1979 SOIL-PLANT NUTRIENT RESEARCH REPORT

Compiled by

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INTRODUCTION

Previous research by the Department of Soil Science, University of Saskatchewan, in the South Saskatchewan River Irrigation Project has shown that the major factors influencing the yield and quality of irrigated crops are nutrient levels and the timing of irrigation applications. Nitrogen was found to be the major nutrient limiting the yields of cereals and oilseed crops. Depending on initial soil NO_3-N levels increases in crop yield were generally obtained with nitrogen fertilizer rates up to 168 to 224 kg N/ha. As well, protein levels increased with an increase in nitrogen fertilization particularly at high application rates where yields had reached a maximum. However, the presence of nitrogen in excess of crop requirements can result in severe lodging of cereals, undesirably high protein content of soft wheat or malting barley and a significant decline in the oil content of oilseed crops.

The timing of irrigation applications was found to be important in preventing moisture stresses at critical stages of crop growth. A moisture stress early in the growing season and midway through the crop growth was found to cause a greater yield reduction than a stress somewhat later in the growing season. As well, the greater the moisture stress the higher the protein content of the crop.

Most of this research has been carried out utilizing barley, soft wheat and rapeseed. Little information is available for hard wheat and utility wheat. Therefore, with the growing interest in protein content of wheat and the introduction of protein grading into the marketing system it was considered important to obtain information on the effects of nitrogen fertilization and irrigation scheduling on different wheat varieties.

OBJECTIVE

To assess the effects of nitrogen fertilization and irrigation scheduling on the yield and quality of hard wheat, utility wheat and soft wheat and thus, determine if different nitrogen recommendations should be provided for these different market classes of wheat.

This was the third year of a three year project.

EXPERIMENTAL METHODS

The site selected for this experiment was on an Elstow loam soil (Tomasiewicz farm). This site had been seeded to hard wheat in 1978 under dryland conditions.

Soil analyses from samples taken at seeding time indicated a low to medium level of available NO_3-N (Table 1.1.1). It should also be noted that large quantities of NO_3^--N were presented in the 30 to 120 cm depth. As well, some salinity was present at depth.

The varieties used were Sinton hard wheat, Glenlea utility wheat, and Fielder soft wheat. The site was cultivated and harrowed prior to seeding with a double disc press drill with seven rows per treatment and an 18 cm row spacing. Individual plot lengths were 4.5 meters.

Phosphate applications with the seed were made to all plots at a rate of 45 kg P_2O_5/ha. Monoammonium phosphate (11-55-0) was used as the phosphate source throughout.

The fertility treatments included a range of nitrogen rates from 0 to 224 kg N/ha (Table 1.1.2). All nitrogen was applied as a surface broadcast application of ammonium nitrate (34-0-0) applied after

Table 1.1.1. Spring soil analyses for the nitrogen x water scheduling x wheat varieties experiment

Treatment	Depth (cm)	pH	Conductivity mmhos/cm	NO_3-N	P	K	SO_4-S
				---------		kg/ha*	---------
Sinton							
Water A & B	0-15	7.5	0.2	7	8	505	15
	15-30	7.4	0.4	10	3	215	12
	30-60	7.8	0.4	14	4	400	40
	60-90	8.0	1.2	22	14	640	48
	90-120	7.8	2.5	10	24	920	48
Water C & X	0-15	7.3	0.7	8	11	575	24
	15-30	7.4	0.4	15	10	190	24
	30-60	7.7	0.6	34	4	370	48
	60-90	7.9	1.4	40	10	420	48
	90-120	7.9	2.6	24	20	580	48
Glenlea							
Water A & B	0-15	7.4	0.3	9	11	560	7
	15-30	7.4	0.4	10	3	230	5
	30-60	7.7	0.6	14	6	440	44
	60-90	7.6	2.6	6	16	680	48
	90-120	7.5	4.6	10	18	830	48
Water C & X	0-15	7.2	0.2	8	10	435	24
	15-30	7.4	0.2	7	10	490	13
	30-60	7.7	0.4	22	6	400	48
	60-90	7.7	2.1	22	4	440	48
	90-120	7.8	2.1	22	6	560	48
Fielder							
Water A & B	0-15	7.1	0.8	11	15	615	24
	15-30	7.3	0.4	19	2	220	14
	30-60	7.6	0.9	30	6	500	48
	60-90	7.5	3.3	28	6	500	48
	90-120	7.4	4.6	14	16	670	48
Water C & X	0-15	7.0	0.3	8	7	485	24
	15-30	7.2	0.4	10	3	210	24
	30-60	7.5	1.0	18	6	470	48
	60-90	7.4	4.2	26	14	720	48
	90-120	7.4	4.6	20	22	760	48

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

seeding.

Post emergent herbicides included Hoegrass-Torch tank mix for the control of wild oats, green foxtail and broadleaf weeds. As well, the plot received an application of 2, 4-D Amine one week later to kill any remaining broadleaf weeds. Weed control was excellent throughout the entire plot area.

For the irrigation scheduling portion of the experiment, four water schedules were utilized (Table 1.1.2). In water schedule A the first irrigation was deleted, in water schedule B the second irrigation was deleted whereas water schedule C received all irrigations. Water schedule X was the dryland treatment and did not receive any irrigation applications.

The actual scheduling or irrigation was determined by tensiometers. Shallow tensiometers were installed at the 10 to 15 cm level initially and then moved down to the 15 to 23 cm level in late June. Deeper tensiometers were installed initially at the 25 to 30 cm level and moved down to the 40 to 45 cm level in late June. The shallow tensiometers were installed in fertility treatment 3 of all water treatments and in all four replicates. The deeper tensiometers were installed only in replicate three of fertility treatment 3 in all water treatments.

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

Table 1.1.2. Fertility and water treatments used in the nitrogen x water scheduling x wheat varieties experiment

Treatment Number	Nitrogen Applied (kg/ha)
1	0
2	56
3	84
4	112
5	168
6	224

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

fertility treatment 3 of all replicates and all water treatments.

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

Deep Tensiometer Reading	Depth of Water (mm)
0.3	64
0.3 - 0.7	89
greater than 0.7	114

Moisture monitoring was then conducted with the neutron probe except for 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 under study. The timing and amounts of irrigation water applied are presented in Table 1.1.4.

At harvest, yield samples were taken from all treatments by clipping at the soil surface the three centre rows of the seven-row plot over a length of 3 meters. The samples were then dried, weighed and threshed. The grain samples were then cleaned and weighed. Subsamples of straw were taken, replicates of individual treatments bulked, mixed and ground. Subsamples of the grain were taken, replicates kept separate, mixed and ground. Analyses were performed for protein content of the grain using a Technicon Infra Analyzer while straw nitrogen content was determined by wet digestion and colormetric analysis using a Technicon Auto Analyser II System.

Table 1.1.4. Amounts and timing of irrigation applications for the nitrogen x water scheduling x wheat varieties experiment

Water Schedule	Dates and Amounts of Irrigation Applications	Total Water (Irrigation & Rain) (mm)
	(Growing Season Rainfall = 114 mm)	
A	June 15, 61 mm; June 26, 33 mm; June 27, 52 mm; July 6, 16 mm; July 7, 66 mm; July 16, 72 mm; July 23, 70 mm; Aug. 2, 82 mm.	566
B	June 8, 51 mm; June 26, 33 mm; June 27, 52 mm; July 6, 16 mm; July 7, 66 mm; July 16, 72 mm; July 23, 70 mm; Aug. 2, 82 mm.	556
C	June 8, 51 mm; June 15, 61 mm; June 26, 33 mm; June 27, 52 mm; July 6, 16 mm; July 7, 66 mm; July 16, 72 mm; July 23, 70 mm; Aug. 2, 82 mm.	617

RESULTS AND DISCUSSION

The results of the effect of nitrogen fertilization and irrigation scheduling on the yield, protein content, and nitrogen uptake of hard wheat, utility wheat, and soft wheat are presented in Tables 1.1.5 to 1.1.7 and Figures 1.1.1 to 1.1.3. The results reported are the mean of four replicates.

Grain yields for the three wheat varieties, grown on the Elstow loam soil which had a low to medium nitrogen content, showed a strong response to nitrogen fertilization under irrigation conditions. Grain yield was only slightly larger where no moisture stress was involved (Water C) than where a moisture stress was involved (Water A and Water B). There was no response to nitrogen fertilization under dryland conditions.

The 1979 data are similar to that obtained in the previous two years except that the Water A Treatment (first irrigation omitted) did not result in as serious a yield reduction in 1979 as in previous years. This can be explained by the nature of the 1979 season. Hot, dry and extremely windy weather conditions in early June resulted in rapid use of the small amount of residual soil moisture and the first irrigation treatment was applied early. The hot, dry conditions, resulted in rapid use of the first irrigation application as well such that the moisture stress applied to the Water A treatment, while severe, only lasted for a few days. Therefore, the effects were not as severe as that measured in previous years.

The differences in grain yield for the three irrigation schedules (Water A, B, and C) were most pronounced for the Sinton hard wheat. There was only a very small difference observed for the Glenlea utility wheat and the Fielder soft wheat. Much larger differences were observed in the previous two years.

