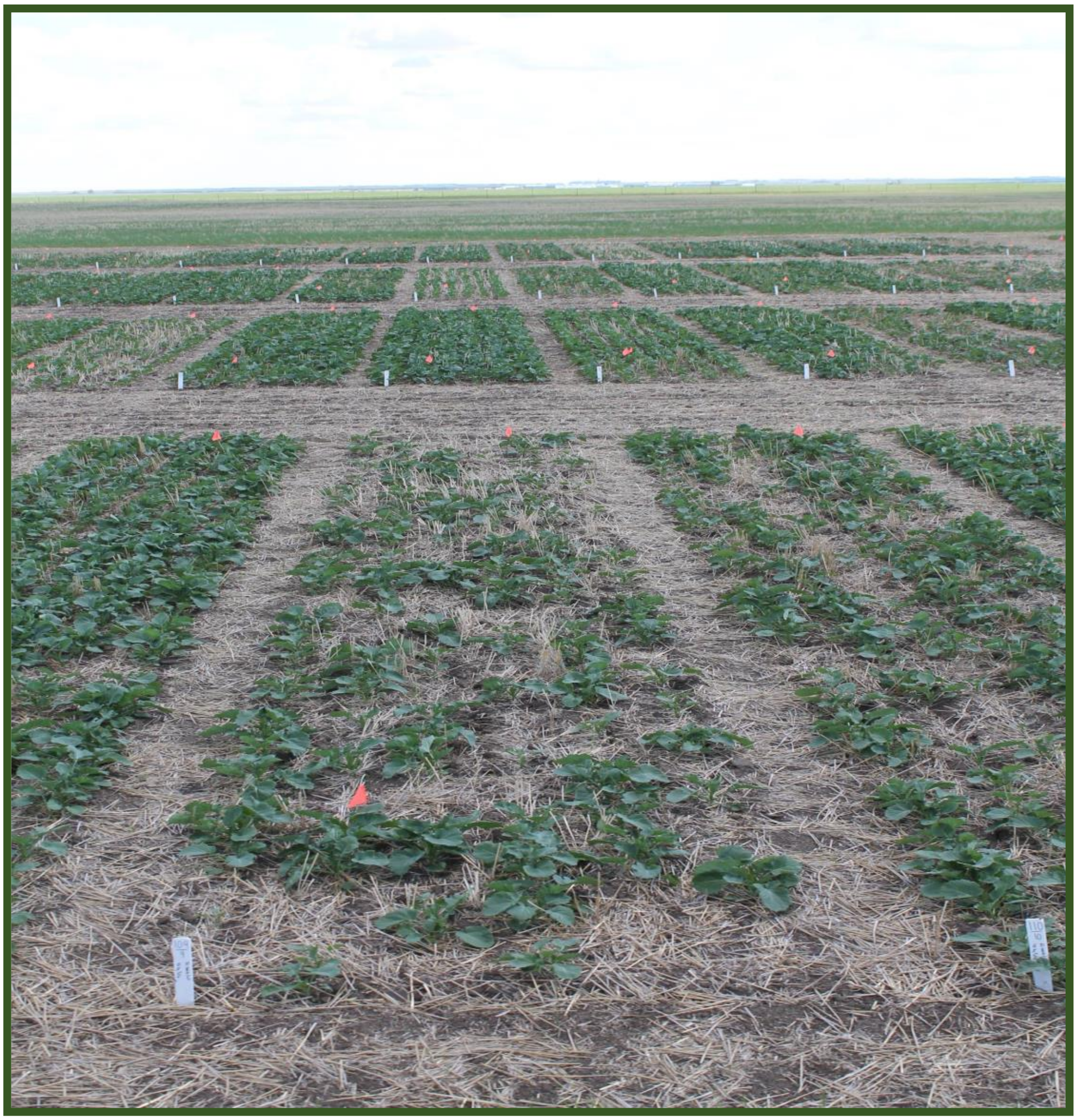
2015 Annual Progress Report
for the
Agriculture Demonstration of Practices and Technologies (ADOPT) Program



Project Title: Risks of seed-placed phosphorus fertilizer with canola

Project Number: 20140348

Producer Group Sponsoring the Project: Western Applied Research Corporation (WARC)

Project Location(s): The project is conducted at the AAFC Scott Research Farm. Legal land description: NE 17 39 20 W3

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Objectives and Rationale

Project objectives

The objective of this project was to demonstrate canola's seed yield response to seed-placed phosphorus fertilizer over a range of plant densities and to re-evaluate current recommended safe rates for seed-placed phosphorus fertilizer for canola in northwest Saskatchewan.

