Agriculture Demonstration of Practices and Technologies (ADOPT)

Project Final Report

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| Project Title: | Benefits of Early Seeding in Spring Wheat |
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| Producer Group Sponsoring the Project: | Western Applied Research Corporation |
| Project Location(s): *Provide the name or number of the rural municipality, nearest town or legal land location if possible. Provide the name of any cooperating landowner(s).* | Western Applied Research Corporation, Scott, RM #380; Wheatland Conservation Area, Swift Current, RM #137; Northeast Agricultural Research Foundation, Melfort, RM #428 |
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# Abstract

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| A 2024 study evaluated the practicality of ultra-early wheat seeding based on soil temperature triggers at three Saskatchewan locations: Swift Current, Scott, and Melfort. The first seeding treatment targeted 2°C soil temperature, followed by weekly intervals for six seeding dates from April 9 to May 27. While early seeding delayed emergence by up to 24 days due to cold conditions, all treatments established well, though plant survival was significantly lower for the earliest seeding date. Plant densities peaked for seeding dates in late April. Early seeding extended the wheat growing season by increasing days to maturity but had minimal effects on lodging and plant height. Yield responses varied by location, with early seeding resulting in yield penalties at Melfort and Scott (north of 51°N), likely due to cool, wet conditions, while Swift Current (south of 51°N) showed no significant yield differences between seeding dates. Protein content was slightly reduced for early seeding at Melfort and Swift Current but remained acceptable, and test weights were higher for early seeding at Swift Current. These results suggest that early seeding north of 51°N may benefit from seed treatments to mitigate risks, while in southern regions like Swift Current, early seeding offers greater flexibility without yield penalties. |

# Project Objectives

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| The objective of this project was to show producers that early seeding can be successfully conducted throughout Saskatchewan and to highlight the benefits associated with extending the frost-free growing period.  |

# Project Rationale

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| A study by Collier et al. (2021) conducted in western Canada from 2015 to 2018 assessed the impact of optimal agronomic management on grain yield, quality, and stability in ultra-early wheat seeding systems. The study began by planting wheat at soil temperatures ranging from 0°C to 2.5°C at a 5 cm depth. Subsequent plantings were conducted at 2.5°C intervals, up to 10°C, resulting in six distinct planting times. Two spring wheat lines were seeded at each planting date, with two seeding depths (2.5 cm and 5 cm) and two seeding rates (200 and 400 seeds/m²). The results showed that soil temperatures between 2°C and 6°C, combined with the highest seeding rate and shallow seeding depth, resulted in the greatest yield and stability. Delaying planting until soil temperatures reached 10°C caused a more significant reduction in grain yield than planting in 0°C soils. Despite extreme ambient air temperatures below 0°C after planting, plant survival was unaffected at the earliest seeding dates. Although grain protein content was higher at later seeding dates, the higher grain yield at earlier planting times resulted in greater protein production per unit area. A similar study assessing conventional and cold-tolerant wheat varieties found that the use of cold-tolerant varieties did not influence yield, suggesting that current wheat varieties can be successfully seeded ultra-early (Collier et al., 2020). These results occurred despite extreme environmental conditions, including air temperatures as low as −10.2°C and as many as 37 nights with temperatures below 0°C (Collier et al., 2020). Additionally, small plot trials conducted between 2017 and 2019 at three locations in western Canada—Scott, SK; Edmonton, AB; and Lethbridge, AB—further supported these findings (Collier et al., 2022). The objective was to base seeding decisions on soil temperatures rather than calendar dates. The trials showed that ultra-early planting at 2°C resulted in improved grain yield and stability compared to the conventional 8°C seeding temperature. Collectively, these studies suggest that wheat growers in western Canada can safely adopt ultra-early seeding with minimal changes to their current practices, and that this approach carries less risk than waiting for soil temperatures to reach 10°C or higher before planting.Traditionally, seeding occurs based on an arbitrary calendar date rather than soil temperature. By altering the seeding date, producers can extend the short frost-free growing period that often limits wheat production in North Central Saskatchewan. Ultra-early seeding allows producers to optimize the short growing season by capturing the benefits of longer frost- free periods including access to early soil moisture, early season growing degree-day accumulation, increased vegetative growth periods, early season precipitation, increased day-length at anthesis and reduced average temperatures at grain fill (Collier et al. 2020). An additional benefit of seeding earlier is that the crop has a better chance of avoiding the negative effects of warmer, drier summers on grain fill. It also helps mitigate the longer days to maturity for new, higher-yielding varieties. Many producers worry that seeding into a semi-frozen soil may result in equipment damage as well as concerns to sinking into partial warmed soils. This demonstration is targeted to show producers that ultra-early seeding can be accomplished throughout multiple areas in Saskatchewan and to highlight the benefits associated with extending the frost-free growing period. |

# Methodology

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| Methodology: The demonstration was established at three locations throughout Saskatchewan; Swift Current in the brown soil zone, Scott in the dark brown soil zone, and Melfort in the black soil zone. At Swift Current the demonstration was set up as a randomized complete block design (RCBD) with four replications. Due to equipment limitations at Scott and Melfort, the demonstration was set up as a strip trial with four replications. The first seeding date treatment at all three sites targeted 2°C soil temperature at a 1” depth at 1:00 pm. The remaining seeding date treatments followed one week after the first for a total of six seeding dates, ranging from April 9 to May 27 (Table 1). Plot size at Swift Current was 1.5 x 6.3 m, at Scott was 1.5 x 8 m, and at Melfort was 1.8 x 9 m. **Table 1.** Treatment list and seeding dates for demonstration of early seeded wheat at Scott, Swift Current, Melfort, SK., 2024.

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| --- | --- | --- | --- |
| **Treatment #** | **Scott** | **Swift Current** | **Melfort** |
|  | **-------------seed dates--------------** |
| 1 | April 09 | April 09 | April 15 |
| 2 | April 15 | April 15 | April 25 |
| 3 | April 23 | April 23 | April 30 |
| 4 | April 29 | April 29 | May 06 |
| 5 | May 05 | May 06 | May 14 |
| 6 | May 14 | May 13 | May 27 |

