2015 Annual Report

for the

Saskatchewan Flax Development Commission

Project Title: Flax Response to Fungicide at Varying Row Spacing and Nitrogen Levels

(Adopt #20140390)

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Project Identification

1. **Project Title:** Flax Response to Fungicide at Varying Row Spacing and Nitrogen Levels
2. **Project Number:** Adopt #20140390
3. **Producer Group Sponsoring the Project:** Saskatchewan Flax Development Commission
4. **Project Location(s):** Indian Head, Saskatchewan. Yorkton, Saskatchewan. Melfort, Saskatchewan
5. **Project start and end dates (month & year):** April 2015 to January 2016
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Objectives and Rationale

7. **Project objectives:**

The objectives are to demonstrate the response of flax to fungicide applications at three locations in Saskatchewan and to evaluate fungicide interactions with row spacing at Indian Head and nitrogen fertilizer rate at Melfort and Yorkton.

Project Rationale:

Pasmo is the most common disease that affects flax yields in Saskatchewan and, like many diseases, is more severe under wet conditions and with heavy crop canopies. With respect to foliar fungicide options, several products are registered to control this disease; however producers frequently question the potential return on investment for fungicide applications on flax. Past field trials and demonstrations at Indian Head have shown reasonably consistent responses to fungicide applications with yield increases of 20-30% when disease pressure is high; however, these benefits are only realized when pasmo is present therefore scouting remains important. Focussing on row spacing, past research in Saskatchewan has shown no yield difference for row spacing ranging from 10-30 cm (4-12") but information is limited for spacing beyond 30 cm. We know that flax can compensate for reduced emergence through increased branching to a certain extent but this crop is a relatively weak competitor with weeds early in the season and there are concerns as to whether row spacing $\geq$ 30 cm will limit yields. With respect to fungicide interactions with row spacing, it is conceivable that disease might be reduced at wider row spacing due to increased air flow through the canopy; but denser canopies are often also conducive to higher yields.

In regards to nitrogen rate, past research and producer testimonials suggest that high rates of nitrogen are possible without lodging. Most producers apply 40 to 80 lbs/ac of actual nitrogen, however it is possible that flax will respond to eve higher rates under high yielding conditions and with fungicide application.

Methodology and Results

8. Methodology:

Fungicide by Row Spacing

The "Fungicide by Row Spacing" field trial was established near Indian Head, Saskatchewan (R.M. #156) in 2015. The treatments were factorial combination of 5 row spacing treatments (25, 30, 36, 41, and 61 cm or 10, 12, 14, 16 and 24") and two fungicide treatments (untreated and treated). The treatments were arranged in a split plot design with fungicide treatment as the main plots and four replicates.

All pertinent agronomic information and dates of field operations are presented in Table 1. The plots were planted using a SeedMaster plot drill with eight openers whose position was adjusted to achieve the various row spacing. All fertilizer was side-banded at planting.

Table 1. Selected Agronomic Information for Flax "Fungicide by Row Spacing" Trial at Indian Head.

Description	2015	
Previous Crop	Spring Wheat	
Pre-Emergent Herbicide 1	April 29	890 g glyphosate ha^{-1} + 140 g sulfentrazone ha^{-1}
Pre-Emergent Herbicide 1	April 29	3.8 kg triallate ha^{-1}
Seeding Date	May 8	
Variety	CDC Bethune	
Seed Rate	50 kg ha^{-1}	
Fertility (kg N-P_2O_5-K_2O-S ha^{-1})	95-22-11-11	
Plant Density	June 4	
In-Crop Herbicide 1	June 10	175 g fluazifop-P-butyl ha^{-1}
In-Crop Herbicide 2	June 13	99 g clopyralid ha^{-1} + 553 g MCPA ester ha^{-1}
In-Crop Herbicide 3	June 24	44 g clethodim ha^{-1}
Foliar Fungicide	July 5	99 g pyraclostrobin ha^{-1}
Pre-Harvest Application	August 24	
Harvest Date	September 13	

Weeds were controlled using registered pre-emergent and in-crop herbicide applications and the fungicides were applied as per protocol with a field sprayer. The fungicide treatments were applied at full bloom and the product used was Headline EC (250 g pyraclostrobin l^{-1}) at a rate of 0.4 l ha^{-1}. The plots were terminated using glyphosate using 890 g glyphosate ha^{-1} all except the outside rows were mechanically harvested using a Wintersteiger plot combine.

Various data were collected over the course of the growing season and from the harvested grain samples. Plant emergence was determined in the spring by counting the number of seedlings in two separate 1 m rows per plot and calculating the average plants m^{-2}. Days from planting to maturity (75% of bolls turned brown) was recorded for each plot. Yields were determined from the harvested grain samples and are corrected for dockage and to 10% seed moisture content.

