2017 Annual Report

for the

Agricultural Demonstration of Practices and Technologies (ADOPT) Program

Project Title: Seed Treatment Effects on Flax at Varying Seeding Rates and Dates

(Project #20160408)

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Project Identification

1. **Project Title:** Seed treatment effects on flax at varying seeding rates and dates
2. **Project Number:** 20160408
3. **Producer Group Sponsoring the Project:** Saskatchewan Flax Development Commission
4. **Project Location(s):** Indian Head (R.M. #156) and Melfort (R.M. #428), Saskatchewan
5. **Project start and end dates (month & year):** Apr-2017 to Feb-2018
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Objectives and Rationale

7. **Project objectives:**

The objectives of this project were: to demonstrate the potential benefits of seed treatments for flax when combined with low, medium and high seeding rates and either early or late seeding dates.

8. **Project Rationale:**

Surveys conducted during the 2016 Saskatchewan Oilseed Producer meetings identified seed treatment performance evaluations with flax as a top priority amongst attendees. For optimal flax yields, minimum plant populations of 300 plants/m^2 are generally recommended. Research with early no-till equipment found that, even with typical seeding rates (i.e. 50 kg/ha), this minimum threshold was only achieved 60% and 73% of the time with early and late plantings, respectively. This suggested that flax producers must pay close attention to their seeding practices and that future agronomic research focussing on management effects on flax establishment is important. Flax is a poor competitor with weeds early in the season and experience has shown that it has difficulty recovering from a poor start, therefore any problems with establishment often lead to sub-optimal yields.

Increasing seeding rates is an obvious but effective way to improve plant stands; however, economics and logistics limit the extent to which producers can do so. Postponing seeding until soils have warmed up generally results in more rapid and complete emergence; however, yields may be compromised if seeding is delayed too long therefore it is typically recommended that flax be seeded by mid-May. Despite the benefits of early seeding, flax is commonly one of the last crops seeded as growers know it can generally be left standing late in the season with minimal risk of yield or quality loss.

Seed-applied fungicides, or seed treatments, are another relatively low0cost tool to help crops fend off seedling diseases and get off to a more vigorous, healthy start, particularly when emerging under stressful conditions (i.e. cold soils). While research on flax response to seed treatments and commercial uptake of this practice are limited, producer adoption of seed treatments has been strong for other crops. Privately funded trials at Indian Head (IHARF) and Melfort (NARF) in 2013 showed a significant increase in emergence and, at Indian Head, higher yields with seed-applied fungicide (Vitaflo).

This project was initiated to help producers understand the potential benefits of using seed treatments and/or higher seeding rates, particularly when seeding early into cool soils. These results are intended to increase awareness and help the industry redefine best management practices for flax establishment.

Methodology and Results

9. Methodology:

Field trials with flax were established on cereal stubble near Indian Head (R.M. #156; 2016 and 2017) and Melfort (R.M. #428; 2017) Saskatchewan. The treatments were a factorial combination of two seeding dates (May 3 vs. May 30), two seed-applied fungicide treatments (untreated vs. 600 ml/100 kg seed of Insure Pulse) and three seeding rates (35, 55 and 75 kg/ha) for a total of 12 treatments. The treatments were arranged in a four-replicate split-plot design with seeding dates as the main plots and seeding rate by seed treatment combinations as the sub-plots.

Selected agronomic information for each site-year is provided in Tables 9-11 of the Appendices. Certified flax seed was direct-seeded in either early or late May (as per protocol) at a target depth of approximately 20 mm. All fertilizer was side- or mid-row banded during seeding at rates intended to be non-limiting. At Indian Head, weeds were controlled using a combination of pre-emergent and in-crop herbicides and tailored to each seeding date. At Melfort, the plots were hand-weeded. Foliar fungicide was applied at mid-bloom with application dates tailored to the individual seeding dates at Indian Head and a single application for both dates at Melfort. Pre-harvest glyphosate was applied at maturity (>75% boll colour change). At Indian Head, the centre five rows of each plot were harvested as soon as possible after it was fit to do so with separate harvest dates for each seeding date while at Melfort the entire plot was harvested at a single date when all plots were mature and dry.

Emergence was assessed by counting the number of seedlings in 2 × 1 m sections of crop row 2-4 weeks after seeding. Maturity (75% bolls turned colour) was recorded for each plot and expressed as days from planting to maturity. Lodging was rated using the Belgian scale which considers both the area of plot affected and intensity of lodging; however, no lodging was observed in any treatments at any sites so data is not reported. Yields were determined from the harvested grain samples and are corrected for dockage determined using standard Canadian Grain Commission methods. At Indian Head, yields were corrected to a uniform moisture content of 10% while at Melfort yields were not corrected for seed moisture content. Monthly weather summaries and long-term averages were extracted from the nearest weather station for each site.

Data was statistically evaluated using Mixed model analyses with seeding date, seed treatment, and seeding rate along with all possible interactions considered fixed and replicate effects considered random. Fisher's protected LSD test was used to separate individual treatment means. Orthogonal contrasts were used to determine whether seeding rate responses were linear, curvilinear (quadratic) or insignificant when averaged across all factors and for individual seeding dates and seed-applied fungicide treatments. All treatment effects and differences between means were considered significant at $P \leq 0.05$. With differences in the observed responses and data quality noted across site-years, a combined (across site-years) analysis was not completed.

