Final Report

from the

Irrigation Crop Diversification Corporation (ICDC)

Hemp Seeding Date Demonstration for Grain Production

(SFP# 20200455)

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1. **Project title and SFP file number.**
   Hemp Seeding Date Demonstration for Grain Production
   Project # 20200455 SFP

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4. **Abstract/ Summary**:
   The primary aim of this project was to identify the optimal seeding date for conventional hemp in Saskatchewan. Three hemp varieties—X59, Picolo, and Kantani—were planted at three distinct times: late May, mid-June, and early July. Field trials were set up at four locations in Saskatchewan [ICDC (Outlook), WARC (Scott), NARF (Melfort), and IHARF (Indian Head)] in a replicated split-plot design. Three of the four trial sites were established under natural rainfed conditions (dryland; IHARF, WARC and NARF), while ICDC was the only irrigated site. The target plant population was 100-125 plants/m2, but some sites experienced lower densities due to drier soil conditions. Throughout the study, all sites faced drier conditions with temperatures exceeding the long-term averages, impacting the yield potential of dryland sites. In the irrigated ICDC trial, the mid-June seeding date exhibited a yield advantage and better plant emergence compared to early and late seeding dates. This trend was consistent across all dryland sites, demonstrating promising yields when seeded in mid-June. Among the three tested varieties, X59 consistently outperformed the other varieties at all sites, showcasing higher yield potential in Saskatchewan's growing conditions. Hemp height was influenced by water availability at each site, with irrigated sites displaying almost double the height of dryland sites. Assessing maturity proved challenging but was also impacted by the seeding date. Expressed as days from seeding, early-seeded hemp took longer to reach physiological maturity than later seeding dates tested in this study.

5. **Extension Messages:**
   <u>Seeding Date Variability</u>: Significant variability in plant density, height, maturity days, and yield was observed across sites and years, emphasizing the need for tailored seeding strategies. Among the three seeding dates investigated, the mid-June seeding date consistently delivered the best results.
   <u>Varietal Differences</u>: Varieties X59 consistently displayed higher yield, providing producers with valuable information for variety selection.
   <u>Environmental Impact</u>: Adverse conditions, such as drought across all three years of this study influenced results, underlining the importance of considering environmental factors in hemp cultivation decisions.
   <u>Economic Potential:</u> The study demonstrated hemp's economic potential in Saskatchewan, with varieties showing promising yields, contributing to crop diversity in rotations.

6. **Introduction:**
   The project demonstrates different seeding dates for three varieties of conventional hemp to show producers the ideal time for seeding in various Saskatchewan locations. This demonstration was intended to provide producers with data for different hemp varieties and a wide range of seeding dates in Saskatchewan. Hemp is a newer crop in Saskatchewan and is a high value crop ($0.75-$0.90/lb.) with good potential yield (average 660-1,070 lbs./acre and up to 2,000 lbs./acre under irrigation). Discovering optimum seeding dates for this higher value crop will encourage local growth in the conventional hemp

industry and help ensure that new growers have access to information that will contribute to their success. Having regional seeding dates and variety recommendations would increase acres of this crop in Saskatchewan and provide economic benefits to producers. With increased pathogens associated with major crops currently grown (fusarium in wheat and clubroot in canola), increasing economic crop options in rotations are becoming more important. Demonstrating the high potential return of this crop and how the currently registered varieties perform will help producers decide if they want to include this crop in their rotation. Demonstrating the wide seeding date window of this crop will also show producers how growing hemp can help with time management in the spring.

7. **Objectives and the progress towards meeting each objective.**
The following table contains completed objectives from this project's years one, two, and three.

Objectives (Please list the original objectives and/or revised objectives if Ministry-approved revisions have been made to original objectives. A justification is needed for any deviation from original objectives).	**Status (e.g. completed/not completed)**
a) Demonstrate different seeding dates of three varieties of conventional hemp to show producers the ideal seeding time in various Saskatchewan locations (Year 1)	Completed as scheduled
b) Demonstrate different seeding dates of three varieties of conventional hemp to show producers the ideal seeding time in various Saskatchewan locations (Year 2)	Completed as scheduled
c) Demonstrate different seeding dates of three varieties of conventional hemp to show producers the ideal seeding time in various Saskatchewan locations (Year 3)	Completed as scheduled

8. Methodology:
This project was set up as a four-replicate split-plot design. Field trials were established at four locations in Saskatchewan [ICDC (Outlook), WARC (Scott), NARF (Melfort), and IHARF (Indian Head)]. Outlook was the only irrigated site, whereas Melfort, Scott, and Indian Head were non-irrigated.
The main factor was the seeding date.