Agronomic management varied based on individual sites (Appendix 1). The demonstration was established on canola stubble at Scott and Melfort, and durum stubble at Swift Current. Plots at each site were seeded with Fabro-built knife opener drills with 8” row spacing at Swift Current, 10” row spacing at Scott, and 12” row spacing at Melfort. A regionally-adapted hard red spring wheat variety was selected at each location and seeded to target 300 seeds/m2 based on individual germination and seed weight for each seed lot. The variety seeded at Swift Current was CDC Adamant VB, at Scott was AAC Wheatland, and at Melfort was AAC Starbuck VB. At Scott and Melfort, wheat was seeded at a depth of 1” and at Swift Current wheat was seeded at a depth of 1.5”. All fertilizer was applied at time of seeding based on each sites spring soil test recommendations (Appendix 2). At Scott, fertilizer was side-band to meet 124 lbs N/ac, 31 lbs P2O5/ac, 11 lbs K2O/ac, 14 lbs S/ac. At Swift Current, fertilizer was side-band to meet 80 lbs N/ac, 40 lbs P2O5/ac, 16 lbs S/ac. At Melfort, 154 lbs N/ac were mid-row band, while 50 lbs P2O5/ac, 15 lbs K2O/ac, 10 lbs S/ac were side-band. There were no pre-seed herbicide applications at Scott or Melfort due to environmental conditions and lack of weed growth early in the season. At Swift Current, an application of glyphosate 540 at 0.5 L/ac and Aim at 35 ml/ac was applied to all treatments on April 16, prior to emergence of early seeded treatments (trt #1&2) and prior to seeding later treatments (trt #3-7). At Swift Current, an in-crop herbicide application occurred on June 11 for all treatments with Liquid Achieve at 200 ml/ac, Buctril M at 400 ml/ac and Carrier at 0.5L/100L. At Scott an application of Axial Xtreme at 0.5 L/ac and Buctril M at 0.4 L/ac occurred on June 18 for all treatments. At Melfort two in-crop applications occurred for all treatments, the first one consisted of Axial at 0.5 L/ac on June 9, and the second application consisted of Enforcer M at 0.5 L/ac on June 14. No fungicide was applied at Swift Current or Melfort locations. At Scott, fusarium head blight fungicide application of Caramba at 400 ml/ac was applied on July 5 for trts #1-3, and on July 11 for trts #4-6. No insecticides were applied at any of the three locations. At Scott, plots were desiccated at the hard dough stage with glyphosate 540 at 0.67 L/ac, Heat LQ at 59 ml/ac and Merge at 200 ml/ac on August 21. Plots were not desiccated prior to harvest at Swift Current or Melfort. At Swift Current, plots were combined on August 6 using a Zurn plot combine. At Scott, all plots were harvested on September 2 using a Wintersteiger plot combine. At Melfort trt #2 & 3 were harvested August 20, trt #4 & 5 were harvested August 30, and trt #6 & 7 were harvested September 9. Data Collection: Soil samples were collected as a composite sample of the trial area at each location in the spring of 2024 at two depth increments, 0-15 cm and 15-60 cm. At each seeding date, the time of seeding and soil temperature at a 1-inch depth were recorded. At two and four weeks after seeding (WAS), plant density assessments were conducted by counting plants in 4 x 1 meter row lengths per plot. When plants reached peak growth, lodging and plant height were assessed. Lodging was determined based on a rating scale of 0-9, where 0 is no lodging and 9 is fully lodged. For plant height measurements 5 plants per plot were measured and recorded. When plants reached physiological maturity (hard dough stage) the date was recorded and Julian calendar for leap years used with the seeding date to determine the days to maturity. Yields were determined from cleaned harvested grain samples and corrected to 14.5% moisture content. Cleaned grain samples were analyzed for protein content using an NIR machine and test weights using Canadian Grain Commission standards. Daily weather was collected by on-site weather stations and long-term weather data was collected from Environment Canada (1981-2010). Statistical Analysis: The data were analyzed using R (ver. 2023.12.0+369; RStudio Team, 2023) to assess the effects of seed dates on various wheat traits, including plant density, lodging, plant height, days to maturity, yield, protein content, and test weight. Given the non-randomization of treatments within replicates at the Scott and Melfort sites, a least-squares model was used to evaluate the potential influence of replication on response variables. Where replication resulted in p-values < 0.05, trends in each replicate were assessed separately to determine whether they impacted the overall results. For the combined analysis, a linear mixed-effects model was used, with seed date as the fixed effect and replicate nested within site as random effects. For individual sites, a linear mixed-effects model was applied with seed date as the fixed effect and replicate as the random effect. All models were evaluated for assumptions of normality and homogeneity of variance. When these assumptions were not met, data were log-transformed. Analysis of variance (ANOVA) was performed to identify significant differences at p < 0.05. Post-hoc pairwise comparisons of means were conducted using estimated marginal means (EMMs) via the emmeans package in R, with the Sidak adjustment for multiple comparisons. Linear and quadratic regression models were used to examine the relationship between response variables and seeding dates. Akaike’s Information Criterion (AIC) was used to determine the best model fit. |

**Results**

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| **Environmental Conditions:** Precipitation at the beginning of the growing season was fairly consistent across all three sites, with differences of only 2.1 mm in April and 1.2 mm in May (Table 2). However, as the season progressed, precipitation differences became more pronounced. Swift Current was drier than the other two sites for June, July, and August, but finally received more moisture by the end of harvest in September. Scott and Melfort were fairly comparable for the months of July to September, but Scott received almost twice as much precipitation as the long-term average at a critical period of the growing season in June. Overall, Scott received the greatest amount of precipitation at 317.3 mm and was 116% above their long-term average. The other two sites were below their long-term averages, receiving only 281.4 mm (96%) at Melfort and 232.5 mm (91%) at Swift Current. Temperatures for the growing season were slightly above long-term averages for all three sites. The month of April appeared to be slightly warmer than the long-term average for all three sites. The months of May and June were relatively cooler for all sites compared to the long-term average. However, temperatures for the remainder of the season, including July, August, and September, were much warmer than average.**Table 2.** Mean monthly temperature (°C) and cumulative monthly precipitation (mm) for Scott, Swift Current, and Melfort from April to September, 2024.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Site** | **Year** | **April** | **May** | **June** | **July** | **August** | **Sept.** | **Average/Sum** | **% of Long-term Average** |
|  |
|   | *------------------------------------------Mean Temperature (°C) -------------------------------------------------* |  |
| Scott | 2024 | 5.7 | 9.8 | 13.3 | 18.9 | 17.4 | 14.7 | 13.3 | 108% |  |
| Long-termz | 3.8 | 10.8 | 15.3 | 17.1 | 16.5 | 10.4 | 12.3 |  |
| Swift Current | 2024 | 6.8 | 10.6 | 14.3 | 21.3 | 19.4 | 16.7 | 14.9 | 111% |  |
| Long-term | 5.2 | 10.9 | 15.4 | 18.5 | 18.2 | 12.0 | 13.4 |  |
| Melfort | 2024 | 5.3 | 10.1 | 13.2 | 19.4 | 17.4 | 15.7 | 13.5 | 109% |  |
| Long-term | 2.8 | 10.7 | 15.9 | 17.5 | 16.8 | 10.8 | 12.4 |  |
|   | *------------------------------------------Cumulative Precipitation (mm)-------------------------------------------------* |  |
| Scott | 2024 | 22.1 | 74.2 | 112.0 | 26.7 | 42.8 | 39.5 | 317.3 | 116% |  |
| Long-term | 21.6 | 36.3 | 61.8 | 72.1 | 45.7 | 36.0 | 273.5 |  |
| Swift Current | 2024 | 22.2 | 73.6 | 52.1 | 18.6 | 18.2 | 47.8 | 232.5 | 91% |  |
| Long-term | 12.1 | 43.8 | 72.8 | 52.6 | 41.5 | 31.5 | 254.3 |  |
| Melfort | 2024 | 24.2 | 73.0 | 84.0 | 36.1 | 31.1 | 33.0 | 281.4 | 96% |  |
| Long-term | 26.7 | 42.9 | 54.3 | 76.7 | 52.4 | 38.7 | 291.7 |  |

