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Project Name: Agronomic and Economic Assessment of Variable Rate Fertilization

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Russell Memory

Flexi-Coil

Other Sponsors: Westco Fertilizers

Potash and Phosphate Institute

Document prepared by D.J. Pennock

Interim Progress Report: January 1, 1999

(a) Abstract/Summary

Our ADF-funded research program was designed to measure the inherent fertility variations in a typical Saskatchewan landscape and to determine the different yield response of wheat and canola to fertilizer levels. The research sites are located on

adjacent quarter-sections of land near Hepburn, Saskatchewan. Climatic conditions in the 1998 growing season overwhelmed the fertility response that had been observed in the previous two years of this study. Seeding was carried out in very dry soil, and no significant precipitation was received for 30 days after seeding. Both crops showed a clear landscape response overall – yields were lowest in the upper slope positions and increased through the midslopes and were highest in the lower slope positions. The response to the different N and P rates were, however, minimal for both crops. No yield increases occurred beyond the 0.5X recommended rate of N and P for either crop. The 1998 data provides an important cautionary note for adopters of this technology – in conditions such as those encountered in 1998, the climatic constraints overwhelmed any possible fertility benefit to a variable rate program.

(b) Executive Summary

All of the field and laboratory work on the above-named project has progressed according to schedule. All of the groups listed as co-investigators and sponsors above have maintained their contributions at the level specified in the original proposal. Summer operations and harvesting were carried out at the two sites successfully.

The results from 1998 strongly reflect the sub-optimal growing season conditions, especially in the early part of the season (Figure 1). Seeding was carried out on May 15 and 16 by staff of the Saskatchewan Wheat Pool. Soil conditions were very dry at the time of seeding and no significant precipitation was received until 30 days after seeding (Figure 1). The very dry soil conditions are reflected in the volumetric moisture contents, which decline from spring seeding to 25 days after planting (DAP) (Tables 1 and 2, Appendix 1). A frost also occurred 2.5 weeks after seeding when the emerging crop was at vulnerable stage and frost damage was noted. These conditions resulted in a poor plant stand for both crops, although the average yields achieved were comparable to those achieved by the cooperating farmers on the same quarter-sections.

The yield response to the N fertilizer treatments was limited for the canola site (Table 3, Appendix 1). The recommended N rate for canola in 1998 was 90 kg/ha. Overall a difference was noted in canola yields between the three management units (Table 3); for example, canola yields in the 0N treatment increased from 356 kg/ha in the upper slopes, to 565 kg/ha in the mid-slopes and 964 kg/ha in the lower slope units. A small increase occurred from the 0N to the 0.5N treatment for the midslope and lower slope positions; however no major increases occurred at higher N rates.

A similar set of results were observed for the wheat site (Table 4, Appendix 1). Again, a management unit difference was observed, although the midslope yields were very similar to the upper slope yields for the wheat crop. As well, the midslope and lower slope units showed a modest increase from the 0N to the 0.5N treatments, but no increases in yields were observed above the 0.5N level. Nor were major differences noted in the grain protein levels for the N treatments – the total range in protein was from 13.0 % to 14.6%.

Yield response to the different P fertilizer levels was also very limited (Tables 6 and 7, Appendix 1. A increase occurred (albeit at very low yields) for the 0 to 0.5X P treatments for the upper slope positions for canola, but no other major increase with higher P rates were observed.

The complete analysis of the results will be presented in the final report for this project, due in March, 1999. However it is clear from the results presented above that the poor soil moisture conditions at the time of seeding and for the first 25 days after planting greatly limited the ability of either crop to respond to the variable fertilizer treatments imposed at the sites. The differences in moisture conditions between the management units at the time of seeding were sufficient to cause minor yield differences between the management units overall, but limited further differences in crop response. The conditions that occurred in 1998 provide an important cautionary note for adopters of this technology – in any given year, variations in the amount and timing of precipitation may overwhelm the ability of the crop to respond to variable rate fertilizer applications.

(c) Technical Summary

The overall objectives of our ADF-funded project are to 1) examine the agronomic implications of VRF, 2) assess the economic component of VRF, and 3) develop the mapping tools to delineate management units on the farm scale. The project has achieved all of the milestones as specified in the original proposal for the reporting period. All of the groups listed as co-investigators and sponsors above have maintained their contributions at the level specified in the original proposal. No additional seeding from Flexi-coil was required in 1998 since all of the leased land was utilized for this year's trials.

