1980 SOIL-PLANT NUTRIENT RESEARCH REPORT

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1.1 Irrigation scheduling of pulse crops.

INTRODUCTION

The production of pulse crops in the South Saskatchewan River Irrigation Project near Outlook, Saskatchewan has been increasing in recent years. Pulse crops provide an alternate cash crop in the rotation and have the added advantage of meeting their own nitrogen requirements through nitrogen fixation. Recent research undertaken jointly by the Crop Development Center and the Department of Soil Science, University of Saskatchewan from 1976 to 1978, has indicated that pulse crops respond to irrigation applications with increased yields, particularly so for fababeans.

The scheduling or timing of irrigation applications as well as the effect of moisture stresses at different times in the growing season on pulse crop yields is not fully known at this time. Previous research by the Department of Soil Science, University of Saskatchewan, indicated that moisture stresses early in the growing season caused a greater yield reduction than a moisture stress later in the growing season for cereal and oilseed crops. Therefore, a project was initiated to determine the effect of moisture stresses at different points in the growing season on the yields of pulse crops.

This is a joint project between the Crop Development Center and the Department of Soil Science, University of Saskatchewan.

OBJECTIVE

To determine the effect of irrigation scheduling on the yield of pulse crops.

EXPERIMENTAL METHODS

The site selected for this experiment was on an Elstow loam soil on the farm of Outlook Agro Limited, Outlook, Saskatchewan (R. Thorstad). This field had been seeded to lentils in 1979. The results of the analyses of soil samples collected in the spring are presented in Table 1.1.1. The results indicate a low nitrogen content and a very low phosphorus content. Other major nutrients were deemed adequate by the present Nutrient Requirement Guidelines for Saskatchewan. Moderate levels of salts were present in the 60-90 cm and 90-120 cm depths of the soil profile but is considered normal for Elstow soils in this area.

The crops fababeans, peas, dry beans, and lentils were seeded with an eight row hoe-press drill having 18 cm row spacings. Blocks of approximately 12 m x 24 m were seeded for each crop-water treatment. The entire plot area received an initial irrigation of approximately 25 mm to ensure the germination of all crops in all water treatments because of the dry seed-bed conditions.

Trifluralin was applied pre-plant and incorporated with three passes of a heavy duty cultivator. This, accompanied by a small amount of hand weeding, constituted the weed control program.

Monoammonium phosphate (11-55-0) was applied at a rate of approximately 130 kg P_2O_5/ha as a sideband application to all crop-water treatments at the time of seeding. For the sideband application, the fertilizer was applied 2.54 cm to the side and 2.54 cm below the seed.

For the irrigation scheduling portion of the experiment, five water schedules were utilized (Table 1.1.2). In water schedule A the first irrigation was deleted, in water schedule B the second irrigation

Table 1.1.1. Spring soil analyses for the pulse crop irrigation scheduling experiment.

Crop	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^=$-S	% Organic Matter
				------- kg/ha*			---------	
Fababeans	0-15	7.9	0.3	13	6	560	11	2.6
	15-30	8.1	0.2	14	3	250	7	
	30-60	8.3	0.8	12	2	540	48+	
	60-90	8.5	1.5	10	6	670	48+	
	90-120	8.2	3.4	18	12	900	48+	
Peas	0-15	7.8	0.3	10	4	535	24+	2.5
	15-30	8.1	0.2	12	2	250	5	
	30-60	8.2	1.0	10	2	600	48+	
	60-90	8.5	1.9	14	10	770	48+	
	90-120	8.3	2.9	28	22	1180	48+	
Dry Beans	0-15	8.0	0.2	10	5	495	11	2.5
	15-30	8.1	0.2	15	3	260	7	
	30-60	8.2	0.9	12	4	570	48+	
	60-90	8.4	2.1	12	6	760	48+	
	90-120	8.3	3.1	22	18	980	48+	
Lentils	0-15	8.0	0.3	11	5	490	17	2.3
	15-30	8.1	0.3	13	3	260	6	
	30-60	8.3	0.9	18	4	620	48+	
	60-90	8.6	1.4	18	8	860	48+	
	90-120	8.2	3.5	28	16	1010	48+	

*kg/ha = ppm x 2 for 15 cm depth and ppm x 4 for 30 cm depth.

Table 1.1.2. Water treatments used in the pulse crop irrigation scheduling experiment.

Water Schedule	Treatment
A	Missed first irrigation
B	Missed second irrigation
C	Missed third irrigation
D	Received all irrigations
X	Dryland

was deleted, in water schedule C the third irrigation was deleted whereas water schedule D received all irrigation applications. Water schedule X was the dryland treatment.

The actual scheduling of irrigation was determined by tensiometers. Shallow tensiometers were installed at the 10 to 15 cm depth initially and then moved down to the 15 to 23 cm depth in late June. Deeper tensiometers were installed initially at the 25 to 30 cm depth and moved down to the 40 to 45 cm depth in late June. Tensiometers were installed in each crop-water treatment except the dryland treatment where no tensiometers were installed.

The tensiometers were utilized to determine both the timing of irrigation and the amount to apply. Irrigation water was applied when the shallow tensiometers indicated a soil moisture tension of 0.5 atm. The amount of water to apply was determined by the readings obtained on the deep tensiometers as indicated in Table 1.1.3.

Neutron access tubes were installed to a depth of 120 cm in three locations in each crop-water treatment. Moisture monitoring was then conducted with the neutron probe for all depths except the 0-15 cm depth which was done gravimetrically. Moisture measurements were made at seeding time, at two week intervals until harvest and again at harvest.

Irrigation water was applied through the use of a custom designed sprinkler system which allowed separate timing and amounts of water to the various irrigation treatments understudy. The timing and amounts of irrigation water applied are presented in Table 1.1.4.

In spite of the preliminary application of approximately 25 mm of irrigation water four days after seeding, there were still problems in germination and plant stands particularly for lentils.

Table 1.1.3. Amount of water required to replenish soil moisture.

Deep Tensiometer Reading (atm.)	Amount of Water to Apply (mm)
0.3 or less	64
0.3 - 0.7	89
greater than 0.7	114

Table 1.1.4. Amounts and timing of irrigation applications for the pulse crop irrigation scheduling experiment.*

Crop	Date	Water A	Water B	Water C	Water D
	Growing Season Rainfall = 77 mm				
Fababeans	May 30	---	70 mm	70 mm	70 mm
	June 27	81 mm	---	81 mm	81 mm
	July 9	135 mm	135 mm	---	135 mm
	July 24	87 mm	87 mm	87 mm	87 mm
		303 mm	292 mm	238 mm	373 mm
Peas	May 27	---	44 mm	44 mm	44 mm
	June 27	96 mm	---	96 mm	96 mm
	July 9	109 mm	109 mm	---	109 mm
	July 24	85 mm	85 mm	85 mm	85 mm
		290 mm	238 mm	225 mm	334 mm
Dry Beans	May 30	---	65 mm	65 mm	65 mm
	June 27	115 mm	---	115 mm	115 mm
	July 13-15	114 mm	114 mm	---	114 mm
		229 mm	179 mm	180 mm	294 mm
Lentils	May 27	---	63 mm	63 mm	63 mm
	June 26	107 mm	---	107 mm	107 mm
	July 13-15	119 mm	119 mm	---	119 mm
		226 mm	182 mm	170 mm	289 mm

*All plots including dryland received approximately a 25 mm irrigation on May 10 to insure uniform germination.

Thus, in mid-June, ten replicates were staked in each crop-water block such that there were three solid rows of plants over a length of approximately three meters. The plant population within this area was then determined.

At harvest, yield samples were taken from each crop-water block by clipping at the soil surface three rows over a length of three meters within the same areas that plant counts had been obtained. Subsamples of both grain (replicates kept separate) and straw (replicates bulked) were ground in preparation for nitrogen, phosphorus and potassium analysis. Grain and straw nitrogen, phosphorus and potassium contents were determined by wet digestion and colorimetric analysis using a Technicon Auto Analyzer II System.

In addition to the yields obtained by manual sampling, total plot yields were determined by Hege combine for all but the dryland lentils. The Hege combine operation was done in late September and hence, some shelling had occurred in some treatments and incomplete threshing due to less than ideal conditions was noted for other treatments.

RESULTS AND DISCUSSION

The results of the effect of irrigation scheduling on the yield and nutrient content of fababeans, peas, dry beans and lentils are presented in Table 1.1.5. The yield data show clearly the response of all of the pulse crops to the supply of adequate water. Approximate maximum grain yields obtained were 7500 kg/ha for fababeans, 6200 kg/ha for peas, 2800 kg/ha for dry beans and 3500 kg/ha for lentils. The yields found in the present work are much higher than those found in

Table 1.1.5. Plant populations, yield and nutrient content of pulse crops grown under different irrigation watering schedules.

Water Schedule	Plants/ Hectare (X1000)	Hege Combine Yield (kg/ha)	Yield (kg/ha) Grain	Yield (kg/ha) Straw	Grain[1] % Protein	Straw[2] % N	% P[2] Grain	% P[2] Straw	% K[2] Grain	% K[2] Straw
				Fababeans						
A	173	3303	5470	6355	27.3	0.45	0.454	0.099	1.10	1.47
B	190	3505	7488	7510	28.3	0.99	0.455	0.147	1.10	1.29
C	165	2563	5188	5488	28.3	0.75	0.494	0.123	1.05	1.41
D	203	2806	6787	7019	26.7	0.99	0.462	0.135	1.05	1.32
Dryland	173	286	797	642	32.2	0.54	0.581	0.108	1.02	3.39
				Peas						
A	173	3805	6203	4968	25.6	0.99	0.376	0.108	1.16	1.53
B	161	3495	5921	5261	23.2	0.90	0.383	0.105	1.27	1.44
C	190	2607	4164	4597	22.0	0.96	0.406	0.114	1.21	1.59
D	153	4081	5466	4789	21.7	0.87	0.398	0.105	1.34	1.59
Dryland	153	639	999	1080	22.4	0.63	0.413	0.066	1.22	1.23
				Dry Beans						
A	319	1299	2512	1648	20.9	0.57	0.553	0.117	1.93	2.64
B	284	1050	2477	1900	19.6	0.54	0.576	0.123	1.78	2.46
C	338	632	1344	1166	20.8	0.66	0.579	0.126	1.68	2.19
D	314	1174	2803	1654	20.8	0.51	0.535	0.084	1.78	2.43
Dryland	314	77	255	570	23.4	1.56	0.642	0.270	1.64	1.89
				Lentils						
A	664	2425	2619	2573	27.3	1.14	0.482	0.138	1.16	1.35
B	669	2732	3004	2758	26.9	0.45	0.474	0.069	1.16	1.77
C	664	1154	2598	2539	25.9	0.72	0.450	0.093	1.12	1.74
D	608	2721	3490	3071	27.6	0.60	0.478	0.057	1.16	2.25
Dryland	511	--	688	716	24.6	0.84	0.435	0.096	1.10	1.59

[1]Grain % Protein based on % N at oven-dry moisture x 6.25.

[2]Oven-dry basis.

previous research, however, it must be noted that the grain yields reported for manual sampling in the present work would be those that might be theoretically obtained at the plant populations indicated. Previous research indicated irrigated pulse crop yields in the Outlook area over a period of three years of 4119 kg/ha for fababeans, 2189 kg/ha for peas, 1930 kg/ha for dry beans and 1746 kg/ha for lentils.

There were substantial differences between irrigation scheduling treatments for all crops. The most significant deficiency came in the treatment where the third irrigation was omitted about mid-July (Water C). This resulted in serious yield reduction for fababeans, peas, and dry beans. Missing the first irrigation (Water A) resulted in serious yield reductions for fababeans and lentils.

Hege combine yields showed somewhat similar trends as the hand sampling yields, however, the yields were lower.

Grain/straw ratios for the pulse crops grown under irrigation were greater than 1 for drybeans, peas and lentils and less than 1 for fababeans (dry beans > peas, lentils > fababeans). Under dryland the opposite occurred with grain/straw ratios greater than 1 for fababeans and less than 1 for drybeans, peas and lentils (fababeans > peas, lentils > dry beans). The relationship of the grain/straw ratios to the irrigation scheduling treatments was the same as noted earlier for the grain yield - water scheduling relationship (i.e., lowest for peas and dry beans in Water C and for fababeans and lentils in Water C and A).