Response data were analysed separately each year using the Mixed procedure of SAS 9.3 with the effects of row spacing, fungicide and their interaction fixed. Treatment means were separated using Fisher's protected LSD test and orthogonal contrasts were used to determine whether the responses to row spacing were linear or quadratic (curvilinear) in shape. All treatment effects and differences between means were considered significant at $P \leq 0.05$.

Fungicide by Nitrogen Rate

The "Fungicide by Nitrogen Rate" trials were established near Yorkton and Melfort Saskatchewan in 2015. The trials were split-plot designs with 4 replicates. The main plot factor was "Fungicide" which contrasted no fungicide with the application of Headline EC (250 g pyraclostrobin l^{-1}) at a rate of 0.4 l ha^{-1} at full bloom. The split plot factor was "Nitrogen Rate" and contrasted nitrogen rates of 30, 60, 90, 120 and 150 lbs/ac of actual nitrogen.

Table 2 contains the agronomic information for the "Fungicide by Nitrogen Rate" trials conducted near Yorkton and Melfort. Plots were seeded with a Fabro disc drill (7 inch row spacing) and a Seedhawk drill (10 inch row spacing) at Melfort and Yorkton, respectively. At seeding 15 kg ha^{-1} of P_2O_5 was seed placed at Melfort and banded to the side at Yorkton. Nitrogen was side banded and varied with treatment. Plots were harvested using a Wintersteiger plot combine at both locations. Whole plots were harvested at Melfort (8.71 m^2) whereas, only the middle 5 rows of each plot were harvested at Yorkton (13.5m^2).

Table 2. Selected Agronomic Information for Flax "Fungicide by Nitrogen Rate" Trials at Yorkotn and Melfort.

Description	Yorkton	Melfort
Previous Crop	Spring Wheat	Spring Wheat
Pre-Emergent Herbicide 1		
Pre-Emergent Herbicide 1	—	
Early Seeding Date	May 2	May 19
Variety	CDC Bethune	CDC Bethune
Seed Rate	50 kg ha^{-1}	50 kg ha^{-1}
Plant Density	May 19	
In-Crop Herbicide 1	June 8 44 g clethodim ha^{-1}	June 16 44 g clethodim ha^{-1}

Table 2 continued. Selected Agronomic Information for Flax "Fungicide by Nitrogen Rate" Trials at Yorkotn and Melfort.

Description	**Yorkton**	**Melfort**
In-Crop Herbicide 2	June 15 75 g clopyralid ha^{-1} + 421 g MCPA ester ha^{-1}	
In-Crop Herbicide 3	June 18 44 g clethodim ha^{-1}	
Foliar Fungicide	July 10 99 g pyraclostrobin ha^{-1}	July 16 99 g pyraclostrobin ha^{-1}
Disease Ratings		September 26
Pre-Harvest Application	September 12	September 11
Harvest Date	September 19	September 28

9. Results:

Growing Season Weather

Mean monthly temperatures and precipitation amounts for Indian Head, Melfort and Yorkton during the 2015 season are presented relative to the long-term averages in Table 3. Seed and fertilizer were placed into adequate soil moisture. However, the spring as a whole was extremely dry at all locations with no significant precipitation events until late in June. From this point onwards, moisture conditions were generally considered adequate. Emergence was uneven at Melfort due to dry conditions and in Yorkton as the result of a killing frost of minus 2 to 4 degrees Celsius on May 30. This thinned out the flax stand and likely impacted yield. Melfort also received 139.7 mm of rain within 6 hours on July 27th. This excess moisture stayed for many days, creating variable soil saturation across the trial.

Table 3. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) normals for the 2015 growing seasons at Indian Head, Melfort and Yorkton in Saskatchewan.

Location	Year	May	June	July	August	Avg. / Total
		------------------------------*Mean Temperature (°C)* ------------------------------				
Indian Head	2015	10.3	16.2	18.1	17.0	15.4
	Long-term	***10.8***	***15.8***	***18.2***	***17.4***	***15.6***
Melfort	2015	9.9	16.4	17.9	17.0	15.3
	Long-term	***10.7***	***15.9***	***17.5***	***16.8***	***15.2***
Yorkton	2015	10.5	16.7	19.3	17.5	16.0
	Long-term	***10.4***	***15.5***	***17.9***	***17.1***	***15.2***
		-------------------------------- *Precipitation (mm)* ------------------------------				
Indian Head	2015	16	38	95	59	207
	Long-term	***52***	***77***	***64***	***51***	***244***
Melfort	2015	7	55	150	57	269
	Long -term	***43***	***52***	***77***	***52***	***226***
Yorkton	2015	8	28	123	46	205
	Long-term	***51***	***80***	***78***	***62***	***272***

<u>Flax Response to Row Spacing and Fungicide</u>

The analyses of variance for each crop response variable are provided in Table 4 and main effect means are presented in Table 5.