Project Rationale

Most farmers in western Canada are applying their phosphorus (P) fertilizer in or near the seed row due to efficiency and convenience. Canola is relatively sensitive to seed-placed P fertilizer; however, canola requires a relatively large amount of P to reach maximum yield potential compared to cereals. To satisfy canola's P requirements in the year of application or to maintain soil fertility, farmers are often required to apply P at rates that exceed the maximum recommended safe rate. High rates of seed-placed P fertilizer may cause seeding damage resulting in delayed emergence, reduced plant stand, crop maturity uniformity, and grain yield and seed quality. Traditionally, high seeding rates could be used to offset reductions in plant stand caused by fertilizer toxicity; however, farmers are reducing seeding rates in an effort to reduce input costs.

Maximum recommended safe rates of P for canola are limited to 15 to 20 kg P_2O_5 ha^{-1} of monoammonium phosphate (MAP) with knife openers with a one-inch spread, nine-inch row spacing and good to excellent soil moisture in Saskatchewan. This may limit yield potential of canola on soil with low P levels (Canola Council of Canada, 2013). Recent research has shown that hybrid *Brassica napus* cultivars are more tolerant of seed-placed fertilizers than other Brassica crops and did not show injury with up to 30-40 kg P_2O_5 ha^{-1} under laboratory conditions. In addition, a study by Grant et al. (2008) demonstrated that 40 kg P_2O_5 ha^{-1} of seed-placed MAP was low risk in terms of seedling toxicity and when statistically significant reductions in plant stand did occur, these reductions were not agronomically significant in that they did not affect seed yield. They concluded that the nutritional benefit of the additional P offset any negative effects on seedling emergence. This is likely because canola has an exceptional capacity to maintain consistent yields across a wide range of plant densities. It is conceivable that the nutritional benefit of the additional fertilizer P may be offset by negative effects on seedling emergence when low seeding rates are used. The study evaluated the risks and benefits of a range of seed-placed phosphorus (P) rates for canola. Because there is a wide range of seeding rates used by farmers, it was also important to evaluate starter P response of the crop at different plant densities.

Methodology and Results

This demonstration was conducted at the AAFC Scott Research Farm in 2015. The study was a 4 x 4 factorial design arranged as a randomized complete block design with four replicates, resulting in a total of 16 treatments (Table 1). The first factor was seeding rate (30, 60, 90, 120 seeds/m^2) and the second factor was the rate of phosphorus (0, 20, 40, 80 kg P_2O_5). Prior to seeding, glyphosate (1 L/ac) + bromoxynil (0.4 L/ac) were applied, and Liberty (1.35 L/ac) was applied in-crop for weed control (Appendix A: Table A.1). The canola was seeded at a depth of ½ to ¾ inch in 10 inch row spacing and the seeding rate was based on the established protocol (Table 1). P fertilizer applications were based on the established protocol (Table 1), while nitrogen (urea) and ammonium sulfate (AS) fertilizer were applied according to soil test recommendations (Appendix A: Table A.2).

Table 1: Treatment list for the 2015 growing season

Treatments	Seeding Rate	P_2O_5 Rate
1	30 seeds/m^2	Control (0 kg P_2O_5)
2	60 seeds/m^2	Control (0 kg P_2O_5)
3	90 seeds/m^2	Control (0 kg P_2O_5)
4	120 seeds/m^2	Control (0 kg P_2O_5)
5	30 seeds/m^2	20 kg P_2O_5
6	60 seeds/m^2	20 kg P_2O_5
7	90 seeds/m^2	20 kg P_2O_5
8	120 seeds/m^2	20 kg P_2O_5
9	30 seeds/m^2	40 kg P_2O_5
10	60 seeds/m^2	40 kg P_2O_5
11	90 seeds/m^2	40 kg P_2O_5
12	120 seeds/m^2	40 kg P_2O_5
13	30 seeds/m^2	80 kg P_2O_5
14	60 seeds/m^2	80 kg P_2O_5
15	90 seeds/m^2	80 kg P_2O_5
16	120 seeds/m^2	80 kg P_2O_5