Grain protein content was greater under dryland than irrigation for fababeans and dry beans and less under dryland than irrigation for lentils. For peas there was little or no difference in grain protein content between dryland and irrigation except for Water A where grain protein content was higher under irrigation than dryland. These results are similar to those found in previous research with the exception that in the previous research fababeans always had higher grain protein under irrigation than dryland. The difference is in the higher grain protein content for fababeans under dryland (32%) in the present work in comparison to that found in the previous research under dryland (1976 - 24%; 1977 - 21%; 1978 - 24%).

Straw N content was greater under irrigation than dryland for fababeans and peas with the exception of Water A for fababeans. For dry beans and lentils, straw N content was greater under dryland than irrigation with the exception of Water A for lentils. Previous research with pulse crops indicated straw N content to generally be greater under irrigation than dryland. The difference for dry beans and lentils as reported in the present work and that in the previous research is not fully known.

Grain phosphorus content was greater under dryland than irrigation for fababeans, peas and dry beans and greater under irrigation than dryland for lentils. Water C had the highest grain phosphorus content for fababeans, peas and dry beans and the lowest grain phosphorus content for lentils of the four irrigation scheduling treatments. Since all the crop-water scheduling treatments received the same application of phosphorus at seeding, differences in phosphorus content could possibly reflect the different water stresses placed on the crops by the irrigation scheduling treatments.

Straw phosphorus content was greater under irrigation than dryland for fababeans and peas and greater under dryland than irrigation for dry beans and lentils. No relationship between straw phosphorus content and the irrigation scheduling treatments was observed.

Potassium content of the grain and straw of the pulse crops was higher under irrigation than dryland except for fababean straw where potassium content was 2-3 times higher under dryland than irrigation. The reason for this high value is not known. Dry beans had the highest potassium content in both the grain and straw while fababeans had the lowest potassium content in both the grain and straw. Straw potassium content of the pulse crops was higher than grain potassium content, the same trend that has been observed for other crops.

Total above ground N, P and K uptake by the pulse crops grown under different irrigation water schedules are given in Table 1.1.6. All of the pulse crops had higher N, P and K uptake under irrigation than dryland. As well, N, P and K uptake was lowest for Water C for all of the pulse crops.

Total aboveground N uptake was greatest for fababeans which was followed by peas > lentils > dry beans. The large total aboveground N uptake for both the fababeans and peas considering the low soil NO_3^--N level 0-16 cm (Table 1.1.1) at the beginning of the experiment indicates the high potential for N-fixation that these crops have.

The total aboveground uptake of P and K for the pulse crops showed the same trend as for the total aboveground N uptake with fababeans > peas > dry beans and lentils.

The seasonal water use for the pulse crops under the different irrigation water schedules is presented in Table 1.1.7. As would be expected, a greater total water use was found for each crop under irrigation than dryland. As well, all four pulse crops investigated showed a yield increase when irrigated indicating they all responded to the irrigation applications.

Table 1.1.6 Grain, straw and total aboveground N, P and K uptake of pulse crops grown under different irrigation water scheuldes.

Water Schedule	Nitrogen Uptake			Phosphorus Uptake			Potassium Uptake		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
	kg/ha								
				Fababeans					
A	239	29	268	25	6	31	60	93	153
B	339	74	413	34	11	45	82	97	179
C	235	41	276	26	7	33	54	77	131
D	290	69	359	31	9	40	71	93	164
Dryland	41	3	44	5	1	6	8	22	30
				Peas					
A	254	49	303	23	5	28	72	76	148
B	220	47	267	23	6	29	75	76	151
C	147	44	191	17	5	22	50	73	123
D	190	42	232	22	5	27	73	76	149
Dryland	36	7	43	4	1	5	12	13	25
				Dry Beans					
A	84	9	93	14	2	16	48	44	92
B	78	10	88	14	2	16	44	47	91
C	45	8	53	8	1	9	23	26	49
D	93	8	101	15	1	16	50	40	90
Dryland	10	9	19	2	2	4	4	11	15
				Lentils					
A	114	29	143	13	4	17	30	35	65
B	129	12	141	14	2	16	35	49	84
C	108	18	126	12	2	14	29	44	73
D	154	18	172	17	2	19	40	69	109
Dryland	27	6	33	3	1	4	8	11	19

Total water use for the pulse crops was of the order fababeans > peas > lentils > dry beans and followed the order of the amounts of water applied as irrigation applications. The yield of the pulse crops also followed their total water use patterns with the greatest yield occurring for the fababeans which had the greatest water use.

The effect of the different irrigation water schedules on total water use was different for each pulse crop. Fababeans and lentils had their greatest total water use where no water stress was applied during the growing season (Water D) while peas and dry beans had their greatest total water use where a water stress was applied during the growing season (Water B and A, respectively). Only lentils and peas had their highest yields associated with their greatest total water use even though high yields were generally associated with high total water use for all the pulse crops.

The reasons for the differences in the effect of the irrigation watering schedules on the yield of the pulse crops is not fully clear at this time. The physiological stage of growth of the plants when irrigation water was applied or when a water stress was applied may possibly have had some effect on the different responses. Further research will be required to fully elucidate these effects.

Table 1.1.7. Seasonal water use of pulse crops under different irrigation watering schedules.

Crop	Water Schedule	Rainfall	Irrigation	ΔS*	Total Water Use**
		mm			
Fababeans	A	77	328	-4	401
	B	77	317	6	400
	C	77	264	43	437
	D	77	398	-27	448
	X	77	25	31	133
Peas	A	77	317	-71	323
	B	77	266	25	368
	C	77	252	-19	310
	D	77	361	-143	295
	X	77	27	21	125
Dry Beans	A	77	248	-3	322
	B	77	198	-53	222
	C	77	199	-46	230
	D	77	313	-79	311
	X	77	18	31	126
Lentils	A	81	275	39	395
	B	77	210	50	337
	C	77	219	-21	275
	D	77	339	-4	412
	X	77	27	75	179

*ΔS = change in soil moisture content (Spring-Fall)

**Total Water Use = rainfall + irrigation + ΔS

1.2 The effect of legume crops on the yields of subsequent cereal crops.

INTRODUCTION

The rising costs of nitrogen fertilizers has resulted in an increased interest in legume crops in the rotation. Legumes fix large quantities of nitrogen and can essentially meet their own nitrogen requirements. The beneficial effect of perenial legume crops such as alfalfa to subsequent cereal crop yields has been well documented. Recent research by the Department of Soil Science, University of Saskatchewan, has indicated that the release of mineral nitrogen in the year of alfalfa breaking under irrigation is sufficiently rapid enough to meet a large portion of a cereal crops nitrogen requirements. Less well known is the residual nitrogen contribution of annual legume crops, such as fababeans, to subsequent cereal crops. Therefore, a research project was initiated to determine the residual nitrogen contribution of annual legume crops on subsequent cereal crop yields. As well, it was decided to monitor the residual nitrogen contribution of alfalfa residues on a field seeded to its second crop since being taken out of alfalfa production.

Objective:

(1) To determine the residual nitrogen contribution of annual legume crops to subsequent cereal crops.

(2) To monitor the residual nitrogen contribution of alfalfa residues in the second year after being taken out of alfalfa production.

EXPERIMENTAL METHODS

Four sites were selected in the spring of 1980 for this experiment as indicated in Table 1.2.1. Three of the sites were on fields that had previously grown fababeans (Larson, Verwimp, and Murray) while the other site had grown alfalfa from 1973 through 1978 and wheat in 1979 on the alfalfa breaking (Pederson).

The results of the analyses of soil samples taken prior to seeding for the four sites are presented in Table 1.2.2. The results for the individual replicates are presented in Appendix Table A2. The results indicate low to medium soil nitrogen levels (0-60 cm) in which strong nitrogen response would be anticipated. The organic matter content of these soils was all in the range of 2.0 to 2.5%.

Neepawa hard wheat was seeded at the Larson site, Fielder soft wheat at the Verwimp and Murray sites and Harmon oats at the Pederson site. All pre-seeding tillage and seeding operations were as conducted by the cooperating farmer. The Pederson site was cross-seeded at right angles. Phosphorus was applied at rates of 30 to 40 kg P_2O_5/ha during the seeding operation by the cooperating farmer except the Verwimp site which received no phosphorus fertilizer application.

The experimental plot established at each site was of a randomized complete block design containing ten treatments replicated six times. The fertility treatments included a range of nitrogen applications as ammonium nitrate (34-0-0) from 28 to 224 kg N/ha (Table 1.2.3). The fertilizer was broadcast after the field had been seeded. Each individual treatment measured 6 meters x 1.5 meters.

All herbicide applications for weed control and irrigation applications were as conducted by the cooperating farmer. The timing and amounts of irrigation water applied along with the total growing season rainfall are presented in Table 1.2.4.

Table 1.2.1. Farmer cooperator, legal location and soil type for the cereal crop nitrogen correlation experiment on legume stubble.

Farmer Cooperator	Legal Location	Soil Type	Previous Crop
Larson	SW25-30-8-W3	Bradwell: very fine sandy loam	Fababeans
Verwimp	NW31-29-7-W3	Asquith: sandy loam	Fababeans
Murray	SE22-29-7-W3	Elstow: loam	Fababeans
Pederson	SW20-28-7-W3	Elstow: loam	Wheat 1979 Alfalfa 1973-1978

Table 1.2.2. Spring soil analyses for the nitrogen correlation experiments after legumes.

Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^{=}$-S	% Organic Matter
			---------	kg/ha*	-------		
		Larson (Bradwell: very fine sandy loam)					
0-15	7.8	0.2	17	10	562	14	2.3
15-30	8.0	0.3	10	5	351	24+	
30-60	8.3	0.6	41	5	473	48+	
60-90	8.5	0.9	28	4	380	48+	
		Verwimp (Asquith: sandy loam)					
0-15	7.7	0.2	12	6	557	6	2.0
15-30	7.8	0.1	11	4	423	12	
30-60	8.1	0.5	24	5	580	25	
60-90	8.4	0.3	14	5	637	18	
		Murray (Elstow: loam)					
0-15	7.9	0.2	9	13	415	14	2.5
15-30	8.0	0.2	5	6	261	14	
30-60	8.2	1.5	14	7	587	48+	
60-90	8.2	2.6	16	10	637	48+	
		Pederson (Elstow: loam)					
0-15	8.0	0.6	21	6	226	103	2.1
15-30	8.0	0.4	7	3	232	75	
30-60	8.2	0.6	11	4	707	170	
60-90	8.4	0.6	9	13	877	217	
90-120	8.5	0.7	9	25	872	308	

*kg/ha = ppm x 2 for 15 cm depth and ppm x 4 for 30 cm depth.

Table 1.2.3. Fertility treatments used for the nitrogen correlation experiments after legumes.

Treatment Number	N Applied (kg/ha)
1	0
2	28
3	56
4	84
5	112
6	168
7	224
8	0
9	0
10	0

Table 1.2.4. Amounts and timing of irrigation applications for the nitrogen correlation on legume stubble experiments.

Site	Growing Season Rainfall (mm)	Dates and Amounts of Irrigation Applications	Total Water (Irrigation & Rain) (mm)
Larson	54	May 20, 26 mm; June 2, 13 mm; June 5, 26 mm; July 3, 13 mm; July 8, 21 mm; July 17, 25 mm; July 21, 20 mm; July 25, 18 mm; July 31, 12 mm.	228
Verwimp	123	May 19, 10 mm; June 8, 9 mm; June 23, 34 mm; July 18, 13 mm; July 27, 25 mm.	214
Murray	87	Border Dyke	---
Pederson	53	Border Dyke	---

One of the control treatments which received no additional nitrogen (Treatment 8) was used for time-step sampling throughout the growing season. The growth stages at which plant samples were taken included tillering, flag leaf, heading, early milk and maturity. The area sampled was three drill rows over a length of 1 meter. Total above ground dry matter yield was recorded and the samples ground in preparation for total nitrogen, phosphorus and potassium analyses.

At harvest yield samples were taken from all treatments, except Treatment 8, by clipping at the soil surface an area equal to 2 m^2. The samples were dried, weighed and threshed. The grain samples were cleaned and weighed. During the threshing operation subsamples of the straw were bulked for individual replicates and ground. All individual grain samples were mixed and ground. Analyses for total nitrogen, phosphorus and potassium content were determined by wet digestion and colorimetric analysis using a Technicon Auto Analyzer II System.