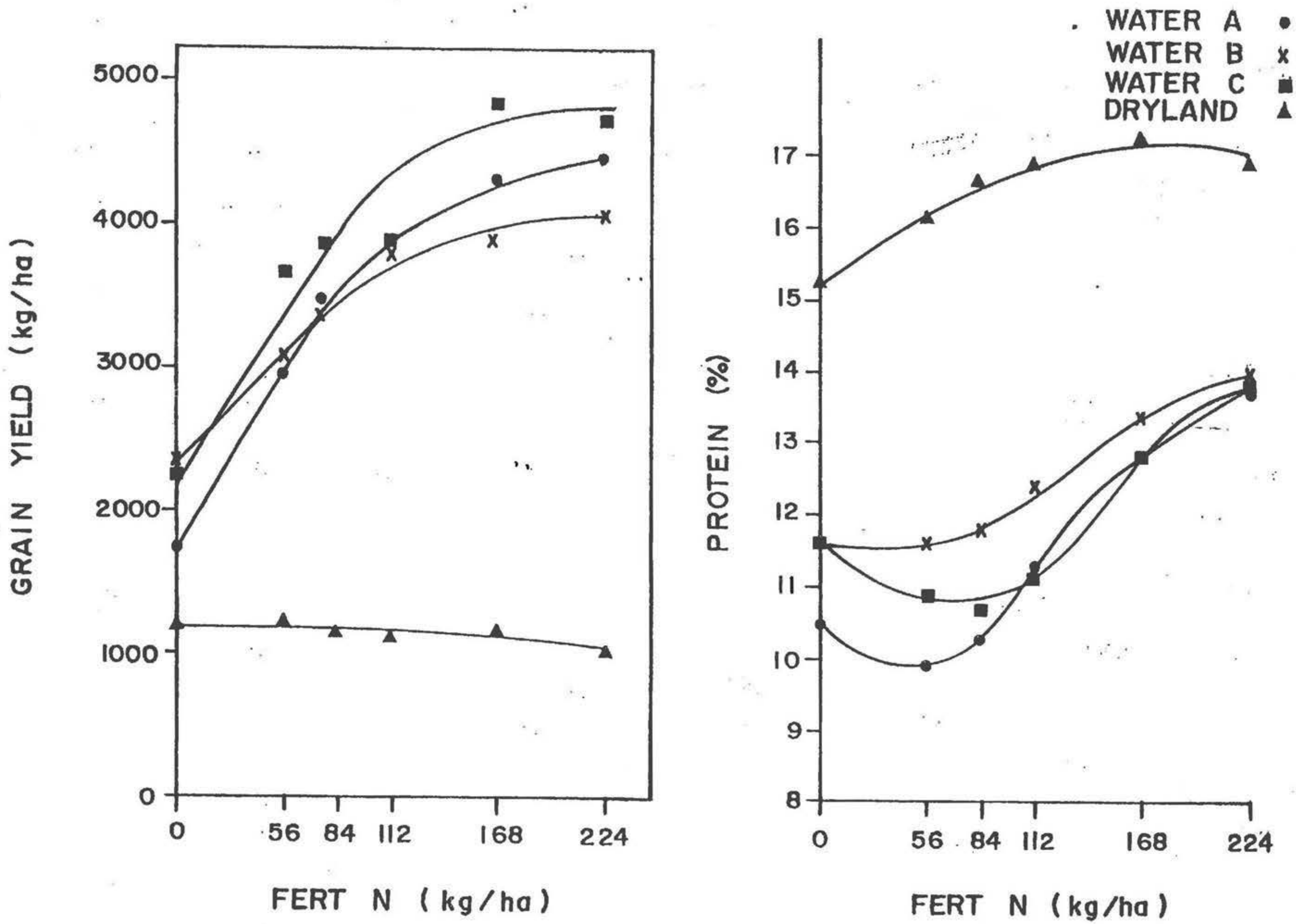

Figure 1.1.1. The effect of nitrogen fertilization on the yield and protein content of Sinton hard wheat.

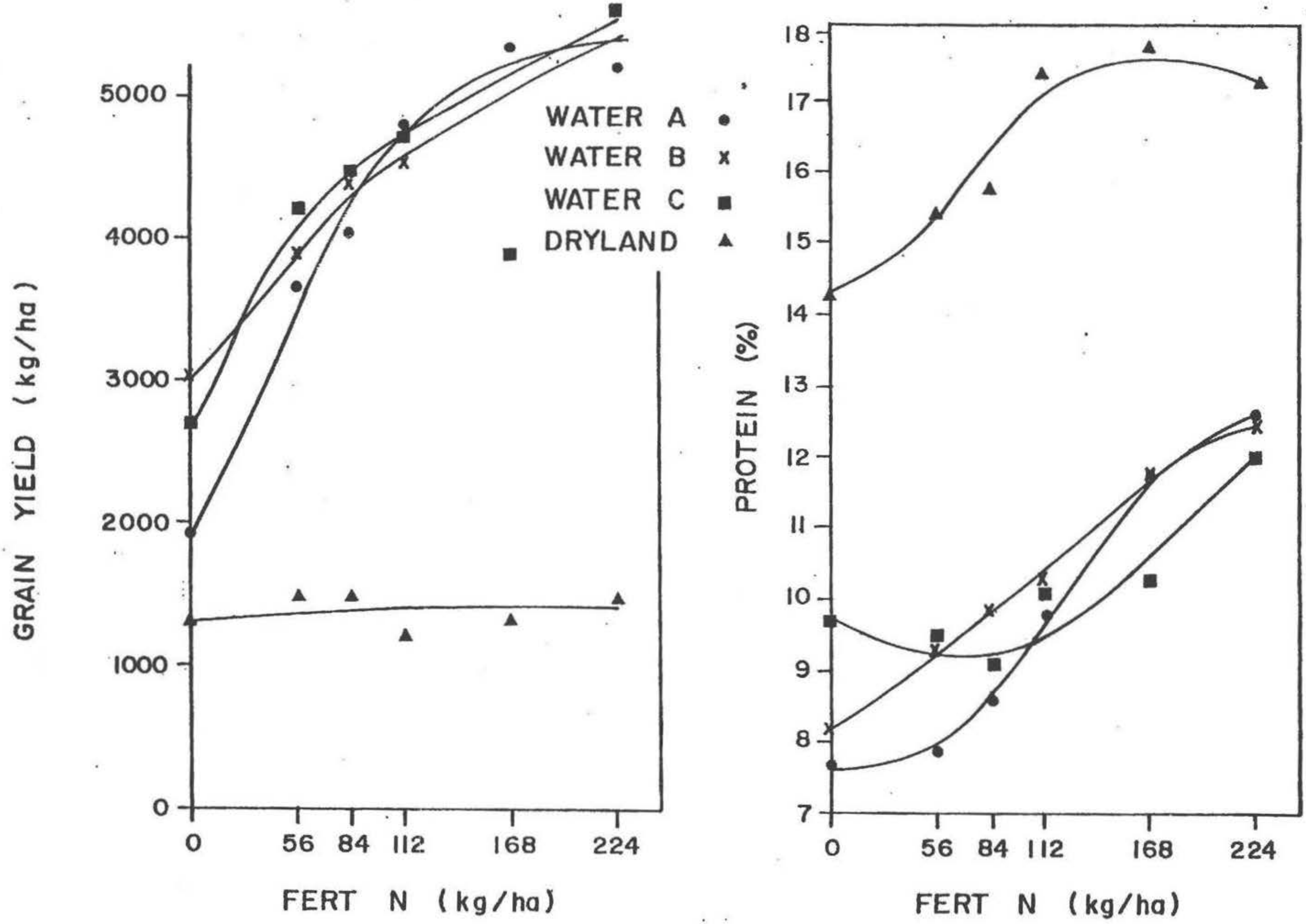

Figure 1.1.2. The effect of nitrogen fertilization on the yield and protein content of Glenlea utility wheat.