Spring plant densities were assessed every week after emergence for five weeks. After five weeks, the process of counting resulted in the removal of flowers and breaking of stems. Therefore, we did not conduct the counts at six weeks after emergence as the protocol had stipulated. Densities were assessed by counting two 1 m rows in the front and back of the plot for a total of four rows per plot. The average of the four rows was converted to plants per m^{-2} based on 10 inch row spacing. Days to maturity was recorded every second day until 60 % of the seed colour changed from green to dark brown. Grain yield was collected using a mechanical plot harvester; seed was cleaned and corrected to 10 % seed moisture content. The percent dockage, green seed content and thousand kernel weights were determined. Weather data was estimated from the nearest Environment Canada weather station (Table 2).

Environmental growing conditions

In 2015, the early growing season was very dry with only 4.1 mm and 19.4 mm accumulated precipitation during the month of May and June, respectively. In contrast, August received approximately 39 % more moisture compared to the long-term average. The mean monthly temperatures were comparable to previous years. Furthermore, there was an increase in precipitation during August (74 mm), an increase of 27 % compared to the long term average (Table 2).

Table 2. Mean monthly temperatures and precipitation amounts along with long-term (1981-2010) averages for 2015 growing season at Scott, SK.

Year	May	June	July	August	Sept.	Average /Total
			Temperature (°C)			
2015	9.3	16.1	18.1	16.8	10.9	14.24
Long-term	10.8	15.3	17.1	16.5	10.4	14.0
			Precipitation (mm)			
2015	4.1	19.4	46.4	74.5	49.6	194.0
Long-term	36.3	61.8	72.1	45.7	36.0	215.9
			Growing Degree Days			
2015	140.3	332	405.1	365.8	179.8	1423.0
Long-term	178.3	307.5	375.1	356.5	162.0	1379.4

Statistical Analysis

An analysis of variance (ANOVA) was conducted on all response variables using the PROC MIXED in SAS 9.3. Seeding rate and phosphorus fertilizer rate were considered as fixed effect factors and replication was considered a random effect factor. The assumptions of ANOVA (random, equal variance and normally distributed) were tested using PROC UNIVARIATE, Levine's test, and Shapiro-Wilks. The data fitted to the ANOVA assumptions and so there was no need for data transformation. Regressions using PROC GLM were conducted for both seeding rate and phosphorus rates to determine if data fitted a linear or quadratic model. The plant counts were analysed using REPEATED MEASURES by using PROC MIXED to determine if emergence changed over times (in weeks). The effect of seeding rate and phosphorus rate on plant density was assessed using a regression in PROC GLM and means were separated using Tukey's HSD and were considered significant at $P < 0.05$ for each week of plant counts. As the effects of seeding rate and phosphorus was the same for all five weeks, the average over five weeks will be presented.

Results

Plant Density

Seeding rate had a significant effect (P <.0001) on plant density, as the highest seeding rate of 120 seeds m^{-2} resulted in 77 plants m^{-2}, while the lowest seeding rate (30 seeds m^{-2}) resulted in the 19 plants m^{-2}. A linear effect was significant for seeding rate, which was expected as a higher seeding rate will positively correlate to a higher plant population. Phosphorus rate also had a significant effect (P <.0001) on plant density, with a decline in density to 45 plants m^{-2} and 37 plants m^{-2} at 40 kg P_2O_5 and 80 kg P_2O_5, respectively. This indicates that a P rate above 20 kg P_2O_5 will result in a significant decline in plant populations. These results correspond with the Canola Council of Canada safe rate recommendations, in which any P fertilizer placed with the seed should be less than 20 kg P_2O_5 (Canola Council of Canada, 2014a). It is important to note that the effects of seeding rate and P rate did not change over time, as time (in weeks) did not significantly affect plant density (P = 0.4209) (data not shown). This indicates that effect of P was prevalent throughout the growing season, and that it consistently influenced the plant population.