RESULTS AND DISCUSSION

The results for the time-step sampling are presented in Table 1.2.5. Total above ground yields for all three crops increased with each growth stage sampled. Nitrogen, phosphorus, and potassium contents of the plant material decreased with time. At maturity, nitrogen and phosphorus content of the grain was larger than that of the straw while the opposite was true for potassium. Nitrogen uptake at the four sites was different and could be an indication of the available soil nitrogen. However, the differences could also be due in part to the different crops used as well as differences in cultural and management practices.

The results for the effect of nitrogen fertilization on the yield and nitrogen content of oats grown on land that had produced one crop

Table 1.2.5. The yield and nutrient content of cereal crops at five growth stages grown on legume stubble.

Growth Stage	Number of Days After Seeding	Yield (kg/ha)	% N	Nitrogen Uptake (kg/ha)	% P	% K
		Larson - Neepawa hard wheat				
Tillering	26	136	4.55	5.9	0.502	4.16
Flagleaf	41	885	4.03	36.0	0.430	4.44
Heading	56	1428	2.43	34.2	0.347	2.78
Early Milk	84	4731	1.32	59.4	0.241	1.05
Maturity - grain	104	2908	2.48	72.1	0.470	0.44
- straw		4013	0.31	12.4	0.073	1.83
		Verwimp - Fielder soft wheat				
Tillering	20	185	4.50	8.3	0.400	4.74
Flagleaf*						
Heading	49	1607	2.52	40.4	0.295	2.70
Early Milk	71	2783	1.45	40.4	0.260	1.25
Maturity - grain	106	2070	1.94	40.2	0.376	0.43
- straw		2154	0.32	6.9	0.061	1.82
		Murray - Fielder soft wheat				
Tillering	29	136	4.36	5.9	0.408	3.86
Flagleaf	47	812	2.58	21.8	0.330	3.20
Heading	57	2016	2.14	43.0	0.289	2.36
Early Milk	70	2869	1.17	33.9	0.227	1.11
Maturity - grain	111	2954	2.09	61.7	0.410	0.43
- straw		2610	0.31	8.1	0.078	2.32
		Pederson - Harmon Oats				
Tillering	30	234	3.28	7.7	0.368	2.58
Flagleaf*	49					
Heading	58	2037	1.49	30.3	0.233	2.10
Early Milk	71	2635	1.17	30.7	0.200	1.45
Maturity - grain	106	3799	1.36	51.7	0.328	0.45
- straw		3900	0.20	7.8	0.031	2.38

*Samples lost due to molding.

after alfalfa are presented in Table 1.2.6. The yield data indicate that there was a response to the applied nitrogen and confirms the visual nitrogen deficiency symptoms observed in the early stages of growth. The grain yield was increased from 3800 kg/ha where no additional nitrogen was applied to a maximum yield of 5500 kg/ha where 224 kg N/ha was applied. As well, both grain protein and straw nitrogen content increased as the rate of nitrogen applied was increased.

In 1972, prior to any history of alfalfa production, this same field was capable of producing only 700 kg/ha barley[1]. After five years of alfalfa production from 1973 through to 1978 and one year of wheat production on the alfalfa breaking in 1979, this same field produced 3800 kg/ha oats in 1980 without any additional nitrogen application. Thus, even though there was a response to the applied nitrogen fertilizer, residual nitrogen contributions from the previous history of alfalfa are still evident.

The results for the effect of nitrogen fertilization on the yield and nitrogen content of wheat grown on fababeans stubble are presented in Table 1.2.7. At all three sites grain yields showed some response to the nitrogen fertilization. As well, grain protein and straw nitrogen content increased as the rate of nitrogen applied was increased.

The effects of fababeans in the rotation are not clear in either the Larson or Verwimp experiments. In the case of the Larson experiment residual soil nitrogen levels were medium and large responses to additional nitrogen would not have been anticipated. In the Verwimp experiment overall yield levels were low possibly because of moisture stress.

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[1]McGill, K. S. 1974. 1972 Soil Plant Nutrient Research Report. Department of Soil Science, University of Saskatchewan, Saskatoon, Saskatchewan. pp. 10-16.

Table 1.2.6. The effect of nitrogen fertilization on the yield and nutrient content of oats grown on second year alfalfa stubble (Pederson site).

lbs N/bu	N Applied (kg/ha)	bus	Yield Grain (kg/ha)	Yield Straw (kg/ha)	Grain[1] % Protein	Straw[2] % N	Nitrogen Uptake Grain (kg/ha)	Nitrogen Uptake Straw (kg/ha)	Nitrogen Uptake Total (kg/ha)	%P[2] Grain	%P[2] Straw	%K[2] Grain	%K[2] Straw
.6	0	95	3629	3269	8.0	0.18	53.7	5.9	59.6	0.323	0.030	0.42	2.46
.7	28	111	4226	4125	8.4	0.18	65.5	7.4	72.9	0.313	0.024	0.41	2.43
.7	56	118	4505	4823	9.0	0.21	74.8	10.1	84.9	0.310	0.024	0.41	2.49
.8	84	129	4925	5357	9.6	0.24	87.2	12.9	100.1	0.319	0.027	0.41	2.58
.8	112	134	5092	5553	9.9	0.24	93.7	13.3	107.0	0.315	0.027	0.39	2.46
.95	168	114	4336	6588	10.4	0.39	83.2	25.7	108.9	0.327	0.036	0.43	2.34
.7	224	144	5496	6313	7.1	0.45	72.5	28.4	100.9	0.339	0.027	0.45	2.61
	L.S.D. (P = 0.05)		690										

[1]Grain % protein based on % N at 13.5% moisture x 6.25.

[2]Oven-dry basis.

Table 1.2.7. The effect of nitrogen fertilization on the yield and nutrient content of cereal crops grown on fababean stubble.

N Applied (kg/ha)	Yield Grain (kg/ha)	Yield Straw (kg/ha)	Grain[1] % Protein	Straw[2] % N	Nitrogen Uptake Grain (kg/ha)	Nitrogen Uptake Straw (kg/ha)	Nitrogen Uptake Total (kg/ha)	%P[2] Grain	%P[2] Straw	%K[2] Grain	%K[2] Straw
Larson - Neepawa hard wheat											
0	2734	3752	12.2	0.24	67.5	9.0	76.5	0.473	0.060	0.46	1.77
28	3137	4241	12.7	0.27	80.9	11.5	92.4	0.464	0.054	0.45	2.04
56	3340	4674	13.0	0.33	87.8	15.4	103.2	0.460	0.066	0.45	2.13
84	2750	3894	13.4	0.42	74.8	16.4	91.2	0.453	0.072	0.43	2.10
112	3233	4585	13.8	0.51	90.2	23.4	114.6	0.456	0.060	0.43	2.16
168	2757	4259	14.2	0.51	92.8	21.7	114.5	0.450	0.063	0.43	2.43
224	3219	4647	14.0	0.60	91.4	27.9	119.3	0.432	0.069	0.42	2.58
L.S.D. (P=0.05)	525										
Verwimp - Fielder soft wheat											
0	1787	1980	8.9	0.24	32.3	4.8	37.1	0.402	0.057	0.45	1.77
28	2412	2680	9.8	0.30	47.8	8.0	55.8	0.362	0.048	0.42	2.01
56	2099	2361	11.8	0.54	50.2	12.7	62.9	0.380	0.066	0.45	2.91
84	2765	3245	12.1	0.51	68.0	16.5	84.5	0.352	0.045	0.42	2.76
112	2635	2911	12.1	0.54	64.6	15.7	80.3	0.344	0.051	0.47	2.97
168	2446	2970	13.5	0.78	67.0	23.2	90.2	0.359	0.063	0.42	3.03
224	2623	3333	13.5	0.78	71.6	26.0	97.6	0.355	0.057	0.42	3.21
L.S.D. (P=0.05)	352										
Murray - Fielder soft wheat											
0	3375	3071	11.4	0.33	78.3	10.1	88.4	0.408	0.084	0.42	2.25
28	4038	3382	10.4	0.33	84.8	11.2	96.0	0.391	0.069	0.42	2.52
56	3867	3590	9.8	0.27	77.0	9.7	86.7	0.354	0.054	0.37	2.28
84	4111	3935	10.8	0.45	90.4	17.7	108.1	0.344	0.057	0.36	2.88
112	4555	4445	10.4	0.42	95.7	18.7	114.4	0.364	0.048	0.40	2.94
168	4487	4638	11.3	0.66	103.2	30.6	133.8	0.365	0.063	0.39	3.03
224	4556	4707	11.8	0.84	108.9	39.5	148.4	0.363	0.066	0.39	3.45
L.S.D. (P=0.05)	821										

[1] Grain % protein based on % N at 13.5% moisture x 5.7.

[2] Oven-dry basis.

The specific small plot experimental location was on very sandy soil requiring more frequent irrigation than the remainder of the field. Hence, moisture stress was noted in the experiment.

At the Murray site the soil nitrogen level (0-60 cm) was only 28 kg/ha and at this soil nitrogen level a yield of 3000 kg/ha wheat, without additional nitrogen, would not be possible on land continuously cropped to cereals. Therefore, this experiment indicates that the previous year's crop of fababeans provided a residual nitrogen contribution to the soft wheat crop in 1980.

At the Murray site, it was also noted in field observations that volunteer fababeans were achieving greater growth in the control plots than in those amended with nitrogen. Therefore, when the experiment was harvested the entire plant material from the harvest area was removed and fababeans material was separated from wheat.

The results obtained for the total dry matter yield of the volunteer fababeans are presented in Table 1.2.8. The results clearly confirm the field observations that the volunteer fababean growth was much greater where additional nitrogen had not been added. Where no additional nitrogen was added the fababeans had a competitive advantage over the wheat in that they could obtain nitrogen through nitrogen fixation. Where additional nitrogen was added the wheat had a competitive advantage. As well, the presence of fertilizer nitrogen could have inhibited the growth of the fababeans.

CONCLUSION

Residual nitrogen contributions to a cereal crop following alfalfa in the rotation were found to still be significant for the second crop

Table 1.2.8. Total dry matter yield of volunteer fababeans in soft wheat on fababean stubble nitrogen correlation experiment (Murray site).

Nitrogen Applied (kg/ha)	Volunteer Fababean Total Dry Matter Yield (kg/ha)
0	527
28	328
56	205
84	217
112	117
168	154
224	159
0	988
0	623

after alfalfa was taken out of production.

The effects of annual legume crops such as fababeans in the rotation with cereal crops is not as clear. Furthermore, extensive work will be required to document the residual nitrogen contribution of annual legume crops.

2.0 The Agricultural Use of Potash in Saskatchewan

INTRODUCTION

Potassium research in Saskatchewan agriculture began as early as 1951. Several research programs were conducted during the period 1951-1963. A concentrated program of research on potassium in Saskatchewan soils was begun by the Soil Science Department, University of Saskatchewan in 1967 as a result of new information made available through the Soil Testing Laboratory. This work has been reported in annual Soil Plant Nutrient Research Reports of the Soil Science Department and was summarized by J.W. Hamm and J.L. Henry in a paper in the Soil Fertility Workshop Proceedings of the University Extension Division in 1973.

Work up to 1972 showed clearly that Carrot River soils in the immediate vicinity of Carrot River town were severely deficient in potassium and that other sandy, grey soils were also potassium deficient. On the basis of the earlier work, it had been estimated that there were a potential two million acres of potassium deficient soils in Saskatchewan. The earlier work also resulted in the development of reasonably sound soil test bench marks such that severely potassium deficient soils could be predicted on the basis of a soil test. This information was incorporated in a modified set of soil test bench marks in 1973. At the end of the 1972 field program, it was considered that the most pressing problems with respect to potash had been solved and work on other nutrients received higher priority in the intervening seven years.

In the meantime, more recent information from Montana has suggested that potassium responses may occur even under soil conditions where existing tests indicate a high level of available potassium. Most of the significant responses were with winter wheat, barley, alfalfa, or potatoes. During the time period that Montana work has been going on, there has been no existing field research program on potassium in Saskatchewan.