The field and laboratory work on this project has progressed according to schedule. The treatment structure used in the ADF-sponsored research was fully documented in the interim report of June 1, 1997. The only change to this structure was to add a 2X P treatment to the canola site in 1998 to ensure that we were not missing the potential for yield responses at higher P levels. Summer spraying and soil sampling operations and fall harvesting were carried out at the two sites successfully. Both sites were sampled in spring prior to seeding to allow us to examine the correlation between pre-seeding soil measurements at final yield. A more extensive set of growing season measurements were made at the wheat site to bring the data base for this site in line with the other sites funded by the AFIF program. As well, the meteorological station was maintained throughout the growing season to provide a suite of climatic variables.

The results from 1998 strongly reflect the sub-optimal growing season conditions, especially in the early part of the season (Figure 1). Seeding was carried out on May 15 by staff of the Saskatchewan Wheat Pool. Soil conditions were very dry at the time of seeding and no significant precipitation was received until 30 days after seeding (Tables 1 and 2, Appendix 1). The very dry soil conditions are reflected in the volumetric moisture contents, which decline from spring seeding to 25 days after planting (DAP) (Tables 1 and 2, Appendix 1). For example, the moisture contents (volumetric moisture content, 0-30 cm) for the wheat site were, on average, 20-25% lower at the time of seeding in 1998 than in 1997; this difference increased to 30-33% lower at 25 days after seeding.

A frost also occurred 2.5 weeks after seeding (Figure 1) when the emerging crop was at vulnerable stage and frost damage was noted. These conditions resulted in a poor plant stand for both crops, although the average yields achieved were comparable to those achieved by the cooperating farmers on the same quarter-sections.

The yield response to the N fertilizer treatments was limited for the canola site (Table 3, Appendix 1). The recommended N rate for canola in 1998 was 90 kg/ha. Overall a difference was noted in canola yields between the three management units (Table 3); for example, canola yields in the 0N treatment increased from 356 kg/ha in the upper slopes, to 565 kg/ha in the mid-slopes and 964 kg/ha in the lower slope units. A small increase occurred from the 0N to the 0.5N treatment for the midslope and lower slope positions; however no major increases occurred at higher N rates.

A similar set of results were observed for the wheat site (Table 4, Appendix 1). Again, a management unit difference was observed, although the midslope yields were very similar to the upper slope yields for the wheat crop. As well, the midslope and lower slope units showed a modest increase from the 0N to the 0.5N treatments, but no increases in yields were observed above the 0.5N level. Nor were major differences noted in the grain protein levels for the N treatments – the total range in protein was from 13.0 % to 14.6%.

The dry conditions also limited the amount of N mineralized from the soil organic N pool, which has been shown at other sites to be a major contributor to the N response of the crops. The amount of N mineralized was assessed at the 0N treatments at both sites over the growing season. The 0N treatment is used for this evaluation because of lack of interactions with added N fertilizers. As noted previously at these sites, no major differences existed in N levels between the three management units at the time of seeding (Tables 8 and 9, Appendix 1). Compared to previous years, however, relatively small increases in mineral N occurred in the first 25 days after planting (Tables 8 and 9, Appendix 1). This lack of N mineralization, coupled with the direct physiological effects of moisture stress early in the growing season, limited the response of the crops to the N treatments.

Yield response to the different P fertilizer levels was also very limited (Tables 6 and 7, Appendix 1. A increase occurred (albeit at very low yields) for the 0 to 0.5X P treatments for the upper slope positions for canola, but no other major increase with higher P rates were observed.

The complete analysis of the results will be presented in the final report for this project, due in March, 1999. However it is clear from the results presented above that the poor soil moisture conditions at the time of seeding and for the first 25 days after planting greatly limited the ability of either crop to respond to the variable fertilizer treatments imposed at the sites. The differences in moisture conditions between the management units at the time of seeding were sufficient to cause minor yield differences between the management units overall, but limited further differences in crop response. The conditions that occurred in 1998 provide an important cautionary note for adopters of this technology – in any given year, variations in the amount and timing of precipitation may overwhelm the ability of the crop to respond to variable rate fertilizer applications.

(d) Personnel

M.P. Solohub (100% for 4 months)[a]

R.F. Anderson (100% for 4 months)[a]

a: Anderson and Solohub are jointly employed by the ADF and AFIF Precision Farming grants.

Miles Dyck (100% for 1.5 months)

(e) Equipment Purchased

None.

(f) Project Developed Materials

None. Dr. Walley and I are currently developing a web-based information sheet that will be posted on the SAF web site.

(g) Project Photos

The major field operations were documented on film.