zLong-term average for all sites (1981-2010); Environment CanadaConsidering the early seeding date component of this study, differences in site characteristics and early spring temperatures following the initial seeding date are noteworthy. Air temperatures in April were fairly consistent across locations, despite geographical differences. The lowest air temperatures recorded after seeding were similar across sites; -8.0°C at Scott, -7.7°C at Swift Current, and -7.9°C at Melfort (Table 3). However, the number of nights below 0°C after the first seeding date varied, with Scott experiencing the most freezing nights (18), while Swift Current and Melfort recorded 13 and 12 nights, respectively. Moisture conditions also differed among sites. Swift Current received substantially more precipitation in April compared to its long-term average, whereas Scott and Melfort were close to their respective long-term averages. In May, all three sites were considerably cooler and wetter than their long-term averages. Overall, the three locations experienced cool and wet spring conditions, which could influence germination and establishment of early-seeded wheat.**Table 3.** Post seeding air temperature extremes and cumulative freezing events for Scott, Swift Current, and Melfort, SK., 2024.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Location** | **Latitude/Longitude** | **Soil Zone** | **Earliest Seeding Date\*** | **Number of Days with Air Temperature below 0°C after Initial Seeding Date** | **Lowest Air Temperature Recorded after Seeding (°C)** |
| Scott | 52°36' N 108°83' W | dark brown | April 09 | 18 | -8.0 |
| Swift Current | 50°29' N 107°80' W | brown | April 09 | 13 | -7.7 |
| Melfort | 52°86' N 104°61' W | black | April 15 | 12 | -7.9 |

\*First seeding date triggered by 2°C soil temperature at each site.**Plant Emergence & Establishment:** This study aimed to assess the impact of early seeding dates on wheat establishment by evaluating plant emergence and density at 2 and 4 weeks after seeding (WAS) across three locations. Plant emergence was delayed for early seeding dates, with no emergence observed by 2 WAS for the first three seeding dates at Scott, and the first two seeding dates at Swift Current and Melfort. Specifically, the first seeding date (April 9) at Scott took 24 days to emerge, the second (April 15) took 20 days, and the third (April 23) took 16 days. Cold spring soil temperatures likely contributed to this delayed emergence, as observed at Scott, where air temperatures reached as low at -8.0°C and there were 18 nights with temperatures below 0°C after the first seeding date. Additionally, two snowfall events at Scott on April 17 and May 1 may have further impacted soil and air temperatures, hindering germination and emergence.Seeding dates beyond the third week of April generally resulted in emergence within a 2-week timeframe. Plant density assessments at 2 weeks after seeding (WAS) revealed significant linear relationships at Scott (p < 0.001) and Melfort (p < 0.001), indicating that plant density increased as seeding dates were delayed (Figure 1). At Scott, the fifth seeding date produced the highest plant density (242 plants/m²), while earlier and later seeding dates resulted in lower densities of 219 and 165 plants/m², respectively. At Melfort, the highest plant density (422 plants/m²) was recorded for the last seeding date, which was significantly greater than earlier dates. The fourth and fifth seeding dates yielded plant densities of 270 and 243 plants/m², respectively, while the third seeding date had the lowest density (138 plants/m²), significantly lower than all other dates. At Swift Current, plant density showed a significant quadratic response (p < 0.001), peaking at the fourth (197 plants/m²) and fifth seeding dates (198 plants/m²). In contrast, later seeding dates resulted in slightly lower densities (183 plants/m²), while earlier seeding dates showed the lowest densities (181 plants/m²).**Figure 1.** The effect of seeding date on plant density (plants/m2) of wheat at 2 weeks after seeding (WAS) at Scott, Swift Current, and Melfort in 2024. Significance determined at p<0.05. By 4 WAS, all seeding dates had fully emerged. At Scott, the relationship shifted from linear to quadratic (p<0.001), with the first seeding date in April now showing the lowest plant density (163 plants/m²) (Figure 2). Plant density increased with later seeding, peaking at 241 plants/m² for the third seed date, then decreasing to 208 plants/m² for the last seed date. At Swift Current, the relationship shifted from quadratic to linear (p=0.037), where later seeding dates resulted in greater plant densities. The first three seeding dates in April showed relatively low plant densities (189–194 plants/m²), while the last three seeding dates in late April and May exhibited higher densities (210–215 plants/m²). At Melfort, the relationship remained linear at 4 WAS (p = 0.004). However, the last seeding date produced plant densities significantly exceeding the seeding target of 300 seeds/m², with a density of 392 plants/m². When these data points were excluded, the relationship followed a quadratic trend similar to Scott. The first seeding date resulted in the lowest plant density (238 plants/m²), while the second seeding date produced the highest density (292 plants/m²). Plant densities declined thereafter, reaching 263 plants/m² by the fifth seeding date. Across all sites, the earliest seeding date at each location consistently resulted in significantly lower plant densities. Plant densities generally peaked or increased as seeding dates moved into late April and May. These findings suggest that early spring conditions, may adversely affect establishment and survivability of wheat seeded in early April.**Figure 2.** The effect of seeding date on plant density (plants/m2) of wheat at 4 weeks after seeding (WAS) at Scott, Swift Current, and Melfort in 2024. Significance determined at p=0.05. In conclusion, early seeding dates generally led to slower emergence, with delays of up to 24 days. Once emerged, most seeding dates achieved adequate plant stands, although seed dates in early April tended to result in lower plant populations. Cool, wet conditions early in the spring can increase the risk of seedling diseases. In this study, wheat seed was not treated with a seed treatment, which likely increased the risk of seedling mortality. While early seeding resulted in reduced plant stands overall, the use of seed treatments might be able to mitigate these effects.**Lodging:**There was minimal lodging observed across all plots at the three locations. There was no significant effect of seeding date on lodging at Scott (p=0.680) or Melfort (p=0.147) (Figure 3). At Scott, lodging was slightly greater at earlier seeding dates, with a rating of 1.6/9.0 for the first seeding date. However, the last seeding date showed slightly lower lodging (1.2/9.0). Similarly, lodging at Melfort was minimal overall, and while the last seeding date had slightly higher lodging (0.3/9.0) compared to all other dates (which had ratings of 0/9.0), these differences were not statistically significant. At Swift Current, no lodging occurred at any seeding date, with all plots receiving a rating of 0. As a result, no statistical analysis could be performed due to the lack of variation in the data. In conclusion, seeding date did not have a significant impact on wheat lodging at any location. It is likely that other agronomic or environmental factors, such as fertility, precipitation, and wind, would have a more substantial influence on lodging.**Figure 3.** The effect of seeding date on lodging (0-9) of wheat at Scott, Swift Current, and Melfort in 2024. Significance determined at p<0.05. **Plant Height:**There were minimal differences in plant height observed between seeding dates at each location (Figure 4). Plant height at Scott showed only slight variation, with a difference of just 2.7 cm between the tallest and shortest treatments (p=0.153). Similarly, seeding date had no effect on plant height at Swift Current with a variation of 4.6 cm between the tallest and shortest treatments. Alternately, Melfort showed a significant quadratic relationship between plant height and seeding date (p=0.014). The shortest plant height (87.8 cm) occurred for the first seeding date. Plant height increased to 91.5 cm for the second seeding date, but remained relatively stable around 91 cm for the third, fourth, and fifth seeding dates, and dropped back to 88.2 cm for the last seeding date. Overall, plant height variation across seeding dates was minimal at all three locations. However, Melfort showed shorter plants at the early and late seeding dates, with peak plant height occurring in the middle of the seeding window.**Figure 4.** The effect of seeding date on plant height (cm) of wheat at Scott, Swift Current, and Melfort in 2024. Significance determined at p<0.05. **Maturity:**Seeding date significantly affected wheat maturity at all three locations: Scott (p<0.001), Swift Current (p<0.001), and Melfort (p<0.001) (Figure 5). The relationship between seeding date and maturity was linear at each location, with the time to maturity decreasing as the seeding date was delayed. Maturity dates varied by location, but the longest times to maturity were observed for the earliest seeding dates at all sites. The first seeding date required 125 days to reach maturity at Scott, 107 days at Swift Current, and 121 days at Melfort. In contrast, the last seeding date at each location led to shorter times to maturity. At Scott, the last seeding date resulted in 98 days to maturity, a reduction of 27 days compared to the first seeding date. Swift Current saw the shortest time to maturity for the last seeding date, at 75 days, which was 32 days shorter than the first seeding date. Lastly, Melfort followed a similar trend, with the shortest maturity time (95 days) occurring for the last seeding date, 26 days shorter than the first seeding date. These findings clearly indicate that earlier seeding dates result in longer growing seasons for wheat. There are many benefits to a longer growing season including early access to soil moisture, early season growing degree-day accumulation, increased vegetative growth periods, early season precipitation, increased day-length at anthesis, and reduced average temperatures at grain fill. **Figure 5.** The effect of seeding date on days to maturity (DTM) of wheat at Scott, Swift Current, and Melfort in 2024. Significance determined at p<0.05. Despite delays in emergence for early-seeded treatments, the timeframe from emergence to maturity closely followed the trend observed for days to maturity, with earlier seeding dates requiring more days compared to later-seeded treatments (Table 4). On average, across all three locations, early seeding dates had the longest days to emergence, taking up to 22 days for the first seeding date. As seeding dates progressed, the time required for seedlings to emerge decreased, reaching just 12 days for the final seeding date. Similarly, the earliest seeding date resulted in the longest period from emergence to maturity at 96 days. This timeframe shortened progressively with later seeding dates, decreasing to 77 days for the final seeding date. These findings reaffirm that while early seeding dates delay emergence, they also extend the physiological growth period of wheat, potentially influencing overall crop development and yield potential.**Table 4.** Mean days to emergence, days to maturity, and emergence to maturity (days) for ultra-early seeded wheat averaged across three sites (Scott, Swift Current, and Melfort), 2024.

