PROJECT DETAILS

- **Title**: Impact of traditional and enhanced efficiency phosphorus fertilizers on canola emergence, yield, maturity and quality
- **Funders:** Agriculture and Agri-Food Canada, Alberta Canola, Canola Council of Canada, Manitoba Canola Growers and SaskCanola
- **Research program:** Growing Forward
- **Principal investigator:** Cynthia Grant (Agriculture and Agri-Food Canada, Brandon)
- **Collaborators/additional investigators:** Jo-Anne Relf-Eckstein, Rong Zhou
- **Year completed:** 2011

Final report

Executive summary

Field studies were conducted at two locations over 3 years to evaluate the effect of various enhanced efficiency P fertilizers on seedling toxicity, yield and quality of canola. Related studies compared the P response of black- and yellow-seeded canola cultivars. Seedling damage occurred with high rates of applied P unless soil conditions were very wet, with damage being particularly evident with liquid P. Where damage occurred, use of polymer coated MAP reduced the risk of seedling damage. Canola could compensate for seedling damage if stands were not reduced below critical levels, but where stand density was low, seed yields declined and maturity was delayed due to seedling toxicity.

Canola yield generally increased with moderate rates of P application. Decreases in seed yield occurred where high rates of application decreased stand density below critical levels. There was little difference among P sources in their effects on canola seed yield, although a benefit may occur from the polymer coated product (CRP) due prevention of seedling damage.

The enhanced efficiency P fertilizers evaluated therefore provided little economic benefit as compared to traditional MAP or APP. There may be a benefit to use of the polymer coated CRP product to reduce the risk of seedling toxicity if it is necessary to exceed safe levels of seed-placed P fertilizer to optimize crop yield.

The yellow-seeded canola displayed extremely poor emergence and vigour. Yields were low in relation to the black-seeded cultivars and assessment of its P responsiveness was difficult due to the poor crop performance. Differences due to P application were larger in the black- than yellow-seeded cultivar, primarily because the yellow-seeded cultivar has very poor initial stand density as compared to the black-seeded cultivar, leading to a lower yield potential and lower ability to respond to applied nutrients.

Introduction

Canola is the dominant oilseed crop in western Canada with over 4.6 million ha grown in the three prairie province. The current market trends of biodiesel growth and rising demand for healthy food are projected to lead to large increases in demand for canola. In response to projected market trends, the Canola Council of Canada has set ambitious targets for Canadian canola to exploit the increase in global demand for oils and fats. "CANOLA – growing great 2015" is a plan to take the Canadian canola industry from the current 7 million tonnes of sustained production, to 15 million tonnes. This production will need to come from a projected 30% increase in canola acreage, a 35% increase in average yield to 40.5 bu/ac, increased average oil content to 45% and increased energy content of canola meal to 90% of soybean meal energy levels (CANOLA – growing great 2015 – The Canola Council of Canada http://www.canola-council.org/PDF/Canolagrowing_great2015final.pdf).

Literature Review

- Phosphate fertilizer is a major input cost for canola production. An adequate supply of P is needed in the first 2 to 6 weeks of growth to optimize canola yield (http://www.canola-council.org/phosmgmt.aspx). Commonly, this P is supplied by applying monoammonium phosphate (MAP). Seed-placing or side-banding the MAP places the fertilizer in a position where it can be accessed by the seedling early in growth, while application in a band minimizes the reactions between the fertilizer and the soil that normally reduce the availability of the P for plant uptake. However, the amount of MAP that can safely be seed-placed in canola is limited due to the risk of seedling damage. Rates of P required to optimise yield of modern, high-yielding hybrids may be higher than can safely be seed-placed. While the rate can be increased by moving the fertilizer away for the seed as a side-, mid-row, or pre-plant band, this may reduce the effectiveness of the fertilizer, increase the cost of fertilizer application, and lead to seed-bed disruption and moisture loss. Many producers are using seed-placed MAP and either reducing the rate of application, which may reduce the crop yield potential, or running the risk of seedling damage.
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A number of enhanced efficiency P products have been developed that may improve the effectiveness of seed-placed P fertilizer, by reducing the risk of seedling damage and/or maintaining the P in an available form for a longer period to enhance crop uptake. These products include a polymer coated MAP that releases the phosphate slowly into the soil, Polyon, another polymer coated product and Avail stabilized phosphate. Ammonium polyphosphate liquid fertilizer may also show improved performance as compared to MAP, particularly on calcareous soils. While these enhanced efficiency fertilizers may have an advantage over traditional MAP, their price is higher. Therefore, it is important to determine if any increases in crop yield, quality, fertilizer use efficiency or simplification of field operations are large enough to justify

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the extra fertilizer costs. The study will provide information to determine if these benefits occur and if the benefit is great enough to justify the higher cost of the products.

Effects of fertilizer on crop yield are critical, but effects on crop quality are also important as canola oil and meal quality play a major role in the ability of canola to compete effectively with soybean on the international market. Canola has traditionally had a market advantage in terms of oil quality over soybean, because of the superior fatty acid profile of the oil. However, because of its relatively high fiber content, canola meal sells for only about 60-70% of the price of soybean meal which has a relatively low (4%) fiber content and offers a higher energy value meal. Thus soybean remains the dominant oilseed crop despite having much lower (18 – 20%) oil content than canola (42 – 43%). Breeding efforts in soybean have narrowed the oil quality gap between soybean oil and canola oil, decreasing canola's competitive advantage. Yellow-seeded canola lines have been developed at Saskatoon Research Centre that have superior oil content to traditional lines, larger seed weight, lower glucosinolate content and significantly reduced meal fibre contents. Yellow-seeded lines have potential to replace traditional black-seeded lines and improve the overall ability of canola to compete with soybean in the market. However, the research evaluating fertilizer effects on canola has been done using traditional black-seed cultivars. Cultivar differences may exist between yellow-seeded and black-seed canola that could influence both the magnitude of fertilizer response and the sensitivity to seed-placed MAP. A comparison of response to seed-placed monoammonium phosphate in yellow-and black-seeded canola will provide important basic agronomic information for production of yellow-seeded canola. The combination of field and laboratory studies will provide quantitative information on the comparative yield and quality responsiveness of yellow-seeded and black-seeded canola to P fertilizer. This will allow the development of specific recommendations for an optimum P management package for production of yellow-seeded lines.