1. End of May
2. Middle of June
3. Beginning of July

The target dates intended were May 31, June 15, and July 1, but the actual seeding date varied between sites (± 5 days) due to expected inclement weather.
The second factor was three hemp varieties (X59, Picolo, and Kantani), all of which were high-yielding dwarfs that are suitable for Saskatchewan conditions.
Plot size and row spacing varied at the four participating sites depending on the equipment. We seeded hemp plots at 30 lb/ac seed rate (sometimes adjusted for differences in germination and thousand kernel weight), with an estimated target plant density of 100-125 plants/m^2. Fertilizer was applied in a sideband to reduce the risk of seedling injury, and rates were dependent on soil test results. Plant vigor was visually assessed for each treatment 2-3 weeks after planting. Plant heights were measured before harvest, and days to maturity were evaluated for each variety and seeding date. At all sites, plots were harvested when the crop had reached physiological maturity (lower grains were hard and the seed bract didn't hold the seeds started to shatter, but the plants were still green). Plots were directly combined depending upon the maturity of each variety and seeding dates. Yields were determined from cleaned harvest grain samples and corrected to the required moisture content.

9. **Results and discussion:**

Environmental Conditions

The environmental conditions at all sites in 2021, 2022, and 2023 are presented in Table 1. Across the board, all sites experienced warmer temperatures than the long-term average during these years. Melfort exhibited exceptionally dry conditions in 2021 and 2023, while Indian Head experienced below-average precipitation levels in 2022. Throughout the study period, Outlook and Scott sites consistently received below-normal rainfall.

Table 1. Environmental conditions from May to September of 2021 2022 and 2023 at all sites in the demonstration

	May	**June**	**July**	**Aug**	**Sept**	**Total/Average**
			-----Temperature (°C)-----			
Melfort 2021	9.6	18.2	20.1	16.9	14	15.7
Melfort 2022	9.8	15.2	18.2	18.7	13.7	15.1
Melfort 2023	14.1	19.2	16.9	17.3	14.5	16.4
Long-term [x]	*10.7*	*15.9*	*17.5*	*16.8*	*11.7*	*14.5*
Indian Head 2021	9	17.7	20.3	17.1	14.5	15.7
Indian Head 2022	10.9	16.1	18.1	18.3	13.7	15.4
Indian Head 2023	14	19.4	16.7	17.7	14.4	16.4
Long-term [x]	*10.8*	*15.8*	*18.2*	*17.4*	*11.5*	*15.5*
Scott 2021	8.9	17.3	19.6	17.2	12.5	15.1
Scott 2022	10	15	18.3	18.9	13.8	15.2
Scott 2023	14.9	17.3	17.1	17.4	13.7	16.1
Long-term [x]	*10.8*	*14.8*	*17.3*	*16.3*	*11.2*	*14.1*
Outlook 2021	10.2	18.6	21.6	17.9	14.4	16.5
Outlook 2022	11.5	16.1	18.9	18	12.3	15.4
Outlook 2023	15.2	19.5	18.5	18.7	15.4	17.5
Long-term [x]	*11.5*	*16.1*	*18.9*	*18*	*13.0*	*15.5*
			-----Precipitation (mm)-----			
Melfort 2021	31.4	37.6	0.2	69.3	7.5	146.0
Melfort 2022	90.8	78.1	34.9	37.5	29.6	270.9
Melfort 2023	17.9	26.4	16.4	50	17.5+	128.2+
Long-term [x]	*42.9*	*54.3*	*76.7*	*52.4*	*36.0*	*226.3*
Indian Head 2021	81.6	62.9	51.2	99.4	0.4	295.5
Indian Head 2022	97.7	27.5	114.5	45.9	14.5	300.1
Indian Head 2023	12.9	49.6	15.9	40.8	9.0	128.2
Long-term [x]	*51.7*	*77.4*	*63.8*	*51.2*	*35.3*	*279.4*

Scott 2021	43.9	43.8	10.4	51.3	6.1	155.5
Scott 2022	38.9	69.7	69.4	48.7	26.5	199.3
Scott 2023	16.6	81.1	29.7	31.7	3.4	162.5
Long-term [x]	*38.9*	*69.7*	*69.4*	*48.7*	*26.5*	*253.2*
Outlook 2021[y]	44.1	13.1	1.5	37.7	0.2	96.6
Outlook 2022[y]	35.7	75.2	53.2	7.0	5.2	176.3
Outlook 2023[y]	17.2	15.3	15.5	46.6	16.6	111.2
Long-term [x]	*42.6*	*63.9*	*56.1*	*42.8*	*30.5*	*235.9*

[x] Long-term average is anywhere from the years 1980-2023, but the exact range of years varies by site

[y] Outlook also received a total of 218 mm cumulative precipitation as irrigation in 2021, 155 mm in 2022, and 245 mm in 2023

[a] The Environment Canada Weather Station at Melfort is missing weather data from September 18th and September 23-30th of 2023; therefore, average temperatures and cumulative precipitation from September 2023 do not include these dates.

For each site, data from all years was combined (except for NARF) for statistical analysis, and the summarized yield and plant characteristics results are presented in Tables 2, 3, and 4. The results for each year/site can be found in the Appendices (Tables 5,6,7, and 8). Plant vigor was not assessed at all sites, and in those where it was evaluated, the differences in vigor across seeding dates and varieties were negligible (data not shown).

