Long-term effects of different soil test based fertilizer rates on crop production, contribution margin, and soil quality in the Peace region

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Summary

Agronomists consider soil test based fertilizer applications a sustainable and economical technique to optimize crop production and profit margin while maintaining soil quality, and minimizing environmental impacts. However, many farmers don't use soil testing regularly to decide their fertilizer application rates. The reasons given include doubts about its effectiveness to economics. In response a project has been initiated in 2009 near Donnelly in the southeast Peace Region (NW7-77-20W5). The objectives are to study the long term effects of different soil test based fertilizer rates on crop production, profit margin, and soil properties; and to communicate the findings to the producers.

Six soil test based fertilizer rates (0, 60, 80, 100,120 and 140% of the recommended rate) are used in a wheat – canola – barley – field pea rotation. All the 4 crops are grown each year. The same fertilizer rate will be repeated in a given plot for 4 years to demonstrate the long term effects.

In 2009, good stand establishment was achieved with all treatments. Yield of crops tended to increase up to the 60% of recommended fertilizer rate, with a significant increase for canola and wheat. Increasing fertilizer rate to the 80% level or higher did not show significant improvement in seed yield, though there was a tendency for an increase. The thousand kernel weight (TKW) and bushel weight of the crops showed no effect of the fertilizer application rates.

In 2010, good stand establishment was achieved for the barley, peas and wheat whereas the canola stand was uneven due to post emergence frost damage. There was no consistent trend for change in population density with increase in fertilizer rates for any of the 4 crops. Barley and canola plants were shorter for the 0% than the higher fertilizer rates while the plant height of peas and wheat showed no effect of the fertilizer treatments. The maturity of cereals was somewhat shortened by fertilizer application. Like 2009, the yield of all crops tended to improve with increase in fertilizer rate. Maximum yield was observed at the 140% fertilizer rate for the barley, canola and peas, and at the 120% fertilizer rate for wheat. The 0% treatment showed lowest or near lowest yield for all the crops. Maximum yield response to fertilization (difference between the treatment with maximum yield and 0%) was 5.3, 14.1, 9.7 and 2.9 bu/ac for the barley, canola, peas and wheat crops, respectively.

Very dry weather during the growing season in combination with low spring soil moisture levels were considered to reduce the effects of fertilizer treatments on seed yield of crops in both 2009 and 2010.

Background

High fertilizer prices make efficient use of nutrients from fertilizers extremely important for the bottom line in crop production. Agronomists consider soil test based fertilizer application a sustainable and economical technique to optimize crop production and profit margin while maintaining soil quality at the farm, and minimizing negative effects on environment. However, many farmers don't regularly use soil tests to decide their fertilizer application rates. The reasons given for this include doubts about its effectiveness to economics.

Soil test laboratories recommend separate sets of fertilizer rates with goals to achieve medium and high yield, or to maintain and build-up nutrients in soil. What effect the long term use of these recommendations has on the production, quality and pests of crops, future fertilizer recommendations, and soil properties are not clear. Most of the work to compare soil test based fertilizer rates has been done using a different site each year, which does not allow assessment of long term effects. Information

from other long term trials suggests that fertilizer application improves soil quality, but information on the long term effects of soil test based fertilizer recommendations is lacking.

Comparison of the yield, quality and contribution margin of crops and soil quality for different soil test based fertilizer rates would allow producers to assess the effectiveness of this technique to optimize fertilizer rates for maximum benefits. Repeating the same rates at same location would provide information on the long term effects of these fertilizer rates. Also, the current techniques to recommend fertilizer rates were developed under conventional tillage systems. Validation of these techniques under direct seeding systems is needed. The long term focus of this project makes it unique from the earlier studies on soil test based fertilizer rates. Reduced inputs and other benefits could also reduce the ecological cost associated with manufacturing, transporting and applying inputs.

This project will showcase how soil test based fertilizer application could potentially reduce input and ecological costs per unit of production, maximize crop production and profit margin, improve soil properties and minimize pest problems. The reliability of soil test technique will be demonstrated to farmers through field tours, presentations, reports, articles, and media, with a focus on the long term effects.