|  |  |  |  |
| --- | --- | --- | --- |
| Seed Date | Days to Emergence | Days to Maturity | Emergence to Maturity (days) |
| 1 | 22 | 118 | 96 |
| 2 | 20 | 111 | 92 |
| 3 | 15 | 105 | 90 |
| 4 | 15 | 101 | 86 |
| 5 | 15 | 97 | 82 |
| 6 | 12 | 89 | 77 |

**Yield:** Wheat yield responses to seeding dates varied by location. A significant quadratic relationship was observed between seeding date and yield at Scott (p=0.020) and Melfort (p<0.001), whereas seeding date had no significant effect on yield at Swift Current (p=0.141). At Scott, the earliest seeding date resulted in the lowest mean yield of 62.6 bu/ac. Yields increased with later seeding dates, peaking at 73 bu/ac on the fifth seeding date, while the last seeding date resulted in a yield of 63.3 bu/ac, similar to earlier dates. At Melfort, the first seeding date produced the lowest yield (68.1 bu/ac), with yields increasing to a peak of 90.8 bu/ac on the fourth seeding date before declining to 80.9 bu/ac on the last seeding date. These peak yields coincide with seeding dates for the first week of May at both sites, suggesting that early May is an ideal time to seed for optimum yield potential. At Swift Current, the highest mean yield was observed on the third seeding date (27.1 bu/ac), with earlier and later seeding dates resulting in lower yields. However, differences in yield between seeding dates at Swift Current were not statistically significant, suggesting that wheat can be seeded earlier than traditional dates without yield penalties in this area.The differences in yield responses can be attributed to geographic and site-specific characteristics. Collier et al. (2020) examined early-seeded wheat across five sites in Alberta and Saskatchewan, identifying distinct yield responses based on latitude, with sites north of 51°N differing from those south of 51°N. Similarly, in this study, Scott and Melfort (north of 51°N) are located in the dark brown and black soil zones, which are characterized by heavier-textured soils. These soils retain moisture for longer periods, which, during cool and wet springs, can delay seedling emergence and increase the risk of seedling mortality. Although heavier soils take longer to warm in the spring, they retain heat more effectively once warmed, creating more stable growing conditions. At these northern sites, early seeding resulted in significantly lower yields compared to seeding in early May. However, it is important to note that the seed in this study was untreated, and the abnormally cool and wet spring conditions may have negatively impacted plant establishment and overall yields. Producers in these areas may want to consider using seed treatments when seeding wheat in early April to mitigate these risks. In contrast, Swift Current (south of 51°N) is situated in the brown soil zone, which typically experiences earlier snowmelt and warmer spring conditions. The lighter-textured soils in this region drain moisture more quickly, reducing risks associated with cold, wet soils. The absence of significant yield differences between seeding dates at Swift Current suggests that wheat in this area is less sensitive to seeding date, likely due to more consistent soil and climatic conditions. **Figure 6.** Wheat yield (bu/ac) response to seeding dates at Scott, Swift Current, and Melfort in 2024. Significance determined at p<0.05. **Seed Quality:**Seeding dates significantly affected wheat protein content at Swift Current (p<0.001) and Melfort (p<0.001), but had no significant effect at Scott (p=0.734) (Figure 7). At Swift Current, the linear relationship between seeding date and protein indicated that earlier seeding dates resulted in slightly lower protein levels. Wheat seeded in April recorded the lowest protein at Swift Current, below 18.8%. Protein levels increased with later seeding dates, reaching 19.4% for the fifth seeding date, and the highest protein content of 20.1% was observed for the last seeding date. Similarly, at Melfort, the lowest protein content (12.2%) occurred for the first seeding date. Protein levels increased as the seeding date progressed, with the highest protein levels (13.9%) recorded for the last two seeding dates. At Scott, seeding date did not significantly affect wheat protein content. The lowest protein (12.3%) was recorded for the third seeding date, while the highest protein (13.1%) was recorded for the last seeding date. Overall, all wheat in the study had protein levels above 10%, which is the minimum required for No. 1 grade wheat. Altogether, seeding date did not affect protein levels of wheat at Scott; however, later seeding into May at Swift Current and Melfort resulted in higher protein levels than early seeding in April. **Figure 7.** Effect of seeding date on wheat protein (%) at Scott, Swift Current, and Melfort in 2024. Significance determined at p<0.05. Test weights were only recorded for Swift Current and Scott sites, as it was not a data collection requirement. At Scott, seeding date did not have an effect on test weight of wheat (p=0.461) (Figure 8). However, at Swift Current, there was a significant negative linear relationship (p=0.001) between seeding date and test weight of grain (Figure 8). Earlier seeding dates resulted in higher test weights, which decreased as seeding was delayed. The greatest test weight (376 g/0.5L) was recorded for the second seeding date, and these values decreased to 344 g/0.5L by the last seeding date. The minimum test weight for No. 1 wheat is 365 g/0.5L, but all May seeding dates at Swift Current resulted in test weights below this threshold, leading to No. 2 grade wheat (CGC, 2024). The lowest test weight, recorded for the second week of May at 344 g/0.5L, even resulted in No. 3 grade wheat, as the minimum for this grade is 350 g/0.5L. These results suggest that early seeding in April at Swift Current may produce grain with greater test weights. **Figure 8.** The effect of seeding date on test weight (g/0.5 L) of wheat at Scott and Swift Current in 2024. Significance determined at p<0.05. **Project Extension:** This project was showcased during the growing season at the annual field days for WARC on July 10th and WCA on July 18th. At the WARC field day, Alex Waldner presented the trial to an audience of approximately 100 people. At the WCA field day, Shannon Chant, a Ministry of Agriculture representative, and Amber Wall presented the trial to around 75 attendees. The project was also featured on the weekly radio program “Walk the Plots”, which airs across three radio stations throughout the Southwest.Throughout the winter, the project will be presented at various conferences and meetings. In November, Amber Wall discussed the project at the Sask Wheat Coffee Talk in Assiniboia, where approximately 70 farmers were in attendance. Alex Waldner is also scheduled to present the project at the WARC Crop Opportunity event in North Battleford on February 27th. In addition to these presentations, a fact sheet and full report will be made available for public access on the websites of WARC, WCA, and NARF. |
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# Conclusions and Recommendations