Table 3. The effect of seeding rate and phosphorus rate on plant density (plants m^{-2}) averaged over five weeks at Scott, SK in 2015. Means separated using Tukey's HSD (significant P < 0.05). Means with different letters indicate significantly different.

Source	**Plant Density (plants m^{-2})**
	--------------- *p value* -----------
Seeding Rate (SR)	<.0001
30 seeds m^{-2}	19^{D}
60 seeds m^{-2}	41^{C}
90 seeds m^{-2}	56^{B}
120 seeds m^{-2}	77^{A}
	--------------- *p value* -----------
Phosphorus Rate (PR)	<.0001
0 kg P_2O_5	58^{A}
20 kg P_2O_5	53^{A}
40 kg P_2O_5	45^{B}
80 kg P_2O_5	37^{C}
	--------------- *p value* -----------
SR* PR	0.0986

Days to Maturity

The interaction of seeding rate and P rate had a significant (P = 0.0510) effect on days to maturity (DTM) (Table 4). Based on this interaction, seeding rate and DTM are negatively correlated (r = -0.50), with days to maturity increasing as seeding rate decreases. The lowest seeding rate (30 seeds m^{-2}) resulted in the longest DTM (104) (Figure 1). This is likely because a thinner stand results in increased branching, prolonged flowering and uninform maturity (Canola Council of Canada, 2014b). Our results coincide with Harker et al. (2015) that found that higher seeding rates led to reduced days to start of flowering and days to crop maturity, while low seeding rates delayed maturity (Harker et al. 2015).

Table 4. The effect of seeding rate and phosphorus rate on days to maturity at Scott, SK in 2015. Means separated using Tukey's HSD (significant P<0.05).

Source	P value
Seeding Rate (SR)	<.0001
Phosphorus Rate (PR)	<.0001
SR*PR	0.0510

In contrast, the effect of P rate on DTM is less obvious, but is slightly negatively correlated (r = -0.02). In general, the lowest P rate of 0 kg P_2O_5 resulted in the longest DTM, but this appears to be dependent on seeding rate. The effect of P rates on DTM has not been well documented; however, as P is an essential nutrient required for growth, development, utilization of sugar and starch, and photosynthesis, a depletion of P can result in delayed growth and maturity (Alberta Agriculture and Forestry, 2013).

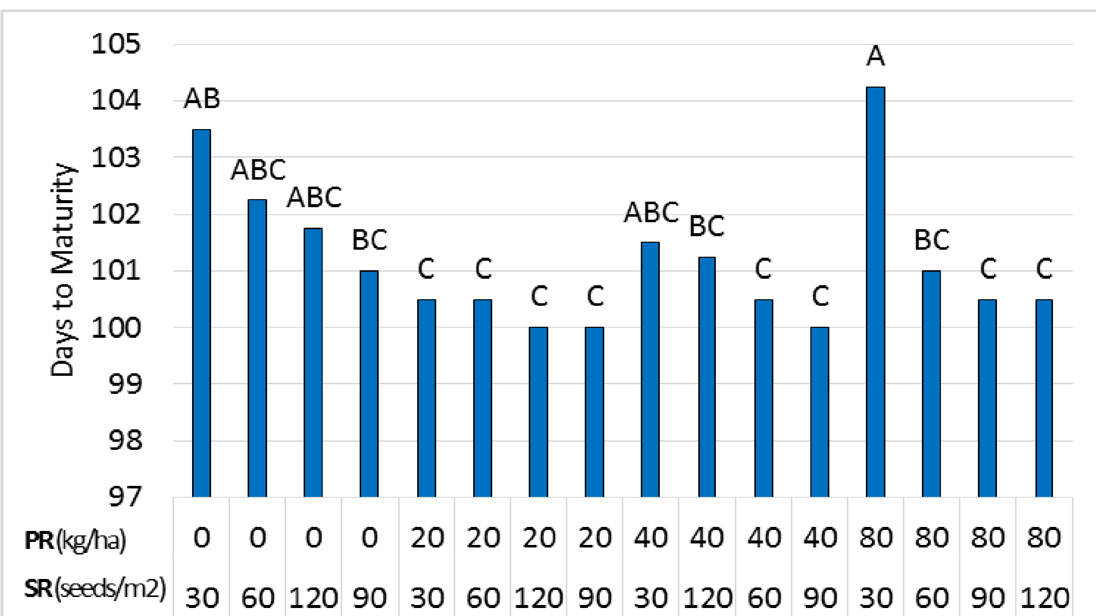

Figure 1. The interaction of P rate (PR) and seeding rate (SR) on days to maturity in canola. Scott, SK. 2015