Objectives

1. To demonstrate the reliability of soil test based fertilizer rate technique to improve crop production, profit margin, and soil properties as well as minimize the input costs and environment impact in the Peace Region.
2. To determine appropriate soil test based fertilizer rate for different crops under a direct seeding system.
3. To measure long term effects of soil test based fertilizer rates on crop production, soil properties and pest issues.
4. To identify the most economic soil test rate calculated from the contribution margin for the treatments.
5. To communicate information on the benefits of using optimum soil test based fertilizer rates for different crops to the producers of the Peace region and beyond.

Experimental

Treatments: Six fertilizer rates based on soil test (0, 60, 80, 100,120 and 140% of the recommended rate) are tested for the wheat, barley, canola and field pea. These treatments are repeated three times using a Randomized Complete Design (RCBD) for each crop. Eight passes of the seed drill are made for each crop to accommodate the 6 fertilizer rate treatments plus a guard plot on each side.

A wheat-canola-barely-peas rotation is being followed. The same fertilizer rate would be repeated in a given plot for 4 years to demonstrate the long term effects on crop production, contribution margin, soil properties and pest issues.

General procedures: The trial started in 2009 is located near Donnelly at the Gauthier farms (NW7-77-20W5) in the Smoky River Municipal District of Peace Region. The site was under wheat in 2008. A direct seeding system and recommended agronomic practices are being followed. Six rows (9 inch pacing) of crops are seeded with a Fabro plot drill equipped with double shoot Atomjet openers. Plots are seeded 8 m long and trimmed back to 5 m for harvest. A Wintersteiger Nursery Master combine is used for harvest. Combinations of seed placed 11-52-0, and side banded 46-0-0, 0-0-60, and 20.5-0-0-24 fertilizers are used to supply the designated amounts of nutrients. The spring soil moisture and growing season rain amounts data are collected from the nearest weather station (Table 1).

2009 Procedures: Being the first year, composite soil samples were collected from the site. The soil test results are presented in Table 2. The amounts of nutrients applied at the 100% of recommended rate are given in Table 3. The 60, 80, 120 and 140% rates for each nutrient were calculated relative to the 100% for each crop.

Preseed: WeatherMax (600 mL/ac) and mowed crop residue; all plots.

Seeding: May 29. Adequate moisture was present.
Seed rates: 90 lb/ac Harvest wheat; 115 lb/ac AC Metcalfe barley; 9 lb/ac 4414 RR canola; 308 lb/ac Cooper peas.
In crop herbicide: Peas: Solo (11.7 g/ac) + Merge (200 mL/ac) on June 25. Canola: WeatherMax (500 mL/ac) on June 25. Cereals: Prestige A (320 mL/ac) + Prestige B (800 mL/ac) on June 23.
Harvest: Reglone was applied on Sept. 22 to the canola and flax plots. The harvest dates were Sept. 29 for barley and wheat and Oct. 1 for canola and flax.

Table 1. Spring soil moisture (SSM) and rain in 2009. The percentages of normal are also given in brackets.

	2009 mm*	2010 mm
SSM	37.0 (49)	15.0 (20)
May	34.4 (75)	65.8(144)
June	19.0 (23)	17.5 (22)
July	55.4 (71)	19.8 (26)
August	18.6 (32)	54.0 (94)
Total Rain	127.4 (48)	157.1 (59)

***** Information from the Ballater weather station.

2010 Procedures: Soil samples were collected from each treatment in spring (0-6 and 6-12 inch depths). The soil test results were used to calculate the amounts of nutrients to be applied. The applied and recommended rates are given in Table 4.

Preseed: Mowed crop residue and glyphosate (360 g/ac) sprayed on May 7.
Seeding: May 7 for peas, May 11 for wheat, and May 12 for barley and canola. Soil moisture was below normal.
Seed rates: 90 lb/ac Harvest wheat; 115 lb/ac Xena barley; 9 lb/ac Invigor 5440 canola; 308 lb/ac Cutlas peas.
In crop herbicide: Peas, Solo (11.5 g/ac) + Merge (200 mL/ac) on June 16. Canola, Liberty 150SN (1.33 L/ac) on June 8. Cereals, Spectrum A (48 mL/ac) + Spectrum B (720 mL/ac) on June 8.
Harvest: Roundup Transorb (0.7 L/ac) was applied on Aug. 24 to the canola plots. The harvest dates were Aug. 25 for barley, Sept. 1 for peas, Sept. 14 for canola and Sept. 18 for wheat.