In light of the background information provided above, the Soil Science Department, University of Saskatchewan prepared and presented a proposed program of research to the Potash Corporation of Saskatchewan. The Potash Corporation subsequently funded a program whose objectives are as follows:

1. To extend potassium soil test bench mark correlation work to soils not currently considered potassium deficient.

2. To determine possible residual responses to potassium on known potassium deficient soils and to relate these responses to soil mineralogy.

3. To determine the potassium requirements of selected irrigated crops such as alfalfa and potatoes.

4. To document potassium uptake levels of Saskatchewan crops.

5. To summarize existing potassium soil test data in Saskatchewan.

This document constitutes the report of the first of a three-year program to meet the above stated objectives.

2.1 Potassium status of Saskatchewan soils

Since its inception in 1966, the Saskatchewan Soil Testing Laboratory has measured available potassium on all samples submitted for routine analysis. During the years 1966 and 1967, the laboratory used ammonium acetate to determine the exchangeable potassium levels and utilize this as the potassium index. In the years 1968 and onwards, this extraction procedure was changed such that potassium extracted by 0.5 N $NaHCO_3$ was utilized as an index of potassium availability. Considerable developmental and comparative analysis were run between the exchangeable and $NaHCO_3$ extractable potassium levels. This work, conducted by the laboratory director, Dr. E.H. Halstead, indicated that $NaHCO_3$ extractable levels on most soils were about 2/3 of that obtained with ammonium acetate and the soil test potassium bench marks were altered accordingly. On some soils, notably some heavy clay soils, the levels extracted by $NaHCO_3$ actually exceeded that extracted by ammonium acetate, but on these soils, the levels were far beyond any suggestion of deficient levels regardless of the extraction method.

In that the same extraction has been utilized for available potassium from 1968 through 1979, this data source was utilized to summarize the available potassium status of Saskatchewan soils. The data base available for such comparison included approximately 45,000 farm fields measured over that time period.

This summary data shows a gradual decline in the soil potassium status in moving from the Brown to Grey soil zones in Saskatchewan (Table 2.1.1). Work by Dr. P.M. Huang, Soil Science Department, University of Saskatchewan has shown that this decline in available potassium status is due in part to the greater leaching conditions in the more humid northeast as opposed to the more arid southwest regions of Saskatchewan and also due to the fundamental mineralogy of soils in these regions. Soils in southwestern Saskatchewan are more dominated by micaceous potassium bearing minerals whereas those in the northeast region are more dominated by feldspathic potassium bearing minerals that release potassium more slowly.

Table 2.1.1. AVAILABLE K STATUS OF SASKATCHEWAN SOILS BY SOIL ZONE - 11 YEAR AVERAGE 1968-1979 ($NaHCO_3$ Extractable K - kg/ha)

Depth (cm)	Brown	Dark Brown	Black	Thick Black	Grey Black	Grey	Total
			Summerfallow (19314 fields)				
0-15	600	631	482	453	326	306	500
15-30	425	416	327	314	244	240	344
30-60	780	727	581	576	459	455	620
			Stubble (25669 fields)				
0-15	646	620	502	471	326	291	495
15-30	473	409	333	331	243	228	341
30-60	872	720	588	572	453	438	610

Source: Saskatchewan Soil Testing Laboratory - Soil Association Summaries

These data also show clearly that there is little or no difference between the available potassium status of stubble or summerfallow fields.

The effect of soil zone within one parent material type and of texture within one soil zone is presented in Tables 2.1.2 and 2.1.3. Within glacial till material, the same zonal effect is noted--i.e. higher available potassium levels are measured in the Brown and Dark Brown soil zones than in other more humid areas.

The texture effect is as would be expected in that the finer textured soils are higher in available potassium than are coarse textured soils. This effect is more marked in the Black soil zone (i.e. Meota vs. Indian Head) than it is in the Brown soil zone (Hatton vs. Sceptre).

A special note should be made of the Carrot River soil association. This soil association is shown in Tables 2.1.2 and 2.1.3 as a Thick Black but in the actual published soil survey information, it is referred to as Grey Black. Carrot River soils exist only in the Carrot River and Hudson Bay areas and within the confines of glacial Lake Agassiz. This soil is very sandy in the upper few meters but has been developed under conditions of poor drainage, resulting in high lime concentrations and in varying degrees of peat accumulation on the soil surface. This combination of soil formation factors has resulted in a soil with an average available potassium level of about 130 kg K per hectare in the upper 15 centimeters. Individual samples with available levels as low as 50 kg/ha to 15 cm have been measured.

Examination of available potassium levels of selected soil associations revealed differences between soils that are known by the author to exist only in certain geographic areas of the province. This

Table 2.1.2. AVAILABLE K STATUS OF GLACIAL TILL AND ALLUVIAL LACUSTRINE SOILS ON FALLOW (11 YEAR AVERAGE 1968-79)

$NaHCO_3$ Extractable K - kg/ha

Soil Zone Depth (cm)	Till	Alluvial Lacustrine Coarse	Alluvial Lacustrine Medium	Alluvial Lacustrine Fine
Brown	Haverhill	Hatton	Fox Valley	Sceptre
0-15	596	522	569	611
15-30	406	335	369	461
30-60	743	581	653	856
Dark Brown	Weyburn	Asquith	Elstow	Regina
0-15	618	516	675	667
15-30	392	331	434	479
30-60	681	572	734	857
Black	Oxbow	Meota	Blaine Lake	Indian Head
0-15	482	358	540	657
15-30	329	243	340	475
30-60	577	446	599	807
Thick Black	Yorkton	(Carrot River*)	Meadow Lake	Melfort
0-15	390	130	261	598
15-30	277	97	202	406
30-60	489	199	500	748
Grey Black	Whitewood	Shellbrook	Beaver River	Tisdale
0-15	331	341	284	425
15-30	261	235	212	319
30-60	484	421	465	611
Grey	Waitville	Sylvania	Dorintosh	Arborfield
0-15	333	215	316	444
15-30	275	161	237	343
30-60	505	337	504	650

* Carrot River is classified as Grey-Black

Table 2.1.3. AVAILABLE K STATUS OF GLACIAL TILL AND ALLUVIAL LACUSTRINE SOILS ON STUBBLE (11 YEAR AVERAGE 1968-79)

$NaHCO_3$ Extractable K - kg/ha

Soil Zone Depth (cm)	Till	Alluvial Lacustrine Coarse	Alluvial Lacustrine Medium	Alluvial Lacustrine Fine
Brown	Haverhill	Hatton	Fox Valley	Sceptre
0-15	630	533	648	640
15-30	427	340	442	480
30-60	775	585	780	878
Dark Brown	Weyburn	Asquith	Elstow	Regina
0-15	614	489	657	678
15-30	400	334	399	472
30-60	714	567	697	829
Black	Oxbow	Meota	Blaine Lake	Indian Head
0-15	496	403	557	605
15-30	334	264	353	425
30-60	588	472	613	726
Thick Black	Yorkton	(Carrot River*)	Meadow Lake	Melfort
0-15	374	135	263	603
15-30	261	102	207	412
30-60	465	202	477	692
Grey Black	Whitewood	Shellbrook	Beaver River	Tisdale
0-15	349	342	266	419
15-30	269	243	227	310
30-60	494	4445	489	593
Grey	Waitville	Sylvania	Dorintosh	Arborfield
0-15	307	239	285	421
15-30	260	178	227	306
30-60	484	346	472	607

*Carrot River is classified as Grey Black data (Table 2.1.4) shows that certain soils that exist only in northwestern Saskatchewan tend to be considerably lower than soils that exist through central and eastern Saskatchewan but are otherwise considered to be comparable in terms of parent material. For example, Loon River soil exists only in the area west and north of Meadow Lake and is a Grey Wooded soil that is quite highly leached. Waitville is a soil occurring in eastern and northeastern Saskatchewan but otherwise being similar in parent material composition to Loon River.

Further mineralogical investigations will be required to determine the reasons for these apparent differences.

Appendix Table B1 provides information on the number of fields that were summarized in the various tables in this section.

EXPERIMENTAL METHODS

In 1980, a total of 11 field experiments were conducted in which potassium fertilization was the experimental variable. These experiments were at widely scattered locations throughout Saskatchewan (Figure 2.1.1).

Two basic types of experiments were conducted. The first type of experiment was designated as a potassium survey experiment. Six such experiments were conducted in which cereals were utilized, three with alfalfa and one with potatoes. All were on dry land except the potato experiment which was under a pivot type sprinkler irrigation system. All except one of the potassium survey experiments were conducted on soils in which the potassium level is above that currently considered to be potassium deficient by existing soil test bench marks in Saskatchewan (see Appendix B2 for these bench marks). The rates, experimental design, plot size and information on other nutrients supplied by the field crews of the University are presented in

Table 2.1.4. AVAILABLE K STATUS OF SELECTED SOILS FROM WESTERN AND EASTERN SASKATCHEWAN (11 YEAR AVERAGE 1968-79)

$NaHCO_3$ Extractable K - kg/ha - average of fallow and stubble

NORTHWEST SASK.		EAST and NORTHEAST SASK.	
GLACIAL TILL			
Dark Grey - Horsehead	197 162 344	Whitewood	340 265 489
Grey - Loon River	203 182 387	Waitville	320 267 495
WATER MODIFIED GLACIAL TILL			
Dark Grey - Makwa	170 145 314	Pelly	327 245 443
MEDIUM TEXTURED LACUSTRINE			
Black - Meadow Lake	262 205 489	Canora	463 340 578
Dark Grey - Beaver River	275 220 477	Kamsack	398 282 524
Grey - Dorintosh	292 230 480	Nipawin	302 237 434

Figure 2.1.1. Location of potassium experiments.

Table 2.1.5. Other information on crop variety, legal location, past cropping, and other nutrient applications made by the farmer are presented in Table 2.1.6.

A second type of experiment was conducted in which the objective was to trace the residual response to applications made in 1980 and to compare single large applications with more frequent applications. The rate structure, experimental design type, and other information is given for this experiment in Table 2.1.5 and 2.1.6.

All cultivation, seeding, herbicide and other weed control measures and all agronomic operations except for the application of potassium fertilizer and the application of certain other fertilizers designed to ensure adequate levels of all nutrients, where as conducted by the cooperating farmer. Potassium applications were as 0-0-60 applied as a broadcast application prior to seeding for all annual crops and as a broadcast application on the established alfalfa stands. All broadcast applications were done in the early spring (late April or early May).

Soil samples were removed from each replicate of all experiments except the Hogg experiment in which case three sets of soil samples were removed. Soil samples were taken to a depth of 120 cm in cases where a soil coring truck was available and on site. In other instances, soil samples were taken to a depth of 60 cm. All soil analysis were conducted by the Saskatchewan Soil Testing Laboratory. This laboratory uses a $NaHCO_3$ extraction for measurement of nitrate nitrogen, phosphorus and potassium, and a calcium chloride extraction to measure sulfur and it conducts pH and conductivity measurements on a 1;1 suspension. Organic matter is by a Walkely-Black oxidation and

Table 2.1.5. EXPERIMENT TYPES, RATES, DESIGN, SIZE, AND OTHER NUTRIENT APPLICATIONS

Experiment Type	No. of Experiments	Rates kg K_2O/ha	Design	Plot Size m^2	Other Nutrients Applied by us
Survey - Cereals	6	0 25 50 100 200 400	Latin Square 6 reps.	25	N-100 kg/ha S-32 kg/ha as 34-0-0-11
Survey - Alfalfa	3	0 25 50 100 200 400	Latin Square 6 reps.	25	P_2O_5-100 kg/ha as 0-45-0 S-50 kg/ha as gypsum
Survey - Potatoes (Irrigation)	1	0 25 50 100 200 400	Latin Square 6 reps.	75	- all other fertilizers applied by farmer
Residual	1	0 30 60 120 240 480 - above rates once only in 1980 - also 1/3 of above rates each year for 3 years	Split plot 4 reps. - Rate as main plot and application schedule as subplot	25	- P_2O_5 - 50 kg/ha as 0-45-0 - N - 100 kg/ha - S - 32 kg/ha - N and S as 34-0-0-11

Table 2.1.6. LEGAL LOCATIONS AND AGRONOMIC INFORMATION ON EXPERIMENTAL SITES

Farmer	Crop	Variety	N	P_2O_5	S	Legal Location	Other Comments
			Nutrients Applied by Farmer -----kg/ha-----				
			K Survey - Cereals				
Armstrong	Barley	Klondike	65	40	20	NE 2-50-13-2	- 9th crop
Pocock	Barley	Klages	105	20	15	SW 11-51-14-2	- stubble
Wilkinson	Barley	Conquest	80	20	0	SE 17-39-2-3	- stubble
Hogg	Wheat	Neepawa	10	30	0	SW 3-4-30-1	- summerfallow
Horn	Wheat	Canuck	8	35	0	SW 22-9-18-3	- summerfallow
Reed	Wheat	Neepawa	95	35	0	SE 27-43-8-2	- stubble
			K Survey - Alfalfa				
Mumm	Seed Alfalfa	Beaver	0	0	40	NE 16-48-3-3	- established 1978. First seed crop in 1979
Espenant	Alfalfa	Beaver	0	0	0	SE 15-42-2-2	- established 1978
Pocock	- 75% Alfalfa - 25% Intermediate Wheat & orchard grass	Beaver				SW 11-51-14-2	- established 1978
			K Survey - Potatoes				
Barrich Farms	Potatoes	Norland	85	85 sideband	0	SE 35-29-8-3	- irrigated
			K Residual				
Kellett	Rapeseed	Altex	7	20	0	NW 31-49-12-3	- herbicide (cobex) spill on one side of plot added variability

percentage clay is as determined by a pipette type particle size analysis. Exchangeable cations are those determined on an ammonium acetate extract.