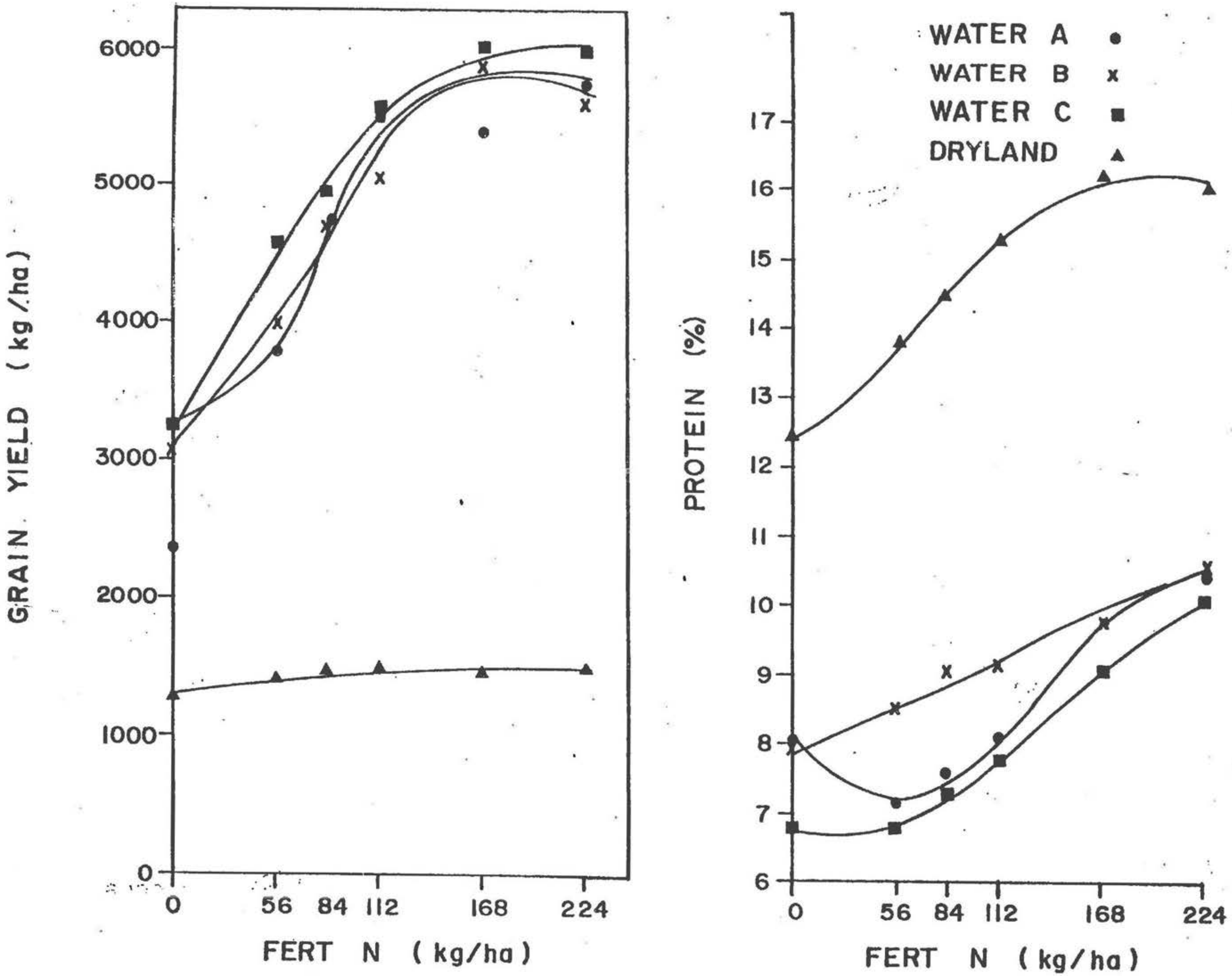

Figure 1.1.3. The effect of nitrogen fertilization on the yield and protein content of fielder soft wheat.

1979

Table 1.1.5. The effect of nitrogen fertilization and irrigation scheduling on the yield, nitrogen content, and nitrogen uptake of Sinton hard wheat grown on Elstow soil.

N Applied (kg/ha)	Yield (kg/ha) Grain	Yield (kg/ha) Straw	Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake (kg/ha) Grain	Nitrogen Uptake (kg/ha) Straw	Nitrogen Uptake (kg/ha) Total
				WATER A				
0	1763	2249	0.79	10.5	0.29	37.5	6.5	44.0
56	2949	4509	0.66	9.9	0.25	59.2	11.3	70.5
84	3488	5111	0.68	10.3	0.33	72.9	16.9	89.8
112	3845	5769	0.67	11.3	0.36	88.1	20.8	108.8
168	4306	6195	0.70	12.8	0.39	111.8	24.2	136.0
224	4458	6331	0.71	13.7	0.54	123.9	34.2	158.1
L.S.D. (P=0.05)	353	525	0.07					
				WATER B				
0	2301	3150	0.74	11.6	0.28	54.1	8.8	62.9
56	3061	4952	0.62	11.6	0.26	72.0	12.9	84.9
84	3369	5535	0.61	11.8	0.26	80.6	14.4	95.0
112	3781	5738	0.66	12.4	0.40	95.1	23.0	118.1
168	3898	6016	0.65	13.4	0.42	105.9	25.3	131.2
224	4087	6018	0.69	14.0	0.48	116.0	28.9	144.9
L.S.D (P=0.05)	280	596	0.10					
				WATER C				
0	2261 1.8	3052	0.75	11.6	0.23	53.2	7.0	60.2
56	3670 1.8	5625	0.65	10.9	0.28	81.1	15.8	96.9
84	3888 1.7	5994	0.65	10.7	0.20	84.4	12.0	96.4
112	3894 1.7	6739	0.58	11.1	0.20	87.7	13.5	101.2
168	4805 2.2	7432	0.65	12.8	0.40	124.7	29.7	154.4
224	4736 2.6	7505	0.63	13.8	0.65	132.6	48.8	181.4
L.S.D. (P=0.05)	280	569	0.07					
				DRYLAND				
0	1209	1520	0.80	15.2	0.73	37.3	11.1	48.4
56	1235	1473	0.84	16.1	0.79	40.3	11.6	51.9
84	1161	1561	0.74	16.7	0.88	39.3	13.7	53.0
112	1109	1512	0.74	16.9	0.87	38.0	13.2	51.2
168	1175	1612	0.73	17.3	1.05	41.2	16.9	58.1
224	1021	1406	0.74	16.9	0.96	35.0	13.5	48.5
L.S.D. (P=0.05)	105	188	0.09					

[1] Grain protein content based on % N at 13.5% moisture x 5.7; straw % N on oven-dry basis.

Table 1.1.6. The effect of nitrogen fertilization and irrigation scheduling on the yield, nitrogen content, and nitrogen uptake of Glenlea utility wheat grown on Elstow soil.

N Applied (kg/ha)	Yield (kg/ha)		Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake (kg/ha)		
	Grain	Straw				Grain	Straw	Total
				WATER A				
0	1978	2844	0.70	7.7	0.20	30.9	5.7	36.6
56	3673	4314	0.86	7.9	0.20	58.9	8.6	67.5
84	4047	5236	0.78	8.6	0.22	70.6	11.5	82.1
112	4826	6107	0.80	9.8	0.23	95.9	14.0	109.9
168	5374	6880	0.78	11.8	0.34	128.6	23.4	152.0
224	5233	6680	0.79	12.6	0.47	133.7	31.4	165.1
L.S.D. (P=0.05)	617	896	0.17					
				WATER B				
0	3054	3283	0.94	8.2	0.20	50.8	6.6	57.4
56	3882	4651	0.84	9.3	0.20	73.2	9.3	82.5
84	4398	5378	0.82	9.8	0.25	87.4	13.4	100.8
112	4545	5863	0.78	10.3	0.34	94.9	19.9	114.8
168	4828	6373	0.76	11.8	0.34	115.5	21.7	137.2
224	5124	6566	0.79	12.5	0.36	129.9	23.6	153.5
L.S.D (P=0.05)	396	495	0.08					
				WATER C				
0	2718	3038	0.93	9.7	0.20	53.5	6.1	59.6
56	4220	5642	0.75	9.5	0.17	81.3	9.6	90.9
84	4464	5933	0.76	9.1	0.19	82.4	11.3	93.7
112	4715	6403	0.77	10.1	0.37	96.6	23.7	120.3
168	3915	8288	0.50	10.3	0.47	81.8	39.0	120.8
224	5672	7365	0.77	12.0	0.40	138.0	29.5	167.5
L.S.D. (P=0.05)	724	1378	0.20					
				DRYLAND				
0	1353	1944	0.71	14.3	0.51	39.2	9.9	49.1
56	1527	2382	0.63	15.4	0.64	47.7	15.2	62.9
84	1508	2608	0.59	15.8	0.67	48.3	17.5	65.8
112	1244	2420	0.52	17.4	0.96	43.9	23.2	67.1
168	1341	2910	0.46	17.8	0.87	48.4	25.3	73.7
224	1496	2974	0.51	17.3	0.93	52.5	27.7	80.2
L.S.D. (P=0.05)	359	733	0.10					

[1]Grain protein content based on % N at 13.5% moisture x 5.7; straw % N on oven-dry basis.

1979

Table 1.1.7. The effect of nitrogen fertilization and irrigation scheduling on the yield, nitrogen content, and nitrogen uptake of Fielder soft wheat grown on Elstow soil.

N Applied (kg/ha)	Yield (kg/ha)		Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake (kg/ha)		
	Grain	Straw				Grain	Straw	Total
				WATER A				
0	2390	2491	0.96	8.0	0.26	38.8	6.5	45.3
56	3814	4064	0.94	7.2	0.30	55.7	12.2	67.9
84	4705	4958	0.95	7.6	0.54	72.5	26.8	99.3
112	5513	5495	1.00	8.1	0.30	90.6	16.5	107.1
168	5417	6356	0.86	9.8	0.42	107.7	26.7	134.4
224	5757	5738	1.01	10.5	0.64	122.6	36.7	159.3
L.S.D. (P=0.05)	717							
				WATER B				
0	3073	3338	0.93	7.9	0.30	49.2	10.0	59.2
56	4007	4265	0.95	8.5	0.37	69.1	15.8	84.9
84	4693	4738	0.99	9.1	0.36	86.6	17.1	103.7
112	5067	5066	1.00	9.2	0.37	94.5	18.7	113.2
168	5875	4921	1.24	9.8	0.51	116.8	25.1	141.9
224	5620	5526	1.02	10.6	0.76	120.8	42.0	162.8
L.S.D. (P=0.05)	618	1026	0.18					
				WATER C				
0	3025	3171	0.96	6.8	0.22	41.7	7.0	48.7
56	4691	4846	0.97	6.8	0.22	64.7	10.7	75.4
84	4950	5224	0.95	7.3	0.22	73.3	11.5	84.8
112	5576	5479	1.02	7.8	0.26	88.2	14.2	102.4
168	6054	6461	0.94	9.1	0.36	111.7	23.3	135.0
224	6007	6632	0.91	10.1	0.67	123.1	44.4	167.5
L.S.D. (P=0.05)	546	440	0.08					
				DRYLAND				
0	1336	1433	0.94	12.5	0.53	33.9	7.6	41.5
56	1445	1863	0.79	13.8	0.62	40.4	11.6	52.0
84	1509	1888	0.80	14.5	0.68	44.4	12.8	57.2
112	1522	1851	0.83	15.3	0.74	47.2	13.7	60.9
168	1494	1970	0.77	16.3	0.88	49.4	17.3	66.7
224	1517	1907	0.80	16.1	0.87	49.5	16.6	66.1
L.S.D. (P=0.05)	195	313	0.14					

[1]Grain protein content based on % N at 13.5% moisture x 5.7; straw % N on oven-dry basis.