Table 4. Foliar fungicide and row spacing effects on plant density, maturity and seed yield of flax at Indian Head in 2015.

	Plant density	**Maturity**	**Yield**
	2015	**2015**	**2015**
Effect	-- p-values [z]	------------------------------------	
Fungicide (F)	0.383	0.778	0.773
Row spacing (RS)	< 0.001	< 0.001	< 0.001
F × RS	0.726	0.150	0.777

[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Plant density was affected by row spacing but not fungicide and with no interaction between factors. Emergence declined as row spacing was increased (Table 5). While the curvilinear responses were not quite significant at the desired level, plant populations tended to be similar for row spacing from 25-41 (10-16”) cm but populations at 61 cm (24”) were significantly lower than all the narrower row spacing treatments. This is a common observation in row spacing trials and is due to increased intraspecific competition with wider row spacing at any given seeding rate. Final populations in all treatments were considered sufficiently high to not be limiting to yield.

Flax maturity was affected by row spacing but not fungicide, regardless of the row spacing level (i.e. no interaction). While statistically significant, the row spacing effect was small with less than a 1 day difference for spacings ranging from 25-41 and a 2.7 day delay in maturity at 61 cm relative to 25 cm row spacing. This effect has been documented in other crops as well but row spacing (within this range) generally has less impact on maturity than other factors such as N fertility level or seeding rate.

Table 5. Least squares means for main effects of foliar fungicide and row spacing on plant density, maturity and seed yield of flax at Indian Head in 2015.

Main effect	Plant Density	Maturity	Seed Yield
	2015	2015	2015
Fungicide	----------- plants m^{-2} -----------	---- days ----	------------- kg ha^{-1} -------------
Fungicide [Z]	492 a	98.9 a	2015 a
No fungicide	459 a	99.0 a	2070 a
S.E.M.	24.7	0.18	93.0
Row spacing			
25 cm (10”)	530 a	98.0 e	2276 a
31 cm (12”)	517 a	98.3 d	2194 b
36 cm (14”)	506 a	98.7 c	2068 c
41 cm (16”)	487 a	98.9 b	2040 c
61 cm (24”)	338 b	100.7 a	1635 d
S.E.M.	23.4	0.14	93.0
Contrast	--------------------------------------- p-values [Y] ---------------------------------------		
RS – linear	< 0.001	< 0.001	< 0.001
RS – quadratic	0.052	0.033	0.558

[Z] 0.4 l Headline EC ha^{-1} applied at full bloom (approximately 7 days after 1st flowers noted)
[Y] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Seed yield was affected by row spacing but not fungicide and, again, there was no RS × FUNG interaction detected in either year (Table 4). According to the orthogonal contrasts, yield declined linearly (but not quadratically) with row spacing. Flax grown at 25 cm (10”) yielded significantly higher than any other treatments. Further declines in yield were detected as spacing was incrementally increased to 61 cm, at which point mean yields were 28% lower than yields at 25 cm.

While the effect of fungicide on flax yield was not significant, significant yield benefits are frequently detected with fungicide applications in this crop. As a crop protection product, fungicides typically only result in yield gains if: 1) the target disease is present at high enough levels to negatively impact yield and 2) factors other than disease are not more limiting to yield. In 2015 at Indian Head, yields were reasonably high but there was very little disease present with only minor symptoms appearing close to maturity when the potential to cause yield reduction was negligible.

Flax Response to Fungicide and Nitrogen rate

Table 6. Foliar fungicide and nitrogen rate effects on plant density, maturity and seed yield of flax at Yorkton in 2015.

	Plant density	Maturity	Seed Yield
Effect	--	p-values [z]	--
Fungicide (F)	0.282	0.171	0.107
Nitrogen Rate (NR)	0.110	<0.001	0.001
F x NR	0.728	0.730	0.201

[z] p-values ≤ 0.05 indicate that a treatment effect was significant and not due to random variability

Flax Response to Nitrogen rate and Fungicide

The analyses of variance for each crop response variable are provided in Tables 6 for Melfort and Yorkton. No interactions between Fungicide and Nitrogen rate were detected at either location. Thus only main effect means for Yorkton and Melfort are presented in Tables 7 and 8, respectively.