Table 2. Soil test results for the spring 2009 samples.

Property	0-15 cm	15-30 cm
Org. Matter, %	4.8	3.4
P – Bicarb, ppm	9	
P- Bray 1	16	
K, ppm	122	90
Mg, ppm	490	675
Ca, ppm	1640	1550
pH, water (2:1)	6.1	6.5
pH, Buffer	6.7	6.9
CEC, meq/100g	16.4	15.0
S, ppm	12	10
Nitrate –N, ppm	17	21
Zn, ppm	8.0	
Mn, ppm	11	
Iron, ppm	93	
Copper, ppm	0.9	
Boron, ppm	0.8	
Al, ppm	593	
Cl, ppm	43	16
Na, ppm	36	36
ENR[a]	61	46

[a]ENR refers to estimated nitrogen release.

Table 3. Fertilizer nutrient application amounts on each crop for the 100% soil test based rate in 2009, as per maintenance rates from the A&L laboratory *.

Nutrient	Barley	Canola	Pea	Wheat
	Nutient rate, lb/ac			
N	60	70	21	55
P_2O_5	35	35	40	30
K_2O	15	20	20	15
S	0	20	20	0

*Target yield for the 100% fertilizer rates was 70, 40, 50, and 50 bu/ac, respectively, for barley, canola, pea, and wheat.

Results and Discussion

2009 Results: Good stand establishment was achieved in all treatments. There were no weeds or other pest issues, except for slight feeding pressure from grasshoppers.

There were visual differences noted between the 0% and higher fertilizer rates during the growing

season. Yields tended to increase with change from the 0% to 60% fertilizer rate (Table 5). The increase in yield was significant for canola and wheat. Increasing the fertilizer rate to the 80% or higher level did not show significant increase in seed yield for any of the four crops. However, there was tendency for an increase in seed yield with increase in the fertilizer rate up to the 120% for wheat, and up to 140% for barley and pea. The TKW and bushel weight of the crops showed no effect of the fertilizer rates (Table 5).

No consistent yield increases above the 60% of recommended rate were considered due to lower soil moisture availability. Spring soil moisture level was only 49% of the normal (Table 1). The drought was further intensified by only 48% rain occurring during the growing season, with only 23% and 32% of the normal rain received in June and Aug, respectively.

Table 4. Fertilizer nutrient application amounts for different treatments in 2010. The recommended rates for the target yield, as per maintenance rates of the A&L laboratory, are given in brackets.

Treat	N	P_2O_5	K_2O	S
Barley (target yield 90 bu/ac)				
0%	0(108)	0(40)	0(0)	0(0)
60%	62(104)	24(40)	9(15)	0(0)
80%	86(107)	32(40)	12(15)	0(0)
100%	108(108)	45(45)	15(15)	0(0)
120%	127(106)	54(45)	18(15)	0(0)
140%	150(107)	63(45)	21(15)	0(0)
Canola (target yield 45 bu/ac)				
0%	0 (96)	0(35)	0(20)	0(40)
60%	62(104)	24(40)	12(20)	24(40)
80%	75 (94)	28(35)	16(20)	32(40)
100%	96 (96)	35(35)	20(20)	40(40)
120%	114(95)	48(40)	24(20)	48(40)
140%	133(95)	49(35)	28(20)	56(40)
Peas (target yield 60 bu/ac)				
0%	0(0)	0(45)	0(20)	0(15)
60%	20(0)	24(45)	12(20)	18(30)
80%	17(0)	36(45)	16(20)	12(15)
100%	30(0)	45(45)	20(20)	25(25)
120%	30(0)	48(40)	24(20)	24(20)
140%	35(0)	56(40)	28(20)	28(20)
Wheat (target yield 60 bu/ac)				
0%	0(89)	0(35)	0(15)	0(10)
60%	53(88)	21(35)	9(15)	0 (5)
80%	73(91)	20(25)	12(15)	0 (0)
100%	87(87)	30(30)	15(15)	0 (0)
120%	110(92)	30(25)	18(15)	0 (0)
140%	122(87)	42(30)	21(15)	0 (0)

2010 Results: There were no weeds or other pest issues. The spring soil moisture level was only 20% of normal, due to drought in the previous years and below normal snowfall in the preceding winter (Table 1). However, there was adequate rain in May and good stand establishment was achieved for the barley, peas and wheat (Table 6). Canola stand was uneven due to post emergence frost damage. Treatments effect on the plant density was significant for peas and wheat but not for barley and canola. However, there was no consistent trend for population density change with increase fertilizer rates for any of the 4 crops. Thus any differences in treatments were considered as random.