Highest grain yields were found where no moisture stress was involved and high rates of nitrogen were applied for all three wheat varieties. Under these conditions the highest grain yield obtained was approximately 6000 kg/ha for the Fielder soft wheat. This yield for the Fielder soft wheat was higher than that found in 1977 (4100 kg/ha) or 1978 (5500 kg/ha). The Glenlea utility wheat produced a yield of 5600 kg/ha and the Sinton hard wheat of 4800 kg/ha under the same conditions. The Glenlea utility wheat showed an increase over that obtained in the previous two years while the yield for the Sinton hard wheat was similar to that obtained in 1978.

Straw yields showed the same response as grain yields to added fertilizer nitrogen in that they increased with an increase in the rate of nitrogen applied. However, the increase in straw yield was greater than the increase in grain yields since grain/straw ratios generally decreased as the rate of nitrogen fertilizer applied was increased. This trend has been observed in previous research and would indicate that grain production does not increase as rapidly as total plant material with an increase in nitrogen fertilization.

The effect of the water treatments on the grain/straw ratios showed a similar trend for the Glenlea utility wheat and the Fielder soft wheat. Generally, grain/straw ratios for these two wheat varieties were greater where water was applied than on the dryland plots suggesting that grain production was more efficient when adequate moisture was available for crop growth. This same trend was observed in 1978 for all three wheat varieties.

Grain protein and straw nitrogen contents increased with increases in nitrogen fertilization. The greater the moisture stress the higher were both grain protein and straw nitrogen contents which were generally of the order Dryland > Water A, Water B > Water C. This same trend was observed in the previous two years.

A direct result of increased yields and increased protein and nitrogen content of the plant material with increased rates of nitrogen applied was an overall increase in total nitrogen uptake by the three wheat varieties. As well, the greater nitrogen uptake generally occurred where no moisture stress was involved, and it decreased the greater was the moisture stress.

The seasonal water use data for the three wheat varieties and irrigation treatments are presented in Table 1.1.8. The amount of irrigation water applied was greater for Water C than either Water A or Water B which were similar. This was expected since both Water A and Water B missed one of the irrigation applications to provide a moisture stress to the plants at different points in the growing season. There was excess water present in the soil in the fall compared to that in the spring for the three irrigation treatments indicating that not all the water applied was used by the crops. However, there was a soil moisture deficit from spring to fall for the dryland treatment indicating that the soil had been dried out.

The overall water use pattern was of the order Water C > Water A, Water B >> Dryland which was the same as the yield pattern indicating greater water use with increased yield. Total water use was similar for the Fielder soft wheat and Glenlea utility wheat which was greater than that for the Sinton hard wheat. Somewhat similar results were found for the previous two years.

The residual NO_3^--N levels in the soil after harvest of the crops

Table 1.1.8. Seasonal water use of hard wheat, utility wheat, and soft wheat.

Crop	Water Schedule	Rainfall	Irrigation	ΔS*	Total Water Use**
		mm			
Sinton	A	114	452	-122	444
	B	114	442	-85	471
	C	114	503	-87	530
	X	110	0	62	172
Glenlea	A	114	452	-82	484
	B	114	442	-101	455
	C	114	503	-68	549
	X	110	0	76	186
Fielder	A	114	452	-57	509
	B	114	442	-66	490
	C	114	503	-68	549
	X	110	0	76	186

*ΔS = change in soil moisture content (spring - fall).

**Total Water Use = rainfall and irrigation + ΔS.

for the 0 and 224 kg N/ha application rates under the Water A, Water C, and dryland irrigation treatments are presented in Table 1.1.9. The results for the individual replicates are presented in Appendix Table A2. The results, though somewhat variable, indicate greater levels of residual NO_3^--N for the Dryland treatment than for either the water A or Water C treatments. The Dryland treatment had large quantities of NO_3^--N present in the 0-15 cm depth with substantial quantities also present at lower depths. For the two irrigated treatments only small quantities of NO_3^--N were found in the top 30 cm with somewhat larger quantities below 30 cm, especially for the Sinton hard wheat. Obviously, more of the applied fertilizer nitrogen was used by the crop when irrigated.

The residual NO_3^--N levels in the 0-15 cm depth for all of the fertilizer nitrogen application rates for the Dryland treatment are presented in Table 1.1.10. The results for the individual replicates are presented in Appendix Table A3. The results indicate that as the rate of fertilizer nitrogen applied was increased more residual NO_3^--N was found in the 0-15 cm depth at the end of the growing season. At the higher rates of nitrogen application more nitrogen was being supplied to the crop than could be utilized under the Dryland growing conditions.

CONCLUSION

Yield data obtained in this project over the past three years has set potential yields under irrigation conditions for soft wheat in the range of 5400 to 6000 kg/ha, at 5000 to 5700 kg/ha for utility wheat and at 4300 to 5000 kg/ha for hard red spring wheat. While the ultimate yield potentials are different the shapes of the nitrogen

Table 1.1.9. Residual NO_3^--N levels from selected rates of nitrogen application and irrigation treatments.

Depth (cm)	Water A N Rate (kg/ha) 0	224	Water C N Rate (kg/ha) 0	224	Dryland N Rate (kg/ha) 0	224
	kg NO_3^--N/ha*					
			Sinton			
0-15	13	10	14	9	17	52
15-30	9	8	6	7	8	36
30-60	18	78	13	35	27	49
60-90	17	21	16	31	51	69
90-120	22	20	20	22	35	41
			Glenlea			
0-15	9	5	10	7	8	46
15-30	6	9	6	5	6	11
30-60	12	23	10	12	32	22
60-90	11	16	11	23	50	37
90-120	13	13	17	20	26	29
			Fielder			
0-15	9	5	8	5	8	96
15-30	4	3	6	5	6	17
30-60	7	15	9	14	58	58
60-90	9	15	7	17	40	43
90-120	13	10	12	12	23	31

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

Table 1.1.10. Residual NO_3^--N levels in the 0-15 cm depth for the dryland treatment.

N Applied (kg/ha)	Residual NO_3^--N (kg/ha)* Sinton**	Glenlea***	Fielder***
0	10	8	8
56	18	13	15
84	24	14	20
112	32	20	35
168	47	31	65
224	52	46	96

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

** Mean of 3 reps.

***Mean of 4 reps.

response curves have been remarkably similar, and it is unlikely that different nitrogen recommendations are warranted for the different market classes of wheat.

1.2 The response of irrigated annual crops to nitrogen fertilization on alfalfa breaking.

INTRODUCTION

Established fields of irrigated alfalfa in the South Saskatchewan River Irrigation Project have been found to become less productive with time. For this reason these alfalfa fields are taken out of production by breaking them up. In most cases the alfalfa is broken up in the late fall or early spring and subsequently seeded to an annual crop. The nitrogen status of alfalfa breaking under irrigation has not been adequately studied with the result that nitrogen recommendations are based on those for stubble seeded crops. Therefore, it was considered necessary to carry out a research project to determine the modifications that should be made to existing soil test nitrogen benchmarks to take into account nitrogen mineralized when alfalfa is broken and seeded to an annual crop in the same year.

Small amounts of data were obtained in 1977 and 1978 for this project.

OBJECTIVE

To assess the response of irrigated annual crops to nitrogen fertilization on alfalfa breaking and thus determine the contribution alfalfa breaking makes to supplying nitrogen to the growing crop.

Experimental Methods

Four sites were selected in the spring of 1979: Verwimp East (Bradwell very fine sandy loam); Verwimp West (Asquith sandy loam); Pederson (Elstow loam); and, Mathison (Bradwell fine sandy loam). All four sites had been in alfalfa for four or more years. With the exception of the Pederson site, the breaking was done in the spring prior to seeding. For the Pederson site, breaking was done in mid-October of the year prior to seeding. On that experiment prior estimates of the nitrogen supplying power were available. An identical experiment had been conducted on the same border strip in 1972[1]. In 1973 the field was planted to wheat and under seeded to alfalfa and alfalfa was then grown and two cuts per year taken during the years 1973 to 1978.

The results of the analyses of soil samples taken prior to seeding for the four sites are presented in Table 1.2.1. The results for the individual replicates are presented in Appendix Table A4. The results indicate low to medium levels of NO_3^--N (0-60 cm) at the Verwimp East and Pederson sites and low levels of NO_3^--N (0-60 cm) at the Verwimp West and Mathison sites. Available P was in the medium category for both of the Verwimp sites but was very low for the Pederson and Mathison sites.

The four sites were all seeded to Neepawa hard red spring wheat. All pre-seeding tillage and seeding operations were as conducted by the cooperating farmer. Phosphorus was applied at rates of 30 to 40 kg P_2O_5/ha during the seeding operation by the cooperating farmer except at the Mathison site where phosphate was inadvertently missed on the plot area.

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 1.2.2). The

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

Table 1.2.1. Spring soil analyses for the alfalfa breaking experiment under irrigation (mean 0/6 reps).

Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^=$-S
			kg/ha*			
Verwimp East (Bradwell: very fine sandy loam)						
0-15	7.5	0.5	30	21	311	12
15-30	7.8	0.3	10	7	218	12
30-60	8.2	0.8	8	5	239	24
60-90	8.4	1.3	6	4	291	24
90-120	8.3	2.3	5	6	328	24
Verwimp West (Asquith: sandy loam)						
0-15	8.1	0.3	11	27	213	10
15-30	8.2	0.2	7	11	194	12
30-60	8.4	0.2	5	7	178	14
60-90	8.5	0.2	4	5	201	21
90-120	8.6	0.3	4	4	234	21
Pederson (Elstow: loam)						
0-15	8.1	0.6	29	7	243	24
15-30	8.2	0.5	23	5	218	24
30-60	8.5	0.6	7	5	276	24
60-90	8.5	0.8	4	8	325	24
90-120	8.4	1.2	4	10	345	24
Mathison (Bradwell: fine sandy loam)						
0-15	8.0	0.4	17	4	288	24
15-30	8.2	0.3	9	3	200	23
30-60	8.4	0.4	6	3	190	24

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

Table 1.2.2. Fertility treatments for annual crops on alfalfa breaking experiment under irrigation.