Yield, TKW & Green Seed Content

The effect of seeding rate and P rate ($P < .0001$; $P < .0001$) and P rate ($P = 0.0003$; $P < .0001$) had a significant, quadratic effect on both yield and TKW, respectively (Table 5). In contrast, the green seed content and percent dockage (data not shown) were not effected by seeding rate, P rate or their interaction. The seeding rate of 95 seeds m^{-2} results in the maximum yield of 3238 kg/ha, while 90 seeds m^{-2} resulted in the highest TKW of 3.4 g/ 1000s (Figure 2). The effect of seeding rate on yield and TKW were highly correlated ($r = 0.99$), as the seeding rate of approximately 95 seeds m^{-2} resulted in the greatest yield with the highest seed quality. In contrast, the lower seeding rates resulted in 13 % and 6 % decrease in yield and TKW, respectively. Similarly, Harker et al. (2015) found that higher seeding rate of 150 seeds m^{-2} led to increased early crop biomass, TKW and seed oil content, compared 70 seeds m^{-2}. However, both Harker et al. (2015) and Kutcher et al. (2013) did not report a significant difference in yield between the two seeding rates. In other research, higher seeding rates increased canola yield (Brandt et al. 2007; Hanson et al. 2008; Harker et al. 2012b). Furthermore, Harker et al. (2003) found that a lower seeding rate of 100 seeds m^{-2} compared with higher seeding rates of 150 and 200 seeds m^{-2} reduced yields of both canola cultivars, InVigor 2153 and Exceed, by 7%. This indicates that perhaps the new varieties such as L130 may have improved genetics that allow for a lowered seeding rate compared to InVigor 2153 and Exceed. Although there are yield discrepancies between studies, the effect of seeding rate on seed quality is clear: a higher seeding rate between 90 and 150 seeds m^{-2}, results in plumper kernels with a better oil quality (Harker et al. 2015). Furthermore, higher seeding rate is critical, as only 50 % of planted canola in western Canada emerge above the soil surface (Harker et al. 2003, 2012a). Thus, if a lower seeding rate of 70 seeds m^{-2} is used, then the likelihood of reduced seed quality and possibly yield can occur if only 35 seeds m^{-2} emerge.

Table 5. The effect of seeding rate and P rate on canola yield (kg/ha), thousand kernel weight (g/1000s), and green seed content (%) in Scott, SK in 2015.

	Yield (kg/ha)	**TKW (g/1000s)**	**Green Seed Content (%)**
Seeding Rate (SR)	<.0001	0.0003	0.0700
P Rate (PR)	<.0001	<.0001	0.6054
SR*PR	0.2474	0.2474	0.6262