10. Results:

Growing Season Weather Conditions

Mean monthly temperatures and precipitation amounts are presented along with the long-term averages (1981-2000) for Indian Head and Melfort in Tables 1 and 2, respectively. At Indian Head, the 2016 growing season was warmer and wetter than average while, in 2017, temperatures were approximately normal but it was dry with more challenging conditions for emergence and lower yield potential. Conditions were ideal for emergence at Indian Head in 2016 (IH-16) with well above-average temperatures in May and frequent precipitation after seeding. The following season (IH-17), while initial soil moisture was adequate, the period following seeding was extremely dry leading to more variable emergence and higher seedling mortality. Furthermore, the early seeded flax in 2017 was mostly emerged and exposed to temperatures of nearly -7 ºC on May 18 resulting in the loss of some plants and increased variability in establishment. At Melfort, temperatures in May and June were below average while July and August were warmer. The soils were initially wet and precipitation in May was slightly above average; however, the total rainfall amount for the four-month period (May-August) was 100 mm below average. Despite below normal precipitation, with wet conditions early on and heavy soils the crop was never considered to be limited by lack of moisture.

Table 1. Mean monthly temperatures and precipitation amounts along with long-term averages (LT; 1981-2010) averages for the 2016 and 2017 growing season at Indian Head, Saskatchewan.

Year	May	June	July	August	Avg/Tot
	---------- Mean Temperature (°C) ----------				
2016	14.0	17.5	18.5	17.2	16.8
2017	11.6	15.5	18.4	16.7	15.6
LT	10.8	15.8	18.2	17.4	15.6
	---------- Precipitation (mm) ----------				
2016	72.6	63.0	112.8	29.8	278
2017	10.4	65.6	15.4	25.2	117
LT	51.8	77.4	63.8	51.2	244

Table 2. Mean monthly temperatures and precipitation amounts along with long-term averages (LT; 1981-2010) averages for the 2017 growing season at Melfort, Saskatchewan.

Year	May	June	July	August	Avg/Tot
			Mean Temperature (°C)		
2017	10.8	15.2	18.7	17.2	15.5
LT	10.7	15.9	17.5	16.8	15.2
			Precipitation (mm)		
2017	46.4	44.1	33.3	3.1	126.9
LT [Z]	42.9	54.3	76.7	52.4	226.3

Treatment Effects on Flax Emergence

Flax emergence was affected by seeding date at Indian Head in 2016 and Melfort but not Indian Head in 2017 (Table 3) with higher populations associated with delayed seeding in 2/3 site-years (Table 4). At IH-16, the overall average plant densities were 566 and 656 plants/m^2 for early and late-May seeding dates while the effect was greater at ME-16 with values of 262 and 504 plants/m^2. The recommended minimum optimum plant populations for flax are approximately 300-400 plants/m^2. At IH-17, the difference was not significant at the desired probability level (P = 0.068) but plant densities tended to be higher with early seeding despite the frost injury to the early seeded plants (423 versus 365 plants/m^2). This was attributed to the drier conditions later in the spring and it is probable that some un-germinated seedlings eventually emerged with the rain later in June. Better emergence with later seeding, as observed at 2/3 sites, is generally attributed to warmer soils; however, actual results will vary with soil conditions at seeding and subsequent weather conditions.

Table 3. Analyses of variance for effects of seeding date, fungicide seed treatment, and seeding rate on flax emergence at three Saskatchewan site-years.

Effect	IH-16	IH-17	ME-17
		p-values	
Seeding Date (D)	0.032	0.068	0.004
Seed Treatment (T)	0.012	0.153	0.613
Seeding rate (R)	< 0.001	< 0.001	< 0.001
D × T	0.320	0.106	0.765
D × R	0.212	0.051	0.041
T × R	0.160	0.062	0.421
D × T × R	0.457	0.052	0.420

The use of a seed treatment increased plant densities by 11% at IH-16 (P = 0.012) but had no effect at either IH-17 (P = 0.153) or ME-17 (P = 0.613). Regardless of site-year or seed-applied fungicide treatment, the overall average plant densities were sufficiently high that they were not expected to be limiting to yields. Somewhat inexplicably, the site-year where seed-treatment applications improved flax establishment (IH-16) was also the site-year where conditions for emergence were most optimal and the highest overall plant populations were achieved. It is generally suggested that seed treatments are most likely to be beneficial when crops are emerging under more stressful conditions.

As expected, seeding rate affected plant density in all cases ($P < 0.001$). In both years at Indian Head, average populations continued to increase through all seeding rate increases and ranged from 472-744 plants/m^2 in 2016 and from 297-479 plants/m^2 in 2017. At Melfort, flax populations increased from 312 plants/m_2 at the 35 kg seed/ha to 415-422 plants/m^2 at 55-75 kg/ha with no difference between the two highest seeding rates. The difference in seeding rate effects on emergence between locations was captured in the orthogonal contrasts which detected a linear response in both years at Indian Head ($P <$ 0.001) and quadratic, or curvilinear, response at ME-17 ($P = 0.039$).

Table 4. Main effect means for flax emergence and orthogonal contrast results for seeding rate for three Saskatchewan site-years. Means for each effect within a column followed by the same letter do not significantly differ (Fisher's Protected LSD test, $P \leq 0.05$).