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| In conclusion, early seeding of wheat was generally successful across all study locations, although there were slight variations in overall performance between sites. While plants established well for early seeding dates, emergence was significantly delayed, with some delays reaching up to 24 days. Cold temperatures can slow germination and emergence, increasing the risk of seedling disease and mortality. This highlights the importance of considering seed treatments when seeding into cold soils. Despite delayed emergence, all seeding date treatments resulted in successful emergence, although plant survival at 4 weeks after seeding (WAS) was significantly lower for the earliest seed date. Plant densities were typically highest for seeding dates between the third and fourth week of April. Seeding date did not impact wheat lodging, suggesting that other agronomic and environmental factors had a greater influence on lodging than seeding dates. Similarly, plant height varied little across seeding dates, though plants tended to be taller for seeding dates between the third week of April and the second week of May, depending on location. Despite delayed emergence for early seeding dates, they resulted in longer growing seasons, as evidenced by the increased number of days to maturity and the extended period from emergence to maturity compared to later seeded wheat. Longer growing seasons can provide benefits such as early access to soil moisture, early season growing degree-day accumulation, increased vegetative growth periods, early season precipitation, longer day length at anthesis, and reduced average temperatures during grain fill.The impact of seeding date on yield varied by location. At sites north of 51°N, early seeding resulted in yield penalties, with peak yields observed for the first week of May. However, the seed in this study was untreated, and cool and wet spring conditions at these sites may have negatively impacted plant establishment and overall yields for early seeded treatments. Producers in these areas may want to consider using seed treatments when seeding wheat in early April to mitigate these risks. In contrast, yields did not significantly differ at Swift Current, suggesting that wheat can be seeded earlier than traditional seeding dates in this area. Regarding protein content, early seeding dates generally resulted in lower protein levels at Melfort and Swift Current, though protein content remained above 10% (the minimum for No. 1 grade wheat). At Scott, no effect of seeding date on protein content was observed. Test weights were higher for early seeding dates at Swift Current, with no significant differences at Scott.Overall, early seeding of wheat was successful at all locations; however, yield responses were location-dependent. Early seeding resulted in yield penalties at Melfort and Scott, while at Swift Current, no significant yield differences were observed across seeding dates. Early seeding in regions north of 51°N (Scott and Melfort) may result in yield penalties due to cool, wet conditions, and producers should consider using seed treatments for early April planting, while in areas like Swift Current, earlier seeding is viable without significant yield differences. |

# Sustainable Canadian Agricultural Partnership (Sustainable CAP) Performance Indicators

1. List of performance indicators

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| --- | --- |
| Sustainable CAP Indicator | Total Number |
| Scientific publications from this project (List the publications under section b) |
| Published | 0 |
| Accepted for publication | 0 |
| Highly Qualified Personnel (HQPs) trained during this project |
| Master’s students | 0 |
| PhD students | 0 |
| Post docs | 0 |
| Knowledge transfer products developed based on this project (presentations, brochures, factsheets, flyers, guides, extension articles, podcasts, videos)1. List the knowledge transfer products under section (c)  |   |

# Please only include the number of unique knowledge transfer products.

b) List of scientific journal articles published/accepted for publication from this project. Please ensure that each line includes the following: **Title, Author(s), Journal, Date Published or Accepted for Publication** **and Link to Article (if available).** *Add additional lines as needed*.

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| 1. |
| 2. |
| 3. |
| 4. |

# c) List of knowledge transfer products/activities developed from this project.

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| --- | --- | --- | --- |
| Knowledge Transfer Product or Activity  | Event/Location Where Knowledge Transfer Was Conducted | Estimated Number of Producers Participated in Knowledge Transfer | Link (if available) |
| Scott Field Day | Scott, SK  | 100 |   |
| WCA Field Day | Swift Current, SK | 75 |   |
| Walk the Plots | Magic 97.1, Country 94.1, CKSW 570 | Southwest Saskatchewan | https://wheatlandconservation.ca/news-events/ |
| SK Wheat Coffee Talks | Assiniboia, SK | 70 |   |
| Crop Opportunity | North Battleford, SK | 100 |   |

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| **Appendices:** **Appendix I: Agronomic Management of Field Sites****Table 1.** Agronomic operations for early seeded wheat at Scott, Swift Current, and Melfort, SK., 2024.

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| --- | --- | --- | --- |
| **Operation** | **Scott** | **Swift Current** | **Melfort** |
| Plot Size | 1.5 x 8 m | 1.5 x 6.3 m | 1.8 x 9 m |
| Seeder | Fabro knife opener | Fabro-built cone seeder | Fabro |
| Row Spacing | 10" | 8.25" | 12" |
| Stubble Type | canola |  durum | canola |
| Variety | AAC Wheatland | CDC Adamant VB | AAC Starbuck VB |
| Seed Rate | 300 seeds/m2 | 300 seeds/m2 | 300 seeds/m2 |
| Seed Depth | 1" | 1.5-1.75" | 1" |
| Fertility | 124 lbs N/ac, 31 lbs P2O5/ac, 11 lbs K2O/ac, 14 lbs S/ac | 80 lbs N/ac, 40 lbs P2O5/ac, 16 lbs S/ac | 154 lbs N/ac, 50 lbs P2O5/ac, 15 lbs K2O/ac, 10 lbs S/ac |
| Fertilizer Types | urea, monoammonium phosate, potash, ammonium sulphate |  urea, monoammonium phosate, potash, ammonium sulphate | urea, monoammonium phosate, potash, ammonium sulphate |
| Fertilizer Placement | side-band | side-band | N midrow; P-K-S side-band |
| Pre-seed herbicide | none | Glyphosate RT540 @ 0.5L/ac + Aim @ 35 ml/ac | none |
| In-crop herbicide | Axial Xtreme@ 0.5 L/ac & Buctril M @ 0.4 L/ac | Liquid Achieve @ 200ml/ac & Buctril M @ 400ml/ac & Carrier @ 0.5L/100L | Axial @ 0.5 L/ac on June 9; Enforcer M @ 0.5 L/ac on June 14 |
| Fungicide | Caramba @ 400 ml/ac | none | none |
| Insecticide | none | none | none |
| Desiccation | Glyphosate 540 @ 0.67 L/ac, Heat LQ @ 59 mL/ac & Merge @ 200 mL/ac | none | none |
| Combine | Wintersteiger | Zurn |  -- |