Objectives

The objectives of this research are:

1) To determine the relative effects of traditional and enhanced efficiency fertilizers in terms of safe rates for seed-row placement, and effects on crop yield, crop maturity and seed quality.
2) To determine if an Argentine canola (*Brassica napus* species) black-seeded, InVigor hybrid canola cultivar differs from a yellow-seeded, open-pollinated breeding line of AAFC, in the response to seed-placed phosphorus fertilizer.

Milestones and deliverables / outputs

Deliverables:

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1. This project will provide specific recommendations as to whether use of enhanced efficiency fertilizers will be of economic and environmental benefit to the producer. Side by side comparisons of several novel enhanced efficiency fertilizers as compared to standard seed-placed application of monoammonium phosphate will allow determination of the relative benefits of the various P fertilizer sources (Grant)

- Seedling damage occurred with high rates of applied P unless soil conditions were very wet, with damage being particularly evident with liquid P. Where damage occurred, use of polymer coated MAP reduced the risk of seedling damage. Canola could compensate for seedling damage if stands were not reduced below critical levels, but where stand density was low, seed yields declined due to seedling toxicity.
- Canola yield generally increased with moderate rates of P application. Decreases in seed yield occurred where high rates of application decreased stand density below critical levels. There was little difference among P sources in their effects on canola seed yield, although a benefit may occur from the polymer coated product (CRP) due prevention of seedling damage
- The enhanced efficiency P fertilizers evaluated provided little economic benefit as compared to traditional MAP or APP. There may be a benefit to use of the polymer coated CRP product to reduce the risk of seedling toxicity if it is necessary to exceed safe levels of seed-placed P fertilizer to optimize crop yield.

2. This project will quantify the effects of P management on oil and meal quality, as well as on the basic parameters of crop emergence, maturity and final crop yield. Oil and meal quality are major factors influencing the ability of canola to compete effectively with soybean in the marketplace. Both oil and meal quality can be affected by nutrient management and by seedling damage (Oil quality factors assessed by Relf-Eckstein; agronomic factors assessed by Grant).

- Information on the oil and quality characteristics were been delayed due to the resignation of collaborator Relf-Eckstein. Arrangements were made with the oil quality laboratory at Saskatoon Research Centre to run the analyses, but the work was delayed. Some of the analytical results have been obtained, but analysis of the final samples and interpretation of the results has been delayed because of a lack of expertise.
- Seedling damage in the canola occurred with P rates of 40 and 80 kg P_sO_5 ha^{-1}. Yields tended to increase to between 20 and 40 kg P_sO_5 ha^{-1} and then decline, in a quadratic relation, reflecting the seedling damage at higher application rates.
- Maturity was delayed at high P application rates, again reflecting differences in stand density.

3. This study will provide quantitative information on the comparative response of black and yellow-seeded control for the formulation of producer recommendations for P fertilizer management of yellow-seeded canola Yellow-seeded canola has specific advantage over black-seeded canola in terms of increased oil

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content and much reduced fibre contents. Yellow- and black-seeded canola may differ in response to nutrient inputs and in sensitivity to seed-placed P. However, no agronomic studies have been conducted to determine the effect of P management on yield or quality of yellow-seeded canola. (Oil quality factors assessed by Relf-Eckstein and Rakow; agronomic factors assessed by Grant).

- The yellow-seeded canola displayed extremely poor emergence and vigour. Yields were low in relation to the black-seeded cultivars and assessment of its P responsiveness was difficult due to the poor crop performance.
- Differences due to P application were larger in the black- than yellow-seeded cultivar, primarily because the yellow-seeded cultivar has very poor initial stand density as compared to the black-seeded cultivar, leading to a lower yield potential and lower ability to respond to applied nutrients.

Timeline

2008-2009: The first year of field studies were conducted. Chemical analysis of samples was initiated. Statistical analysis of data was completed and reports prepared for funding agencies

2009-2010: The second year of field studies was conducted. Chemical analysis of samples was initiated. Statistical analysis of data was completed and reports prepared for funding agencies. Oil and quality analyses were delayed because of the resignation of collaborator Relf-Eckstein.

2010-2011: The third year of field studies was conducted. Chemical analysis of samples was initiated. Statistical analysis of data was completed and reports prepared for funding agencies. Arrangements were made to have the oil and quality analysis conducted by the oil laboratory at the Saskatoon Research Centre, but completion of sample analysis and interpretation of results were delayed because of a lack of input from collaborator Relf-Eckstein.

2011-2012: Results will be presented at technology transfer meetings and preparation of manuscripts for peer-reviewed scientific journals initiated.

Materials and Methods

Field studies were conducted at two locations in Western Manitoba, on a fine sandy loam (FSL) and a clay loam (CL) soil, in 2008, 2009 and 2010. Soil analysis was conducted to select sites low in P to increase the likelihood of seeing a P response. At each location, nitrogen and sulphur were applied before seeding to ensure an adequate nutrient supply for optimum yield, based on soil test results. Pre-plant banding was used to avoid any risk of seedling damage from the N. Plots were seeded using a Seed-Hawk type plot seeder equipped with narrow hoe openers. Seeding rate for the canola was 5 kg ha^{-1}.