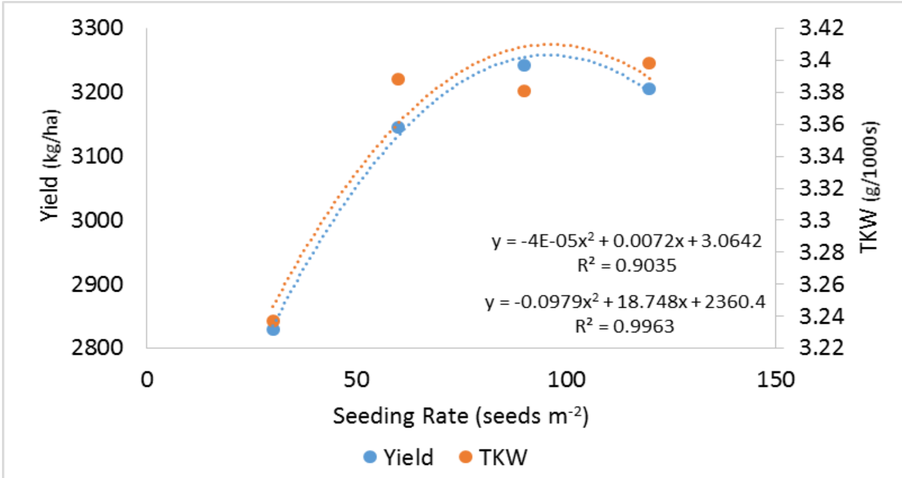

Figure 2. The effect of seeding rate (seeds m^{-2}) on canola yield and thousand kernel weight at Scott SK, 2015.

In contrast, the P rate on yield and TKW were not highly correlated, as the highest yield of 3238 kg/ha was obtained using 63 kg P_2O_5, while the TKW was the highest (3.4g/1000s) when 30 kg P_2O_5 was seed placed. Thus, using a high P rate may result in the greatest yield but seed quality may be significantly reduced when higher rates above 30 kg P_2O_5 are used (Figure 3). Based on the recommendations of the Canola Council of Canada (2013), the maximum safe P_2O_5 seed-placed rate is approximately 22 kg/ha. However, this rate can change depending on soil moisture, soil type, type of seeding implement (disk or know, vs. spoon or hoe, vs. sweep), and row spacing. From the recommendation by Manitoba Agriculture, Food and Rural Development, a safe rate to be used in this study would have been approximately 15 kg P_2O_5 seed placed (based on a 10 inch row spacing, 1 inch spread, with a sandy loam soil type and low soil moisture). However, 30 kg P_2O_5 was safely placed with the seed. This could indicate that the new cultivars, such as L130, are possibly more tolerant to higher rates of P_2O_5, as this growing condition should have resulted in a poor seed quality and lower yields, but conversely, both yield and seed quality were excellent.

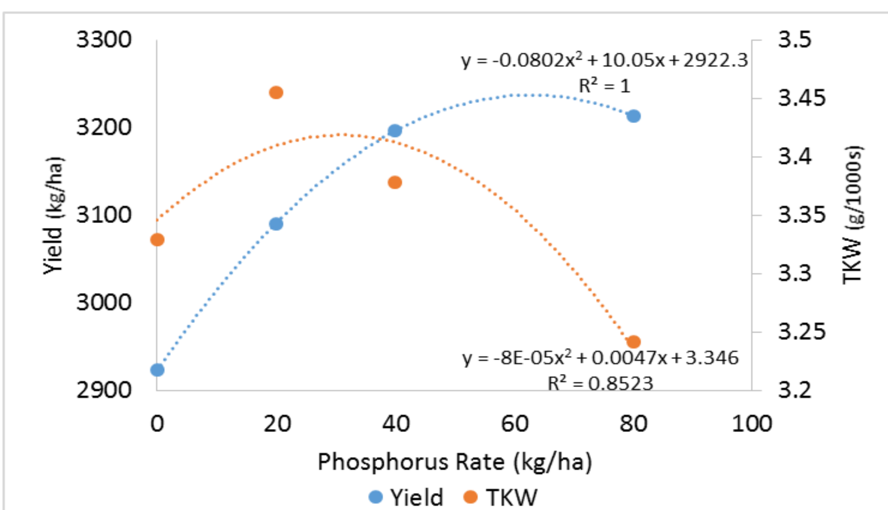

Figure 3. The effect of P rate (kg/ha) on canola yield and thousand kernel weight at Scott SK, 2015.

Conclusions and Recommendations

In conclusion, this project demonstrated that canola grain yield and seed quality is responsive to both seeding rates and seed-placed phosphorus fertilizer over a range of seeding rates. Increasing the seeding rate from 30 to 90 seeds m^{-2} significantly increased yield and TKW by 13 % and 6 %, respectively. Although there is contradicting evidence on proper seeding rate to achieve target yields, it is clear that a higher seeding rate will improve seed quality. Furthermore, as approximately only 50 % of the seeds will successfully establish, it is critical to ensure that the final plant stand ranges between 70 to 80 plants m^{-2}. The effect of P on seed quality and yield were not consistent, as maximum yield was achieved with 63 kg P_2O_5, while 30 kg P_2O_5 resulted in the highest TKW. Although most recommendations suggest that the ideal safe rate for seed-placed P is around 17 to 22 kg/ha, depending on several factors, this study found that 30 kg P_2O_5 could safely be placed with the seed, regardless of the low seed bed utilization and dry soil conditions.