Main effect	IH-2016	IH-2017	ME-2017
Seeding date (D)	----------------------------------	plants/m^2	----------------------------------
Early	566 b	423 a	262 b
Late	656 a	365 a	504 a
S.E.M. (LSD)	16.9 (75.1)	21.5 (67.0)	23.2 (94.3)
Seed Treatment (T)			
Untreated	579 b	379 a	378 a
Treated	643 a	409 a	389 a
S.E.M.	16.9 (48.2)	21.5 (43.0)	20.7 (42.6)
Seeding rate (R)			
35 kg/ha	472 c	297 c	312 b
55 kg/ha	618 b	406 b	415 a
75 kg/ha	744 a	479 a	422 a
S.E.M.	23.7 (59.0)	23.9 (52.6)	23.1 (52.2)
Orthogonal Contrasts	--------------------------------	p-values	--------------------------------
Seed rate – linear	< 0.001	< 0.001	< 0.001
Seed rate – quad	0.690	0.418	0.039

In general, establishment was considered quite good at all sites with, perhaps unfortunately given the objectives of the project, no cases where the main effect means were palpably below the recommended minimum population of 300 plants/m^2. There were no significant interactions between seed treatment and either seeding date or seeding rate detected for plant density at the three sites; however, treatment means for the various interactions are provided in Tables 12-15. It was hypothesized that seed treatments may provide greater emergence benefits when combined with early seeding (i.e. cool soils) or sub-optimal seeding rates (i.e. 35 kg/ha); however, no such effects were demonstrated under the environmental conditions encountered.

Treatment Effects on Flax Maturity

Tests of fixed effects for maturity and main effect treatment means for the two years at Indian Head are provided in Tables 5 and 6 below. Means for the interactions are provided in Tables 16-19 of the appendices. In both years, seeding date ($P < 0.001$), seed treatment ($P = 0.002$-0.003), and seeding rate ($P < 0.001$) all affected maturity. In 2016, there was an interaction between seeding date and seeding rate ($P < 0.001$) while in 2017 no interactions were significant for this variable ($P = 0.194$-0.388). The effects of seeding date were consistent with past demonstrations whereby days to maturity were substantially reduced with delayed seeding. Flax seeded in early May matured in approximately 101 days while flax seeded in late May matured in 91-92 days at Indian Head (Table 6). Maturity data from Melfort was not statistically analyzed because there were was not enough variation noted across replicates and treatments; however, a general observation was that early seeded flax matured in approximately 104 days while late seeded flax matured in 99 days (data not shown).

Table 5. Analyses of variance for effects of seeding date, fungicide seed treatment, and seeding rate on flax maturity at two Saskatchewan site-years.

Effect	IH-16	IH-17
	------------------------- p-values	--------------------------
Seeding Date (D)	< 0.001	< 0.001
Seed Treatment (T)	0.003	0.002
Seeding rate (R)	< 0.001	< 0.001
D × T	0.234	0.194
D × R	< 0.001	0.280
T × R	0.136	0.220
D × T × R	0.245	0.388

While statistically significant, the effects of seed-applied fungicide on maturity at Indian Head were small (0.4-0.6 days) and of little practical agronomic importance. Early maturity with seed treatment could potentially be attributed to higher plant populations, more vigorous early season growth, or a combination of the two factors.

While the response was subtle, the number of days to maturity declined linearly ($P < 0.001$) with increasing seeding rate in both years at Indian Head. In 2016 maturity was reduced from 97.5 to 95.9 days (averaged across seeding dates and seed treatments) while in 2017 it fell from 97.1 to 95.3 days as seeding rate was increased from 35 kg/ha to 75 kg/ha. The significant date by rate interaction in 2016 was due to subtle inconsistencies in the differences between seeding rate means at the two dates; however, overall the effects were similar with a significant linear response ($P < 0.001$) at both dates (Table 17). Again, the seed treatment by seeding date interaction was not significant in either year ($P =$ 0.194-0.234) and any potential trends were inconsistent with a tendency for a stronger seed-treatment effect with early seeding in 2016 but with late seeding in 2017.

Table 6. Main effect means for flax maturity and orthogonal contrast results for seeding rate for two Saskatchewan site-years. Means for each effect within a column followed by the same letter do not significantly differ (Fisher's Protected LSD test, $P \leq 0.05$).

Main effect	IH-2016	IH-2017
Seeding date (D)	------------------------ days from planting ------------------------	
Early	101.4 a	101.1 a
Late	92.0 b	91.1 b
S.E.M. (LSD)	0.12 (0.54)	0.20 (0.91)
Seed Treatment (T)		
Untreated	96.9 a	96.4 a
Treated	96.5 b	95.8 b
S.E.M.	0.10 (0.21)	0.17 (0.35)
Seeding rate (R)		
35 kg/ha	97.5 a	97.1 a
55 kg/ha	96.6 b	95.9 b
75 kg/ha	95.9 c	95.3 c
S.E.M.	0.11 (0.26)	0.19 (0.43)
Orthogonal Contrasts	--------------------------- p-values ---------------------------	
Seed rate – linear	< 0.001	< 0.001
Seed rate – quad	0.397	0.210

Treatment Effects on Flax Yield

Overall F-test results for treatment effects on flax yield and main effect means for all three sites are presented in Tables 7 and 8, respectively. Flax yields were affected by seeding date in 2/3 site-years (IH-16 and ME-17). In both cases where the effect was significant yields were higher with early seeding. The difference was dramatic at IH-16 with a 1096 kg/ha (17 bu/ac), or 43%, yield loss associated with delayed seeding. While it is not common to see slight yield advantages to early seeding with flax, this large of a response was unexpected and it is suspected that it was largely due to wildlife damage (deer feeding) at the final crop stages of the later seeding date. The seeding date response at ME-17 was more typical with a small (191 kg/ha or 9%) but significant yield advantage to early seeding. At IH-17, there was a tendency for higher yields with early seeding but, due to high variability across replicates, it was not significant. Wildlife damage was also problematic for the late seeded flax at IH-17 and contributed to the observed yield variability.