Study 1: Impact of Seed-Placed Enhanced Efficiency P fertilizers on Canola Production and Quality

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The following P sources were seed-placed:

1. Control – no P application
2. MAP – standard monoammonium phosphate
3. CRP – a polymer coated MAP product formulated for broad acre agriculture
4. Avail MAP – MAP with treatment to sequester antagonistic ions and reduce soil P reactions
5. Liquid P – ammonium polyphosphate
6. Avail Liquid P – liquid P with treatment to sequester ions and reduce soil P reactions
7. Polyon – a polymer coated MAP product formulated for horticulture

- Each of the P sources was be applied at four application rates (10, 20, 40 and 80 kg P_2O_5 ha^{-1}), with a single 0 kg P_2O_5 ha^{-1} included for a total of 25 treatments per site. Each treatment was replicated 4 times per site, for a total of 100 plots per site and 200 plots in total.
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- Study 2: Impact of Rate of Seed-Placed MAP on Production and Quality of Yellow and Black-Seeded Canola.
- In an additional study, yellow- and black-seeded canola cultivars were seeded following the methodology described for the previous study. Each cultivar was treated with seed-placed MAP fertilizer at 0, 10, 20, 30, 40 and 80 kg P_2O_5 ha^{-1}, replicated four times at the two locations to determine if there were genetic differences in the response of yellow- and black-seeded canola to seed-placed P.
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- In both studies, weeds, diseases and insects were controlled using recommended, registered control products as required.
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- The following information was collected at each site:

1. Rainfall and air and soil temperature from seeding to harvest.
2. Initial soil N, P, S, pH, conductance and soil texture.
3. Soil moisture at time of seeding
4. Emergence at 2 weeks
5. Biomass production at flowering
6. Crop seed and straw yield
7. Seed oil, protein, seed colour and digestible fibre content, glucosinolate content and fatty acid

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composition are awaiting analysis.

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- Statistical analysis was conducted with contrast analysis using PROC Mixed and Proc REG of SAS. Samples have been submitted for quality analysis and the results should be available later in 2011.

Results

Study 1: Impact of Seed-Placed Enhanced Efficiency P fertilizers on Canola Production and Quality

2010 Results

Canola emergence was slow and uneven, as indicated by the high SE values, regardless of the fertilizer treatment, however stand density was relatively high. Stand density at 2 weeks generally decreased with increasing P rate at the fine sandy loam site, with no significant differences among sources (
Table 1). At the clay loam site, there was no significant effect of either P rate or fertilizer source on stand density at 2 weeks. At 4 weeks, stand density also decreased with increasing P rate on the fine sand loam soil, with the decrease being less with the Agrium CRP than other sources, particularly Liquid P, or the two Avail products ($p<0.025$) (Table 2). On the clay loam soil, a significant decrease in stand density occurred only with the highest rate of MAP.

Table 1: Stand density at two weeks after emergence (plants m^{-1}) as affected by source and rate of phosphorus fertilizer at two locations in 2010.

	Fine sandy loam						
P Rate kg ha^{-1}	MAP	Agrium CRP	Avail MAP	Liquid P	Avail Liquid	Polyon	Mean
0	61.3	61.3	61.3	61.3	61.3	61.3	61.3
10	72.5	69.4	57.5	50.0	66.9	56.9	62.2
20	56.3	61.9	56.3	56.3	57.5	43.1	55.2
40	46.3	63.1	55.0	58.1	39.4	45.0	51.1
80	44.4	46.3	42.5	39.4	35.0	43.1	41.8
Mean (excluding control)	54.8	60.2	52.8	50.9	49.7	47.0	52.6
SE	7.1						
	Clay loam						
0	65.6	65.6	65.6	65.6	65.6	65.6	65.6

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10	61.3	80.0	70.6	72.5	55.0	65.8	67.5
20	55.8	85.8	65.0	65.0	36.3	70.0	63.0
40	64.2	67.5	54.2	65.0	75.0	80.0	67.6
80	51.7	61.3	54.2	48.8	81.3	102.5	66.6
Mean (excluding control)	58.2	73.6	61.0	62.8	61.9	79.6	66.2
SE	10.8						

Table 2: Stand density at four weeks after emergence (plants m^{-1}) as affected by source and rate of phosphorus fertilizer at two locations in 2010.

	Fine sandy loam						
P Rate kg ha^{-1}	MAP	Agrium CRP	Avail MAP	Liquid P	Avail Liquid	Polyon	Mean
0	53.8	53.8	53.8	53.8	53.8	53.8	53.8
10	55.0	48.8	46.3	47.5	47.5	45.0	48.3
20	43.8	53.1	40.6	41.3	43.1	49.4	45.2
40	43.8	56.3	40.6	36.3	34.4	48.1	43.2
80	40.6	45.0	38.8	39.4	28.8	49.4	40.3
Mean (excluding control)	45.8	50.8	41.6	41.1	38.4	48.0	44.3
SE	5.5						
	Clay loam						
0	58.1	58.1	58.1	58.1	58.1	58.1	58.1
10	65.0	71.3	69.4	72.5	42.5	55.0	62.6
20	44.2	85.8	63.8	65.6	41.3	66.3	61.1
40	59.2	64.2	58.3	65.0	65.6	69.2	63.6
80	38.3	51.3	52.5	56.3	72.5	61.3	55.3
Mean (excluding control)	51.7	68.1	61.0	64.8	55.5	62.9	60.7
SE	7.9						

Dry matter yield at flowering was not significantly increased by P application at either site, in spite of the low soil test P level (Table 3 and 4). At the fine sandy loam site, the dry matter yield at flowering showed a non-significant tendency ($0.05<P<0.10$) to be higher with the MAP than with the Avail-treated products or the

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Polyon. In contrast, at the clay loam site, there was a similar tendency for yield to be higher with the Avail-treated liquid fertilizer than with the MAP

Table 3: Dry matter yield at flowering (t ha^{-1}) as affected by source and rate of phosphorus fertilizer at two locations in 2010.