<u>ICDC (irrigated-dark brown)</u>

Throughout the study period, there was notable variability in plant density, height, maturity days, and yield. Plant density at ICDC in all three years was in the acceptable range of 100 -125 plants/m^2. Plant count peaked in 2023 compared to 2021 and 2022. Plant densities varied across seeding dates and were higher for mid-June seeding dates. Additionally, plant densities differed between varieties, with the X59 variety exhibiting higher plant density (Table 2).

Most industrial hemp varieties exhibit dioecious characteristics, maintaining a roughly 50:50 ratio of male to female plants. Male plants flower and pollinate female plants, after which the male plants die off, allowing the female plants to continue growth and seed development (Growing Hemp in Alberta, 2020. Government of Alberta – Agriculture and Forestry). Six female plants were measured for height, and the average was used for statistical analysis. While plant height wasn't recorded in 2021, variations were observed between 2022 and 2023. Among seeding dates, late May and mid-June plant heights were comparable but taller than early July-seeded plots. Also, the hemp height for the irrigated sites was almost double that of the three dryland sites (Table 2).

Estimating maturity in hemp proved challenging due to its indeterminate growth. Seed maturation starts from the bottom of the seed head, progressing upwards, resulting in mature seeds at the bottom and immature green seeds at the top. Our trials defined maturity when the lower 2/3 of the seed head was mature and with occasional observations of shattered seeds on the ground. Maturity data collected in 2021 and 2023 showed differences in days to maturity between years, seeding dates, and varieties. Late May-seeded plots took longer to mature within the three seeding dates, while mid-June and early July-seeded plots showed similar maturity timelines. Variety X59 consistently took longer to mature compared to the other two varieties (Table 2).

The study coincided with Saskatchewan's driest and warmest conditions in recent decades, as highlighted in Table 1. Our field trials average yield across three years (Grand mean – 1,006 kg/ha) demonstrated similarity to the average hemp yield under irrigation (996 kg/ha; ICDC 2024 Economics and Agronomics guide). Notably, the 2021 yield surpassed those of 2023 and 2022. In 2022, bird damage, particularly from red-winged blackbirds and starlings, affected the ICDC field trial, contributing to reduced yields. At ICDC, under irrigation, hemp plots seeded in mid-June exhibited the highest followed by late May, while delaying seeding until early July led to a substantial decrease in yield. Across the three varieties, X59 consistently displayed higher yields, as indicated in Table 2, whereas Katani and Picolo showed lower and comparable yields. Statistical analyses revealed a significant interaction between seeding date and hemp varieties (Table 2 and Figure 1). The most pronounced interactions occurred between the X59 variety and seeding dates. X59 consistently yielded better than the other two varieties at all seeding dates, especially in late May and mid-June.

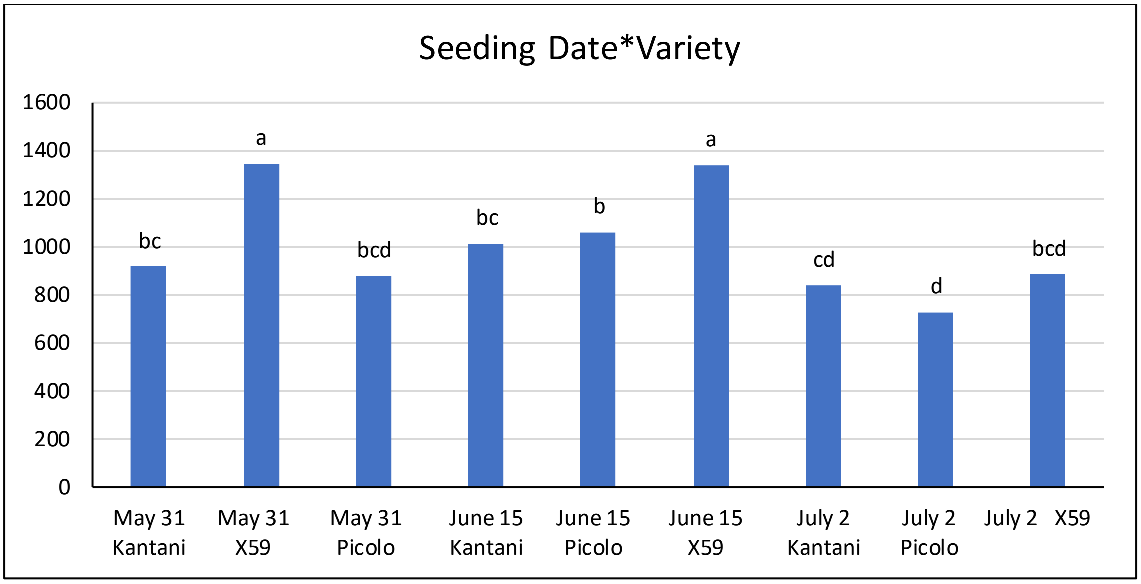

Fig 1. Hemp seed yield as Influenced by seeding date and varieties at ICDC.