Seed-applied fungicide treatment did not significantly affect flax yield at any of the three site-years (P = 0.142-0.370) As previously discussed, the seed treatment did lead to higher plant populations at IH-16; however, the established populations were always well-above the recommended minimum threshold (300 plants/m^2) so it was not necessarily expected that this would specifically translate into a yield benefit. With no interactions between seed-applied fungicide treatment and either seeding date (P =

0.103-0.736) or seeding rate (*P* = 0.065-0.552) the lack of a seeding rate effect on yield was consistent for both early and late planting dates and across the range of seeding rates evaluated.

Table 7. Analyses of variance for effects of seeding date, fungicide seed treatment, and seeding rate on flax seed yield at three Saskatchewan site-years.

Effect	IH-16	IH-17	ME-17
	------------------------------- p-values -------------------------------		
Seeding Date (D)	< 0.001	0.266	0.025
Seed Treatment (T)	0.142	0.370	0.199
Seeding rate (R)	0.005	0.816	0.932
D × T	0.513	0.736	0.103
D × R	0.290	0.221	0.818
T × R	0.552	0.065	0.533
D × T × R	0.420	0.641	0.385

Table 8. Main effect means for flax yield and orthogonal contrast results for seeding rate for three Saskatchewan site-years. Means for each effect within a column followed by the same letter do not significantly differ (Fisher's Protected LSD test, *P* ≤ 0.05).

Main effect	IH-2016	IH-2017	ME-2017
Seeding date (D)	------------------------------------ kg/ha ------------------------------------		
Early	2552 a	1529 a	2285 a
Late	1456 b	1277 a	2094 b
S.E.M. (LSD)	100.6 (245.9)	173.3 (588.7)	110.4 (146.0)
Seed Treatment (T)			
Untreated	2035 a	1385 a	2159 a
Treated	1973 a	1422 a	2220 a
S.E.M.	95.1 (83.0)	145.0 (82.4)	110.4 (93.7)
Seeding rate (R)			
35 kg/ha	2055 a	1413 a	2184 a
55 kg/ha	2055 a	1385 a	2201 a
75 kg/ha	1902 b	1411 a	2182 a
S.E.M.	97.2 (101.6)	149.3 (100.9)	112.7 (114.8)
Orthogonal Contrasts	------------------------------- p-values -------------------------------		
Seed rate – linear	0.005	0.965	0.972
Seed rate – quad	0.083	0.528	0.712

Seeding rate affected flax yield at only 1/3 site-years, despite the lowest seeding rate of 35 kg/ha being well below the typical recommended minimum for this crop. Traditionally, seeding rates for flax Saskatchewan are generally in the range of 50-60 kg/ha. The responsive site was IH-16; however, the observed seeding rate effects were not what was expected with no yield difference between seeding rates of 35-55 kg/ha but a slightly, albeit significant, reduction in yield at the highest seeding rate. While unexpected, this result can likely be partly attributed to the exceptionally high plant populations achieved at that site-year. Even at the lowest seeding rate in IH-16, the average plant population was 472 plants/m^2, well beyond the recommended minimum threshold. At the highest seeding rate, where yields tended to decline, the mean population (across dates and seed treatments) was 744 plants/m^2.

Extension and Acknowledgement

This project was highlighted during the Indian Head Crop Management Field Day in 2017 (July 18, approximately 200 guests). Chris Holzapfel (IHARF) and Rachel Evans (Flax Council of Canada) discussed the results of past flax establishment research and demonstrations completed in western Canada along with other agronomic issues and research priorities for flax. In addition, the trial was shown on smaller tours hosted by IHARF for FCL (July 13) and Richardson-Pioneer (July 21) and was visited by numerous growers, agronomists and researchers over the course of the season. Chris Holzapfel also presented on flax production at the Melfort Field Day (July 26) drawing from numerous projecting the current demonstration. The full report will be made available online (www.iharf.ca) and results will also be made available through a variety of other media (i.e. oral presentations, popular agriculture press, social media, fact sheets, etc.) as opportunities arise.

Conclusions and Recommendations

Overall, this project has demonstrated that successful flax establishment depends on numerous factors and that, while seed-applied fungicides can be beneficial in this regard, they will not necessarily provide tangible benefits under all conditions. A common basic recommendation for good establishment is to seed into warm soils at adequate rates; however, seeding date effects on emergence and plant densities varied depending on the specific environmental conditions encountered. At 2/3 sites better establishment was achieved with later seeding (i.e. warmer soils) while at one, the driest of the three, there was a slight (not significant) reduction in plant populations with delayed seeding. As expected, increasing seeding rates was an effective means of increasing plant populations; however, in addition to the added cost, excessive seeding rates can result in more plants than are desired under some conditions which could potentially lead to undesirable side effects such as increased lodging or disease pressure. Seed treatments are seen as relatively low cost, easy to use tool for improve establishment by warding off seedling diseases and potentially resulting in more vigorous growth under stressful emergence conditions. While using a seed-applied fungicide did result in higher plant densities at 1/3 site-years (IH-16), the difference in response was difficult to explain as the benefits were observed under the most optimal conditions with warm soils and frequent precipitation after seeding. With respect to seed treatment effects on emergence, there was no evidence to suggest stronger responses when combined with either early seeding or low seeding rates.