P Rate kg ha^{-1}	MAP	Agrium CRP	Avail MAP	Liquid P	Avail Liquid	Polyon	Mean
	Fine sandy loam						
0	3.43	3.43	3.43	3.43	3.43	3.43	3.43
10	3.32	2.52	2.67	3.12	2.74	2.73	2.85
20	2.88	2.93	2.12	2.64	2.81	2.73	2.69
40	2.92	3.09	2.30	2.58	2.11	2.45	2.58
80	3.33	3.35	3.40	2.30	2.55	2.40	2.89
Mean (excluding control)	3.11	2.97	2.62	2.66	2.55	2.58	2.75
SE	0.415						
	Clay loam						
0	2.39	2.39	2.39	2.39	2.39	2.39	2.39
10	2.21	1.95	2.79	2.43	2.61	2.09	2.35
20	2.51	2.22	2.72	2.39	2.72	2.14	2.45
40	2.74	2.63	2.65	2.77	2.62	2.21	2.60
80	2.04	2.88	2.60	2.58	3.16	2.20	2.58
Mean (excluding control)	2.37	2.42	2.69	2.54	2.78	2.16	2.49
SE	0.300						

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Table 4: ANOVA and contrast analysis for effect of fertilizer source, rate and their interaction on dry matter yield at flowering on two soil types in 2010 (excluding the control treatment).

		Fine Sandy Loam		Clay Loam	
Source	DF	F Value	Pr>F	F Value	Pr>F
Source	5	1.38	ns	2.03	0.0965
Rate	3	0.79	ns	0.59	ns
Source*Rate	15	0.78	ns	0.60	ns

Contrast	F Value	Pr>F	F Value	Pr>F
MAP vs CRP	0.25	ns	0.03	ns
MAP vs Avail MAP	3.00	0.0880	2.15	ns
MAP vs Liquid P	2.58	ns	0.70	ns
MAP vs Avail Liquid	3.96	0.0506	2.93	0.0950
MAP vs Polyon	3.61	0.0616	0.96	ns
Agrium CRP vs Avail MAP	1.52	ns	1.60	ns
Liquid P vs Avail Liquid	0.15	ns	0.63	ns
CRP vs Polyon	1.96	ns	1.25	ns

Straw yield was not significantly affected by treatment at the fine sandy loam site (Table 5 and 6). On the clay loam soil, straw yield increased with application of P fertilizer with the numerically highest yield generally occurring with the highest rate of application. Polyon produced the lowest straw yield, possibly because of limited release. Agrium CRP produced slightly lower yields than other treatments, mainly due to unreasonably low yields at the two lowest rates of application. This may be related to some excess water damage, leading to a random depression in yield, as the yields in these two treatments were below that of the control.

Table 5: Straw yield (t ha^{-1}) as affected by source and rate of phosphorus fertilizer at two locations in 2010.

	Fine sandy loam						
P Rate kg ha^{-1}	MAP	Agrium CRP	Avail MAP	Liquid P	Avail Liquid	Polyon	Mean
0	4.57	4.57	4.57	4.57	4.57	4.57	4.57
10	4.45	4.31	4.18	4.81	4.52	4.30	4.43

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20	4.32	4.33	4.18	4.56	4.86	4.95	4.53
40	4.06	4.41	4.66	4.55	4.63	4.36	4.44
80	4.69	4.31	4.74	4.37	4.65	4.40	4.53
Mean (excluding control)	4.38	4.34	4.44	4.57	4.67	4.50	4.48
SE	0.282						
	Clay loam						
0	3.57	3.57	3.57	3.57	3.57	3.57	3.57
10	3.35	2.89	3.40	3.26	4.13	3.39	3.40
20	3.53	2.59	3.52	3.78	3.08	3.60	3.35
40	3.89	3.88	3.59	4.05	3.73	3.59	3.79
80	4.11	3.79	4.24	4.26	4.08	3.61	4.01
Mean (excluding control)	3.72	3.29	3.68	3.84	3.75	3.55	3.64
SE	0.232						

Table 6: ANOVA and contrast analysis for effect of fertilizer source, rate and their interaction on straw yield on two soil types in 2010 (excluding the control treatment).

		Fine Sandy Loam		Clay Loam	
Source	DF	F Value	Pr>F	F Value	Pr>F
Source	5	0.97	ns	2.74	0.0328
Rate	3	0.30	ns	8.22	0.0002
Source*Rate	15	0.96	ns	1.53	ns

Contrast	F Value	Pr>F	F Value	Pr>F
MAP vs CRP	0.05	ns	7.08	0.0114
MAP vs Avail MAP	0.11	ns	0.04	ns
MAP vs Liquid P	1.20	ns	0.34	ns
MAP vs Avail Liquid	2.65	ns	0.35	ns
MAP vs Polyon	0.50	ns	1.03	ns
Agrium CRP vs Avail MAP	0.31	ns	6.23	0.0171

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Liquid P vs Avail Liquid	0.28	ns	0.00	ns
CRP vs Polyon	0.85	ns	2.92	0.0957

Table 7: Seed yield (t ha^{-1}) as affected by source and rate of phosphorus fertilizer at two locations in 2010.