Table 2: Analysis of variance (P-values) for seeding dates and varieties effect on plants/m^2 (PPMS), days to maturity (days), plant height (cm), and mean yield (kg/ha) at ICDC, Outlook (combined year 2021, 2022, and 2023). Different letters indicated significant differences between treatments (ANOVA, P ≤ 0.05).

ICDC (irrigated)	**PPMS**	**Height**	**Maturity**	**Yield (kg/ha)**
Year	<0.01	<0.0001	<0.0001	<0.0001
Seeding Date	0.04	0.001	<0.0001	<0.0001
Variety	0.004	0.0002	<0.0002	<0.0001
Seeding Date*Variety	NS	NS	NS	0.03
Grand Mean	110.8	134.3	99.6	1002.1
CV	21.8	9.07	-	20.81
<u>Year</u>				
2021	115 a	-	105 a	1235 a
2022	101 b	127.8 b	-	781 c
2023	117 a	140.8 a	94 b	990 b
<u>*Date*</u>				
Late May	106 b	135.8 a	104 a	1048 b
Mid-June	119 a	140.1 a	97 b	1140 a
Early July	107 b	127.1 b	98 b	819 c
<u>*Variety*</u>				
Katani	105 b	130.1 b	99 b	925 b
Picolo	104 b	129.4 b	98 b	890 b
X59	122 a	143.5 a	103 a	1192 a

<u>***IHARF (dryland – thin-Black soil zone)***</u>

Hemp plant characteristics and yield varied across years and treatments (seeding dates and varieties) at IHARF, Indian Head. Plant densities were notably higher in all years than at other participating sites. In 2021 and 2022, plant densities averaged 114 plants/m^2 but averaged 171 plants/m^2 in 2023. Moreover, mid-June and early July seeding plots had higher plant densities compared to late May seeding date treatments. Additionally, plant densities were consistently higher for the X59 variety than for other varieties (Table 3). Plant height also differed based on years, seeding dates, and varieties. The highest average plant height was recorded in 2022, followed by 2021 and 2023. The height differences were related to moisture conditions with considerably more precipitation in 2022 compared to the other two seasons at this location. Late May seeding hemp plants were taller than those from the other two seeding dates, and the X59 variety was taller than Katani and Picolo.

While plant maturity was not recorded in 2021, hemp plants took more days to mature in 2022 than in 2023, a response that could be explained by the hotter, drier weather in 2023. The maturity period differed between seeding dates, with late May-seeded hemp plants requiring more time to mature compared to mid-June and early July seeding dates. Similar to irrigated sites, X59 took longer to mature than other varieties (Table 3).

The hemp yield at Indian Head stood out as the highest among dryland sites, reaching a yield average of 990 kg/ha, and it was comparable to irrigated sites (Mean of 1,002 kg/ha). While hemp yield exhibited variations based on years and seeding dates, there were no significant differences observed among varieties. Among three years, the peak yield was recorded in 2022, while the lowest yield was noted when plots were seeded in early July. A significant interaction was identified between seeding dates and hemp varieties (Table 3 and Figure 2). The Katani hemp variety demonstrated the highest yields when seeded in mid-June, compared to both early and late seeding dates. Similarly, the Picolo hemp variety exhibited better yields at mid-June and early July seeding dates, but the yield declined when Picolo was seeded early. In contrast, the X59 variety showcased its highest yield when seeded early (end-May), with a tendency for decreased yield as the seeding date was delayed.