At harvest time for cereal and oilseed crops, a sample was removed from each treatment of each replicate from a 2 m^2 area with samples being cut at the soil surface. After drying, total weights were obtained prior to threshing. During the threshing operation, all replicates of an individual treatment were passed through the threshing machine in order. As each replicate passed through, a grab sample of straw was placed into a Wiley mill. Thus, when threshing is complete, a composite sample of the straw is available for analysis. Straw weight was obtained as the difference between total and grain weight.

In the alfalfa experiment, samples were cut at approximately a 10 cm height using a Motte forage harvestor which is 60 cm wide. A sample size of approximately 60 cm by 5 m was obtained and wet weight taken directly in the field. A 500 gm grab sample of the chopped material from the Motte harvestor was returned to the laboratory for drying and subsequent analysis. These dry weights were then used to calculate the field dry weight yields.

In the potato experiment, the plot size was such that an individual treatment covered three rows (row spacing approximately 2.8 meters). A length of 10 meters from one row from each plot was dug with a one-row potato harvestor. A weight was obtained on this size in the field and a subsample of approximately 10 kg was brought to the laboratory for specific gravity and moisture determination. Core samples were taken from the tubers and this material oven dried prior to chemical analysis. Potato tops were removed from the sample area one week prior to digging the tubers. This material was dried for subsequent analysis. Unfortunately, the yields were not recorded for the tops.

Chemical analysis of total nitrogen, phosphorus, and potassium on all plant materials was conducted by standard wet digestion and chemical assay by the Saskatchewan Soil Testing Laboratory.

The yield data and potassium uptake data was subjected to regression analysis with potassium application rate as the independent variable and yield or potassium concentration or potassium uptake as the dependent variable. In cases where the correlation coefficient was significant at the 5% level of probability, the coefficient of determination (R2) is reported.

RESULTS AND DISCUSSION

Soil analysis results are presented in Table 2.1.7. Levels of available N, P, K, and S are reported as kg/ha which was obtained by multiplying the concentration in ppm x 2 for a 15 cm layer and x 4 for a 30 cm layer. Thus, they can be directly related to soil test results as now reported on farm reports in lbs/acre with no conversion necessary.

Available potassium levels throughout all experiments varied from lows of 93 and 96 kg/ha to 15 cm at the Espenant and Kellett experiments respectively to high values of 788 and 795 on the Wilkinson and Horn experiments.

Within the cereal grains, nitrogen was a serious limiting factor on the Reed, Pocock, and Armstrong experiments; at a moderate level in the Wilkinson and Horn experiment; and in adequate quantities at the Hogg experiment. Phosphorus was limiting to more or less degrees on all experiments. It is interesting to note the high phosphorus

Table 2.1.7. **ANALYSIS OF SOIL SAMPLES TAKEN PRIOR TO SEEDING**

A. Potassium survey experiments with cereal crops

Farmer; Town Soil Association: Texture Crop	Depth cm	N	P	K	S	pH	Cond. mmhos/cm	Organic Matter (%)	Clay (%)	Na	Ca	Mg	K
		----- kg/ha			-----					---------m.e./100 g			-------
G. Armstrong;	0-15	7	7	255	19+	7.8	0.3	4.9	23	0.04	22.3	6.3	0.38
Nipawin	15-30	4	4	231	21+	8.0	0.3	1.5	24	0.04	17.4	6.0	0.32
Weirdale:	30-60	4	7	423	39+	8.1	0.3	---	25	0.04	21.9	5.7	0.27
loam	60-90	4	6	368	31+	8.1	0.3	---	21	0.04	20.6	4.3	0.19
Barley	90-120	5	4	393	22	8.1	0.2	---	19	0.04	20.3	4.2	0.18
D. Pocock;	0-15	8	24	299	19+	7.0	0.1	2.3	14	0.05	9.1	1.8	0.36
Nipawin	15-30	5	17	190	12	7.0	0.1	0.8	26	0.07	12.6	3.2	0.34
Nipawin:	30-60	6	29	265	23	7.2	0.2	---	14	0.07	17.9	2.8	0.19
loam	60-90	7	15	227	27	7.8	0.2	---	11	0.06	17.2	2.1	0.13
Barley	90-120	7	14	248	22	7.9	0.2	---	10	0.07	20.4	2.9	0.16
T. Hogg;	0-15	53	16	683	24+	7.2	0.8	5.3	24	0.21	17.8	6.0	1.20
Gainsborough	15-30	27	9	350	24+	7.7	0.9	---	23	0.44	20.6	7.7	0.60
Oxbow:	30-60	31	12	420	48+	7.9	2.2	---	19	1.20	21.6	8.9	0.36
loam													
Wheat													
V. Horn;	0-15	30	8	795	6	6.5	0.3	2.9	27	0.07	11.5	4.3	1.29
Shaunavon	15-30	18	5	638	3	6.7	0.2	---	28	0.07	11.9	5.1	1.03
Cypress:	30-60	26	7	1097	6	6.7	0.3	---	28	0.09	18.5	6.3	0.82
loam													
Wheat													
K. Wilkinson;	0-15	24	16	788	24+	7.4	0.6	4.0	44	0.13	17.6	10.6	1.35
Aberdeen	15-30	15	10	592	24+	7.3	0.8	---	40	0.20	16.9	10.2	0.91
Sutherland:	30-60	17	13	945	48+	7.4	1.7	---	38	0.56	17.2	11.1	0.70
Clay													
Barley													
G. Reed;	0-15	9	7	153	6	7.6	0.2	2.8	9	0.06	10.6	2.0	0.16
Porcupine Plain	15-30	7	6	142	6	7.6	0.1	---	10	0.06	13.0	2.1	0.17
Shellbrook:	30-60	11	7	255	6	7.7	0.2	---	12	0.06	15.0	2.2	0.15
Sandy Loam													

Table 2.1.7. (continued)

B. Potassium survey experiments with alfalfa

Farmer; Town Soil Association: Texture Crop	Depth cm	N	P	K	S	pH	Cond. mmhos/cm	Organic Matter (%)	Clay (%)	Exchangeable cations Na	Ca	Mg	K
		kg/ha								m.e./100 g			
J. Mumm;	0-15	3	9	312	6	6.5	0.1	2.7	8	0.04	6.0	1.4	0.34
Shellbrook	15-30	2	7	238	3	6.6	0.1	---	12	0.04	4.5	1.3	0.18
Shellbrook:	30-60	2	13	407	5	6.8	0.1	---	8	0.04	4.3	1.6	0.21
Sandy Loam	60-90	3	17	472	3	6.9	0.1	---	8	0.04	4.7	1.6	0.27
alfalfa-seed	90-120	4	16	413	2	6.9	0.1	---	7	0.04	4.7	1.7	0.25
H. Espenant;	0-15	5	3	93	15	8.1	0.3	4.6	9	0.04	21.4	7.0	0.10
Hudson Bay	15-30	3	2	63	10	8.3	0.3	2.3	7	0.04	17.9	6.5	0.06
Carrot River:	30-60	3	3	117	35+	8.5	0.3	---	6	0.09	15.2	4.0	0.05
Fine sandy loam	60-90	3	3	175	43+	8.5	0.3	---	13	0.18	15.9	4.8	0.09
alfalfa-hay	90-120	4	3	270	41+	8.3	0.4	---	13	0.40	16.8	6.9	0.17
D. Pocock;	0-15	4	16	288	4	7.1	0.1	3.3	14	0.07	11.4	1.8	0.44
Nipawin	15-30	3	23	195	3	7.0	0.1	1.0	21	0.08	11.3	2.9	0.29
Nipawin:	30-60	5	38	293	4	7.0	0.1	---	16	0.09	12.0	2.2	0.19
Loam	60-90	5	26	277	11+	7.6	0.1	---	6	0.08	15.0	1.8	0.13
alfalfa-grasshay	90-120	6	17	220	4	8.1	0.1	---	2	0.08	15.4	1.8	0.11

C. Residual potassium experiment

Farmer; Town Soil Association: Texture Crop	Depth cm	N	P	K	S	pH	Cond. mmhos/cm	Organic Matter (%)	Clay (%)	Na	Ca	Mg	K
J. Kellett;	0-15	65	8	96	24+	8.0	0.7	5.4	12	0.28	22.8	12.3	0.11
Carrot River	15-30	11	4	79	19+	8.5	0.2	---	9	0.29	19.0	9.3	0.10
Carrot River:	30-60	14	5	135	42+	8.6	0.2	---	6	0.29	18.1	5.8	0.05
Fine sandy loam	60-90	14	4	135	34+	8.7	0.2	---	5	0.21	18.8	3.3	0.04
	90-120	19	4	168	29	8.5	0.2	---	7	0.28	20.0	5.3	0.06

D. Potassium experiment with potatoes

Farmer; Town Soil Association: Texture Crop	Depth cm	N	P	K	S	pH	Cond. mmhos/cm	Organic Matter (%)	Clay (%)	Na	Ca	Mg	K
Barrich Farms;	0-15	18	34	313	7	7.7	0.2	2.4	12	0.16	12.0	3.5	0.40
Outlook	15-30	11	23	167	15	7.9	0.2	---	12	0.18	14.6	3.2	0.22
Bradwell:	30-60	32	22	213	48+	8.1	0.3	---	7	0.10	19.3	4.3	0.15
very fine	60-90	20	14	248	25	8.5	0.2	---	5	0.07	15.9	4.7	0.14
sandy loam	90-120	17	12	292	18	8.8	0.2	---	7	0.09	14.7	7.0	0.15

analysis on the Pocock experiment at Nipawin and that these relatively high values also continue to some depth in the soil. Sulfur was limiting at the Reed and Horn experiments but adequate at all others. No significant salts were present in any of these experiments. Organic matter levels ranged from 2.3 (Pocock) to 5.4 (Kellett).

In the alfalfa experiments, the Espenant experiment at Hudson Bay was in a range definitely deficient for potassium. This experiment was conducted even though the original objectives indicated seeking only medium to high soil tests for known potassium sensitive crops. This was because experiments have not been done with potassium on Carrot River soils in the Hudson Bay region, and it will be desirable to determine if the Carrot River soils in this region are as severely deficient in potassium as similar soils in the Carrot River region. The other two experiments were at higher levels of available potassium. Phosphorus was a severely limiting factor at the Espenant site, and it is unlikely that full benefit to potassium fertilization will take place until the phosphorus level of the soil is built up. Similarly, the Shellbrook and Nipawin soils were severely deficient in sulfur, and potassium responses will not be likely until sulfur deficiencies are overcome. The Carrot River soil also exhibits a relatively high exchangeable calcium level and, in fact, free lime at the surface is a frequent occurrence on Carrot River soil. This undoubtedly contributes to the seriousness of potassium deficiencies on this particular soil.