Seed-applied fungicides resulted in a statistically significant but agronomically inconsequential reduction in maturity of 0.4-0.6 days. While maturity can be concern with flax, particularly in more northern growing areas such as Melfort, the observed seed treatment effects were too small to have much impact on harvest date or noticeably reduce the risk of yield/quality loss associated with fall frost.

The effect of seeding rate on maturity was also small with less than a 2 day spread (on average) between the highest and lowest rates; however, it did show the potential for lower plant populations to delay maturity. Higher seeding rates may be seen as one way to improve crop stage uniformity across variable landscapes but, on average, cannot be expected to have a major impact on maturity and there can be drawbacks if populations are too excessive. Seeding date had, by far, the greatest and most consistent effect on days to maturity with the later seeded crop maturing up to 10 days ahead of the early seeded crop. That said, the early seeded crop was still always ready to combine first so if earlier harvest or reduced risk of fall frost damage is an objective then seeding earlier is still the most desirable option.

Flax yield was not affected by seed-applied fungicide treatment at any site-years, regardless of when or at what rate the crop was seeded. In the year where the positive effect on emergence was observed, overall populations were always well-above the recommended minimum; therefore, a yield response to the increase in populations was not necessarily expected. The highest yields were consistently achieved with early seeding although the response was not always statistically significant and, at Indian Head in particular, much of the observed difference was attributed to wildlife damage in the late-seeded crop. Seeding rate effects on flax yield were rare and, when observed, inconsistent with the expected results. The only case in which seeding rate had an effect on flax yield was IH-16 where it declined linearly with increases in seeding rate. While it not entirely clear why the negative response occurred, overall plant populations that season were more than twice the recommended minimum in certain treatments (i.e. 845 plants/m^2 with late seeding and a 75 kg/ha rate of treated seed). Lodging was not observed in any treatments and the plots were sprayed with foliar fungicide at an optimal time; however, it is conceivable that disease was more limiting at the highest plant populations under the wet conditions encountered that season.

Overall, results from this demonstration suggest that flax should be seeded early (within the first 2 weeks of May) at rates of approximately 55 kg/ha to achieve the earliest maturity possible and optimum yield. Seed treatments have potential to improve establishment but this will not necessarily occur under all circumstances and yield responses are likely to be even less frequent. It is possible and worth noting that small plot trials, typically conducted on relatively uniform and well drained land, may not be ideal for capturing the potential seed-treatment benefits that may occur on a larger scale where the factors affecting emergence and development of root disease are more spatially variable.

Supporting Information

11. Acknowledgements:

This project was financially supported by the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement and the Saskatchewan Flax Development Commission (SaskFlax). The project was a collaborative effort between the Saskatchewan Flax Development Commission, the Indian Head Agricultural Research Foundation (IHARF), and the Northeast Agriculture Research Foundation (NARF). Acknowledgement of the Saskatchewan Ministry of Agriculture's support for this demonstration will be included as part of all written reports and oral presentations that arise from this work. Certain crop protection products were provided in-kind by BASF, Bayer CropScience, and FMC of Canada. The many contributions of IHARF and NARF staff are greatly appreciated.

12. Appendices

Table 9. Selected agronomic information for ADOPT flax seed treatment demonstration in 2016 at Indian Head, Saskatchewan.

Factor / Field Operation	IH-16 (Early)	IH-16 (Late)
Previous Crop	Barley	Barley
Pre-emergent herbicide	2250 g triallate/ha (May-3) 140 g sulfentrazone/ha (May-7) 890 g glyphosate/ha (May-15)	2250 g triallate/ha (May-3) 140 g sulfentrazone/ha (May-30) 890 g glyphosate/ha (May-24)
Cultivar	CDC Bethune	CDC Bethune
Seeding Date	May-3	May-30
Row spacing	30 cm	30 cm
kg $N-P_2O_5-K_2O-S\ ha^{-1}$	74-31-16-16 [Z]	74-31-16-16 [Z]
Emergence Counts	May-20	Jun-14
In-crop herbicide 1	100 g clopyralid/ha + 555 g MCPA ester/ha (Jun-13) 50 g tepraloxydim/ha (Jun-18)	100 g clopyralid/ha + 555 g MCPA ester/ha (Jun-21) 50 g tepraloxydim/ha (Jun-18)
Fungicide	75 g fluxapyroxad/ha + 150 g pyraclostrobin/ha (July 3)	75 g fluxapyroxad/ha + 150 g pyraclostrobin/ha (July 21)
Pre-harvest herbicide	890 g glyphosate/ha (Aug-21)	890 g glyphosate/ha (Sep-8)
Harvest date	Sep-15	Oct-1

[Z] Original target was 90-22-11-11 (drill setting error on 1st date)

Table 10. Selected agronomic information for ADOPT flax seed treatment demonstration in 2017 at Indian Head, Saskatchewan.