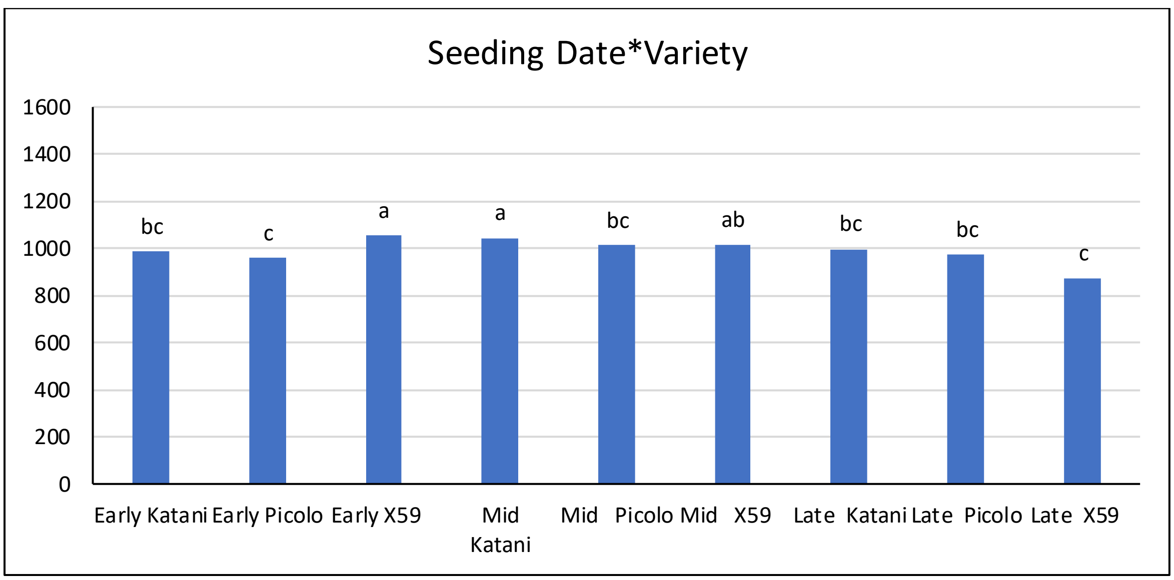

Fig 2. Hemp seed yield as Influenced by seeding date and varieties at IHARF.

Table 3: Analysis of variance (P-values) for seeding dates and varieties effect on plants/m^2 (PPMS), days to maturity (days), plant height (cm), and mean yield (kg/ha) at IHARF, Indian Head (combined year 2021, 2022, and 2023). Different letters indicated significant differences between treatments (ANOVA, P ≤ 0.05).

IHARF (dryland)	**PPMS**	**Height**	**Maturity**	**Yield**
Year	<0.0001	<0.0001	<0.0001	<0.0001
Seeding Date	0.0001	<0.0001	<0.0001	0.0001
Variety	<0.0001	<0.0001	<0.0001	NS
Seeding Date*Variety	NS	NS	NS	<0.0001
Grand Mean	132.9	107.2	97.6	990.1
CV	19.5	3.9	0.3	6.9
<u>Year</u>				
2021	114 b	106.4 b	-	1077 b
2022	114 b	123.6 a	105 a	1162 a
2023	171 a	91.7 c	90 b	731 c
<u>*Date*</u>				
Late May	117 b	115.2 a	106 a	999 a
Mid-June	146 a	108.5 b	97 b	1024 a
Early July	135 a	98.1 c	90 c	948 b
<u>*Variety*</u>				
Katani	115 b	106.4 b	97 b	1009
Picolo	125 b	105.3 b	97 b	981
X59	158 a	110.0 a	99 a	980

<u>WARC (dryland – Dark Brown soil zone)</u>

Similar to ICDC and IHARF, the characteristics and yield of hemp plants exhibited variability across different years and treatments (seeding dates and varieties) at WARC, Scott. Plant densities at WARC consistently remained low in all years, reaching their lowest point in 2022 and the highest in 2023. Seeding dates did not have a significant impact on plant densities. However, plots seeded with the X59 variety consistently displayed higher average densities than Katani and Picolo, a pattern consistent across all sites (Table 4). Like plant densities, plant height demonstrated variability across years but remained consistent between varieties. The highest average plant height was observed in 2022, nearly doubling that of 2021, followed by 2023. Additionally, average plant height was higher for mid-June and early-July seeding dates compared to the late-May seeding date.

Days to maturity differed across years, with hemp plants maturing early in 2022, while the three hemp varieties did not show significant differences in days to maturity. Seeding date treatment significantly affected days to maturity, with late May-seeded hemp taking seven and nine extra days to mature compared to mid-June and early July-seeded plots, respectively (Table 4).

Hemp yield displayed high variability over the three years (Coefficient of variation – 27.8), with a lower average yield than IHARF (mean - 735 kg/ha vs 990 kg/ha). Yield differences were observed between years, peaking in 2022 (despite lower plant count) and remaining comparable in 2021 and 2023. Seeding date significantly influenced hemp yield, with the highest yield recorded for late May seeding, comparable to mid-June, but decreasing when the seeding date was delayed to early July. Statistical analyses failed to identify any significant interaction between seeding date and hemp varieties at WARC, Scott (Table 4).

Table 4: Analysis of variance (P-values) for seeding dates and varieties effect on plants/m^2 (PPMS), days to maturity (days), plant height (cm), and mean yield (kg/ha) at WARC, Scott (combined year 2021, 2022, and 2023). Different letters indicated significant differences between treatments (ANOVA, P ≤ 0.05).

WARC (dryland)	**PPMS**	**Height**	**Maturity**	**Yield**
Year	<0.0001	<0.0001	<0.0001	<0.0001
Seeding Date	NS	0.002	<0.0001	0.0001
Variety	0.001	NS	0.01	NS
Seeding Date*Variety	NS	NS	NS	NS
Grand Mean	65.4	81.7	91.3	735
CV	23.8	8.7	4.1	27.8
<u>Year</u>				
2021	70 b	59 c	93 a	653 b
2022	44 c	109 a	88 b	989 a
2023	83 a	78 b	93 a	566 b
<u>*Date*</u>				
Late May	70	77.6 b	97 a	846 a
Mid-June	64	83.3 a	90 b	790 a
Early July	62	84.2 a	88 b	570 b
<u>*Variety*</u>				
Katani	57 b	81.6	90 b	734
Picolo	60 b	82.1	91 ab	724
X59	78a	81.4	93 a	749

<u>NARF (dryland- Black soil zone)</u>

Melfort site experienced adverse effects from drought conditions in 2021 and 2023, resulting in poor germination in plots seeded in early July in both years (refer to Appendix for corresponding photos, Figure 4). Due to missing data points and the unbalanced nature of the data, a comprehensive analysis encompassing all three years for the NARF site proved challenging. However, data from individual years are presented in table 8. The final interpretation is primarily based on the 2022 data collection, which represents the most favorable conditions at this site.