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

[1]Treatment number 8 used for time-step sampling.

[2]Nitrogen applied as surface broadcast ammonium nitrate (34-0-0) after seeding.

six replicates were extended down one border strip at each site. The fertilizer was broadcast after the field had been seeded. Each individual treatment covered an area 6 meters x 1.5 meters.

All herbicide applications for weed control and irrigation applications were as conducted by the cooperating farmer.

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

At harvest, yield samples were taken from all treatments, except Treatment 8, by clipping at the soil surface three rows over a length of three meters. The samples were dried, weighed and then threshed. The grain samples were cleaned and weighed. Subsamples of straw, replicates of individual treatments composited, and all individual grain samples were mixed and ground. Analyses for protein content of the grain were performed using a Technicon Infra Analyzer while straw nitrogen and grain and straw phosphorus 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 1.2.3. Total above ground yields for the Neepawa wheat at the four sites increased while the nitrogen content and phosphorus content of the plant material

Table 1.2.3. The yield, nitrogen content, nitrogen uptake, phosphorus content and phosphorus uptake of irrigated Neepawa wheat at five growth stages on alfalfa breaking*.

Growth Stage	Number of Days After Seeding	Yield (kg/ha)	% N	N Uptake (kg/ha)	% P	P Uptake (kg/ha)
		Verwimp East				
Tillering	29	713	5.79	41.3	0.59	4.2
Flagleaf	44	3155	3.24	73.8	0.45	14.2
Heading	50	5974	2.34	139.8	0.33	19.7
Early Milk	62	6862	1.38	94.7	0.23	15.8
Maturity - grain	92	4362	2.94	128.2	0.49	21.4
- straw		5621	0.36	20.2	0.07	3.9
		Verwimp West				
Tillering	25	324	6.90	22.4	0.79	2.6
Flagleaf	39	2707	4.13	111.8	0.49	13.3
Heading	45	4249	2.87	121.9	0.35	14.9
Early Milk	59	6085	1.65	100.4	0.26	15.8
Maturity - grain	90	3786	2.64	100.0	0.46	17.4
- straw		6266	0.36	22.6	0.05	3.1
		Pederson				
Tillering	31	474	4.78	22.7	0.34	1.6
Flagleaf	46	2502	2.42	60.5	0.28	7.0
Heading	53	3615	1.68	60.7	0.22	8.0
Early Milk	66	6765	1.27	85.9	0.19	12.9
Maturity - grain	94	3990	2.31	92.2	0.40	16.0
- straw		5107	0.21	10.7	0.02	1.0
		Mathison				
Tillering	27	358	4.15	14.9	0.28	1.0
Flagleaf	37	1268	3.66	46.4	0.24	3.0
Heading	46	2812	2.51	70.6	0.19	5.3
Early Milk	61	4248	1.23	52.3	0.10	4.2
Maturity - grain	89	2429	2.71	65.8	0.33	8.0
- straw		4804	0.38	18.8	0.02	1.0

*Reported values are the mean of six reps.

decreased with each growth stage sampled. Lower yields were found at the Mathison site than the other three sites and were probably due to the fact that low available phosphorus levels were present in the soil and no fertilizer phosphorus was applied to the plot area. As well, the phosphorus content of the plant material was lower at the Mathison site and coupled with the lower yields resulted in a lower phosphorus uptake than at the other three sites. Nitrogen uptake values increased up until heading after which they levelled off or decreased slightly. Differences in nitrogen uptake among the four sites could be due to differences in nitrogen minerallization rates. However, the reduced nitrogen uptake at the Mathison site was probably due to the lower yields which resulted from the low available soil phosphorus levels and the missed phosphorus fertilizer application.

The results for the effect of nitrogen fertilization on the yield, protein content and nitrogen uptake of the Neepawa at the four sites are presented in Tables 1.2.4 to 1.2.7. Grain and straw yields showed a small increase where fertilizer nitrogen was applied at the Verwimp East and Pederson sites. This indicates mineralization of nitrogen from the alfalfa residues was not quite adequate enough to meet the crops requirements at these two sites. Little or no response to the fertilizer nitrogen was observed at the Verwimp West or Mathison sites indicating adequate nitrogen mineralization from the alfalfa residues to meet the crops requirements. Care must be taken in interpreting the results from the Mathison site since it was shown in the time-step sampling data that yields were reduced by low available soil phosphorus levels. Grain/straw ratios were lowered at the high rates of fertilizer nitrogen application for the Pederson plot, an indication of yield

Table 1.2.4. The effect of nitrogen fertilization on the yield, nitrogen content, and nitrogen uptake of irrigated Neepawa wheat grown on alfalfa breaking (Verwimp East).

N Applied (kg/ha)	Yield (kg/ha) Grain	Yield (kg/ha) Straw	Grain/Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake (kg/ha) Grain	Nitrogen Uptake (kg/ha) Straw	Nitrogen Uptake (kg/ha) Total	Grain % P	Straw % P
0	4088	5680	0.73	14.1	0.38	116.9	21.6	138.5	0.468	0.084
28	4076	5724	0.72	14.9	0.48	123.2	27.5	150.7	0.455	0.060
56	4536	6430	0.71	14.6	0.63	134.3	40.5	174.8	0.440	0.078
84	4425	6274	0.71	14.7	0.60	131.9	37.6	169.5	0.439	0.060
112	4220	6490	0.68	15.1	0.78	129.2	50.6	179.8	0.449	0.090
168	4785	6521	0.74	14.8	0.75	143.6	48.9	192.5	0.438	0.060
224	4603	6502	0.71	14.9	0.66	139.1	42.9	182.0	0.436	0.057
0	4441	5790	0.77	14.0	0.39	126.1	22.6	148.7	0.464	0.066
0	4283	5452	0.80	14.4	0.35	125.1	19.1	144.2	0.461	0.066
L.S.D. (P=0.05)	558	872	0.11							

[1]Grain protein content based on % N at 13.5% moisture x 5.7; straw % N on oven-dry basis.

Table 1.2.5. The effect of nitrogen fertilization on the yield, nitrogen content, and nitrogen uptake of irrigated Neepawa wheat grown on alfalfa breaking (Verwimp West).

N Applied (kg/ha)	Yield Grain (kg/ha)	Yield Straw (kg/ha)	Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake Grain (kg/ha)	Nitrogen Uptake Straw (kg/ha)	Nitrogen Uptake Total (kg/ha)	Grain % P	Straw % P
0	3950	6298	0.64	12.1	0.35	96.9	22.0	118.9	0.436	0.036
28	3732	6260	0.61	12.4	0.38	93.9	23.8	117.7	0.424	0.042
56	3647	6411	0.58	12.8	0.51	94.7	32.7	127.4	0.432	0.051
84	3861	6356	0.61	13.7	0.53	108.9	33.7	142.6	0.427	0.045
112	3921	7590	0.52	13.6	0.54	108.2	41.0	149.2	0.398	0.042
168	3676	6456	0.58	13.7	0.57	102.1	36.8	138.9	0.409	0.051
224	3321	6025	0.57	14.2	0.72	95.6	43.4	139.0	0.425	0.060
0	3796	6360	0.60	12.1	0.30	93.2	19.1	112.3	0.430	0.051
0	3776	6171	0.62	11.9	0.29	91.1	17.9	109.0	0.437	0.024
L.S.D. (P=0.05)	522	1194	0.07							

[1]Grain protein content based on % N at 13.5% moisture x 5.7; straw % N on oven-dry basis.

Table 1.2.6. The effect of nitrogen fertilization on the yield, nitrogen content, and nitrogen uptake of irrigated Neepawa wheat grown on alfalfa breaking (Pederson).

N Applied (kg/ha)	Yield (kg/ha)		Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake (kg/ha)			Grain % P	Straw % P
	Grain	Straw				Grain	Straw	Total		
0	3971	5389	0.74	10.9	0.23	87.8	12.4	100.2	0.432	0.021
28	4052	5734	0.71	11.3	0.30	92.9	17.2	110.1	0.333	0.027
56	4470	5936	0.75	11.8	0.38	107.0	22.6	129.6	0.397	0.030
84	4073	5885	0.70	12.2	0.33	100.8	19.4	120.2	0.398	0.025
112	4433	6422	0.69	12.9	0.44	116.0	28.3	144.3	0.375	0.033
168	4540	6604	0.69	13.4	0.54	123.4	35.7	159.1	0.400	0.033
224	4616	7395	0.64	13.7	0.65	128.3	48.1	176.4	0.371	0.039
0	4153	5170	0.80	10.9	0.23	91.8	11.9	103.7	0.424	0.021
0	3826	5043	0.76	10.6	0.24	82.3	12.1	94.4	0.437	0.021
L.S.D. (P=0.05)	633	1082	0.08							

[1]Grain protein content based on %N at 13.5% moisture x 5.7; straw % N on oven-dry basis.

Table 1.2.7. The effect of nitrogen fertilization on the yield, nitrogen content, and nitrogen uptake of irrigated Neepawa wheat grown on alfalfa breaking (Mathison).