(h) Acknowledgement

Presentations based, in part, on the ADF-funded work have been made by the principal investigators at the following venues:

Title: **Yield response of wheat and canola to a topographically based variable rate fertilization program in Saskatchewan**

Audience: 120+

Venue: 4th International Conference on Precision Agriculture, St. Paul, Minnesota

Date: July 22, 1998

Title: **Fertilizer Inputs for Precision Farming: Saskatchewan Research Results**

Audience 100+

Venue: 3rd Annual Manitoba Precision Farming Conference, Brandon, Manitoba

Date: November 18, 1998

(i) Expense Statement

To be provided by the University of Saskatchewan

APPENDIX 1

Table 1: Hepburn Canola Site 1998; Volumetric Moisture Content over the Growing Season for the 0N treatment (mean of six replicates)

	Volumetric Moisture Content 0-30 cm (% v/v)		
Sampling Date	Upper Slope	Mid Slope	Lower Slope
Spring	22.2 (0.7)*	24.1 (0.5)	26.7 (0.8)
25 D.A.P.	20.6 (1.0)	19.5 (0.6)	23.0 (1.0)
50 D.A.P.	22.5 (0.8)	21.0 (0.9)	22.2 (1.0)
75 D.A.P.	16.8 (1.0)	14.4 (0.9)	14.4 (0.8)
Fall	13.5 (0.6)	12.9 (0.6)	16.2 (0.8)

* values in parentheses represent the standard error of the mean.

Table 2: Hepburn Wheat Site 1998; Volumetric Moisture Content over the Growing Season for the 0N treatment (mean of six replicates)

	Volumetric Moisture Content 0-30 cm (% v/v)		
Sampling Date	Upper Slope	Mid Slope	Lower Slope
Spring	25.3 (0.5)*	26.4 (0.5)	33.9 (0.7)
25 D.A.P.	21.1 (0.5)	22.4 (0.7)	30.2 (0.9)
50 D.A.P.	23.8 (0.5)	24.9 (0.9)	29.9 (0.6)
75 D.A.P.	17.9 (0.8)	18.0 (0.8)	18.3 (0.7)
Fall	18.7 (1.1)	18.6 (0.7)	18.6 (0.8)

* values in parentheses represent the standard error of the mean.

Table 3: Hepburn Canola Site 1998; Canola Yield vs. N Fertilizer Rate.

	Grain Yield (kg/ha)		
N treatment	Upper Slope	Mid Slope	Lower Slope
0.0X*	356 (83)**	565 (89)	964 (32)
0.5X	384 (31)	788 (119)	1187 (49)
1.0X	430 (99)	892 (96)	1187 (83)
1.5X	474 (64)	828 (121)	1206 (58)
2.0X	473 (104)	845 (152)	1145 (72)

* recommended N fertilizer rate was 90 kg/ha.
** values in parentheses represent the standard error of the mean.

Table 4: Hepburn Wheat Site 1998; Yield vs. N Fertilizer Rate (mean of six replicates)

	Grain Yield (kg/ha)		
N treatment	Upper Slope	Mid Slope	Lower Slope
0.0X*	1192 (134)**	1333 (89)	1819 (125)
0.5X	1205 (116)	1458 (109)	2040 (62)
1.0X	1177 (135)	1393 (151)	1942 (147)
1.5X	1129 (174)	1423 (126)	2093 (115)
2.0X	1222 (125)	1404 (99)	1936 (137)

* recommended N fertilizer rate was 70 kg/ha.

** values in parentheses represent the standard error of the mean.

Table 5: Hepburn Wheat Site 1998; Grain Protein vs. N Fertilizer Rate (mean of six replicates).

	Grain Protein (%)		
N treatment	Upper Slope	Mid Slope	Lower Slope
0.0X*	13.8 (0.3)	13.7 (0.3)	13.0 (0.2)
0.5X	14.1 (0.1)	14.2 (0.2)	14.1 (0.2)
1.0X	14.3 (0.1)	14.7 (0.1)	14.2 (0.3)
1.5X	14.4 (0.1)	14.7 (0.1)	14.5 (0.2)
2.0X	14.6 (0.2)	14.4 (0.1)	14.3 (0.1)

* recommended N fertilizer rate was 70 kg/ha.

** values in parentheses represent the standard error of the mean.

Table 6: Hepburn Canola Site 1998; Yield vs. P Fertilizer Rate (mean of six replicates).