In 2022, plant densities averaged 99 plants/m^2, with no significant impact observed from seeding dates. Similar to other locations, the hemp variety X59 exhibited a higher plant count. Conversely, while seeding dates significantly influenced plant height, there was no discernible difference between hemp varieties. Notably, at NARF, plant height increased as the seeding date was delayed, with early July-seeded hemp displaying the tallest plants in 2022.

Hemp maturity in 2022 exhibited variation based on seeding dates, with the end of May-seeded hemp maturing earlier than the other two seeding dates. However, there was no significant difference in maturity between hemp varieties. The hemp yield at NARF was the lowest among the three dryland sites, averaging at 598 kg/ha in 2022. Surprisingly, in that year, the yield was unaffected by both seeding date and hemp varieties.

In summary, the Melfort site did not emerge as the optimal location for hemp cultivation in 2021 and 2023, primarily attributed to drier conditions throughout the growing season. The assessment of treatment impacts, particularly seeding dates, is constrained by limited data, as only one year of information is available for analysis.

10. **Conclusions and Recommendations:**
This project offered valuable insights into the overall effects of and interactions between seeding dates and varieties for commercial hemp establishment and yield across diverse Saskatchewan conditions. Optimal weather conditions showed variations among locations and years, emphasizing the importance of tailored recommendations for each site. Commercial hemp yield and plant characteristics exhibited differences between years and sites, including irrigated vs. dryland and among dryland sites. Among the three seeding dates investigated, the mid-June seeding date consistently delivered the best results, leading to enhanced yield and plant densities. While late May seeding generally performed reasonably well, late June / early July seeding often resulted in lower yields and, in some cases, the plants failed to reach maturity when seeded this late. Variety X59 consistently outperformed other varieties tested, establishing itself as the preferred choice for achieving higher yields. Producers should consider site-specific seeding dates and varieties based on local conditions for optimal hemp cultivation. Despite these successes, challenges persist in accessing maturity and harvesting hemp across all sites. Combining too early often resulted in dirtier grain samples with high moisture dockage, while delayed harvest tended to result in more issues with straw wrapping and hanging up inside the combine. Notably, hemp remains susceptible to bird-related damage, necessitating vigilant monitoring by farmers as the crop approaches maturity.

11. **Is there a need to conduct follow up work?**
Overall, this trial was successfully completed at all sites, yielding some intriguing findings and recommendations. However, it's important to note that the weather conditions throughout this study were predominantly hot and dry across all sites. Consequently, asserting or recommending that these findings will be applicable in years characterized by wet spring and summer conditions is challenging. Continued research on hemp cultivation, considering environmental factors, is crucial for refining recommendations.

12. **Patents/ IP generated/ commercialized products:**
No products were developed from this project.

13. **List technology transfer/demonstration activities undertaken in relation to this project.**
In 2021, a YouTube video was created to create awareness of the project (https://www.youtube.com/watch?v=Z4g5g1jvkH4) and presented at WARC's virtual field day. In 2022, this project was discussed at the virtual CSIDC field day and the in-person ICDC field day. The project was also presented at the Irrigation Saskatchewan Conference and North Battleford's Crop Opportunity Meeting. In 2023, this project was tweeted about through ICDC's Twitter page (https://twitter.com/ICDC_SK), an informative YouTube video was created (https://youtu.be/qYfmVJ30GIw?feature=shared), and was presented at NARF and IHARF field. A factsheet highlighting the key findings of this project will be produced and made available to an interested audience, an article highlighting results will be included in the ICDC Irrigators newsletter, and the final report will be included in ICDC's 2023 Research and Demonstration Report.

14. **List any industry contributions or support received.**
There are no changes to record.

15. **Acknowledgements**.
This project was funded through the Strategic Field Program (SFP); we acknowledge the funding support by the Ministry of Agriculture and the Canadian Agriculture Partnership.

16. **Appendices:**

Table 5: Seeding dates and varieties' effect on Plants/m^2 (PPMS), Days to Maturity (days), Plant height (cm), and mean yield (kg/ha) measured at ICDC in 2021, 2022, and 2023. Different letters indicated significant treatment differences (ANOVA, P ≤ 0.05).