Factor / Field Operation	IH-17 (Early)	IH-17 (Late)
Previous Crop	Wheat	Wheat
Pre-emergent herbicide	140 g sulfentrazone/ha (May-15) 890 g glyphosate/ha (May-10)	140 g sulfentrazone/ha (May-27) 890 g glyphosate/ha (May-27)
Cultivar	CDC Bethune	CDC Bethune
Seeding Date	May-6	May-26
Row spacing	30 cm	30 cm
kg $N\text{-}P_2O_5\text{-}K_2O\text{-}S\ ha^{-1}$	100-20-10-10	100-20-10-10
Emergence Counts	May-29	Jun-13
In-crop herbicide 1	200 g clopyralid/ha (Jun-6) 280 g bromoxynil/ha + 280 g MCPA ester/ha + 290 g sethoxydim/ha (Jun-16)	200 g clopyralid/ha (Jun-16) 280 g bromoxynil/ha + 280 g MCPA ester/ha + 290 g sethoxydim/ha (Jun-24)
Fungicide	75 g fluxapyroxad/ha + 150 g pyraclostrobin/ha (July 10)	75 g fluxapyroxad/ha + 150 g pyraclostrobin/ha (July 20)
Pre-harvest herbicide	890 g glyphosate/ha (Aug-21)	890 g glyphosate/ha (Sep-8)
Harvest date	Aug-20	Sep-4

Table 11. Selected agronomic information for ADOPT flax seed treatment demonstration in 2017 at Melfort, Saskatchewan.

Factor / Field Operation	ME-17 (Early)	ME-17 (Late)
Previous Crop	Wheat	Wheat
Pre-emergent herbicide	None	None
Cultivar	CDC Sorrel	CDC Sorrel
Seeding Date	May-5	May-24
Row spacing	30 cm	30 cm
kg $N\text{-}P_2O_5\text{-}K_2O\text{-}S\ ha^{-1}$	72-18-0-8	72-18-0-8
Emergence Counts	Jun-2	Jun-20
In-crop herbicide 1	None (hand-weeded)	None (hand-weeded)
Fungicide	75 g fluxapyroxad/ha + 150 g pyraclostrobin/ha (July 18)	75 g fluxapyroxad/ha + 150 g pyraclostrobin/ha (July 18)
Pre-harvest herbicide	890 g glyphosate/ha (Sep-6)	890 g glyphosate/ha (Sep-6)
Harvest date	Sep-18	Sep-18

Table 12. Seeding date by seed treatment interactions for flax emergence at three Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test, *P* ≤ 0.05).

Two-way Interactions	IH-2016	IH-2017	ME-2017
Seed Date × Seed Trt		plants/m^2	
Early – untreated	547 b	390 b	260 b
Early – treated	586 b	457 a	264 b
Late – untreated	612 b	367 b	496 a
Late – treated	699 a	362 b	513 a
S.E.M. (LSD)	23.7 (68.1)	26.1 (60.8)	27.5 (69.4)

Table 13. Seeding date by seeding rate interactions for flax emergence and orthogonal contrast results for seeding rate at three Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test, *P* ≤ 0.05).

Two-way Interactions	IH-2016	IH-2017	ME-2017
Seed Date × Seed Rate		plants/m^2	
Early – 35 kg/ha	419 c	288 d	227.2 c
Early – 55 kg/ha	551 b	454 ab	289.1 c
Early – 75 kg/ha	728 a	528 a	269.5 c
Late – 35 kg/ha	524 b	306 d	397.2 b
Late – 55 kg/ha	684 a	358 cd	541.0 a
Late – 75 kg/ha	759 a	430 bc	575.2 a
S.E.M. (LSD)	29.0 (83.4)	30.1 (74.5)	31.2 (73.8)
Orthogonal Contrasts		p-values	
Rate-early – linear	< 0.001	< 0.001	0.251
Rate-early – quad	0.537	0.152	0.202
Rate-late – linear	< 0.001	0.002	< 0.001
Rate-late – quad	0.242	0.761	0.090

Table 14. Seed treatment by seeding rate interactions for flax emergence and orthogonal contrast results for seeding rate at three Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test, $P \leq 0.05$).

Two-way Interactions	**IH-2016**	**IH-2017**	**ME-2017**
Seed Trt × Seed Rate		------ plants/m^2 ------	
Untr – 35 kg/ha	449 c	274 d	287 c
Untr – 55 kg/ha	609 b	426 b	422 a
Untr – 75 kg/ha	680 b	436 b	424 a
Trt – 35 kg/ha	495 c	320 ac	337 bc
Trt – 55 kg/ha	626 b	387 bc	408 ab
Trt – 75 kg/ha	807 a	522 a	421 a
S.E.M. (LSD)	29.0 (83.4)	30.1 (74.5)	29.4 (73.8)
Orthogonal Contrasts		------ p-values ------	
Rate-Untr – linear	< 0.001	< 0.001	< 0.001
Rate-Untr – quad	0.214	0.033	0.041
Rate-Trt – linear	< 0.001	< 0.001	0.027
Rate-Trt – quad	0.489	0.290	0.366

Table 15. Seeding date by seed treatment by seeding rate interactions for flax emergence at three Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test, $P \leq 0.05$).