**Table 2.** Date of agronomic operations for all seed date treatments of wheat at Scott, Swift Current, and Melfort, SK., 2024.

|  |  |  |
| --- | --- | --- |
| **Location** | **Operations** | **Seed Date Treatment**  |
| 1 | 2 | 3 | 4 | 5 | 6 |
| Scott | Seed Date | Apr-09 | Apr-15 | Apr-23 | Apr-29 | May-05 | May-14 |
| Soil Temp (°C) | 4.5 | 4.9 | 10.0 | 11.3 | 11.5 | 15.5 |
| Emergence Date | May-03 | May-05 | May-09 | May-14 | May-20 | May-28 |
| Pre-seed herbicide | none | none | none | none | none | none |
| In-crop herbicide | Jun-18 | Jun-18 | Jun-18 | Jun-18 | Jun-18 | Jun-18 |
| Fungicide | Jul-05 | Jul-05 | Jul-05 | Jul-11 | Jul-11 | Jul-11 |
| Insecticide | none | none | none | none | none | none |
| Desiccation | Aug-21 | Aug-21 | Aug-21 | Aug-21 | Aug-21 | Aug-21 |
| Harvest Date | Sep-02 | Sep-02 | Sep-02 | Sep-02 | Sep-02 | Sep-02 |
| Swift Current | Seed Date | Apr-09 | Apr-15 | Apr-23 | Apr-29 | May-06 | May-13 |
| Soil Temp (°C) | 5.0 | 9.2 | 7.1 | 10.3 | 10.4 | 18.3 |
| Emergence Date | 30-Apr | 07-May | 11-May | 14-May | 21-May | 21-May |
| Pre-seed herbicide | Apr-16 | Apr-16 | Apr-16 | Apr-16 | Apr-16 | Apr-16 |
| In-crop herbicide | Jun-11 | Jun-11 | Jun-11 | Jun-11 | Jun-11 | Jun-11 |
| Fungicide | none | none | none | none | none | none |
| Insecticide | none | none | none | none | none | none |
| Desiccation | none | none | none | none | none | none |
| Harvest Date | Aug-06 | Aug-06 | Aug-06 | Aug-06 | Aug-06 | Aug-06 |
| Melfort | Seed Date | Apr-15 | Apr-25 | Apr-30 | May-06 | May-14 | May-27 |
| Soil Temp (°C) | 5°C | 13°C | 12.2°C | 5.8°C | 13.2°C | 14.8°C |
| Emergence Date | May-06 | May-12 | May-12 | -- | -- | -- |
| Pre-seed herbicide | none | none | none | none | none | none |
| In-crop herbicide | June 9 & June 14 | June 9 & June 14 | June 9 & June 14 | June 9 & June 14 | June 9 & June 14 | June 9 & June 14 |
| Fungicide | none | none | none | none | none | none |
| Insecticide | none | none | none | none | none | none |
| Desiccation | none | none | none | none | none | none |
| Harvest Date | Aug-20 | Aug-20 | Aug-30 | Aug-30 | Sep-09 | Sep-09 |

**Appendix II: Soil Characteristics for Field Sites****Table 1.** Soil nutrient concentration and characteristics at Scott, Swift Current, and Melfort sampled in the spring of 2024.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|   |   | Scott | Swift Current | Melfort |
| Soil Zone |   | dark brown | brown | black |
| Nitrate (NO3)- 0-6" depth | lbs/ac | 15 | 12 | 17 |
| Nitrate (NO3)- 6-24" depth |  | 18 | 63 | 18 |
| Phosphorus (Olsen) | ppm | 12 | 11 | 12 |
| Potassium | ppm | 294 | 260 | 334 |
| Sulphur- 0-6" depth | lbs/ac | 16 | 8 | 28 |
| Sulphur- 6-24" depth |  | 54 | 18 | 30 |
| Organic Matter | % | 4 | 3.1 | 9.5 |
| pH  |  | 5.6 | 7.4 | 5.8 |
| Cation Exchange Capacity  | meq | 14.1 | 27.1 | 34.0 |

**Appendix III: Summary of Statistical Analysis****Table 1.** Summary of fixed effects (seed date and replicate) and their interaction on response variables for all sites combined and individual sites (Scott, Swift Current, and Melfort). Bold values indicate significance when p<0.05.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Site | Main Effect | Plant Density (2 WAS) | Plant Density (4 WAS) | Lodging | Height | Days to Maturity | Yield | Protein | Test Weight |
|   |  | --------------------------------------------------------Pr>F (p-value)\*------------------------------------------------------ |
| All Sites | Seed Date (SD) | **<0.001** | **0.003** | 0.961 | 0.225 | **<0.001** | **0.001** | **<0.001** | 0.257 |
| Replicate (REP) | 0.955 | 0.334 | 0.567 | 0.851 | 0.958 | 0.264 | 0.640 | 0.934 |
| SD x REP | 1.000 | 0.999 | 0.617 | 0.259 | 1.000 | 0.855 | 0.977 | 0.978 |
| Scott | Seed Date (SD) | **<0.001** | **0.001** | 0.897 | 0.449 | **<0.001** | **<0.001** | 0.500 | 0.168 |
| Replicate (REP) | 0.999 | 0.786 | 0.060 | 0.239 | 0.971 | **0.001** | **0.001** | **<0.001** |
| Swift Current | Seed Date (SD) | **<0.001** | 0.093 | --\*\* | 0.555 | 1.000 | 0.298 | **0.002** | **0.005** |
| Replicate (REP) | 0.986 | **0.038** | -- | **0.014** | 1.000 | 0.999 | 0.215 | 0.506 |
| Melfort | Seed Date (SD) | **<0.001** | **<0.001** | 0.446 | 0.064 | **<0.001** | **<0.001** | **<0.001** | NA\*\*\* |
| Replicate (REP) | 0.988 | 0.689 | 0.413 | 0.446 | 0.895 | 0.914 | 0.850 | NA |