ICDC (Irrigated)	**PPMS**			**Height**			**Maturity**			**Yield**		
	2021	*2022*	*2023*	*2021*	*2022*	*2023*	*2021*	*2022*	*2023*	*2021*	*2022*	*2023*
Seeding Date	0.04	NS	NS	NC	0.031	0.02	NC	NC	<0.0001	0.0051	NS	0.0002
Variety	0.003	0.04	NS	NC	0.007	0.003	NC	NC	<0.0001	NS	<0.0001	0.0007
Seeding Date*Variety	NS	NS	NS	NC	NS	NS	NC	NC	NS	NS	NS	NS
Grand Mean	115	101	167	-	128.5	140.8	-	-	94.3	1334.9	598	990.5
CV	12.64	26.7	34.2	-	11.3	4.6	-	-	0.32	20.6	12.8	13.8
Date												
Late May	105 b	100.0	162.0	-	119 b	138.3 b	-	-	92 b	1247 ab	584	1182 b
Mid-June	128 a	107.0	173.0	-	132 a	148.2 a	-	-	89 b	1546 a	497	1233 a
Early July	112 ab	96.0	166.0	-	134 a	136 .0 b	-	-	102 a	1211 b	715	556 c
Variety												
Katani	110 b	91 b	163.0	-	122 b	138.3 b	-	-	92 b	1278	557 b	938 b
Picolo	107 b	93 b	167.0	-	122 b	137.4 b	-	-	90 b	1239	540 b	892 b
X59	129 a	118 a	170.0	-	141 a	146.8 a	-	-	101 a	1487	946 a	1141 a

NS = Not Significant

NC = Observation Not Captured

Table 6: Seeding dates and varieties' effect on Plants/m^2 (PPMS), Days to Maturity (days), Plant height (cm), and mean yield (kg/ha) measured at IHARF in 2021, 2022, and 2023. Different letters indicated significant treatment differences (ANOVA, P ≤ 0.05).

IHARF	**PPMS**			**Height**			**Maturity**			**Yield**		
	2021	2022	2023	2021	2022	2023	2021	2022	2023	2021	2022	2023
Seeding Date	0.01	0.003	0.02	NS	<0.01	<0.0001	NC	<0.01	<0.001	0.0001	0.001	0.03
Variety	NS	0.007	0.001	NS	<0.01	0.003	NC	NS	<0.001	0.0003	<0.005	<0.001
Seeding Date*Variety	NS	NS	NS	NS	NS	NS	NC	NS	0.0001	NS	NS	0.0008
Grand Mean	114.8	113.5	171.3	106.4	123.6	91.8	NC	95	90.2	1084.3	1162.1	730.1
CV	16.82	18.5	21.31	4.9	2.5	3.84		2.4	0.32	5.19	3.6	4.44
Date												
Late May	114 ab	142 a	168 b	106.9	106.0	107 a	-	84	98 a	918 c	1093 b	722 a
Mid-June	125 a	127 a	189 a	105.7	132.0	88 b	-	96	90 b	1221 a	1037 b	820 ab
Early July	105 b	71 b	157 b	106.7	132.0	81 c	-	106	83 c	1114 b	1356 a	647 b
Variety												
Katani	113	97 b	135 b	106.2	123.0	91 b	-	95	90 b	1047 b	1207 a	776 b
Picolo	110	107 b	160 b	105.1	121.0	90 b	-	95	90 b	1053 b	1156 b	736 b
X59	120	136 a	218 a	108.0	127.0	95 a	-	97	92 a	1153 a	1123 b	678 a
*Date*Variety*												
1. Late May Katani	-	-	-	-	-	-	-	-	97.7 a	-	-	729 bc
2. Late May Picolo	-	-	-	-	-	-	-	-	97.7 a	-	-	710 c
3. Late May X59	-	-	-	-	-	-	-	-	98.7 a	-	-	727 bc
4. Mid June Katani	-	-	-	-	-	-	-	-	89.5 c	-	-	876 a
5. Mid June Picolo	-	-	-	-	-	-	-	-	89.0 c	-	-	834 a
6. Mid June X59	-	-	-	-	-	-	-	-	91.7 b	-	-	751 b
7. Early July Katani	-	-	-	-	-	-	-	-	82.0 e	-	-	723 bc
8. Early July Picolo	-	-	-	-	-	-	-	-	81.5 e	-	-	664 d
9. Early July X59	-	-	-	-	-	-	-	-	84.0 d	-	-	557 e

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Table 7: Seeding dates and varieties' effect on Plants/m^2 (PPMS), Days to Maturity (days), Plant height (cm), and mean yield (kg/ha) measured at WARC in 2021, 2022, and 2023. Different letters indicated significant treatment differences (ANOVA, P ≤ 0.05).