Table 6. Foliar fungicide and nitrogen rate effects on plant density, maturity and seed yield of flax at Yorkton and Melfort in 2015.

	Plant density	Maturity	Seed Yield
Yorkton	--	p-values [z]	--
Fungicide (F)	0.282	0.171	0.107
Nitrogen Rate (NR)	0.110	<0.001	0.001
F x NR	0.728	0.730	0.201
Melfort			
Fungicide (F)	0.877	—	0.200
Nitrogen Rate (NR)	0.423	—	<0.001
F x NR	0.573	—	0.986

Plant density was low at both Melfort and Yorkton. Dry seed bed conditions at Melfort may have been an issue. While not significant at the 5% level there was a strong trend for reduced emergence of flax as nitrogen rates were increased at Yorkton (Table 7). This has been observed many times with the SeedHawk drill and inadequate separation with the banded fertilizer must be occurring. Seed safety was not an issue at Melfort. Increasing nitrogen rate significantly delayed maturity at Yorkton (Table 7) but did not affect maturity at Melfort (data not shown). Increasing nitrogen rate is known to delay maturity in many crops but the delay in maturity at Yorkton may have been accentuated by decreasing plant populations with increasing nitrogen. The fact that N rate did not affect maturity at Melfort was unexpected, but may reflect the wet conditions experienced latter in the growing season. Seed yield was increased significantly with applied nitrogen at both locations. Yields continued to increase strongly up to 150 lbs/ac at Melfort with a yield gain of 55% between the lowest and highest rates. There was a yield gain of 23% between the highest and lowest N rates at Yorkton but yields started to level off between 90 to 120 lbs/ac. Yield response to nitrogen was undoubtedly high in Melfort as the trial area had not received nitrogen for the past 5 years. Soil tests revealed marginal levels of soil N were present at the Yorkton site.

The application of fungicide did result in higher seed yields of 9 and 5% at Yorkton and Melfort, respectively (Tables 7 and 8). However, differences could not be separated at the 5% level of significance at either location. Pasmo levels were very low at Melfort. Disease levels were also low at Yorkton but ratings did indicate lower levels of disease were fungicide had been applied. Fungicide delayed maturity by 5 days at the Yorkton site but this was not significant at the 5% level (Table 7). No effects of Fungicide on maturity were detected at Melfort as disease levels were very low.

Table 7. Least squares means for main effects of foliar fungicide and nitrogen rates on plant density, maturity and seed yield of flax at Yorkton in 2015.

Main effect	Plant density	Maturity	Seed Yield
Fungicide	-----plants m^{-2}------	---days---	---------- kg ha^{-1} -------
Fungicide [z]	116 a	122.4 a	1959 a
No fungicide	130 a	117.5 a	1796 a
Nitrogen Rate (actual)			
30 lbs/ac	152 a	114.9 c	1633 b
60 lbs/ac	132 a	117.8 bc	1869 a
90 lbs/ac	123 a	120.6 ab	1908 a
120 lbs/ac	114 a	121.5 ab	1981 a
150 lbs/ac	96 a	124.8 a	2015 a

Table 8. Least squares means for main effects of foliar fungicide and nitrogen rates on plant density, maturity and seed yield of flax at Melfort in 2015.

Main effect	Plant density	Seed Yield
Fungicide	-----plants m^{-2}------	---------- kg ha^{-1} -------
Fungicide [z]	173 a	2212 a
No fungicide	174 a	2099 a
Nitrogen Rate (actual)		
30 lbs/ac	178 a	1657 c
60 lbs/ac	168 a	1932 c
90 lbs/ac	164 a	2282 b
120 lbs/ac	170 a	2333 ab
150 lbs/ac	187 a	2575 a

Extension and Acknowledgement

This demonstration was a formal stop during 2015 IHARF ECRF and NARF Crop Management Field Days. The tours were well attended and signs were in place to acknowledge the support of the Saskatchewan Flax Development Commission (SaskFlax) and the ADOPT program. At IHARF, the provincial oilseed specialists were on site to discuss major issues in flax production and some of the treatments being demonstrated. These results were presented by Chris Holzapfel and Stu Brandt on the 2015 Provincial Oilseed Producer Meetings (Nov. 16-20) and by Chris Holzapfel at CropSphere 2016. Results from the project will be made available in the 2015 IHARF Annual Report (available online) and also through a variety of other media (i.e. oral presentations, popular agriculture press, fact sheets, etc.) as opportunities arise.