P Rate kg ha^{-1}	MAP	Agrium CRP	Avail MAP	Liquid P	Avail Liquid	Polyon	Mean
	Fine sandy loam						
0	3.03	3.03	3.03	3.03	3.03	3.03	3.03
10	3.07	2.92	2.84	2.96	2.96	2.91	2.95
20	2.88	2.89	2.58	2.47	2.77	3.21	2.80
40	2.83	3.12	2.97	2.94	2.66	2.83	2.89
80	2.84	2.90	2.91	2.50	2.36	2.70	2.70
Mean (excluding control)	2.90	2.96	2.83	2.72	2.69	2.91	2.83
SE	0.236						
	Clay loam						
0	2.26	2.26	2.26	2.26	2.26	2.26	2.26
10	2.25	2.08	2.22	2.21	2.50	1.96	2.20
20	2.17	1.77	2.26	2.58	1.99	2.38	2.19
40	2.70	2.63	2.34	2.92	2.44	2.56	2.60
80	2.66	2.65	2.79	2.95	2.87	2.53	2.74
Mean (excluding control)	2.44	2.28	2.40	2.66	2.45	2.36	2.43
SE	0.205						

Table 8: ANOVA and contrast analysis for effect of fertilizer source, rate and their interaction on seed yield on two soil types in 2010 (excluding the control treatment).

		Fine Sandy Loam		Clay Loam	
Source	DF	F Value	Pr>F	F Value	Pr>F
Source	5	1.12	ns	1.73	ns
Rate	3	1.58	ns	11.63	0.0001

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Source*Rate	15	0.78	ns	1.16	ns

Contrast	F Value	Pr>F	F Value	Pr>F
MAP vs CRP	0.13	ns	1.87	ns
MAP vs Avail MAP	0.27	ns	0.12	ns
MAP vs Liquid P	1.58	ns	2.35	ns
MAP vs Avail Liquid	2.13	ns	0.21	ns
MAP vs Polyon	0.00	ns	0.40	ns
Agrium CRP vs Avail MAP	0.78	ns	1.09	ns
Liquid P vs Avail Liquid	0.04	ns	0.90	ns
CRP vs Polyon	0.09	ns	0.59	ns

Seed yield was not affected by fertilizer application on the fine sandy loam soil, but was affected by fertilizer application on the clay loam soil (Table 7 and 8). Yield increased by between 0.4 and 0.6 T ha^{-1} with the highest yield occurring with 40 or 80 kg phosphate ha$^{-1.}$ There was little difference among fertilizer sources in final seed yield, although the liquid P had the numerically highest seed yields.

Summary 2008-2010

In both 2009 and 2010, wet conditions led to poor emergence of the crop and high variability although treatment effects were still apparent. In 2009, the very wet conditions led to a lack of seedling damage. In 2008 and 2010, seedling damage occurred with high rates of uncoated phosphate fertilizer, with the damage mainly occurring on the FSL soil. In 2008, stand density at the highest rate of application was reduced to below 20 plants m^{-2} while in 2010, stand density was still generally near 40 plants m^{-2}. Both the Agrium CRP and the Polyon coated product prevented seedling damage and led to plant density values near those of the control even with high rates of application. In contrast, some indications of damage and stand loss occurred with liquid P and Avail liquid P, even at the recommended rate of P (20 kg P_2O_5 ha^{-1}).

Seed yields generally increased with P application, but there was no consistent difference among sources. Seed yield on the FSL soil in 2008 increased with low rates of liquid P then decreased when rates were increased to 40 kg P_5O_5 ha^{-1} or higher, indicating a persistent effect of seedling damage. Highest yield in 2010 was attained with the 40 or 80 kg phosphate rate in spite of the earlier damage, indicating the ability of canola to recover from reduced stand density if growing conditions are favourable and the stand density is not reduced below critical levels. However, where stand density fell below critical levels, as occurred in 2008, seed yield was reduced.

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Summarized over the three years of the study, seedling damage occurred with high rates of applied P unless soil conditions were very wet, with damage being particularly evident with liquid P. Where damage occurred, use of polymer coated MAP reduced the risk of seedling damage. Canola could compensate for seedling damage if stands were not reduced below critical levels, but where stand density was low, seed yields declined due to seedling toxicity.

Canola yield generally increased with moderate rates of P application. Decreases in seed yield occurred where high rates of application decreased stand density below critical levels. There was little difference among P sources in their effects on canola seed yield, although a benefit may occur from the polymer coated product (CRP) due prevention of seedling damage

Study 2: Impact of Rate of Seed-Placed MAP on Production and Quality of Yellow and Black-Seeded Canola.

2010 Results

As in the previous study, excessive water was a serious concern in this study in 2010. An additional concern was the extremely low germination of the yellow-seeded line. Emergence on this cultivar was so low as to be unacceptable.

Average stand density at two weeks with the black-seeded cultivar was similar on the CL soil and the FSL soil **(**Figure 1). However, emergence with the yellow-seeded cultivar was very low, especially on the FSL site, where stand was too sparse to justify counting. Stand density was highly variable, however there was a tendency ($p<0.0966$) on the FSL site for stand density to decrease with increasing P rate, while on the CL site, there was a significant difference between stand with the yellow and black-seeded cultivars.

