A1. Ranking of cabbage cultivars grown near Prince Albert SK in 2023.

Rank	Cultivar	Yield (kg/head)	Rank	Cultivar	Sclerotinia rating (0-5)	Rank	Cultivar	Marketable (%)	Rank	Cultivar	Splitting (%)	Rank	Cultivar	Total yield (Mg/ha)
1	Promise	1.8	1	Cairo Hybrid	0.1	1	Acclaim	83	1	Cairo Hybrid	0	1	Promise	50.4
2	Bronco	1.6	2	Acclaim	0.3	2	Expectation	81	2	Expectation	0	2	Gunma	49.1
3	Multi-keeper	1.6	3	Copenhagen Market	0.3	3	Cheers	80	3	Promise	0	3	Bronco	48.9
4	Grand Vantage	1.5	4	Xtreme Vantage	0.4	4	Promise	74	4	Bronco	2	4	Cheers	44
5	Gunma	1.5	5	Expectation	0.5	5	Cairo Hybrid	71	5	Cheers	3	5	Multi-keeper	43.4
6	Acclaim	1.4	6	Bronco	1.4	6	Bronco	68	6	Gunma	4	6	Acclaim	42.5
7	Cheers	1.4	7	Grand Vantage	1.5	7	Xtreme Vantage	66	7	Xtreme Vantage	8	7	Xtreme Vantage	42.2
8	Xtreme Vantage	1.4	8	Cheers	1.6	8	Multi-keeper	64	8	Multi-keeper	10	8	Expectation	39.9
9	Expectation	1.2	9	Promise	2.1	9	Copenhagen Market	50	9	Grand Vantage	18	9	Grand Vantage	38.1
10	Copenhagen Market	1.1	10	Multi-keeper	2.8	10	Grand Vantage	48	10	Copenhagen Market	30	10	Cairo Hybrid	26.9
11	Cairo Hybrid	0.9	11	Gunma	3.1	11	Gunma	44	11	Acclaim	31	11	Copenhagen Market	26.9



Alternaria Black Spot

Grey, brown or black circular lesions with concentric markings, surrounded by a chlorotic halo.

0 – No lesions
1 – Lesions are brown/black specks between 2-5 mm
2 – Lesions are brown/black specks and exceed 5 mm in size and/or have chlorotic halos
3 – Circular lesions have connected to form large areas of dead tissue covering between 25-50% of the affected area
4 – Circular lesions have connected to form large areas of dead tissue covering 51-75% of the affected area
5 – Circular lesions have connected to form large areas of dead tissue covering over 75% of the affected area

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Sclerotinia White Mold

Symptoms include white cottony growth. Hard, black sclerotia may be visible.

0 – No lesions
1 – Lesions apparent on the stem only.
2 – Lesions apparent on the roots and/or lower leaves.
3 – Lesions visible on the head and upper leaves, covering 25-50% of the plant.
4 – Lesions visible on the head and upper leaves, covering 51-75% of the plant.
5 – Lesions cover over 75% of the plant.

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Downy Mildew

Symptoms progress from sporadic yellow patches to purple-brown moldy lesions. Under surface of infected leaves appears water soaked with white mealy growth.

0 – No lesions
1 – Lesions are patchy and yellow.
2 – Purple-brown moldy lesions are visible. Lesions cover <25% of the plant.
3 – Purple-brown moldy lesions are visible. Lesions cover 26-50% of the plant.
4 – Purple-brown moldy lesions are visible. Lesions cover 51-75% of the plant.
5 – Purple-brown moldy lesions are visible. Lesions cover >75% of the plant.

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Black Rot

Infected foliage has yellow V shaped spots starting in the margin and extending towards the midrib. Next, vascular system turns black. Whole leaf eventually shows discoloration and falls off.

0 – No lesions
1 – V shaped lesions apparent on leaf margins only.
2 – V shaped lesions run from leaf margins to the midrib. Blackening of vascular system may be evident.
3 – One or more of the outer leaves have completely discoloured and have fallen off or are falling off.
4 – The outside of the head of the cabbage is affected.
5 – The inside of the head of the cabbage is affected.

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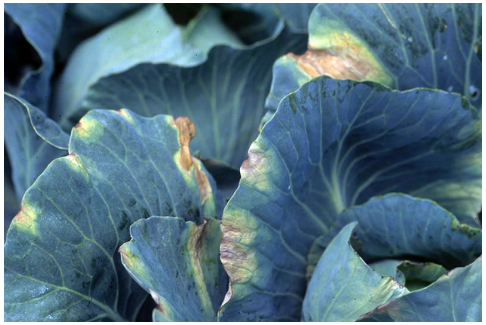

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