Scott	PPMS			Height			Maturity			Yield		
	2021	2022	2023	2021	2022	2023	2021	2022	2023	2021	2022	2023
Seeding Date	0.03	NS	0.004	0.04	<0.01	0.001	NC	<0.01	<0.001	0.0002	<0.005	<0.0001
Variety	0.007	NS	0.0008	NS	<0.01	NS	NC	<0.01	<0.001	0.0007	NS	NS
Seeding Date*Variety	NS	NS	NS	NS	NS	NS	NC	0.02	NS	NS	NS	NS
Grand Mean	76.2	50.4	82.9	65.7	115	77.8	NC	91	92.7	221.66	917.6	599.8
CV	15.5	34.2	16.4	7.4	2.8	7.63		0.75	1.26	18.94	11.4	12.3
Date												
Late May	88 a	49	93 a	64.9 ab	124 a	80.7 a	-	86 b	102 b	437 b	637 c	846 a
Mid-June	69 b	52	71 b	70.0 a	114 b	84.2 a	-	87 b	90 b	652 a	890 b	648 b
Early July	72 b	52	85 a	62.0 b	108 c	68.5 b	-	101 a	86 a	469 b	1226 a	305 c
Variety												
Katani	75 ab	52	70 b	68.2	111 b	78.3	-	89 b	91 c	495 b	941	597
Picolo	68 b	46	82 b	64.8	118 a	78.0	-	90 b	93 b	483 b	911	593
X59	85 a	54	97 a	65.0	118 a	77.2	-	95 a	95 a	580 a	900	609
*Date*Variety*												
1. Late May Katani	-	-	-	-	-	-	-	84 e	-	-	-	-
2. Late May Picolo	-	-	-	-	-	-	-	84 e	-	-	-	-
3. Late May X59	-	-	-	-	-	-	-	90 c	-	-	-	-
4. Mid June Katani	-	-	-	-	-	-	-	87 d	-	-	-	-
5. Mid June Picolo	-	-	-	-	-	-	-	85 e	-	-	-	-
6. Mid June X59	-	-	-	-	-	-	-	91 c	-	-	-	-
7. Early July Katani	-	-	-	-	-	-	-	100 b	-	-	-	-
8. Early July Picolo	-	-	-	-	-	-	-	100 b	-	-	-	-
9. Early July X59	-	-	-	-	-	-	-	104 a	-	-	-	-

NS = Not Significant

NC = Observation Not Captured

Table 8: Seeding dates and varieties' effect on Plants/m^2 (PPMS), Days to Maturity (days), Plant height (cm), and mean yield (kg/ha) measured at NARF in 2021, 2022, and 2023. Different letters indicated significant treatment differences (ANOVA, P ≤ 0.05).

NARF	**PPMS**			**Height**			**Maturity**			**Yield**		
	2021	*2022*	*2023*	*2021*	*2022*	*2023*	*2021*	*2022*	*2023*	*2021*	*2022*	*2023*
Seeding Date	<0.001	NS	0.0005	0.0005	<0.01	<0.001	<0.001	<0.01	<0.0001	0.04	NS	<0.0001
Variety	NS	0.0002	NS	NS	NS	NS	<0.001	NS	NS	<0.001	NS	<0.0001
Seeding Date*Variety	NS	NS	0.0052	NS	NS	NS	<0.0001	NS	NS	NS	NS	0.0002
Grand Mean	43.7	98.9	51.26	80.3	87.1	72.7	112.8	95	100	221.6	598	441.0
CV	28.6	22.8	24.9	16.6	13.8	10.5		2.4		18.9	28.8	20.6
<u>Date</u>												
Late May	71 a	86.0	91 a	105.2 a	75 c	96.6 a	116 a	84	92 b	242	584	581 b
Mid-June	57 b	93.0	50 b	72.8 b	86 b	99.5 a	110 b	96	108 a	201	497	742 a
Early July	4 c	116.0	12 c	63.1 b	101 a	22.1 b	-	106	-	-	715	0
<u>Variety</u>												
Katani	69	85 b	44.0	87.3	89.0	73.4	110 b	95	100	-	585	361 b
Picolo	58	83 b	52.0	91.3	85.0	72.0	110 b	95	100	-	595	336 b
X59	64	126 a	58.0	88.2	88.0	72.8	117 a	97	100	-	616	626 a
*<u>Date*Variety</u>*												
1. Late May Katani	-	-	69 b	-	-	99.88	-	-	100	-	-	453 c
2. Late May Picolo	-	-	89 ab	-	-	96.5	-	-	100	-	-	463 c
3. Late May X59	-	-	114 a	-	-	93.38	-	-	100	-	-	829 ab
4. Mid June Katani	-	-	55 bc	-	-	99	-	-	100	-	-	632 bc
5. Mid June Picolo	-	-	48 bc	-	-	98.75	-	-	100	-	-	544 c
6. Mid June X59	-	-	49 bc	-	-	100.62	-	-	100	-	-	1049 a
7. Early July Katani	-	-	9 c	-	-	21.25	-	-	-	-	-	0
8. Early July Picolo	-	-	18 c	-	-	20.63	-	-	-	-	-	0
9. Early July X59	-	-	9 c	-	-	24.38	-	-	-	-	-	0

NS = Not Significant

NC = Observation Not Captured

Figure 3. Hemp seed on plant, overview of hemp plants, hemp seedlings and hemp plots at ICDC.

Figure 4: Plots showing poor germination/ crop stand and height variation due to lack of moisture at Melfort, SK. The early July seed date is located on the left as compared to the mid-June seed date on the right.