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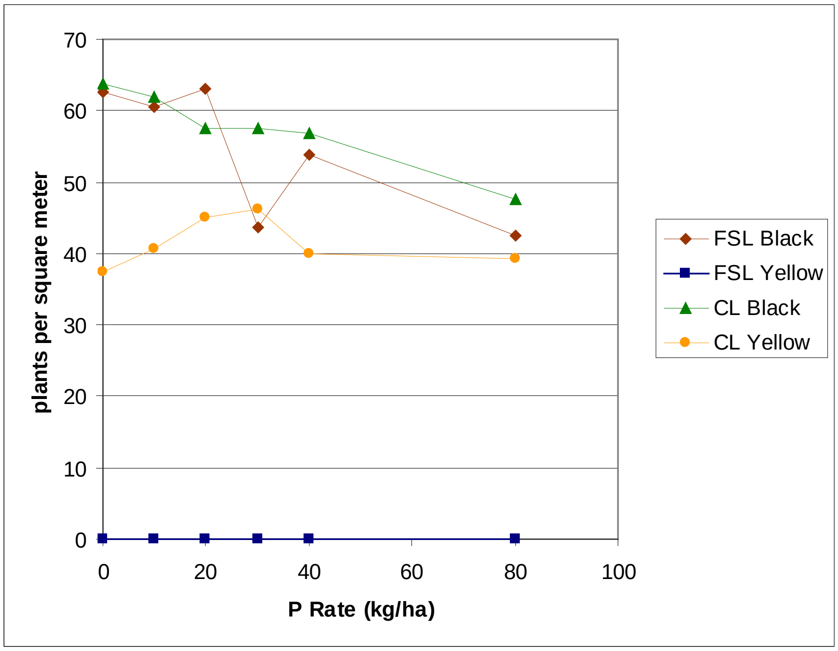

Figure 1: Effect of rate of seed-placed MAP on stand density at 2 weeks of yellow and black-seeded canola on a fine sandy loam and clay loam soil in 2010.

A similar pattern occurred for stand density at 4 weeks, with yellow-seeded having lower stand density than black-seeded canola (Figure 2). On the FSL farm, stand density at 4 weeks declined with increasing P rate in the black-seed cultivar ($p<0.0448$). At the CL site, stand density was higher than at the FSL site and the decrease in stand density at four weeks was not statistically significant.

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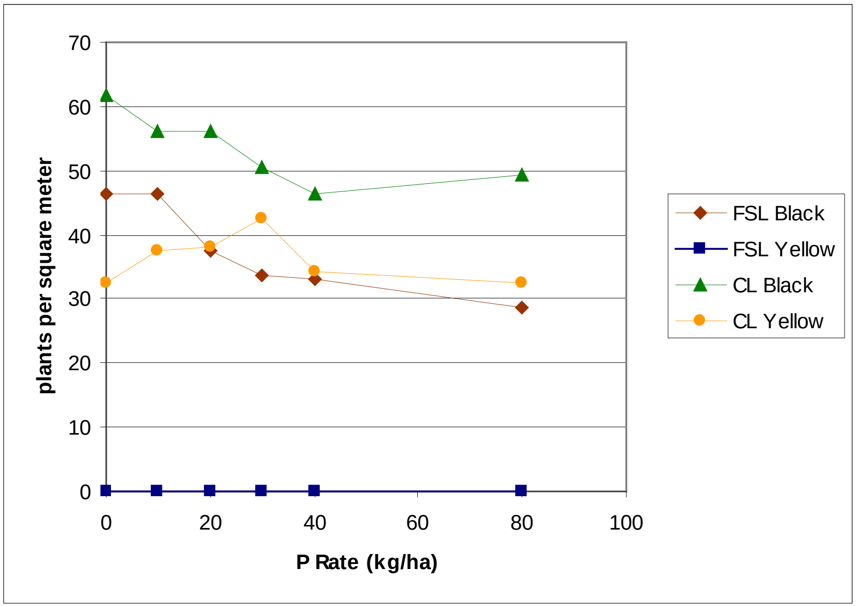

Figure 2: Effect of rate of seed-placed MAP on stand density at 4 weeks of yellow and black-seeded canola on a fine sandy loam and clay loam soil in 2010.

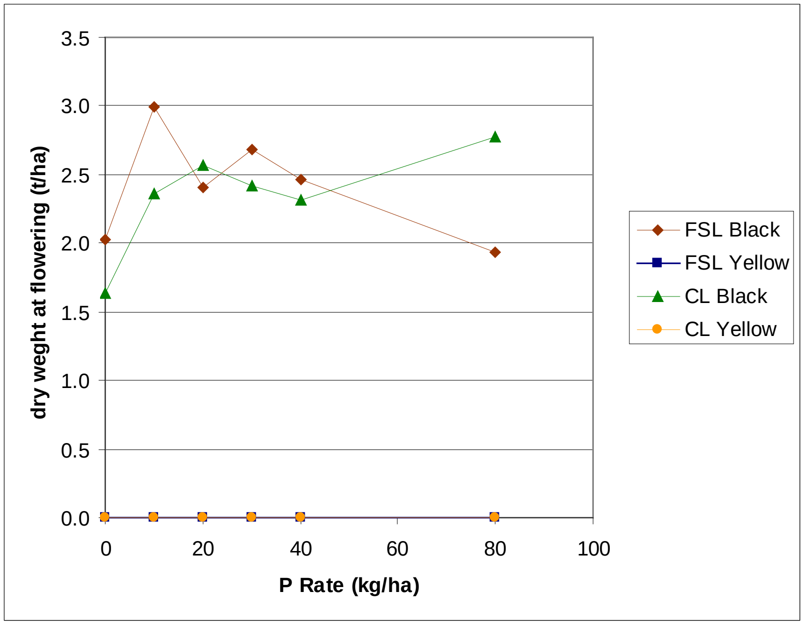

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Figure 3: Effect of rate of seed-placed MAP on dry matter yield at flowering of yellow and black-seeded canola on a fine sandy loam and clay loam in 2009.