There were visual differences between the 0% and higher fertilizer rates during the growing season. Plant height of barley and canola was significantly increased with fertilizer application (Table 6). Plant height of peas and wheat showed no effect of the fertilizer treatments. The maturity of cereals was somewhat shortened by fertilizer application (Table 6), indicating another beneficial effect of fertilizer application in short growing season.

Like 2009, the yield of all crops tended to increase with fertilizer rate (Table 5). However, only the canola and peas yield showed significant positive effect of the treatments. Maximum yields were observed at the 140% fertilizer rate for the barley, canola and peas and at the 120% fertilizer rate for wheat (Fig. 1). The 0% rate had lowest or near lowest yield for all the crops. Maximum yield benefit from fertilization (difference between the treatment with maximum yield and 0%) was 5.3, 14.1, 9.7 and 2.9 bu/ac for the barley, canola, peas and wheat crops, respectively. Like 2009, the bushel weight of the crops showed no effect of the fertilizer rates.

A combination of low spring soil moisture level (20% of the normal) and much below normal rain during the June (22%) and July (26%) months were considered to reduce the seed yield response of crops to the fertilizer treatments.

Table 6. Crop density, plant height and cereals maturity period in 2010.

Fert Rate,%	Density #/Sq. ft	Height cm	Maturity Days
		Barley	
0	21.3	53.8	87.0
60	22.6	60.0	80.1
80	23.5	58.1	78.8
100	20.8	60.0	78.2
120	22.3	59.4	78.7
140	21.8	62.4	77.7
$LSD_{0.05}$	*3.54*	*4.89*	*5.20*
CV, %	*8.8*	*2.7*	*2.5*
Prob.	*NS*	*	*
		Canola	
0	6	65.2	ND[a]
60	9.8	74.0	ND
80	5.5	73.4	ND
100	7.0	71.5	ND
120	7.5	74.8	ND
140	7.9	74.2	ND
$LSD_{0.05}$	*6.32*	*6.62*	ND
CV, %	*47.6*	*5.0*	
Prob.	*NS*	*†*	
		Peas	
0	9.1	38.2	ND
60	8.2	37.1	ND
80	9.4	39.9	ND
100	8.2	41.0	ND
120	7.6	37.8	ND
140	8.7	41.2	ND
$LSD_{0.05}$	*1.07*	*4.61*	
CV, %	*6.9*	*6.5*	
Prob.	*	*NS*	
		Wheat	
0	13.7	71.9	90.5
60	13.3	71.5	89.1
80	14.1	71.9	88.6
100	13.2	71.8	87.9
120	12.4	71.3	89.6
140	12.8	71.8	89.1
$LSD_{0.05}$	*0.86*	*5.30*	*4.58*
CV, %	*3.6*	*4.1*	*2.0*
Prob.	*	*NS*	*NS*

[a]ND refers to not determined.

Communication Activities

Following were done to communicate the results to farmers, industry and public.

- SARDA organized an open house at the trial site on July 15, 2010. It was well attended by the farmers and others.
- Trials map and related information were made available at the sites entrance for self-guided tours by the farmers and others during the July and Aug. 2010.
- A poster, "Field pea response to fertilizers in southeast Peace region of Alberta" was presented at the 8th Canadian Pulse research Workshop on Nov. 3-5, 2010, Calgary; and Advanced Agronomy Conference on Nov. 24-25, 2010, Leduc.
- The abstract of above mentioned poster was printed as part of the proceedings and its summary has been submitted for the Alberta Pulse Growers web site.
- An article, "Field pea response to fertilizers in southeast Peace region of Alberta" was published in the December 2010 issue of the SARDA's newsletter Back Forty, which has also been posted on the web page www.areca.ab.ca/SARDA.
- Abstract and full report of the project will be published in the annual report of SARDA.