The soil selected for the residual potassium experiment was on land that had been fallowed in 1979 and hence, had a high level of residual nitrogen in the nitrate form. Phosphorus was again severely deficient and exchangeable calcium at a high level. The soil selected for the experiment for potatoes had a relatively high phosphorus level which is due to residual effects of high phosphorus fertilizer applications which are commonly encountered under the irrigated cropping program in that region. That particular soil had also received some potassium fertilizer (130 kg K_2O/ha) in 1975.

At the Espenant site on Carrot River soil near Hudson Bay, it was noted that alfalfa growing within the burn rows was growing at a much higher level than in the general field. The farmer also reported that this was a common occurrence in the area and had occurred on this field since it had been brought into cultivation. For this reason, samples were taken from burn rows adjacent to the plot to compare with the soil analysis from the experiment which was placed in such a manner as to not encounter any burn rows. This data (Table 2.1.8) indicates clearly the build up that has occurred of phosphorus and potassium to some considerable depth in the soil due to the nutrients accumulated by pushing the trees and other materials into rows and burning them in that location.

Observation of the experimental area in July also showed a strong interaction between the residual soil fertility from the burning and weed infestation. Within the burn rows where alfalfa was actively growing, essentially no weeds are present. In the general field area where both the phosphorus and potassium levels were extremely low, dandelion was a serious problem. This observation is recorded on 35 mm slide film for use in extension purposes.

Yield, N, P, K analysis and nutrient uptake for the potassium survey experiments with cereal grains are presented in Table 2.1.9.

Table 2.1.8. SOIL ANALYSIS FROM BURN ROWS AND UNAFFECTED PLOT AREA ON ESPENANT FARM AT ERWOOD

Sample Depth (cm)	N		P		K		S		pH	
	Plot*	Burn* Row	Plot	Burn Row	Plot	Burn Row	Plot	Burn Row	Plot	Burn Row
0-15	5	19	3	32	93	215	15	24+	8.1	7.9
15-30	3	10	2	17	63	93	10	13	8.3	8.3
30-60	3	11	3	18	117	155	35+	33+	8.5	8.4
60-90	3	8	3	12	175	210	43+	38+	8.5	8.4
90-120	4	9	3	9	270	290	41+	48+	8.3	8.3

Samples Taken - April 30, 1980

Soil: Carrot River: fine sandy loam

Location: SE15-42-2-2

*Plot - is composite of 6 replicates of K experiment laid down on alfalfa on the day samples were taken.

*Burn Row - is the average of samples taken in the burn rows immediately north and south of the plot area.

Table 2.1.9. (Armstrong)

YIELD AND NUTRIENT UPTAKE DATA FOR K SURVEY EXPERIMENTS WITH CEREAL CROPS

Farmer Soil Crop	K_2O Applied kg/ha	Yield Grain kg/ha	Yield Straw kg/ha	Yield Total kg/ha	N % Grain	P % Grain	K % Grain	Uptake N kg/ha Grain	Uptake P kg/ha Grain	Uptake K kg/ha Grain
Armstrong	0	4346	3891	8237	1.95	0.25	0.43	85	10.9	18.7
Weirdale:	25	4683	4261	8944	1.97	0.22	0.45	92	10.3	21.1
loam	50	4461	4149	8610	1.92	0.24	0.45	86	10.7	20.1
Barley	100	4722	4344	9066	1.97	0.25	0.47	93	11.8	22.2
	200	4800	4220	9020	1.88	0.25	0.48	90	12.0	23.0
	400	5056	4227	9283	1.76	0.26	0.46	89	11.6	23.3
	R^2	.80	N.S.	.56	----	----	N.S.	--	----	.66

	K_2O Applied kg/ha	Total Uptake N kg/ha	Total Uptake P kg/ha	Total Uptake K kg/ha	N % Straw	P % Straw	K % Straw	Uptake N kg/ha Straw	Uptake P kg/ha Straw	Uptake K kg/ha Straw
	0	120	13.2	89.9	0.90	0.06	1.83	35	2.3	71.2
	25	127	11.5	109.3	0.81	0.03	2.07	35	1.3	88.2
	50	113	11.9	98.5	0.66	0.03	1.89	27	1.2	73.4
	100	120	13.1	118.6	0.63	0.03	2.22	27	1.3	96.4
	200	116	13.3	105.3	0.60	0.03	1.95	25	1.3	82.3
	400	118	12.9	143.8	0.69	0.03	2.85	29	1.3	120.5
	R^2	---	----	.74	----	----	.74	--	---	.71

Table 2.1.9. (Pocock)

YIELD AND NUTRIENT UPTAKE DATA FOR K SURVEY EXPERIMENTS WITH CEREAL CROPS

Farmer Soil Crop	K_2O Applied kg/ha	Yield Grain (kg/ha)	Yield Straw (kg/ha)	Yield Total (kg/ha)	N % Grain	P % Grain	K % Grain	Uptake N kg/ha Grain	Uptake P kg/ha Grain	Uptake K kg/ha Grain
Pocock	0	4116	4943	9057	2.14	0.36	0.41	88	14.8	16.9
Nipawin:	25	3676	4657	8333	2.26	0.34	0.40	83	12.5	14.7
loam	50	3427	4748	8175	2.22	0.36	0.41	76	12.3	14.1
Barley	100	3702	4638	8340	2.26	0.34	0.41	84	12.6	15.2
	200	3863	5125	8988	2.25	0.33	0.43	87	12.7	16.6
	400	3381	4501	7882	2.27	0.34	0.44	77	11.5	14.9
	R^2	N.S.	N.S.	N.S.	----	----	.87	--	----	N.S.

K_2O Applied kg/ha	Total Uptake N kg/ha	Total Uptake P kg/ha	Total Uptake K kg/ha	N % Straw	P % Straw	K % Straw	Uptake N kg/ha Straw	Uptake P kg/ha Straw	Uptake K kg/ha Straw
0	124	17.8	71.8	0.72	0.06	1.11	36	3.0	54.9
25	125	16.7	72.0	0.90	0.09	1.23	42	4.2	57.3
50	119	16.6	82.5	0.90	0.09	1.44	43	4.3	68.4
100	122	15.4	73.6	0.81	0.06	1.26	38	2.8	58.4
200	133	17.3	104.2	0.90	0.09	1.71	46	4.6	87.6
400	120	15.6	85.1	0.96	0.09	1.56	43	4.1	70.2
R^2	---	----	N.S.	----	----	.76(2)	--	---	.67(2)

Table 2.1.9. (Wilkinson)

YIELD AND NUTRIENT UPTAKE DATA FOR K SURVEY EXPERIMENTS WITH CEREAL CROPS

Farmer Soil Crop	K_2O Applied kg/ha	Grain (Yield kg/ha)	Straw (Yield kg/ha)	Total (Yield kg/ha)	N (% Grain)	P (% Grain)	K (% Grain)	N (Uptake kg/ha Grain)	P (Uptake kg/ha Grain)	K (Uptake kg/ha Grain)
Wilkinson	0	2077	2149	4225	2.38	0.26	0.35	49	5.4	7.3
Sutherland	25	2099	2053	4152	2.30	0.25	0.32	48	5.2	6.7
Clay	50	2073	2339	4412	2.36	0.28	0.34	49	5.8	7.0
Barley	100	2087	2308	4395	2.16	0.23	0.29	45	4.8	6.1
	200	2123	2228	4351	2.11	0.23	0.28	45	4.9	5.9
	400	2138	2402	4540	2.16	0.25	0.31	46	5.3	6.6
	R^2	.80	N.S.	.62	----	----	N.S.	--	---	N.S.

K_2O Applied kg/ha	N (Total Uptake kg/ha)	P (Total Uptake kg/ha)	K (Total Uptake kg/ha)	N (% Straw)	P (% Straw)	K (% Straw)	N (Uptake kg/ha Straw)	P (Uptake kg/ha Straw)	K (Uptake kg/ha Straw)
0	65	6.0	56:3	0.75	0.03	2.28	16	0.6	49.0
25	64	6.4	56.7	0.78	0.06	2.43	16	1.2	50.0
50	68	7.2	68.0	0.81	0.06	2.61	19	1.4	61.0
100	63	6.2	60.8	0.78	0.06	2.37	18	1.4	54.7
200	66	6.2	71.4	0.96	0.06	2.94	21	1.3	65.5
400	66	7.2	92.4	0.81	0.08	3.57	20	1.9	85.8
R^2	--	---	.91	----	----	.93	--	---	.93

Table 2.1.9. (Horn)

YIELD AND NUTRIENT UPTAKE DATA FOR K SURVEY EXPERIMENTS WITH CEREAL CROPS

Farmer Soil Crop	K_2O Applied kg/ha	Grain (Yield, kg/ha)	Straw (Yield, kg/ha)	Total (Yield, kg/ha)	N (% Grain)	P (% Grain)	K (% Grain)	N (Uptake kg/ha Grain)	P (Uptake kg/ha Grain)	K (Uptake kg/ha Grain)
Horn	0	3354	6211	9565	2.77	0.35	0.35	93	11.7	11.7
Cypress:	25	2836	4963	7799	2.96	.38	.38	84	10.8	10.8
loam	50	3399	5874	9273	2.74	.36	.36	93	12.2	12.2
Wheat	100	3095	5171	8266	2.89	.36	.37	90	11.1	11.5
	200	3103	5433	8536	2.92	.37	.37	91	11.5	11.5
	400	3144	5532	8675	3.08	.34	.36	97	10.7	11.3
	R^2	N.S.	N.S.	N.S.	----	---	N.S.	--	----	N.S.

K_2O Applied kg/ha	N (Total Uptake kg/ha)	P (Total Uptake kg/ha)	K (Total Uptake kg/ha)	N (% Straw)	P (% Straw)	K (% Straw)	N (Uptake kg/ha Straw)	P (Uptake kg/ha Straw)	K (Uptake kg/ha Straw)
0	123	13.6	121.8	0.48	0.03	1.77	30	1.9	109.9
25	103	12.3	88.2	.39	.03	1.56	19	1.5	77.4
50	116	14.0	95.0	.39	.03	1.41	23	1.8	82.8
100	109	12.7	84.4	.36	.03	1.41	19	1.6	72.9
200	112	13.1	89.7	.39	.03	1.44	21	1.6	78.2
400	125	12.4	102.6	.51	.03	1.65	28	1.7	91.3
R^2	---	----	N.S.	---	---	N.S.	--	---	N.S.

Table 2.1.9. (Reed)

YIELD AND NUTRIENT UPTAKE DATA FOR K SURVEY EXPERIMENTS WITH CEREAL CROPS

Farmer Soil Crop	K_2O Applied kg/ha	Yield Grain (kg/ha)	Yield Straw (kg/ha)	Yield Total (kg/ha)	N % Grain	P % Grain	K % Grain	Uptake N kg/ha Grain	Uptake P kg/ha Grain	Uptake K kg/ha Grain
Reed	0	3777	4025	7802	2.83	0.36	0.38	107	13.6	14.4
Shellbrook:	25	3781	4104	7885	2.82	0.35	.37	107	13.2	14.0
sandy loam	50	3981	4410	8391	2.85	.36	.37	113	14.3	14.7
Wheat	100	4102	4305	8407	2.85	.36	.39	117	14.8	16.0
	200	3939	4237	8176	2.85	.36	.38	112	14.2	15.0
	400	3968	4541	8509	2.77	.36	.36	110	14.3	14.3
	R^2	N.S.	.56	N.S.	----	---	N.S.	---	----	N.S.

K_2O Applied kg/ha	Total Uptake N kg/ha	Total Uptake P kg/ha	Total Uptake K kg/ha	N % Straw	P % Straw	K % Straw	Uptake N kg/ha Straw	Uptake P kg/ha Straw	Uptake K kg/ha Straw
0	129	14.8	45.8	0.54	0.03	0.78	22	1.2	31.4
25	126	14.4	47.2	.45	.03	.81	19	1.2	33.2
50	137	15.6	47.8	.54	.03	.75	24	1.3	33.1
100	142	16.1	56.0	.57	.03	.93	25	1.3	40.0
200	135	15.5	60.8	.54	.03	1.08	23	1.3	45.8
400	135	15.7	74.3	.54	.03	1.32	25	1.4	60.0
R^2	---	----	.98	---	.03	.96	--	---	.99

Table 2.1.9. (Hogg)

YIELD AND NUTRIENT UPTAKE DATA FOR K SURVEY EXPERIMENTS WITH CEREAL CROPS

Farmer Soil Crop	K_2O Applied kg/ha	Yield Grain (kg/ha)	Yield Straw (kg/ha)	Yield Total (kg/ha)	N % Grain	P % Grain	K % Grain	Uptake N % Grain	Uptake P % Grain	Uptake K % Grain
Hogg	0	1959	3133	5092	3.23	0.42	0.36	63	8.2	7.1
Oxbow	25	1876	2896	4772	3.21	0.42	0.35	60	7.9	6.6
loam	50	1889	2903	4792	3.14	0.39	0.34	59	7.4	6.4
Wheat	100	1779	2900	4679	3.22	0.43	0.35	57	7.6	6.2
	200	2022	3230	5250	3.15	0.39	0.34	64	7.9	6.9
	400	1995	2951	4946	3.13	0.40	0.34	62	8.0	6.8
	R^2	N.S.	N.S.	N.S.	----	----	.57(2)	--	---	N.S.