\*Bold values denote significance at p<0.05\*\*No variation in data, could not run model\*\*NA = data was not collected as it was not a requirement in the protocol**Table 2.** Summary of means and post hoc letter groups from mixed effects model and p-values for linear and quadratic relationships for the effect of seeding date on mean plant density of wheat at 2 weeks after seeding (WAS) for all sites combined and individual sites (Scott, Swift Current, Melfort) in 2024. Different letters within columns denotes significance at p<0.05. SEM is standard error of the mean.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | All Sites |  | Scott |   | Swift |   | Melfort |   |
| Seed Date | -----------------------------mean plant density (plants/m2)--------------------- |
| 1 | 0 | *c* | 0 | *c* | 0 | *b* | 0 | *d* |
| 2 | 0 | *c* | 0 | *c* | 0 | *b* | 0 | *d* |
| 3 | 107 | *b* | 0 | *c* | 181 | *a* | 138 | *c* |
| 4 | 229 | *a* | 219 | *a* | 197 | *a* | 270 | *b* |
| 5 | 228 | *a* | 242 | *a* | 198 | *a* | 243 | *b* |
| 6 | 256 | *a* | 165 | *b* | 183 | *a* | 422 | *a* |
| Grand Mean | 137 |  | 104 |  | 127 |  | 179 |  |
| SEM | 15 |  | 22 |  | 19 |  | 32 |  |
|  | -----------------------------Pr>F (p-value)-------------------------- |
| seed date - mixed model | <0.001 |  | <0.001 |  | <0.001 |  | <0.001 |  |
| seed date - linear | <0.001 |  | <0.001 |  | <0.001 |  | <0.001 |  |
| seed date - quadratic | 0.133 |   | 0.345 |   | <0.001 |   | 0.324 |   |

**Table 3.** Summary of means and post hoc letter groups from mixed effects model and p-values for linear and quadratic relationships for the effect of seeding date on mean plant density of wheat at 4 weeks after seeding (WAS) for all sites combined and individual sites (Scott, Swift Current, Melfort) in 2024. Different letters within columns denotes significance at p<0.05. SEM is standard error of the mean.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | All Sites |  | Scott |   | Swift |   | Melfort |   |
| Seed Date | -----------------------------mean plant density (plants/m2)--------------------- |
| 1 | 198 | *b* | 163 | *b* | 192 | *a* | 238 | *b* |
| 2 | 238 | *ab* | 228 | *a* | 194 | *a* | 292 | *b* |
| 3 | 240 | *ab* | 241 | *a* | 189 | *a* | 290 | *b* |
| 4 | 242 | *a* | 235 | *a* | 215 | *a* | 276 | *b* |
| 5 | 235 | *ab* | 232 | *a* | 210 | *a* | 263 | *b* |
| 6 | 270 | *a* | 208 | *ab* | 211 | *a* | 392 | *a* |
| Grand Mean | 237 |  | 218 |  | 202 |  | 292 |  |
| SEM | 7 |  | 7 |  | 4 |  | 12 |  |
|  | -----------------------------Pr>F (p-value)-------------------------- |
| seed date - mixed model | 0.003 |  | 0.001 |  | 0.093 |  | <0.001 |  |
| seed date - linear | 0.007 |  | 0.098 |  | 0.037 |  | 0.004 |  |
| seed date - quadratic | 0.681 |   | <0.001 |   | 0.982 |   | 0.143 |   |

**Table 4.** Summary of means and post hoc letter groups from mixed effects model and p-values for linear and quadratic relationships for the effect of seeding date on mean lodging ratings (0-9) of wheat for all sites combined and individual sites (Scott, Swift Current, Melfort) in 2024. Different letters within columns denotes significance at p<0.05. SEM is standard error of the mean.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | All Sites |  | Scott |   | Swift |   | Melfort |   |
| Seed Date | -----------------------------mean lodging rating (0-9)--------------------- |
| 1 | 0.5 | *a* | 1.6 | *a* | 0.0 |  | 0.0 | *a* |
| 2 | 0.5 | *a* | 1.4 | *a* | 0.0 |  | 0.0 | *a* |
| 3 | 0.5 | *a* | 1.4 | *a* | 0.0 |  | 0.0 | *a* |
| 4 | 0.5 | *a* | 1.4 | *a* | 0.0 |  | 0.0 | *a* |
| 5 | 0.6 | *a* | 1.8 | *a* | 0.0 |  | 0.0 | *a* |
| 6 | 0.5 | *a* | 1.2 | *a* | 0.0 |  | 0.3 | *a* |
| Grand Mean | 0.5 |  | 1.5 |  | 0.0 |  | 0.0 |  |
| SEM | 0.1 |  | 0.1 |  | 0.0 |  | 0.04 |  |
|  | -----------------------------Pr>F (p-value)-------------------------- |
| seed date – mixed model | 0.961 |  | 0.897 |  | -- |  | 0.446 |  |
| seed date - linear | 0.993 |  | 0.680 |  | -- |  | 0.147 |  |
| seed date - quadratic | 0.919 |   | 0.854 |   | -- |   | 0.176 |   |

**Table 5.** Summary of means and post hoc letter groups from mixed effects model and p-values for linear and quadratic relationships for the effect of seeding date on mean height (cm) of wheat for all sites combined and individual sites (Scott, Swift Current, Melfort) in 2024. Different letters within columns denotes significance at p<0.05. SEM is standard error of the mean.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | All Sites |  | Scott |   | Swift |   | Melfort |   |
| Seed Date | -----------------------------mean height (cm)------------------------ |
| 1 | 81.5 | *a* | 85.0 | *a* | 71.8 | *a* | 87.8 | *a* |
| 2 | 82.9 | *a* | 84.9 | *a* | 72.3 | *a* | 91.5 | *a* |
| 3 | 82.0 | *a* | 83.1 | *a* | 72.1 | *a* | 91.0 | *a* |
| 4 | 82.2 | *a* | 82.3 | *a* | 73.6 | *a* | 90.8 | *a* |
| 5 | 82.6 | *a* | 83.0 | *a* | 73.8 | *a* | 91.0 | *a* |
| 6 | 80.3 | *a* | 83.6 | *a* | 69.2 | *a* | 88.2 | *a* |
| Grand Mean | 81.9 |  | 83.7 |  | 72.1 |  | 90.1 |  |
| SEM | 1.0 |  | 0.5 |  | 0.9 |  | 0.5 |  |
|  | -----------------------------Pr>F (p-value)-------------------------- |
| seed date - mixed model | 0.225 |  | 0.449 |  | 0.555 |  | 0.064 |  |
| seed date - linear | 0.735 |  | 0.153 |  | 0.690 |  | 0.933 |  |
| seed date - quadratic | 0.781 |  | 0.156 |  | 0.467 |  | 0.014 |  |

**Table 6.** Summary of means and post hoc letter groups from mixed effects model and p-values for linear and quadratic relationships for the effect of seeding date on mean days to maturity of wheat for all sites combined and individual sites (Scott, Swift Current, Melfort) in 2024. Different letters within columns denotes significance at p<0.05. SEM is standard error of the mean.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | All Sites |  | Scott |   | Swift |   | Melfort |   |
| Seed Date | -----------------------------mean days to maturity------------------------ |
| 1 | 118 | *a* | 125 | *a* | 107 |  | 121 | *a* |
| 2 | 111 | *b* | 120 | *b* | 101 |  | 113 | *b* |
| 3 | 105 | *c* | 113 | *c* | 93 |  | 110 | *bc* |
| 4 | 101 | *d* | 108 | *d* | 87 |  | 108 | *cd* |
| 5 | 97 | *e* | 104 | *e* | 82 |  | 105 | *d* |
| 6 | 89 | *f* | 98 | *f* | 75 |  | 95 | *e* |
| Grand Mean | 104 |  | 111 |  | 91 |  | 109 |  |
| SEM | 1.6 |  | 1.9 |  | 2.3 |  | 1.7 |  |
|  | -----------------------------Pr>F (p-value)-------------------------- |
| seed date - mixed model | <0.001 |  | <0.001 |  | 1.000 |  | <0.001 |  |
| seed date - linear | <0.001 |  | <0.001 |  | <0.001 |  | <0.001 |  |
| seed date - quadratic | 0.912 |  | 0.329 |  | 0.017 |  | 0.679 |  |