Dry matter yield at flowering was too erratic in the yellow-seeded cultivar to be assessed (Figure 3). At the FSL site, the black-seeded cultivar showed a numerical increase with the first increment of P fertilizer, and then decreased with increasing P rate. At the CL site, dry matter yield at flowering in the black cultivar increased to approximately 20 kg P_sO_5 ha^{-1}, then remained fairly constant.

Straw yield was higher in the black-seed than yellow seed cultivar at both FSL ($p<0.0001$) and CL ($p<0.04$) (Figure 4). The straw yield values of the yellow-seeded cultivar are artificially increased because of the inclusion of weed biomass in the measurements. At the FSL, straw yield was not affected by P application, while at the CL site, straw yield of both the black ($p<0.05$) and the yellow (p,).0005) cultivar increased with increasing P rates, with the optimum rate occurring between 20 and 40 kg P_sO_5 ha^{-1}.

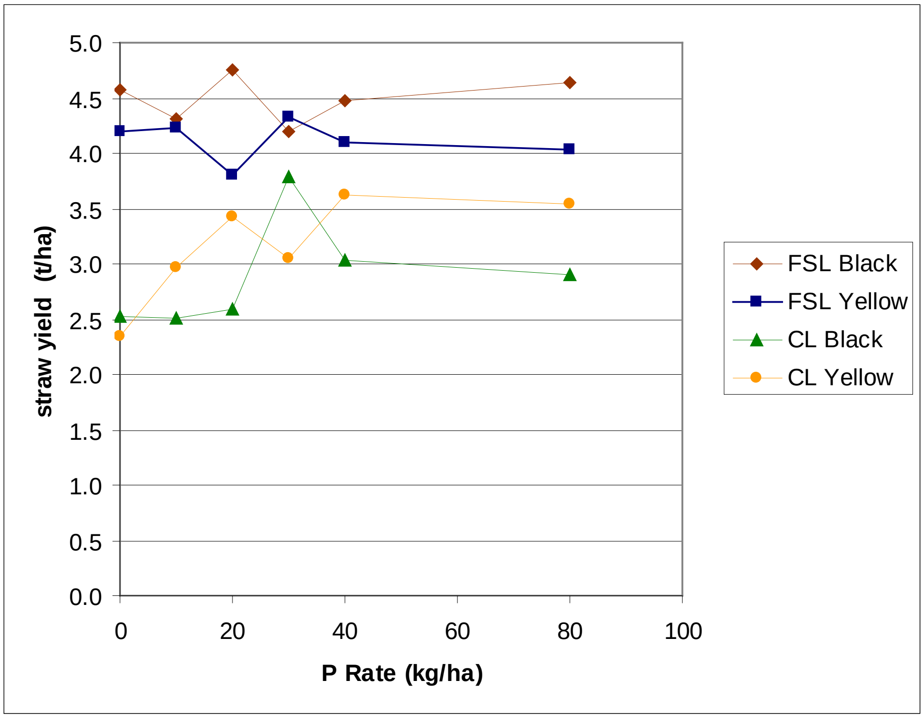

Figure 4: Effect of rate of seed-placed MAP on straw yield of yellow and black-seeded canola on a fine sandy loam and clay loam.

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On both the FSL and the CL site, seed yield was much higher in the black-seeded cultivar than the yellow-seeded cultivar (Figure 5) ($p<0.0001$ in each site). At the FSL site, seed yield was not affected by P application. However, at the CL site, seed yield increased with P application in both cultivars. The response was quadratic, with seed yield increasing to 40 kg P_5O_5 ha^{-1} in both cultivars.