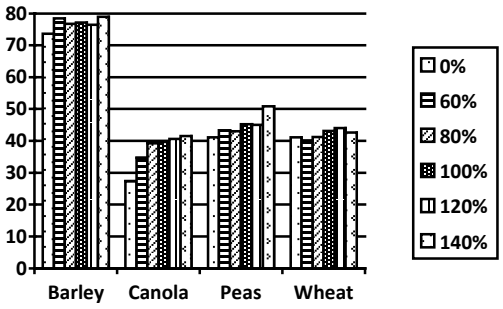

Fig. 1. Seed yield (bu/ac) of crops with different fertilizer rates in 2010

2011 Plan

Soil samples have been collected to determine the fertilizer requirements for the crops in designated treatments. Designated crops will be grown using the recommended agronomic practices. A report on the 3 year data will be prepared.

Acknowledgements

Alberta Pulse Growers (APG), Alberta Canola Producers Commission (ACPC), Alberta Agriculture & Rural Development (Agriculture Opportunity Fund, AOF) and local municipalities (Big Lakes, Greenview, Northern Sunrise County, Smoky River) for funding the project.

Co-operators: Gauthier Farms, Donnelly.

Agri-Pro St. Isidore Co-op – for donating fertilizers.

Bremont Farms, BrettYoung, Denis Alexandre, Dion Farms, Falher Seed Cleaning Plant, Little Smoky seeds, Roy Boy Farms - for donating seeds.

Table 5. Seed yield, TKW and bushel weight of crops for different fertilizer rates in 2009 and 2010.

	2009				2010		
Fert Rate,%	Yield kg/ha	Yield bu/ac	TKW g/1000	Bushel lb/bu	Yield kg/ha	Yield bu/ac	Test Wt. lb/bu
Barley							
0	4957	92.2	44.0	51.1	3965	73.6	52.9
60	5254	97.7		45.0	4220	78.4	52.6
80	5210	96.9	43.0	51.1	4128	76.7	52.2
100	5413	100.7	46.0	51.9	4154	77.1	52.4
120	5274	98.1	49.0	52.6	4115	76.4	51.6
140	5733	106.6	45.0	51.4	4251	78.9	52.0
$LSD_{0.05}$	811.0	15.09			601.5	11.17	0.92
CV, %	8.4	8.4			8.0	8.0	1.0
Prob.	NS	NS			NS	NS	†
Canola							
0	2457	43.9	3.1	53.3	1845	27.4	52.6
60	3143	56.1	3.4	53.0	2334	34.7	53.4
80	3023	54.0	3.2	53.1	2647	39.3	53.7
100	3041	54.3	3.4	53.6	2671	39.7	53.2
120	3015	53.8	3.5	54.0	2731	40.6	53.5
140	2827	50.5	3.4	52.9	2797	41.5	53.4
$LSD_{0.05}$	449.1	8.02			240.5	3.57	0.66
CV, %	8.46	8.46			5.3	5.3	0.7
Prob.	†	†			**	**	NS
Peas							
0	3793	56.4	272	66.2	2767	41.1	65.1
60	4096	61.0	256	65.4	2917	43.3	64.8
80	4100	61.0	262	65.1	2898	43.0	64.6
100	4270	63.5	262	66.3	3041	45.2	65.3
120	4439	66.1	271	66.3	3033	45.0	64.8
140	4499	66.9	264	66.3	3420	50.8	65.2
$LSD_{0.05}$	657.2	9.78			293.7	4.36	0.94
CV, %	8.6	8.6			5.4	5.4	0.8
Prob.	NS	NS			**	**	NS
Wheat							
0	3976	59.2	33.0	65.0	2765	41.1	64.2
60	4602	68.5	37.0	66.2	2694	40.1	63.5
80	4685	69.7	33.0	64.3	2768	41.2	63.8
100	4617	68.7	38.0	65.9	2896	43.1	63.8
120	4793	71.3	36.0	65.7	2955	44.0	63.7
140	4793	71.3	37.0	65.9	2860	42.6	63.4
$LSD_{0.05}$	542.6	8.07			314.9	4.69	0.39
CV, %	6.5	6.5			6.1	2.6	0.3
Prob.	†	†			NS	NS	*

**, *, and refer to significant at 1%, 5% and 10% probability. NS refers to not significant at 10% probability.