N Applied (kg/ha)	Yield (kg/ha) Grain	Straw	Grain/ Straw Ratio	Grain[1] % Protein	Straw % N	Nitrogen Uptake (kg/ha) Grain	Straw	Total	Grain % P	Straw % P
0	2464	4906	0.50	12.9	0.41	64.5	20.1	84.6	0.319	0.024
28	2375	4674	0.52	13.5	0.44	65.0	20.6	85.6	0.310	0.024
56	2380	5016	0.48	14.0	0.51	67.6	25.6	93.2	0.312	0.027
84	2483	5274	0.47	13.9	0.50	70.0	26.4	96.4	0.329	0.024
112	2250	5145	0.44	14.0	0.54	63.9	27.8	91.7	0.320	0.024
168	2511	4750	0.55	14.2	0.51	72.3	24.2	96.5	0.306	0.021
224	2782	5494	0.51	14.4	0.50	81.3	27.5	108.8	0.307	0.015
0	2529	4906	0.52	13.2	0.36	67.7	17.7	85.4	0.323	0.018
0	2328	4702	0.50	13.2	0.35	62.3	16.5	78.8	0.326	0.018
L.S.D. (P=0.05)	293	594	0.08							

[1]Grain protein content based on % N at 13.5% moisture x 5.7; straw % N on oven-dry basis.

increase in the above ground plant material. Little change was observed in the grain/straw ratios at the other three sites. Grain protein content and straw nitrogen content increased where fertilizer nitrogen was applied and resulted in an increased nitrogen uptake at the four sites.

As atated earlier, the Pederson site was unique in that the nitrogen supplying power of the soil had been estimated prior to any history of alfalfa production. In 1972 an experiment was set up on the same border strip used in the present experiment to measure the response of barley to nitrogen fertilization. The nitrogen supplying power of the soil was estimated to be approximately 15 kg N/ha, as measured in the barley crop. The five intervening years of full alfalfa production essentially raised the nitrogen supplying power of the soil to a value of approximately 90 kg N/ha, which was measured in the 1979 wheat crop. Obviously, the introduction of alfalfa into the rotation markedly increased the nitrogen supplying power of the soil at the Pederson site. The results of the analyses of soil samples collected in the fall after the harvest of the plots are presented in Table 1.2.8. The results for the individual replicates are presented in Appendix Table A5. The results indicate that the NO_3^--N levels were similar at the four sites and that they were not excessively large. Thus, the wheat crops basically removed all the nitrogen minerallized from the alfalfa residues throughout the growing season.

CONCLUSION

The results obtained in this project from field plots in 1977, 1978, and 1979 clearly indicate that the release of mineral nitrogen in the year of alfalfa breaking under irrigation is sufficiently rapid enough

Table 1.2.8. Fall soil analyses for the alfalfa breaking experiment under irrigation (mean of six reps).

Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K
			--------	kg/ha*	---------
		Verwimp East			
0-15	7.7	0.3	17	24	290
15-30	7.8	0.2	8	8	207
30-60	8.1	0.5	15	8	483
60-90	8.3	1.5	13	15	653
90-120	8.2	2.4	12	17	727
		Verwimp West			
0-15	8.2	0.3	12	29	206
15-30	8.3	0.2	6	9	165
30-60	8.2	0.2	11	7	387
60-90	8.5	0.3	11	7	483
90-120	8.5	0.3	10	5	627
		Pederson			
0-15	8.1	0.4	10	6	234
15-30	8.2	0.5	9	3	265
30-60	8.4	0.7	17	6	690
60-90	8.6	1.0	15	19	797
		Mathison			
0-15	8.1	0.5	17	4	312
15-30	8.1	0.3	9	1	217
30-60	8.3	0.4	12	3	387
60-90	8.5	0.4	11	4	437
90-120	8.6	0.5	12	6	490

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

to meet a large portion of a cereal crops nitrogen requirements. Some additional fertilizer nitrogen is required but at a much lower rate of application than for soils of similar NO_3^--N contents but history of straight cereal production. Therefore, as an interim measure, on the basis of the data available to date, the Saskatchewan Soil Testing Laboratory has implemented a reduction in nitrogen rates of 30kg N/ha where cerals or oilseeds are to be seeded on alfalfa breaking.

1.3 Phosphorus requirements of annual crops under irrigation.

INTRODUCTION

With several years of above average and in some cases very high applications of phosphorus in the South Saskatchewan River Irrigation Project at Outlook it is now quite common to encounter phosphorus soil test levels that are out of the range of any previous experience in soil test correlation with these types of soils. Current soil test benchmarks suggest no further phosphorus application when the soil test level exceeds 45 kg P_2O_5/ha (0-15 cm) for cereals or 35 kg P_2O_5/ha (0-15 cm) for oilseeds and pulse crops. Therefore, in 1976 a project was initiated to investigate the response of annual crops under irrigation to phosphorus fertilization on fields with residual phosphate from previous high rates of phosphorus fertilizer applications and thus verify the lack of response at the high soil test levels existing in these fields.

The results obtained to date from eight sites in 1976 and 1977 on two soil types (Asquith sandy loam and Bradwell loam) utilizing four different crops (hard wheat, soft wheat, barley, and flax) has indicated no response to added phosphorus fertilizer in fields having a high soil test phosphorus level. In order to provide adequate information for making phosphorus fertilizer recommendations to irrigation farmers who have large accumulations of residual phosphorus in their soil, data on a wide range of soil types and crops is required. Therefore, it was considered necessary to continue this work and provide more information on soils with high phosphorus soil test levels.

OBJECTIVE

To investigate the response of annual crops under irrigation to phosphorus fertilization on fields with residual phosphate from previous high rates of application.

EXPERIMENTAL METHODS

Two sites were selected in 1979 for the third year of this project. One site was on an Asquith sandy loam soil (Barrich Farms Ltd.) while the other site was on a Bradwell fine sandy loam soil (B. Niska farm). The Asquith soil (Barrich Farms Ltd.) has had a history of large fertilizer applications.

The results of the analyses of soil samples taken at the time of seeding are presented in Table 1.3.1. The results indicate that the Bradwell soil (B. Niska farm) had a medium level of phosphorus (0-15 cm) while the Asquith soil had a high level of phosphorus (0-15 cm). As well, the soil analyses indicated a considerable quantity of phosphorus at depth for the Asquith soil, the same soil that had a history of large fertilizer applications.

Small plots of randomized complete block design with four replicates and seven treatments were established at each site. The treatments included a range of phosphorus rates from 0 to 121 kg P_2O_5/ha and are as presented in Table 1.3.2. Monoammonium phosphate (11-55-0) was used as the phosphate source. The plots were seeded using a double-disc press drill with seven rows per treatment and an 18 cm. row spacing over a length of 4.6 meters. The phosphorus was seed-placed through a set of cones while the seed was applied through the seed box. The plots were situated within the cooperating farmers field and completely

Table 1.3.1. Spring soil analyses for the phosphorus correlation experiments.

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^=$-S
				kg/ha*			
			Niska				
1	0-15	7.4	0.2	19	18	545	15
	15-30	7.6	0.3	16	12	310	24
	30-60	7.7	0.3	24	12	380	48
2	0-15	7.4	0.2	19	23	570	12
	15-30	7.5	0.3	16	10	300	24
	30-60	7.7	0.3	20	10	440	48
3	0-15	7.4	0.3	16	21	510	11
	15-30	7.4	0.4	13	10	245	24
	30-60	7.6	0.4	24	10	420	48
			Barrich				
1	0-15	7.9	0.2	8	37	670	9
	15-30	7.7	0.2	10	54	660	11
	30-60	8.1	0.3	6	17	245	24
2	0-15	7.9	0.2	9	47	745	9
	15-30	7.6	0.3	13	54	515	18
	30-60	8.1	0.4	8	18	280	24
3	0-15	7.7	0.2	8	34	635	10
	15-30	7.2	0.2	13	83	485	18
	30-60	7.4	0.3	5	10	300	24
4	0-15	7.6	0.2	6	36	645	12
	15-30	7.4	0.3	7	36	520	14
	30-60	7.6	0.4	6	14	275	22

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

Table 1.3.2. Fertility treatments used in the phosphorus correlation experiments.

Treatment Number	P_2O_5 Applied (kg/ha)
1	0
2	20
3	40
4	61
5	81
6	101
7	121

surrounded by his crop. The Niska site was seeded to Fielder soft wheat and the Barrich site to Neepawa hard wheat.

The Niska site received a pre-seeding application of anhydrous ammonia as applied by the cooperating farmer. The Barrich site received a hand broadcast application of ammonium nitrate (34-0-0) on June 7, 1979 at a rate of 112 kg N/ha to ensure no nitrogen deficiencies existed.

The Niska site received a post-plant pre-emerge aerial application of Avadex BW for the control of wild oats. Incorporation consisted of two harrowings at right angles to one another. Broadleaf weeds were controlled by a post-emergent aerial application of 2,4-D.

The Barrich site received a post-emergent Application of Hoegrass-Torch tank mix for the control of wild oats, green foxtail and broadleaf weeds.

All 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 1.3.3.

At harvest, yield samples were taken from all treatments by clipping at the soil surface the three center rows over a length of three meters. The samples were then dried, weighed and threshed. The grain samples were cleaned and weighed. Subsamples of both grain (replicates kept separate) and straw (replicates bulked) were mixed and ground. Protein content of the grain was determined with a Technicon Infra Analyzer while nitrogen and phosphorus content of the straw and phosphorus content of the grain were determined by wet digestion and colorimetric analyses using an Auto Analyzer II System.

RESULTS AND DISCUSSION

The results for the effect of phosphorus fertilization on the yield,

Table 1.3.3. Amounts and timing of irrigation applications for the phosphorus correlation experiments.

Site	Growing Season Rainfall (mm)	Dates and amounts of Irrigation applications	Total Water (Irrigation & Rain) (mm)
Niska	86	June 18, 20mm; June 26, 43mm; July 5, 43mm; July 12, 20mm; July 20, 30mm; July 27, 56mm; August 3, 36mm.	334
Barrich	134	July 7, 48mm; July 20, 61mm;	243

nitrogen content, phosphorus content and nitrogen uptake of the irrigated Fielder soft wheat and Neepawa hard wheat are presented in Table 1.3.4. The results for the grain and straw yields indicate that there was no response to the phosphorus fertilization at either site. As well, grain/straw ratios were similar for all the treatment.