10. Conclusions and Recommendations

Flax yields were reduced with increasing row spacing. This is not to say that seeding equipment with row spacing ≥ 30 cm (12”) cannot be used to seed flax; however, with all other factors being equal, lower mean yields or increased yield variability may occur as row spacing is increased. No interactions between fungicide and row spacing or fungicide and nitrogen rate could be detected at any of the locations. No fungicide affects were significant, however there was a trend for the application of fungicide to increase yields by 9 and 5% at Yorkton and Melfort. There was a trend for fungicide to delay maturity at Yorkton but no such affects were observed at Indian Head or Melfort. Disease levels were low at all locations, as spring was very dry. The variability in fungicide response reinforces the recommendation to scout fields on individual basis and each year prior to committing to a fungicide application. While scouting for many diseases can be difficult at the time when fungicides must be applied, in the years where the greatest responses were observed substantial disease was already observed on the bottom leaves and lower stem at mid-bloom.

Flax responded well to added nitrogen at both Yorkton and Melville with yield gains of 23 and 55%, respectively. Optimum N rates were in the range of 90 to 150 lbs/ac. This is higher than expected. High rates of nitrogen are known to delay maturity and this was the case at Yorkton. Lower emergence associated with high rates of N at Yorkton would have also contributed to the delay in maturity and may have held yield back. Added nitrogen did not affect emergence or maturity at Melfort.

Supporting Information

11. Acknowledgements:

This project was initiated by the Saskatchewan Flax Development Commission (SaskFlax) and funded through the Agricultural Demonstration of Practices and Technologies (ADOPT) initiative under the Canada-Saskatchewan Growing Forward 2 bi-lateral agreement. Crop protection products used in the project at Indian Head were provided in-kind by BASF, FMC Bayer CropScience and Syngenta and SeedMaster Manufacturing contributed to the initial design and manufacturing of the drill. The support and contributions of Christiane Catellier, Dan Walker, Carly Miller and Danny Petty at Indian Head are greatly appreciated.

12. Appendices

Table 2. Least squares means for effects of interactions between foliar fungicide and row spacing on plant density and seed yield of flax at Indian Head.

Interaction	Plant Density	Maturity	Seed Yield
Fungicide × Row Spacing	------- plants m^{-2} -------	--- days ---	-------- kg ha^{-1} --------
Check – 25 cm	512	98.0	2309
Check – 31 cm	492	98.3	2196
Check - 36 cm	491	98.8	2102
Check – 42 cm	460	99.1	2080
Check – 61 cm	342	100.6	1665
Fung – 25 cm	547	98.0	2243
Fung – 31 cm	543	98.3	2193
Fung – 36 cm	522	98.6	2034
Fung – 42 cm	515	98.8	2001
Fung – 61 cm	334	100.8	1606
S.E.M.	33.1	0.20	131.5
Orthogonal Contrasts	------------------------------------- Pr. > *F* -------------------------------------		
RS (check) – lin	< 0.001	< 0.001	< 0.001
RS (check) – quad	0.370	0.033	0.551
RS (fung) – lin	< 0.001	< 0.001	< 0.001
RS (fung) – quad	0.060	0.004	0.816

Abstract

13. Abstract/Summary:

Field trials were conducted at Indian Head in 2015 to demonstrate row spacing and fungicide effects and interactions with flax. The treatments were a combination of five row-spacings (25-61 cm) and two fungicide (treated vs untreated) levels. At Yorkton and Melville field trials in 2015 were conducted to demonstrate nitrogen rate (30 to 150 lbs/ac) and fungicide effects with flax. Increasing row spacing at Indian Head reduced emergence; however, plant populations were considered sufficient for all row spacing treatments. Increasing row spacing also delayed maturity but by less than 1 day within the practical range of 25-41 cm. Yields declined with increasing row spacing. Flax at 25 cm yielded higher than all other treatments and yields continued to decline as spacing was incrementally increased. No interactions between fungicide and row spacing or fungicide and nitrogen rate were detected at any location. At the 5% level of significance, the application of fungicide did not significantly affect maturity or yield. However, there was a trend for applied fungicide to increase yield by 9 and 5% at Yorkton and Melville, respectively. There was also a trend for the application of fungicide to delay maturity of flax by 5 days at Yorkton. Increasing nitrogen rates from 30 to 150 lbs/ac increased yield by 23% at Yorkton and by 55% at Melfort. Yield continued to increase substantially up to a 150 lbs/ac at Melfort but tended to level off around 90 to 120 lbs/ac at Yorkton. Increasing nitrogen rates

substantially delayed maturity at Yorkton but not Melfort. High rates of nitrogen are known to delay maturity but these effects were likely accentuated Yorkton as increasing rates of nitrogen tended to decreased plant populations.