Three-way Interactions	IH-2016	IH-2017	ME-2017
Seed Date × Trt × Rate	---------- plants/m^2 ----------		
Early – Untrt – 35 kg/ha	387 f	253 f	219 e
Early – Untrt – 55 kg/ha	566 cde	421 bcd	279 de
Early – Untrt – 75 kg/ha	687 b	497 ab	281 de
Early – Trt – 35 kg/ha	452 ef	324 def	235 e
Early – Trt – 55 kg/ha	537 de	488 ab	299 de
Early – Trt – 75 kg/ha	769 ab	558 a	258 de
Late – Untrt – 35 kg/ha	511 e	296 ef	356 cd
Late – Untrt – 55 kg/ha	653 bcd	430 bc	566 a
Late – Untrt – 75 kg/ha	674 bc	374 cde	566 a
Late – Trt – 35 kg/ha	538 de	316 ef	438 bc
Late – Trt – 55 kg/ha	715 b	286 ef	516 ab
Late – Trt – 75 kg/ha	845 a	486 ab	584 a
S.E.M. (LSD)	40.9 (118.0)	39.6 (105.3)	40.3 (109.0)

Table 16. Seeding date by seed treatment interactions for flax maturity at two Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test, $P \leq 0.05$).

Two-way Interactions	IH-2016	IH-2017
Seed Date × Seed Trt	-------------------- days from planting	--------------------
Early – untreated	101.6 a	101.3 a
Early – treated	101.2 b	100.9 a
Late – untreated	92.1 c	91.5 b
Late – treated	91.9 c	90.7 c
S.E.M. (LSD)	0.14 (0.30)	0.24 (0.62)

Table 17. Seeding date by seeding rate interactions for flax maturity and orthogonal contrast results for seeding rate at two Saskatchewan site-years Means followed by the same letter do not significantly differ (Fisher's Protected LSD test; $P \leq 0.05$).

Two-way Interactions	IH-2016	IH-2017
Seed Date × Seed Rate	-------------------- days from planting	--------------------
Early – 35 kg/ha	102.7 a	101.9 a
Early – 55 kg/ha	101.3 b	101.1 b
Early – 75 kg/ha	100.3 c	100.4 c
Late – 35 kg/ha	92.3 d	92.3 d
Late – 55 kg/ha	92.0 d	90.8 e
Late – 75 kg/ha	91.6 e	90.2 f
S.E.M. (LSD)	0.16 (0.36)	0.27 (0.70)
Orthogonal Contrasts	----------------------- p-values	-----------------------
Rate-early – linear	< 0.001	< 0.001
Rate-early – quad	0.167	0.811
Rate-late – linear	< 0.001	< 0.001
Rate-late – quad	0.841	0.127

Table 18. Seed treatment by seeding rate interactions for flax maturity and orthogonal contrast results for seeding rate at two Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test; *P* ≤ 0.05).

Two-way Interactions	IH-2016	IH-2017
Seed Trt × Seed Rate	-------------------- days from planting	--------------------
Untr – 35 kg/ha	97.6 a	97.6 a
Untr – 55 kg/ha	96.8 b	96.1 bc
Untr – 75 kg/ha	96.3 c	95.6 cd
Trt – 35 kg/ha	97.4 a	96.6 b
Trt – 55 kg/ha	96.5 bc	95.8 c
Trt – 75 kg/ha	95.6 d	95.0 d
S.E.M. (LSD)	0.14 (0.36)	0.24 (0.61)
Orthogonal Contrasts	---------------------- p-values	------------------------
Rate-Untr – linear	< 0.001	< 0.001
Rate-Untr – quad	0.320	0.063
Rate-Trt – linear	< 0.001	< 0.001
Rate-Trt – quad	0.841	0.905

Table 19. Seeding date by seed treatment by seeding rate interactions for flax maturity at two Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test; $P \leq 0.05$).

Three-way Interactions	IH-2016	IH-2017
Seed Date × Trt × Rate	-------------------- days from planting	--------------------
Early – Untrt – 35 kg/ha	102.9 a	102.4 a
Early – Untrt – 55 kg/ha	101.5 b	101.1 bc
Early – Untrt – 75 kg/ha	100.5 cd	100.4 c
Early – Trt – 35 kg/ha	102.5 a	101.4 b
Early – Trt – 55 kg/ha	101.0 bc	101.0 bc
Early – Trt – 75 kg/ha	100.0 d	100.4 c
Late – Untrt – 35 kg/ha	92.3 e	92.8 d
Late – Untrt – 55 kg/ha	92.0 e	91.0 ef
Late – Untrt – 75 kg/ha	92.0 e	90.8 f
Late – Trt – 35 kg/ha	92.4 e	91.8 e
Late – Trt – 55 kg/ha	92.0 e	90.6 f
Late – Trt – 75 kg/ha	91.3 e	89.6 g
S.E.M. (LSD)	0.20 (0.51)	0.34 (0.93)

Table 20. Seeding date by seed treatment interactions for flax yield at three Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test; $P \leq 0.05$).

Two-way Interactions	IH-2016	IH-2017	ME-2017
Seed Date × Seed Trt	------------------	kg/ha	------------------
Early – untreated	2569 a	1518 a	2216 b
Early – treated	2535 a	1541 a	2353 a
Late – untreated	1500 b	1252 a	2103 b
Late – treated	1412 b	1302 a	2085 b
S.E.M. (LSD)	104.6 (117.4)	175.7 (296.6)	(132.5)

Table 21. Seeding date by seeding rate interactions for flax yield and orthogonal contrast results for seeding rate at three Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test; $P \leq 0.05$).