	Grain Yield (kg/ha)		
N treatment	Upper Slope	Mid Slope	Lower Slope
0.0X*	240 (48)	846 (87)	1074 (88)
0.5X	429 (77)	790 (151)	1119 (68)
1.0X	430 (99)	892 (96)	1187 (83)
2.0X	591 (160)	885 (159)	1193 (78)

* recommended P fertilizer rate was 32.5 kg/ha.

** values in parentheses represent the standard error of the mean.

Table 7: Hepburn Wheat Site 1998; Yield vs. P Fertilizer Rate (mean of six replicates).

	Grain Yield (kg/ha)		
N treatment	Upper Slope	Mid Slope	Lower Slope
0.0X*	1112 (150)**	1300 (109)	1889 (144)
0.5X	1335 (131)	1343 (71)	1786 (182)
0.1X	1177 (135)	1393 (151)	1942 (147)
2.0X	1156 (125)	1307 (113)	1830 (133)

* recommended P fertilizer rate was 30 kg/ha.

** values in parentheses represent the standard error of the mean.

Table 8: Hepburn Canola Site 1998; Mineral Nitrogen (kg/ha) over the Growing Season (0N treatment, mean of six replicates).

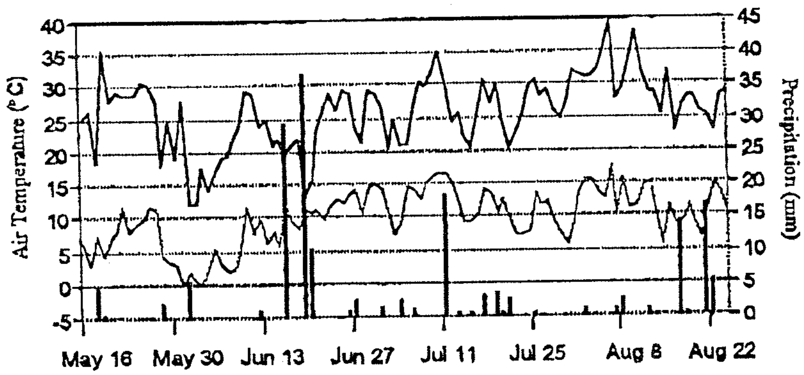
	Mineral Nitrogen 0-30 cm (kg/ha)		
Sampling Date	Upper Slope	Mid Slope	Lower Slope
Spring	22.7 (2.7)*	26.4 (3.8)	33.7 (7.5)
25 D.A.P.	26.9 (3.4)	27.6 (3.1)	49.4 (4.7)
50 D.A.P.	23.7 (3.3)	17.4 (5.2)	10.8 (1.6)
Fall	15.1 (1.6)	16.7 (5.3)	13.6 (4.2)

* values in parentheses represent the standard error of the mean.

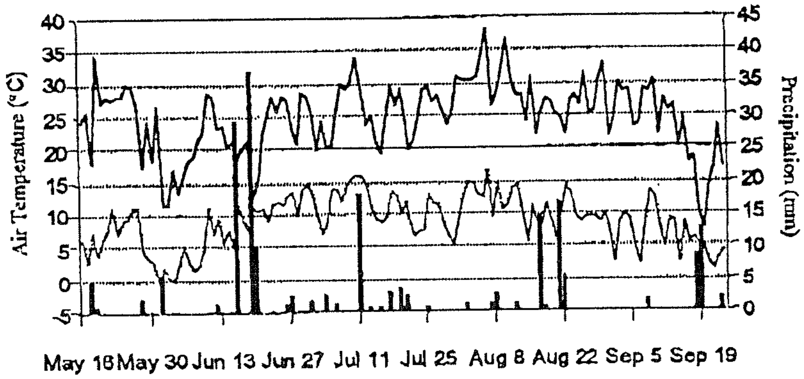
Table 9: Hepburn Wheat Site 1998; Mineral Nitrogen (kg/ha) over the Growing Season (0N treatment, mean of six replicates).

	Mineral Nitrogen 0-30 cm (kg/ha)		
Sampling Date	Upper Slope	Mid Slope	Lower Slope
Spring	25.8 (6.0)*	32.8 (5.1)	32.9 (3.2)
25 D.A.P.	37.7 (7.0)	49.7 (7.8)	53.1 (7.0)
50 D.A.P.	31.7 (4.1)	38.6 (3.3)	52.9 (6.2)
Fall	27.1 (7.2)	22.9 (3.9)	30.9 (6.3)

* values in parentheses represent the standard error of the mean.



Climate Data: Hepburn Canola 1998



Climate Data: Hepburn Wheat 1998

Figure 1: Climate data for the 1998 growing season at the Hepburn Canola and Wheat sites. Seeding occurred on May 15 and 16.