K_2O Applied kg/ha	Total Uptake N (kg/ha)	Total Uptake P (kg/ha)	Total Uptake K (kg/ha)	N % Straw	P % Straw	K % Straw	Uptake N % Straw	Uptake P % Straw	Uptake K % Straw
0	77	9.8	56.9	0.42	0.05	1.59	13	1.6	49.8
25	72	9.6	53.5	0.42	0.06	1.62	12	1.7	46.9
50	70	8.6	45.6	0.36	0.04	1.35	10	1.2	39.2
100	68	9.1	49.7	0.36	0.05	1.50	10	1.5	43.5
200	74	9.2	62.1	0.33	0.04	1.71	11	1.3	55.2
400	72	9.2	49.3	0.33	0.04	1.44	10	1.2	42.5
R^2	--	---	N.S.	----	----	N.S.	--	---	N.S.

Positive grain yield response was recorded only at the Armstrong location on a Weirdale loam soil with barley as the experimental crop and also on the Sutherland clay soil. While the correlation coefficient was significant on the Sutherland clay soil, the difference in yield between the highest rate of application and the control was only about 60 kg/ha and would have been clearly noneconomic. The response obtained on the Weirdale loam was somewhat larger but this response was also not economic at current grain and fertilizer prices.

The total nutrient uptake data confirms standard literature patterns which indicate that about two thirds of the nitrogen and phosphorus are present in the grain with one third in the straw whereas the potassium distribution is opposite to that i.e. about two thirds of the potassium in the straw and one third in the grain.

Very little variation was noted from site to site in the potassium concentration in the grain. At all sites, it was approximately 0.4%. However, there was considerably more variation in the potassium concentration of the straw. At the Pocock and Reed locations where soil potassium levels were near or at levels of current recommendations, positive yield responses were not recorded but relatively low potassium straw concentrations were measured. Also, at these locations there was a positive increase in the potassium concentration in the straw with potassium fertilization. This data suggests that perhaps potassium content of straw may be a useful indicator to augument soil analysis in an attempt to more accurately predict the probabilities of positive and economic response to potassium with cereal grains.

It should be noted that the climatic conditions of 1980 over much of Saskatchewan were such that little or no rainfall was received during the months of May and June. This would preclude possible response to potassium that might occur in years when rainfall patterns are more nearly normal. As well, above normal air temperatures were experienced in the early part of the growing season throughout all of the grain growing areas of Saskatchewan. Access to the land and seeding dates in the Hudson Bay and Carrot River areas were among the earliest that had been recorded in those areas.

Yield and nutrient uptake data for the alfalfa experiments are presented in Table 2.1.10.

No yield response to alfalfa was recorded at any of the sites. Hay yields at both the Pocock and Espenant sites were quite low due to almost no rainfall during the months of May and June. Potassium concentration in the alfalfa plant material was below generally accepted adequate values at both the Espenant and Pocock sites where no potassium was applied. In the second cut of the Espenant site, the values did reach adequate levels at rates of application of greater than 100 kg K_2O per hectare. It is anticipated that positive yield response to the potassium applications would definitely be recorded in subsequent years at the Espenant site and perhaps at the Pocock site as well.

In the experiment where alfalfa seed was the objective, there was a small increase in potassium concentration of the seed with potassium application rate indicating that at least some of the material had moved into the soil and been translocated to the plant.

All of the alfalfa experiments have been marked in such a way that residual responses can be measured in subsequent years.

The single experiment with potatoes (Table 2.1.11) shows no

Table 2.1.10 YIELD AND NUTRIENT UPTAKE DATA FOR K SURVEY EXPERIMENTS WITH ALFALFA

Farmer Soil	K_2O Applied kg/ha	Yield kg/ha	N	P	K	Uptake N	Uptake P	Uptake K
			---------- % --------			------ kg/ha ------		
		CUT 1 - July 2						
Espenant	0	1892	2.09	0.12	1.14	39.5	2.3	21.6
Carrot	25	1775	2.23	0.13	1.05	39.6	2.2	18.6
River:	50	1718	2.28	0.12	1.10	39.2	2.1	18.9
Fine	100	1709	2.18	0.13	1.14	37.3	2.1	19.5
Sandy	200	1767	2.16	0.12	1.33	38.2	2.2	23.5
Loam	400	1635	2.29	0.13	1.49	37.4	2.2	24.4
	R^2	N.S.	----	----	0.92	----	---	0.63
		CUT 2 - August 19						
	0	1942	3.08	0.23	1.56	59.8	4.5	30.3
	25	2064	2.91	0.21	1.73	60.1	4.3	35.7
	50	1875	2.95	0.22	1.87	55.3	4.1	35.1
	100	2034	2.88	0.21	1.95	58.6	4.3	39.7
	200	2070	2.76	0.20	2.29	57.1	4.1	47.4
	400	2101	2.74	0.20	2.69	57.6	4.2	56.5
	R^2	N.S.	----	----	0.97	----	---	0.97
		CUT 2 - August 13						
Pocock*	0	1065	2.87	0.22	1.50	30.6	2.3	16.0
Nipawin:	25	964	2.85	0.22	1.54	27.5	2.1	14.8
Loam	50	1088	2.82	0.21	1.54	30.7	2.3	16.8
	100	988	2.71	0.22	1.71	26.8	2.2	16.9
	200	986	2.86	0.21	1.66	28.2	2.1	16.4
	400	991	2.86	0.21	1.75	28.3	2.1	17.3
	R^2	N.S.	----	----	0.70	----	---	N.S.

.....continued

Table 2.1.10 continued

Farmer Soil	K_2O Applied kg/ha	Yield kg/ha	N	P	K	Uptake N	P	K
			----------	%	---------	-------	kg/ha	------
		CUT 3 - October 16						
Pocock	0	576	3.39	0.28	2.45	19.5	1.6	14.1
Nipawin:	25	614	3.43	0.29	2.64	21.1	1.8	16.2
Loam	50	600	3.48	0.30	2.68	20.9	1.8	16.1
	100	643	3.45	0.29	2.88	22.2	1.9	18.5
	200	630	3.51	0.30	3.02	22.1	1.9	19.0
	400	655	3.43	0.29	3.12	22.5	1.9	20.4
	R^2	0.63	----	----	0.81	----	---	0.79

* Due to drought the plot was clipped but no yields measured in the first cut in June.

Table 2.1.10. (continued) YIELD AND NUTRIENT UPTAKE DATA FOR K SURVEY EXPERIMENTS WITH ALFALFA

Farmer Soil	K_2O Applied kg/ha	Yield kg/ha	N (%)	P (%)	K (%)	Uptake N (kg/ha)	Uptake P (kg/ha)	Uptake K (kg/ha)
			SEED					
Mumm	0	366	4.57	0.55	0.82	16.7	2.0	3.0
Shellbrook	25	293	5.23	0.61	0.99	15.3	1.8	2.9
Sandy loam	50	413	5.27	0.62	1.00	21.8	2.6	4.1
	100	340	5.36	0.62	1.00	18.2	2.1	3.4
	200	250	5.37	0.64	1.06	13.4	1.6	2.6
	400	327	5.39	0.65	1.08	17.6	2.1	3.5
	R^2	N.S.	----	----	.72(2)	----	---	N.S.
			STRAW					
	0	2341	1.35	0.09	1.20	31.6	2.1	28.1
	25	2013	1.32	.09	1.35	26.6	1.8	27.2
	50	2819	1.11	.09	1.08	31.3	2.5	30.4
	100	2199	1.32	.09	1.26	29.0	2.0	27.7
	200	2067	1.35	.12	1.41	27.9	2.5	29.1
	400	2398	1.23	.09	1.23	29.5	2.2	29.5
	R^2	N.S.	----	---	N.S.	----	---	N.S.
			TOTAL					
	0	2707				48.3	4.1	31.1
	25	2306				41.9	3.6	30.1
	50	3232				53.1	5.1	34.5
	100	2539				47.2	4.1	31.1
	200	2317				41.3	4.1	31.7
	400	2725				42.9	4.3	33.0
	R^2	N.S.						N.S.

Table 2.1.11. YIELD AND NUTRIENT UPTAKE DATA FOR K SURVEY EXPERIMENT WITH POTATOES

Farmer Soil	K_2O Applied kg/ha	Tuber Yield kg/ha	D.M. Tuber Yield kg/ha	Dry Tuber N (%)	Dry Tuber P (%)	Dry Tuber K (%)	Dry Tops N (%)	Dry Tops P (%)	Dry Tops K (%)	Uptake by Tubers N (kg/ha)	Uptake by Tubers P (kg/ha)	Uptake by Tubers K (kg/ha)
Barrich	0	36152	6157	2.47	0.32	1.72	2.53	0.26	3.21	152	19.7	106
Farm	25	36315	6431	2.36	.32	1.72	2.62	.26	3.31	152	20.6	111
Bradwell	50	35679	6066	2.33	.32	1.62	2.66	.25	3.28	141	19.4	98
very fine	100	36969	6340	2.18	.30	1.75	2.65	.25	4.22	138	19.0	111
sandy loam	200	35171	5842	2.42	.32	1.89	2.73	.26	3.96	141	18.7	110
	400	36788	6339	2.19	.30	1.69	2.63	.25	4.22	139	19.0	107
	R^2	N.S.	N.S.	----	---	N.S.	----	---	.59	---	----	N.S.

positive yield response to potassium. There was a slight increase in the potassium concentration of the above ground material.

The residual experiment with rapeseed (Table 2.1.12) did show a positive response in grain yield although the data was highly variable. It should be noted that during the farmers application of herbicides (Cobex) on this particular field, a ruptured hose resulted in contamination of a portion of the plot area which added considerably to experimental variability. The use of this site to follow subsequent residual response may be in jeopardy because of that.

On the rapeseed experiment, the potassium concentration in the straw was also increased by potassium fertilization, and the total potassium uptake in the straw was increased substantially.

Post harvest soil analysis was conducted at the barley experiment on the Armstrong farm near Nipawin. Samples of the 0-7.5 and 7.5 cm layers were taken from a composite of two separate one square foot areas of each replicate of each treatment. The data (Table 2.1.13) show an increase in $NaHCO_3$ extractable K and that most of this increase is in the top few centimeters of soil.

CONCLUSIONS AND SUGGESTIONS FOR FURTHER WORK

On the basis of the 11 field experiments conducted in 1980, the following conclusions can be drawn:

1. The existing soil test bench marks for potassium as utilized by the Saskatchewan Soil Testing Laboratory appear adequate.

2. Very large and significant differences in potassium concentration of the straw suggest further study in this area might provide useful guidelines to increase the accuracy of prediction of potassium requirement.

Table 2.1.12. YIELD AND NUTRIENT UPTAKE DATA FOR K RESIDUAL EXPERIMENT WITH RAPESEED

Farmer Soil	K_2O Applied kg/ha	Yield Grain (kg/ha)	Yield Straw (kg/ha)	Yield Total (kg/ha)	N % Grain	P % Grain	K % Grain	Uptake N kg/ha Grain	Uptake P kg/ha Grain	Uptake K kg/ha Grain
Kellett	0	1456	4775	6231	3.80	0.51	0.63	55.6	7.4	9.0
Carrot	10	1537	4861	6398	3.69	0.50	0.65	56.7	7.7	10.0
River:	20	1655	5333	7930	3.55	0.50	0.54	58.7	8.3	8.9
Fine	*30	1890	6275	7222	3.63	0.49	0.59	68.6	9.3	11.1
sandy	40	1878	5226	7104	3.82	0.52	0.55	71.7	9.8	10.3
loam	*60	1652	5232	6884	3.73	0.53	0.62	61.6	8.8	10.2
	80	1724	5606	7330	3.93	0.51	0.57	67.8	8.8	9.8
	*120	2056	6174	8230	3.45	0.48	0.54	70.9	9.9	11.1
	160	1791	4430	6222	3.51	0.54	0.62	62.9	9.7	11.1
	*240	1702	5013	6714	3.43	0.48	0.53	58.4	8.2	9.0
	*480	2092	4271	6362	3.68	0.53	0.58	77.0	11.1	12.1
	R^2	.37	N.S.	N.S.	----	----	N.S.	----	---	N.S.