The phosphorus content of the grain was increased where phosphorus fertilizer was applied. However, grain phosphorus content did not increase with each increase in the rate of phosphorus applied. The straw phosphorus content showed no response to the phosphorus fertilizer application.

Grain protein content was similar for the different treatments while straw nitrogen content was increased where the ammonium phosphate fertilizer was applied. This could be due to the nitrogen applied with the phosphate fertilizer.

The results obtained for these two sites are in general agreement with the results found in 1976 and 1977. Generally, where soil test phosphorus levels are high there is no response to added phosphate fertilizer.

Table 1.3.4. The effect of phosphorus fertilization on the phosphorus and nitrogen content of irrigated Fielder soft wheat and Neepawa hard wheat.

P_2O_5 Applied (kg/ha)	Yield Grain (kg/ha)	Yield Straw (kg/ha)	Grain/ Straw Ratio	Grain % P	Straw % P	Grain % Protein	Straw % N	Nitrogen Uptake Grain (kg/ha)	Nitrogen Uptake Straw (kg/ha)	Nitrogen Uptake Total (kg/ha)
				Niska (Fielder soft wheat)						
0	3674	4347	0.57	0.338	0.096	8.8	0.454	65.6	19.7	85.3
20	3856	4402	0.59	0.359	0.105	9.2	0.484	72.0	21.3	93.3
40	3955	5630	0.51	0.367	0.090	9.3	0.469	74.6	26.4	101.0
61	2859	3317	0.57	0.359	0.093	8.9	0.484	51.6	16.1	67.7
81	3703	4400	0.57	0.345	0.102	9.6	0.681	72.1	30.0	102.1
101	3635	4197	0.57	0.355	0.117	9.3	0.560	68.6	23.5	92.1
121	3663	4352	0.56	0.351	0.099	9.7	0.575	72.1	25.0	97.1
L.S.D.	1560	2697	0.14							
				Barrich (Neepawa hard wheat)						
0	3333	4938	0.68	0.458	0.138	12.0	0.409	81.1	20.2	101.3
20	3352	4931	0.69	0.466	0.126	12.2	0.484	82.9	23.9	106.8
40	3258	4746	0.69	0.465	0.135	12.0	0.439	79.3	20.8	100.1
61	3316	4858	0.69	0.462	0.150	12.5	0.484	84.1	23.5	107.6
81	3356	5176	0.65	0.465	0.141	11.8	0.439	80.3	22.7	103.0
101	3620	5128	0.71	0.470	0.141	12.6	0.469	92.5	24.1	116.6
121	3568	5005	0.72	0.472	0.114	12.5	0.454	90.5	22.7	113.2
L.S.D. (P=0.05)	483	821	0.11							

APPENDIX A. Selected tables of data from the 1979 irrigation experiments

Appendix Table A1. Farmer cooperator, legal location and soil type of experimental field plots for the 1979 irrigation trials.

Farmer Cooperator	Crop Investigated	Legal Location	Soil Type
	N x Wheat Varieties x Water Scheduling Experiment		
Tomasiewicz	Sinton hard wheat Glenlea utility wheat Fielder soft wheat	SW28-28-7-W3	Elstow loam
	N Status of Alfalfa Breaking		
Verwimp (East)	Neepawa hard wheat	NE32-29-7-W3	Bradwell very fine sandy loam
Verwimp (West)	Neepawa hard wheat	NE32-29-7-W3	Asquith sandy loam
Pederson	Neepawa hard wheat	SW20-28-7-W3	Elstow loam
Mathison	Neepawa hard wheat	NW31-30-7-W3	Bradwell fine sandy loam
	P Response of Annual Crops		
B. Niska	Fielder soft wheat	NW23-27-7-W3	Bradwell fine sandy loam
Barrich Farms Ltd.	Neepawa hard wheat	SE35-29-8-W3	Asquith sandy loam

Appendix Table A2. Residual NO_3^--N levels from selected rates of nitrogen application and irrigation treatments for the nitrogen x wheat varieties x water scheduling experiment.

Depth (cm)	Residual NO_3^--N (kg/ha)*											
	Water A				Water C				Dryland			
	Rep 1	Rep 2	Rep 3	Rep 4	Rep 1	Rep 2	Rep 3	Rep 4	Rep 1	Rep 2	Rep 3	Rep 4
					Sinton 0 kg N/ha							
0-15	10	15	13	13	15	11	13	15	9	91	10	12
15-30	9	9	9	10	7	5	6	7	8	14	7	10
30-60	18	18	18	18	16	12	10	14	22	32	28	30
60-90	16	16	16	18	18	14	18	14	32	50	76	46
90-120	18	22	20	26	24	18	18	18	18	32	56	32
					Sinton 224 kg N/ha							
0-15	10	9	10	12	9	8	10	8	45	10	17	94
15-30	8	8	8	9	8	6	6	7	11	7	83	15
30-60	14	70	60	168	12	44	26	56	26	18	52	70
60-90	14	18	20	30	16	26	46	36	20	46	124	64
90-120	20	18	22	18	18	16	32	20	22	28	64	38
					Glenlea 0 kg N/ha							
0-15	9	9	9	8	9	10	10	10	6	8	8	9
15-30	6	6	5	6	6	4	6	6	7	6	5	6
30-60	12	10	12	12	10	8	12	10	14	18	44	52
60-90	10	8	14	12	10	10	14	10	14	50	66	70
90-120	14	8	18	12	12	16	16	24	18	28	26	32

Appendix Table A2 (continued)

Depth (cm)	Residual NO_3^--N (kg/ha)*											
	Water A				Water C				Dryland			
	Rep 1	Rep 2	Rep 3	Rep 4	Rep 1	Rep 2	Rep 3	Rep 4	Rep 1	Rep 2	Rep 3	Rep 4
Glenlea 224 kg N/ha												
0-15	6	6	5	4	6	5	7	8	22	30	28	102
15-30	16	9	5	5	4	4	6	6	8	10	10	14
30-60	20	24	12	34	12	12	12	12	16	16	22	32
60-90	8	18	14	22	40	20	12	20	20	14	62	52
90-120	12	16	10	14	18	20	20	22	20	18	40	36
Fielder 0 kg N/ha												
0-15	9	8	9	9	5	8	8	10	5	7	6	12
15-30	5	4	4	3	9	5	4	4	3	4	5	12
30-60	8	6	6	6	6	10	8	10	8	42	92	88
60-90	10	8	8	8	6	10	6	6	14	36	62	48
90-120	8	10	20	14	12	18	8	8	18	26	22	24
Fielder 224 kg N/ha												
0-15	6	3	5	4	7	4	5	4	106	77	109	90
15-30	3	4	3	3	5	7	4	3	16	13	17	22
30-60	8	6	6	38	28	12	8	8	34	56	76	64
60-90	10	8	16	26	10	12	32	12	40	38	40	54
90-120	6	8	14	12	12	8	12	14	24	28	40	32

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

Appendix Table A3. Residual NO_3^--N levels in the 0-15 cm depth for the dryland treatment for the nitrogen x wheat varieties x water scheduling experiment.

N Applied (kg/ha)	Rep 1	Residual NO_3^--N (kg/ha)* Rep 2	Rep 3	Rep 4
		Sinton		
0	9	91	10	12
56	14	16	20	19
84	21	22	26	25
112	21	21	26	50
168	34	53	46	61
224	45	10	17	94
		Glenlea		
0	6	8	8	9
56	11	10	15	16
84	10	11	19	14
112	13	28	18	21
168	22	31	35	36
224	22	30	28	102
		Fielder		
0	5	7	6	12
56	16	10	18	15
84	19	17	20	25
112	20	36	35	49
168	56	42	62	99
224	106	77	109	90

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

Appendix Table A4. Spring soil analyses for the alfalfa breaking experiment under irrigation.

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^=$-S
				----------		kg/ha	--------
			Verwimp East				
1	0-15	7.3	0.4	21	19	285	15
	15-30	7.5	0.3	11	9	230	24
	30-60	7.7	0.4	7	6	240	24
	60-90	8.2	1.4	6	4	355	24
	90-120	8.0	0.8	6	5	225	24
2	0-15	7.5	0.4	34	22	325	12
	15-30	7.6	0.3	14	9	200	11
	30-60	7.9	0.4	9	4	220	24
	60-90	8.1	1.0	8	3	270	24
	90-120	8.4	1.3	4	4	300	24
3	0-15	7.7	0.6	29	19	260	11
	15-30	8.1	0.3	7	7	185	9
	30-60	8.3	0.6	8	5	185	24
	60-90	8.5	1.5	4	4	245	24
	90-120	8.4	1.7	4	6	340	24
4	0-15	7.7	0.6	34	21	260	10
	15-30	8.1	0.3	9	5	185	9
	30-60	8.4	0.6	10	3	235	24
	60-90	8.7	1.1	6	5	320	24
	90-120	8.5	1.5	4	6	320	24
5	0-15	7.4	0.6	28	19	310	12
	15-30	7.9	0.3	9	7	245	7
	30-60	8.5	2.5	4	10	315	24
	60-90	8.4	1.0	7	5	275	24
	90-120	8.4	3.9	4	8	360	24
6	0-15	7.4	0.4	35	26	425	10
	15-30	7.8	0.3	11	6	265	11
	30-60	8.3	0.4	7	3	240	24
	60-90	8.4	1.5	5	3	280	24
	90-120	8.2	4.8	6	8	420	24

Appendix Table A4 (continued)