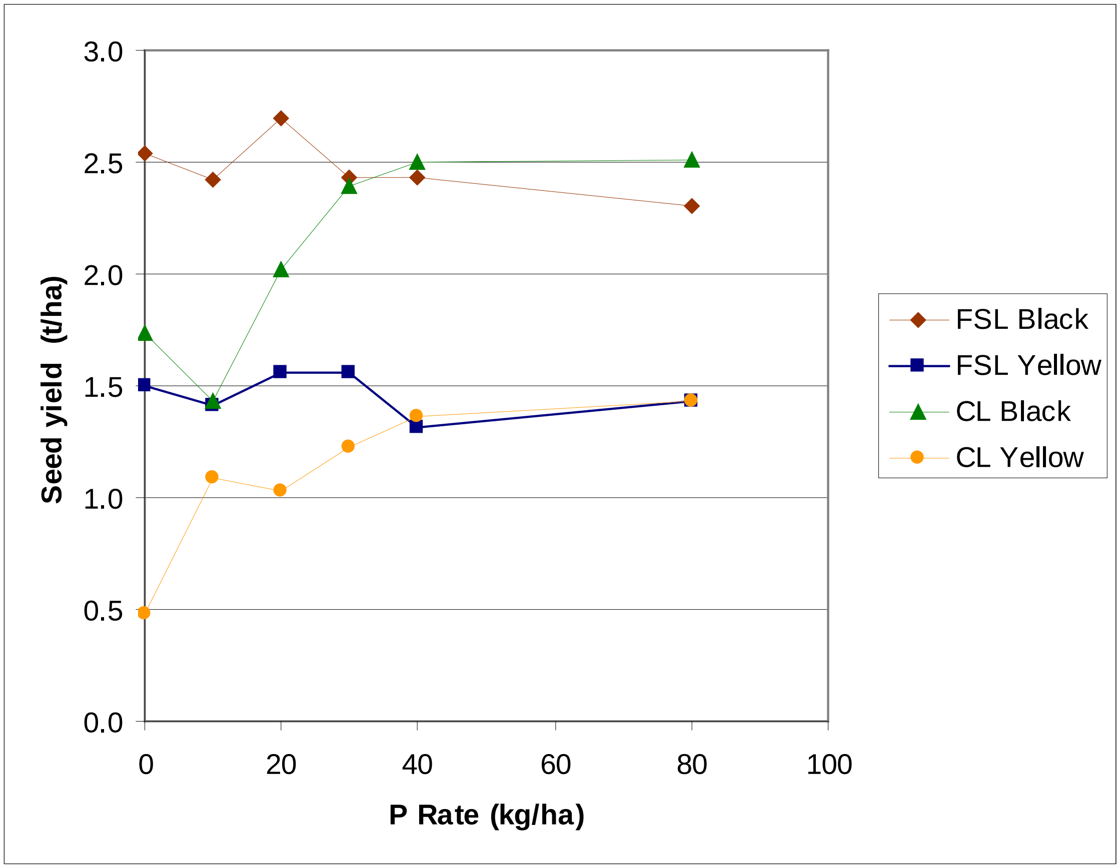

Figure 5: Effect of rate of seed-placed MAP on seed yield of yellow and black-seeded canola on a fine sandy loam and clay loam.

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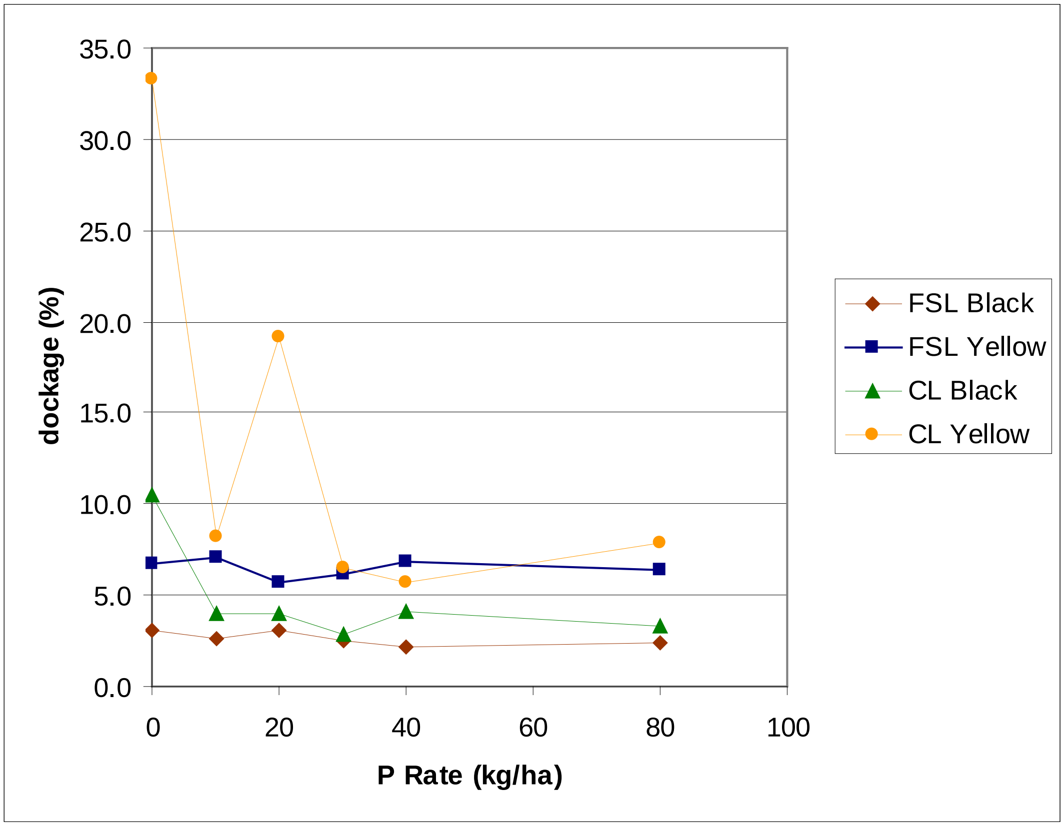

Figure 6: Effect of rate of seed-placed MAP on dockage of yellow and black-seeded canola on a fine sandy loam and clay loam.

Dockage included weed seeds, chaff and small canola seeds (Figure 6). Dockage was higher for the yellow-seeded cultivar than the black-seeded cultivar on the FSL ($p<0.0001$) and the CL (p< ($p<0.018$), reflecting the lack of competition provided by the poorly established yellow-seeded cultivar. There was no significant response of dockage to P application on the FSL soil. On the CL soil, dockage in the yellow-seeded cultivar showed a quadratic response to P application, decreasing with increasing P rate to between 20 and 40 kg P_2O_5 ha^{-1}. The effect in the black-seeded cultivar was not statistically significant. The relationship between dockage and P application was the inverse of the yield response. Presumably, dockage decreased with increasing crop vigour provided by optimal rates of P application, then increased when crop vigour declined due to seedling damage at the higher rate of application.

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Summary of 2008-2010

Over the three years of the study, the yellow-seeded cultivar showed very poor emergence and vigour, resulting in low seed yield at the end compared to the black-seeded cultivar. Seedling damage in the black-seeded cultivar occurred with P rates of 40 and 80 kg P_2O_5 ha^{-1}. Yields tended to increase to between 20 and 40 kg P_5O_5 ha^{-1} and then decline, in a quadratic relation, reflecting the seedling damage at higher application rates. Differences were larger in the black- than yellow-seeded cultivar, primarily because the yellow-seeded cultivar has very initial poor stand density than the black-seeded cultivar, leading to a lower yield potential and lower ability to respond to applied nutrients.

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