Supporting Information

Acknowledgements

We would like to thank the Ministry of Agriculture for the funding support on this project. We would like to acknowledge Herb Schell and our summer staff for their technical assistance with project development and implementation for the 2015 growing season. This report will be distributed through WARC's website and included in WARC's and Agri-Arm annual reports.

Appendices

Appendix A – Agronomic information for the demonstration

Abstract/Summary

Most farmers in western Canada are applying their phosphorus (P) fertilizer in or near the seed row due to efficiency and convenience. Canola is relatively sensitive to seed-placed P fertilizer; however, canola requires a relatively large amount of P to reach maximum yield potential compared to cereals. Furthermore, high seeding rates could be used to offset reductions in plant stand caused by fertilizer toxicity; however, farmers are reducing seeding rates in an effort to reduce input costs. To determine the absolutely maximum canola seeding rate and safe rate seed-placed phosphorus, this study was designed as a 4 x 4 factorial with seeding rate (30, 60, 90, 120 seeds/m^2) and P rate (0, 20, 40, 80 kg P_2O_5) arranged as a randomized complete block design with four replications. From the study, increasing the seeding rate from 30 seeds m^{-2} to 90 seeds m^{-2} significantly increased yield and TKW by 13% and 6%, respectively. Although there is contradicting evidence on proper seeding rate to achieve target yields, it is clear that a higher seeding rate will improve seed quality. Furthermore, as approximately only 50% of the seeds will successfully establish, it is critical to ensure that the final plant stand ranges between 70 to 80 plants m^{-2}. The effect of P rate on canola grain yield and seed quality was less distinct, as the highest yield of 3238

kg/ha was obtained using 63 kg P_2O_5, while the TKW was the highest (3.4g/1000s) when 30 kg P_2O_5 was seed placed. Based on the recommendation from Manitoba Agriculture, Food and Rural Development, a safe rate of P fertilizer seed-placed would have been approximately 15 kg P_2O_5. However, 30 kg P_2O_5 was safely placed with the seed. This could indicate that the new cultivars, such as L130, are possibly more tolerant to higher rates of P_2O_5, as this growing condition should have resulted in a poor seed quality and lower yields, but conversely, both yield and seed quality were excellent.

Appendix A

Agronomic information for 2015 demonstration

Table A.1. Selected agronomic information for Risks of Seed-Placed Phosphorus Fertilizer with Canola at Scott, Saskatchewan, 2015.

Seeding Information	2015
Seeder	R-Tech Drill, 10 inch row spacing, knife openers
Seeding Date	May 20, 2015
Cultivar	Canola- L130
Seeding Rate	Dependent on Protocol
Stubble Type	Wheat
Fertilizer applied	MAP was seed placed based on protocol Treatment 5,6,7,8: Urea (203.7 lb/ac) and AS (62.5) mid row Treatment 9,10,11,12: Urea (195.4 lb/ac) and AS (62.5 lb.ac) mid row Treatment 13,14,15,16: Urea (179.1 lb/ac) and AS (62.5 lb/ac) mid row
Plot Maintenance Information	
Pre-plant herbicide	Roundup ¾ L/ac + Pardner 0.4 L/ac (May 18, 2015)
In-crop herbicide	Buctril M 0.4 L/ac + Axial 0.48 L/ac (June 10, 2015)
Treatment Application	None
Desiccation	Reglone @ 1.25 L/ha (August 27, 2015)
Data Collection	
Emergence Counts	May 29, 2015
Harvest Date	September 2, 2015

Table A.2. Residual Soil Nutrients for the 2015 growing seasons at Scott, SK.

Depth	***0-15 cm***	***15-30 cm***	***15-60 cm***	***Total***
NO_3-N	21	9	6	**36**
PO_4-P	42	-	-	**42**
K	508	-	-	**508**
SO_4-S	16	9	26	**51**

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