**Table 7.** Summary of means and post hoc letter groups from mixed effects model and p-values for linear and quadratic relationships for the effect of seeding date on mean yield (bu/ac) of wheat for all sites combined and individual sites (Scott, Swift Current, Melfort) in 2024. Different letters within columns denotes significance at p<0.05. SEM is standard error of the mean.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | All Sites |  | Scott |   | Swift |   | Melfort |   |
| Seed Date | -----------------------------mean yield (bu/ac)----------------------- |
| 1 | 51.3 | *b* | 62.6 | *c* | 23.2 | *a* | 68.1 | *b*  |
| 2 | 58.5 | *ab* | 67.3 | *bc* | 25.2 | *a* | 83.0 | *a* |
| 3 | 61.0 | *a* | 67.0 | *bc* | 27.1 | *a* | 88.8 | *a* |
| 4 | 60.8 | *a* | 71.4 | *ab* | 20.0 | *a* | 90.8 | *a* |
| 5 | 60.6 | *a* | 73.0 | *a* | 21.7 | *a* | 87.2 | *a* |
| 6 | 54.9 | *ab* | 63.3 | *c* | 20.6 | *a* | 80.9 | *a* |
| Grand Mean | 57.9 |  | 67.4 |  | 23.0 |  | 83.1 |  |
| SEM | 3.1 |  | 1.3 |  | 1.0 |  | 1.8 |  |
|  | -----------------------------Pr>F (p-value)-------------------------- |
| seed date - mixed model | 0.001 |  | <0.001 |  | 0.298 |  | <0.001 |  |
| seed date - linear | 0.708 |  | 0.347 |  | 0.141 |  | 0.049 |  |
| seed date - quadratic | 0.293 |   | 0.020 |   | 0.468 |   | <0.001 |   |

**Table 8.** Summary of means and post hoc letter groups from mixed effects model and p-values for linear and quadratic relationships for the effect of seeding date on mean grain protein (%) of wheat for all sites combined and individual sites (Scott, Swift Current, Melfort) in 2024. Different letters within columns denotes significance at p<0.05. SEM is standard error of the mean.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | All Sites |  | Scott |   | Swift |   | Melfort |   |
| Seed Date | -----------------------------mean protein (%)------------------------ |
| 1 | 14.3 | *b* | 12.8 | *a* | 18.0 | *b* | 12.2 | *c* |
| 2 | 14.6 | *b* | 13.0 | *a* | 17.8 | *b* | 12.9 | *bc* |
| 3 | 14.4 | *b* | 12.3 | *a* | 17.8 | *b* | 13.1 | *abc* |
| 4 | 14.9 | *ab* | 12.6 | *a* | 18.8 | *ab* | 13.3 | *ab* |
| 5 | 15.4 | *a* | 12.8 | *a* | 19.4 | *ab* | 13.9 | *a* |
| 6 | 15.7 | *a* | 13.1 | *a* | 20.1 | *a* | 13.9 | *a* |
| Grand Mean | 14.9 |  | 12.8 |  | 18.7 |  | 13.2 |  |
| SEM | 0.3 |  | 0.2 |  | 0.2 |  | 0.1 |  |
|  | -----------------------------Pr>F (p-value)-------------------------- |
| seed date - mixed model | <0.001 |  | 0.500 |  | 0.002 |  | <0.001 |  |
| seed date - linear | 0.158 |  | 0.734 |  | <0.001 |  | <0.001 |  |
| seed date - quadratic | 0.692 |  | 0.300 |  | 0.102 |  | 0.419 |  |

**Table 9.** Summary of means and post hoc letter groups from mixed effects model and p-values for linear and quadratic relationships for the effect of seeding date on mean test weight (g/0.5L) of wheat for all sites combined and individual sites (Scott, Swift Current, Melfort) in 2024. Different letters within columns denotes significance at p<0.05. SEM is standard error of the mean.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|   | All Sites |  | Scott |   | Swift |   |
| Seed Date | -----------------------------mean test weight (g/0.5L)------------------------ |
| 1 | 384.0 | *a* | 399.0 | *a* | 370 | *a* |
| 2 | 387.0 | *a* | 397.0 | *a* | 376 | *a* |
| 3 | 385.0 | *a* | 398.0 | *a* | 372 | *a* |
| 4 | 383.0 | *a* | 397.0 | *a* | 368 | *ab* |
| 5 | 379.0 | *a* | 397.0 | *a* | 362 | *ab* |
| 6 | 373.0 | *a* | 402.0 | *a* | 344 | *b* |
| Site Mean | 381.8 |  | 398.3 |  | 365 |  |
| SEM | 2.3 |  | 1.2 |  | 2.9 |  |
|  | -----------------------------Pr>F (p-value)-------------------------- |
| seed date - mixed model | 0.257 |  | 0.168 |  | 0.005 |  |
| seed date - linear | 0.170 |  | 0.461 |  | 0.001 |  |
| seed date - quadratic | 0.442 |  | 0.234 |  | 0.009 |  |

**References:** Collier, G.R., Spaner, D.M., Graf, R.J. and Beres, B.L. (2021). Optimal Agronomics Increase Grain Yield and Grain Yield Stability of Ultra-Early Wheat Seeding Systems. *Agronomy*, 11(2): 240.Collier, G.R., Spaner, D.M., Graf, R.J. and Beres, B.L. (2020). The integration of spring and winter wheat genetics with agronomy for ultra-early planting into cold soils. *Frontiers in Plant Science*, 11: 89.Collier, G.R., Spaner, D.M., Graf, R.J., Gampe, C.A. and Beres, B.L. (2022). Canadian spring hexaploid wheat (*Triticum aestivum* L.) cultivars exhibit broad adaptation to ultra-early wheat planting systems. *Canadian Journal of Plant Science,* 102(2): 442-448. <https://doi.org/10.1139/cjps-2021-0155>Canadian Grain Commission (CGC). (2024). Wheat: Primary grade determination table for Canada Western Red Spring (CWRS) wheat. <https://www.grainscanada.gc.ca/en/grain-quality/official-grain-grading-guide/04-wheat/primary-grade-determination/cwrs-wheat.html>. [Accessed January 21, 2025].Saskatchewan Ministry of Agriculture (Sask Ag). (n.d.). Wheat: Canada Prairie Spring Wheat. <https://www.saskatchewan.ca/business/agriculture-natural-resources-and-industry/agribusiness-farmers-and-ranchers/crops-and-irrigation/field-crops/cereals-barley-wheat-oats-triticale/wheat-canada-prairie-spring-wheat#:~:text=Aim%20for%20the%20same%20plant,per%201%2C000%20kernels%20(TKW)>. [Accessed January 21, 2025]. |

# Expenditure Statement

|  |
| --- |
| **Available upon request.** |