Two-way Interactions	IH-2016	IH-2017	ME-2017
Seed Date × Seed Rate	------------------	kg/ha	------------------
Early – 35 kg/ha	2620 a	1557 a	2259 ab
Early – 55 kg/ha	2632 a	1461 a	2305 a
Early – 75 kg/ha	2405 b	1569 a	2289 a
Late – 35 kg/ha	1489 c	1269 a	2110 bc
Late – 55 kg/ha	1478 c	1309 a	2098 bc
Late – 75 kg/ha	1399 c	1253 a	2075 c
S.E.M. (LSD)	108.5 (143.7)	178.0 (294.3)	119.5 (162.3)
Orthogonal Contrasts	------------------	p-values	------------------
R-early – linear	0.005	0.868	0.704
R-early – quad	0.058	0.100	0.654
R-early – linear	0.211	0.819	0.668
R-early – quad	0.581	0.434	0.941

Table 22. Seed treatment by seeding rate interactions for flax yield and orthogonal contrast results for seeding rate at three Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test; $P \leq 0.05$).

Two-way Interactions	**IH-2016**	**IH-2017**	**ME-2017**
Seed Trt × Seed Rate	------------------	kg/ha	------------------
Untr – 35 kg/ha	2072 a	1345 a	2124 a
Untr – 55 kg/ha	2118 a	1434 a	2205 a
Untr – 75 kg/ha	1914 bc	1376 a	2149 a
Trt – 35 kg/ha	2037 ab	1482 a	2244 a
Trt – 55 kg/ha	1993 abc	1336 a	2198 a
Trt – 75 kg/ha	1890 c	1447 a	2216 a
S.E.M. (LSD)	103.4 (143.7)	153.4 (142.7)	119.5 (162.3)
Orthogonal Contrasts	------------------	p-values	------------------
R-Untr – linear	0.032	0.664	0.761
R-Untr – quad	0.050	0.233	0.328
R-Trt – linear	0.045	0.619	0.724
R-Trt – quad	0.627	0.043	0.645

Table 23. Seeding date by seed treatment by seeding rate interactions for yield at three Saskatchewan site-years. Means followed by the same letter do not significantly differ (Fisher's Protected LSD test; $P \leq 0.05$).

Three-way Interactions	IH-2016	IH-2017	ME-2017
Seed Date × Trt × Rate	--	kg/ha	--
Early – Untrt – 35 kg/ha	2638 a	1512 a	2200 ab
Early – Untrt – 55 kg/ha	2643 a	1527 a	2231 ab
Early – Untrt – 75 kg/ha	2427 bc	1514 a	2217 ab
Early – Trt – 35 kg/ha	2601 ab	1603 a	2318 a
Early – Trt – 55 kg/ha	2622 ab	1395 a	2380 a
Early – Trt – 75 kg/ha	2382 c	1625 a	2362 a
Late – Untrt – 35 kg/ha	1506 de	1177 a	2049 b
Late – Untrt – 55 kg/ha	1592 d	1341 a	2179 ab
Late – Untrt – 75 kg/ha	1401 de	1238 a	2081 b
Late – Trt – 35 kg/ha	1472 de	1361 a	2171 ab
Late – Trt – 55 kg/ha	1365 e	1277 a	2016 b
Late – Trt – 75 kg/ha	1398 de	1269 a	2070 b
S.E.M. (LSD)	119.4 (203.3)	184.7 (321.0)	132.1 (229.5)

Figure 1. Discussion on flax seeding date and seed treatment considerations at the 2017 Indian Head Crop Management Field Day, July 18.

Figure 2. Flax agronomy segment of the 2017 Indian Head Crop Management Field Day, July 18.

Abstract

13. Abstract/Summary:

Field trials with flax were conducted near Indian Head in 2016-17 and Melfort in 2017. The objective was to demonstrate flax response to seed treatments at varying seeding rates and planting dates. Flax establishment was improved when seeding was delayed at 2/3 sites while, at the driest site, populations tended to be higher with early seeding. As anticipated, establishment was also improved with higher seeding rates, but this increases production costs and excessive populations can potentially lead to increased lodging and disease pressure. The use of a seed treatment improved flax establishment at one site-year (IH-16) but had no effect at the remaining two. There were no interactions between seed treatment and the other factors in any cases; therefore, it could not be concluded from these results that greater benefits are likely when seeding into cooler soils or using sub-optimal seeding rates. Maturity was slightly earlier with seed treatments at 2/3 sites but, at only 0.4-0.6 days, the difference was negligible from a practical perspective. Increasing seeding rates from 35 to 75 kg/ha shortened maturity by approximately 2 days while delayed seeding reduced the number of days (from planting) to maturity by as much as 10 days; however, the crop was always ready to combine substantially earlier with early seeding. Flax yields were affected by seeding date at 2/3 sites and seeding rate at 1/3 sites but not by seed treatment in any cases. In both cases where the effect was significant, yields were higher with early seeding; however, much of the observed yield loss observed with delayed seeding at Indian Head was attributed to wildlife damage. For the only case where seeding rate affected yield (IH-16), the results were the opposite of what was anticipated with a slight linear decline in yield with increasing seeding rate. Overall, the results from this project demonstrate that flax should be seeded early and at adequate but not excessive rates for maximum yield potential and the earliest possible harvest. Seed treatments may lead to improved establishment but not under all circumstances and the evidence suggests that yield responses may be less likely. It is possible that flax responses to seed treatments might be more likely on a larger scale where emergence issues and seedling disease pressure are often spatially variable.