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^=$-S
				----------	kg/ha	----------	
			Verwimp West				
1	0-15	8.2	0.2	13	21	230	13
	15-30	8.3	0.2	7	8	205	13
	30-60	8.5	0.2	5	5	145	10
	60-90	8.7	0.2	4	3	175	17
	90-120	8.7	0.2	4	2	200	11
2	0-15	8.3	0.3	11	14	210	8
	15-30	8.3	0.3	6	5	195	14
	30-60	8.5	0.2	4	3	175	17
	60-90	8.6	0.2	3	2	150	22
	90-120	8.7	0.3	5	2	185	24
3	0-15	8.3	0.2	11	37	200	7
	15-30	8.5	0.2	8	14	170	6
	30-60	8.6	0.2	4	9	190	13
	60-90	8.5	0.3	3	9	250	24
	90-120	8.4	0.3	4	6	300	24
4	0-15	8.2	0.3	12	56	250	8
	15-30	8.3	0.2	7	18	170	6
	30-60	8.5	0.2	5	8	200	12
	60-90	8.3	0.2	4	6	255	18
	90-120	8.4	0.4	3	4	270	19
5	0-15	7.7	0.4	9	15	185	13
	15-30	8.0	0.3	7	9	235	20
	30-60	8.2	0.3	5	6	175	16
	60-90	8.5	0.2	4	5	185	22
	90-120	8.6	0.3	4	4	225	23
6	0-15	7.8	0.3	10	17	205	13
	15-30	7.9	0.2	7	13	190	14
	30-60	8.3	0.2	5	8	180	18
	60-90	8.6	0.2	4	4	190	24
	90-120	8.6	0.3	4	4	225	24

Appendix Table A4 (continued)

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^=$-S
				---------- kg/ha ----------			
			Pederson				
1	0-15	8.0	0.7	36	8	265	24
	15-30	8.3	0.6	16	4	240	24
	30-60	8.5	0.6	5	8	270	24
	60-90	8.5	1.0	3	7	315	24
	90-120	8.3	1.3	3	9	330	24
2	0-15	8.1	0.4	25	8	230	24
	15-30	8.2	0.6	18	6	225	24
	30-60	8.4	0.4	7	5	275	24
	60-90	8.5	0.6	5	8	335	24
	90-120	8.4	1.0	4	11	360	24
3	0-15	8.1	0.6	20	7	220	24
	15-30	8.2	0.4	21	4	220	24
	30-60	8.5	0.4	5	4	270	24
4	0-15	8.0	0.6	39	6	295	24
	15-30	8.2	0.6	28	5	215	24
	30-60	8.6	0.6	9	4	275	24
5	0-15	8.2	0.4	28	6	245	24
	15-30	8.2	0.4	28	5	195	24
	30-60	8.6	0.6	6	5	305	24
6	0-15	8.1	0.6	23	5	200	24
	15-30	8.1	0.6	27	3	215	24
	30-60	8.6	0.7	8	5	260	24

Appendix Table A4 (continued)

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^=$-S
				----------	kg/ha	----------	
			Mathison				
1	0-15	8.1	0.6	16	9	255	24
	15-30	8.3	0.4	8	5	205	24
	30-60	8.6	0.4	6	4	210	24
2	0-15	8.1	0.4	14	4	205	24
	15-30	8.3	0.3	6	3	155	24
	30-60	8.5	0.3	4	3	155	24
3	0-15	8.0	0.4	14	3	235	24
	15-30	8.2	0.3	8	2	175	24
	30-60	8.4	0.4	6	2	160	24
4	0-15	7.9	0.4	15	3	260	24
	15-30	8.1	0.3	10	2	195	24
	30-60	8.3	0.4	6	2	200	24
5	0-15	7.8	0.4	24	3	435	24
	15-30	8.0	0.3	11	2	245	23
	30-60	8.3	0.4	6	2	220	24
6	0-15	8.0	0.4	18	3	340	24
	15-30	8.1	0.3	11	2	225	18
	30-60	8.4	0.3	6	2	200	24

Appenidix Table A5. Fall soil analyses for the alfalfa breaking experiment under irrigation.

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K
				-------	kg/ha	-------
			Verwimp East			
1	0-15	7.3	0.3	15	32	400
	15-30	7.5	0.2	8	12	250
	30-60	7.6	0.3	14	12	500
	60-90	7.9	1.5	12	10	660
	90-120	8.2	1.7	16	12	880
2	0-15	7.6	0.2	14	23	310
	15-30	7.6	0.1	7	11	220
	30-60	7.8	0.6	14	12	520
	60-90	8.2	1.4	12	6	620
	90-120	8.0	2.6	10	12	740
3	0-15	7.4	0.3	10	31	280
	15-30	7.7	0.2	6	11	230
	30-60	7.9	0.3	12	14	420
	60-90	8.4	0.8	10	10	600
	90-120	8.5	0.6	10	16	620
4	0-15	8.3	0.2	12	16	220
	15-30	8.2	0.3	6	4	180
	30-60	8.5	0.4	14	4	520
	60-90	8.0	2.3	14	20	720
	90-120	8.0	2.6	12	16	600
5	0-15	7.3	0.2	27	21	250
	15-30	7.7	0.1	9	6	180
	30-60	8.2	0.8	18	4	520
	60-90	8.3	2.2	12	18	660
	90-120	8.1	3.2	10	20	600
6	0-15	8.0	0.3	21	18	280
	15-30	8.1	0.2	10	6	180
	30-60	8.4	0.3	18	4	420
	60-90	8.7	0.8	16	24	660
	90-120	8.1	3.9	16	28	920

Appendix Table A5 (continued)

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P kg/ha	K
			Verwimp West			
1	0-15	8.2	0.3	11	39	200
	15-30	8.2	0.2	7	11	180
	30-60	8.3	0.2	10	12	480
	60-90	8.6	0.2	10	14	660
	90-120	8.7	0.2	10	10	900
2	0-15	8.5	0.2	12	12	250
	15-30	8.3	0.2	6	5	180
	30-60	8.5	0.2	10	4	340
	60-90	8.6	0.2	10	4	380
	90-120	8.7	0.2	10	2	460
3	0-15	8.4	0.2	8	21	160
	15-30	8.6	0.1	5	10	140
	30-60	7.4	0.3	12	4	400
	60-90	8.3	0.3	10	4	540
	90-120	8.3	0.3	10	4	660
4	0-15	8.0	0.3	13	29	220
	15-30	8.3	0.2	5	9	170
	30-60	8.3	0.3	14	8	480
	60-90	8.3	0.4	12	6	520
	90-120	8.1	0.6	10	4	680
5	0-15	8.0	0.4	15	38	215
	15-30	8.3	0.3	7	11	150
	30-60	8.6	0.2	10	8	300
	60-90	8.7	0.3	14	6	460
	90-120	8.7	0.3	12	4	650
6	0-15	7.9	0.2	15	32	190
	15-30	7.9	0.2	7	8	170
	30-60	8.2	0.2	12	8	320
	60-90	8.6	0.2	10	6	340
	90-120	8.6	0.2	10	4	410

Appendix Table A5 (continued)

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K
				-------	kg/ha	-------
			Pederson			
1	0-15	8.1	0.4	9	9	240
	15-30	8.2	0.4	9	4	260
	30-60	8.4	0.4	20	4	720
	60-90	8.5	0.6	14	16	860
	90-120	8.3	0.7	20	26	920
2	0-15	8.1	0.3	8	4	220
	15-30	8.1	0.4	10	2	270
	30-60	8.4	0.6	16	4	680
	60-90	8.4	0.7	16	12	780
3	0-15	8.2	0.4	11	4	220
	15-30	8.2	0.4	9	2	300
	30-60	8.5	0.4	18	4	760
	60-90	8.7	0.7	16	20	960
4	0-15	8.2	0.4	11	6	240
	15-30	8.3	0.3	9	4	250
	30-60	8.5	0.4	18	6	660
	60-90	8.9	0.7	14	22	620
5	0-15	8.2	0.4	9	5	230
	15-30	8.1	0.4	8	3	260
	30-60	8.4	0.4	18	4	760
	60-90	8.7	0.6	14	22	960
6	0-15	8.0	0.7	11	9	255
	15-30	8.0	1.2	8	4	250
	30-60	8.1	1.7	14	4	560
	60-90	8.4	2.8	16	22	600

Appendix Table A5 (continued)

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K
				-------	kg/ha	-------
			Mathison			
1	0-15	8.2	0.8	17	9	290
	15-30	8.3	0.4	10	2	190
	30-60	8.5	0.4	14	4	380
	60-90	8.6	0.4	14	2	380
	90-120	8.6	0.8	16	2	400
2	0-15	8.2	0.6	13	2	220
	15-30	8.3	0.3	10	1	180
	30-60	8.4	0.4	16	4	360
	60-90	8.7	0.4	12	6	420
	90-120	8.9	0.4	6	4	520
3	0-15	8.2	0.4	15	2	240
	15-30	8.1	0.2	8	1	220
	30-60	8.4	0.4	10	2	400
	60-90	8.5	0.6	10	4	460
	90-120	8.8	0.4	10	6	460
4	0-15	8.0	0.4	17	3	360
	15-30	7.9	0.2	7	1	250
	30-60	8.1	0.3	8	2	400
	60-90	8.4	0.4	8	2	460
	90-120	8.7	0.6	12	6	540
5	0-15	8.0	0.3	22	4	400
	15-30	8.0	0.3	8	2	230
	30-60	8.2	0.3	10	2	400
	60-90	8.4	0.3	8	4	480
	90-120	7.8	0.3	14	10	580
6	0-15	7.8	0.3	20	5	360
	15-30	7.9	0.3	9	1	230
	30-60	8.2	0.3	14	2	380
	60-90	8.6	0.3	14	4	420
	90-120	8.8	0.3	14	10	440