* Once only		Total Uptake N kg/ha	Total Uptake P kg/ha	Total Uptake K kg/ha	N % Straw	P % Straw	K % Straw	Uptake N kg/ha Straw	Uptake P kg/ha Straw	Uptake K kg/ha Straw
	0	132.9	13.8	37.7	1.63	0.14	0.60	77.3	6.4	28.7
	10	129.6	13.5	42.1	1.50	0.12	0.66	72.9	5.8	32.1
	20	135.9	13.9	44.7	1.23	0.09	0.57	77.2	5.6	35.8
	*30	132.6	14.1	44.7	1.20	0.09	0.63	64.0	4.8	33.6
	40	121.9	12.9	54.2	0.96	0.06	0.84	50.2	3.1	43.9
	*60	126.0	13.5	47.9	1.23	0.09	0.72	64.4	4.7	37.7
	80	126.7	12.2	43.4	1.05	0.06	0.60	58.9	3.4	33.6
	*120	141.3	15.5	55.6	1.14	0.09	0.72	70.4	5.6	44.5
	160	104.1	12.4	47.0	0.93	0.06	0.81	41.2	2.7	35.9
	*240	105.0	11.2	54.0	0.93	0.06	0.90	46.6	3.0	45.1
	*480	116.7	13.7	58.2	0.93	0.06	1.08	39.7	2.6	46.1
	R^2	-----	----	.51	----	----	.78	----	---	.46

Table 2.1.13.

Post harvest soil analyses for K survey experiment with barley on the Armstrong farm

K_2O Applied kg/ha	Depth cm	Soil Available NO_3-N	P	K
		---------- kg/ha	----------	----------
0	0-7.5	8	7	157
	7.5-15	8	5	126
25	0-7.5	9	7	133
	7.5-15	9	5	156
50	0-7.5	9	8	203
	7.5-15	8	6	120
100	0-7.5	9	7	168
	7.5-15	8	5	144
200	0-7.5	9	11	175
	7.5-15	8	6	103
400	0-7.5	8	8	274
	7.5-15	7	6	125

3. Summary of soil test data in Saskatchewan suggests that certain soils in northwestern Saskatchewan are lower in potassium than comparable soils in northcentral, northeast, and eastern Saskatchewan. Further mineralogical work might be useful to determine the fundamental basis for this observation and field experimentation in northwestern Saskatchewan to confirm potassium response on these soils would be useful.

APPENDIX -- Selected tables of data from the 1980 irrigation experiments

APPENDIX A Selected tables of data from the 1980 irrigation experiments

Table A1. Co-operating farmer, legal location and soil type for the 1980 irrigation experiments

Co-operating Farmer	Crop Investigated	Legal Location	Soil Type
	Pulse Crop Irrigation Scheduling		
R. Thorstad	Fababeans Peas Dry Beans Lentils	NW4-28-7-W3	Elstow loam
	Legume Breaking N Correlation		
Pederson	Harmon Oats	SW20-28-7-W3	Elstow loam
Larson	Neepawa Hard Wheat	SW25-30-8-W3	Bradwell very fine sandy loam
Verwimp	Fielder Soft Wheat	NW31-29-7-W3	Asquith sandy loam
Murray	Fielder Soft Wheat	SE22-29-7-W3	Elstow loam

Table A2. Spring soil analyses for the legume stubble experiment

Rep.	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3-N	P	K	SO_4-S	% Organic Matter
				-------- kg/ha* ------				
LARSON								
1	0-15	8.1	0.3	10	8	450	13	2.04
	15-30	8.2	0.2	11	4	180	24+	
	30-60	8.5	0.3	64	4	260	48+	
	60-90	8.9	0.2	14	4	320	28	
2	0-15	7.4	0.2	19	8	465	11	2.00
	15-30	7.9	0.3	10	5	220	24+	
	30-60	8.1	0.8	22	6	400	48+	
	60-90	8.2	2.2	20	6	470	48+	
3	0-15	7.7	0.3	16	10	535	20	2.41
	15-30	8.0	0.3	14	5	280	24+	
	30-60	8.4	0.6	64	6	400	48+	
	60-90	8.8	0.6	38	4	380	48+	
4	0-15	7.7	0.2	28	11	665	13	2.51
	15-30	8.0	0.2	9	6	550	12	
	30-60	8.3	0.2	24	6	840	48+	
	60-90	8.5	0.2	26	4	420	48+	
5	0-15	8.0	0.2	10	7	760	9	2.52
	15-30	8.3	0.2	6	4	615	16	
	30-60	8.4	0.2	26	4	630	48+	
	60-90	8.7	0.2	36	4	330	48+	
6	0-15	7.8	0.2	17	13	495	16	2.35
	15-30	7.8	0.6	10	7	260	24+	
	30-60	8.0	1.5	46	6	310	48+	
	60-90	8.1	2.0	32	4	360	48+	
VERWIMP								
1	0-15	7.2	0.2	13	3	600	6	1.97
	15-30	7.4	0.1	10	2	325	10	
	30-60	7.9	0.2	24	2	410	28	
	60-90	8.4	0.1	14	4	420	10	
2	0-15	7.9	0.2	11	11	735	6	1.55
	15-30	8.1	0.1	9	8	900+	9	
	30-60	8.4	0.1	20	12	1120	12	
	60-90	8.5	0.1	22	12	1800+	14	

.....continued

Table A2 continued

Rep.	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	SO_4-S	% Organic Matter
				-------	kg/ha*	-------		
3	0-15	7.6	0.1	10	6	445	6	2.02
	15-30	7.7	0.1	11	3	270	9	
	30-60	8.2	0.1	20	4	310	20	
	60-90	8.5	0.1	12	4	340	10	
4	0-15	7.7	0.1	12	8	485	7	2.26
	15-30	7.7	0.1	11	4	325	8	
	30-60	8.1	0.1	26	4	680	20	
	60-90	8.5	0.1	14	4	420	18	
5	0-15	7.8	0.1	11	4	510	6	2.28
	15-30	7.8	0.1	10	2	250	9	
	30-60	8.2	0.1	20	2	360	22	
	60-90	8.4	0.1	12	2	360	6	
6	0-15	8.0	0.2	15	3	565	7	2.16
	15-30	7.9	0.3	16	2	465	24+	
	30-60	7.8	2.2	32	4	600	48+	
	60-90	8.3	1.4	12	6	480	48+	
MURRAY								
1	0-15	7.6	0.2	9	11	505	16	2.95
	15-30	7.7	0.1	5	6	250	11	
	30-60	8.1	3.9	20	8	740	48+	
	60-90	8.1	0.9	16	4	520	48+	
2	0-15	8.0	0.2	6	9	340	7	2.26
	15-30	8.1	0.2	4	5	220	17	
	30-60	8.5	0.6	18	4	460	48+	
	60-90	8.5	2.5	24	8	500	48+	
3	0-15	8.1	0.3	7	11	350	15	2.16
	15-30	8.3	0.4	5	5	250	24+	
	30-60	8.4	2.6	10	8	710	48+	
	60-90	8.2	5.1	14	18	840	48+	
4	0-15	7.9	0.2	12	10	425	24+	2.38
	15-30	7.9	0.1	4	5	225	13	
	30-60	8.4	0.8	8	6	540	48+	
	60-90	8.4	3.2	10	12	850	48+	
5	0-15	8.0	0.2	6	8	410	11	2.62
	15-30	8.0	0.2	6	4	320	9	
	30-60	8.3	0.7	12	4	570	48+	
	60-90	8.0	3.6	16	8	650	48+	

.....continued

Table A2 continued

Rep.	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	SO_4-S	% Organic Matter
				-------	kg/ha*		-------	
6	0-15	7.9	0.2	11	26	460	13	2.47
	15-30	7.8	0.2	8	12	300	11	
	30-60	7.7	0.1	16	12	500	48+	
	60-90	7.7	0.3	18	8	460	48+	
PEDERSON								
1	0-15	7.7	0.7	26	4	200	150	1.97
	15-30	7.9	0.4	8	3	230	60	
	30-60	8.0	0.4	12	4	600	100	
	60-90	8.2	0.4	8	6	710	100	
	90-120	8.3	0.6	8	10	740	160	
2	0-15	7.9	0.6	18	5	225	120	2.09
	15-30	8.0	0.4	7	2	215	90	
	30-60	8.2	0.6	10	4	680	220	
	60-90	8.3	0.7	10	8	900	240	
	90-120	8.3	0.8	10	16	880	450	
3	0-15	8.0	0.4	22	6	260	70	2.23
	15-30	8.1	0.3	9	3	250	60	
	30-60	8.2	0.6	12	4	720	140	
	60-90	8.3	0.6	10	6	860	100	
	90-120	8.3	0.6	10	18	900	140	
4	0-15	8.0	0.4	12	5	210	60	2.14
	15-30	8.0	0.3	6	2	220	60	
	30-60	8.2	0.4	10	4	710	120	
	60-90	8.3	0.6	8	6	1020	100	
	90-120	8.5	0.4	10	22	1050	120	
5	0-15	8.0	0.6	27	6	240	110	1.82
	15-30	8.1	0.4	7	3	255	70	
	30-60	8.3	0.6	12	4	870	140	
	60-90	8.6	0.6	10	22	1050	160	
	90-120	8.8	0.7	10	40	920	280	
6	0-15	8.1	0.6	23	9	220	110	2.18
	15-30	8.1	0.4	7	4	220	110	
	30-60	8.3	0.7	12	4	660	300	
	60-90	8.6	0.9	8	30	720	600	
	90-120	8.7	1.0	8	44	740	700	

* kg/ha = ppm x 2 for 15 cm depth and ppm x 4 for 30 cm depth

Appendix B1 NUMBER OF FIELDS IN SOIL K SUMMARIES

1968-79

A. Soil Zone

	Brown	Dark Brown	Black	Thick Black	Grey Black	Grey	Total
Stubble	2460	6513	6844	2999	5428	1425	25669
Summerfallow	3548	5652	4344	1339	3466	965	19314

B. Soil Associations

	Stubble	Fallow
Arborfield	143	87
Asquith	613	348
Beaver River	80	20
Blaine Lake	1121	581
Canora	406	237
Carrot River	365	288
Dorintosh	74	25
Elstow	994	703
Fox Valley	135	228
Halton	79	83
Haverhill	936	1493
Horsehead	105	47
Indian Head	291	189
Kamsack	373	201
Loon River	139	46
Makwa	172	67
Meadow Lake	214	49
Melfort	960	341
Meota	515	287
Nipawin	260	140
Oxbow	3178	2280
Pelly	514	284
Regina	1243	1043
Sceptre	792	1149
Shellbrook	531	358
Sylvania	174	123
Tisdale	1223	723
Waitville	591	410
Weyburn	2316	2401
Whitewood	718	623
Yorkton	975	496

Appendix B2
Potassium soil test bench marks in Saskatchewan.

POTASH REQUIREMENTS

DRYLAND

Recommendations for dryland production;

Rates in lb/Ac

$NaHCO_3K$ 0-6" in lb/Ac	Spring Wheat, Winter Wheat, Utility Wheat, Soft Wheat, Durum, Oats, Fall Rye, Spring Rye, Mixed Grain, Triticale, Canary Seed, Buckwheat, Sunflower, Rape, Mustard, Safflower, and Pre-Plant Grass, Native Grass	Flax, Field Peas, Fababeans Dry Beans, Lentils and Established Stands of Cultivated Grasses, Soybeans
	All Zones	All Zones
0-60	40	60
61-90	30	40
91-120	20	25
121-150	10	10
151-180	0	0
181-210	0	0
211-240	0	0
241+	0	0