1981 SOIL-PLANT NUTRIENT RESEARCH REPORT

Compiled by

J.L. Henry and T.J. Hogg

Department of Soil Science
University of Saskatchewan
Saskatoon, Saskatchewan

Program Coordinator: J.L. Henry

TABLE OF CONTENTS

Page

1.0 NUTRIENT AND WATER REQUIREMENTS OF IRRIGATED CROPS

1.1 Irrigation scheduling of pulse crops. 1

1.2 The effect of annual legume crops on the yield of subsequent cereal crops 18

2.0 APPENDICES 26

Appendix A. Selected tables of data from the 1981 irrigation experiments. 26

LIST OF TABLES

		Page
Table 1.1.1	Spring soil analyses for the pulse crop irrigation scheduling experiment.	3
Table 1.1.2	Water treatments used in the pulse crop irrigation scheduling experiment.	5
Table 1.1.3	Amount of water required to replenish soil moisture.	7
Table 1.1.4	Amounts and timing of irrigation applications for the pulse crop irrigation scheduling experiment.	8
Table 1.1.5	Plant populations and nutrient content of pulse crops grown under different irrigation water schedules	10
Table 1.1.6	Grain, straw and total aboveground N, P and K uptake by pulse crops grown under different water schedules	14
Table 1.1.7	Seasonal water use of pulse crops under different irrigation watering schedules (1981). .	16
Table 1.2.1	Farm co-operator, legal location and soil type for the cereal crop nitrogen correlation experiment on annual legume stubble	20
Table 1.2.2	Spring soil analyses for the nitrogen correlation experiments after annual legumes.	21
Table 1.2.3	Fertilizer treatments used for the nitrogen correlation experiments after annual legumes. . .	22
Table 1.2.4	The effect of nitrogen fertilization on the yield and nutrient content of cereal crops grown on fababean stubble	24

APPENDICES

Table A1	Grain nitrogen, phosphorus and potassium content of pulse crops grown under different irrigation water schedules	27
Table A2	Spring soil analyses for the nitrogen correlation experiment after annual legumes	29

1.0 Nutrient and water requirements of irrigated crops.

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 conducted 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[1].

The importance of the timing of irrigation applications and thus, the effect of moisture stresses at different times in the growing season on pulse crop yields in Saskatchewan is not fully known at this time. Research in 1980[2] on the effect of irrigation scheduling of pulse crops indicated a moisture stress later in the growing season caused a greater yield reduction in most pulse crops than did moisture stresses earlier in the growing season, the opposite that has been found for cereal and oilseed crops. However, this data was only for one growing season. Therefore, it was considered necessary to continue this research into the effect of irrigation scheduling on pulse crops and thus, determine at what time or times during the growing season that a moisture stress has the most adverse effect on yield.

---

[1] Soil-Plant Nutrient Research Reports for 1976, 1977 and 1978. Department of Soil Science, University of Saskatchewan, Saskatoon, Sask.

[2] 1980 Soil-Plant Nutrient Research Report. Department of Soil Science, University of Saskatchewan, Saskatoon, Sask.

OBJECTIVE

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

This was the second year of a joint project between the Crop Development Center and the Department of Soil Science, University of Saskatchewan, Saskatoon, Saskatchewan.

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; NW4-28-7-W3). The area of this field on which the plot was to be located had been seeded to winter wheat in 1980. This was the same field that was used for the 1980 pulse crop irrigation scheduling experiment.

The results of the analysis of soil samples collected in the spring from the plot area are presented in Table 1.1.1. The results indicate a low nitrogen content and a low phosphorus content. Other major nutrients were adequate according to 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 were considered normal for Elstow soils in this area.

The crops fababeans (Erfordia), peas (Tara), dry beans (Pinto) and lentils (Eston) 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. Two passes with the drill were required when seeding the dry bean plot since an error was made in the drill setting and thus, only one-half the normal seeding rate was used with both passes. The entire plot area received an initial 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	S
				------	kg/ha*	-------	
Fababeans	0-15	8.4	0.3	16	18	459	9
	15-30	8.4	0.2	9	4	202	7
	30-60	8.5	0.4	13	4	515	54+
	60-90	8.6	1.4	25	18	627	54+
	90-120	8.4	3.0	31	29	829	54+
Peas	0-15	8.2	0.3	17	9	437	9
	15-30	8.3	0.2	10	2	202	6
	30-60	8.4	0.3	16	4	470	29
	60-90	8.6	1.0	22	13	717	54+
	90-120	8.5	1.9	29	18	963	54+
Dry beans	0-15	8.6	0.2	17	18	392	7
	15-30	8.5	0.2	10	6	202	4
	30-60	8.5	0.3	16	4	448	54+
	60-90	8.5	1.3	16	13	605	54+
	90-120	8.5	1.9	22	18	784	54+
Lentils	0-15	8.5	0.3	18	28	448	7
	15-30	8.4	0.2	12	8	202	4
	30-60	8.5	0.4	18	4	493	54+
	60-90	8.6	1.4	29	13	605	54+
	90-120	8.5	2.5	43	20	694	54+

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

5 days after seeding of approximately 25 mm to ensure the germination of all crops in all water treatments because of dry seed-bed conditions.

Trifluralin was applied pre-plant and incorporated with two cultivations at right angles and a final harrowing in the same direction as the first cultivation. 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 40 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 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 then 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

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

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 under study. 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 five days after seeding, there were still problems in germination and plant stands for the lentils and emergence of the dry beans. Thus, 3 weeks after the initial seeding date the lentils were reseeded (May 28) to try and establish a better stand. The entire reseeded lentil plot received an irrigation application of 25 mm to aid germination and in addition all treatments of the dry beans received a 30 mm irrigation application to aid in emergence.

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 for the fababeans and lentils. For the peas and dry beans 3 m^2 samples were collected from the dryland treatment and 2 m^2 samples were sampled from the irrigated treatments. Subsamples of grain (replicates 1 to 5 bulked and 6 to 10 bulked) and straw (replicates

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 = 135 mm (additional 8 mm for fababeans A,B,C,D; dry beans B,C,D; lentils B,C,D)					
Fababeans	June 11	---	94 mm	89 mm	97 mm
	July 2	89 mm	---	102 mm	86 mm
	July 17	89 mm	91 mm	---	86 mm
	Aug. 8	74 mm	64 mm	71 mm	74 mm
	Aug. 20	74 mm	86 mm	79 mm	90 mm
		326 mm	335 mm	341 mm	433 mm
Peas	June 10	---	79 mm	66 mm	81 mm
	July 6	91 mm	---	97 mm	84 mm
	July 28	107 mm	117 mm	---	109 mm
	Aug. 18	114 mm	114 mm	117 mm	102 mm
		312 mm	310 mm	280 mm	376 mm
Dry Beans	July 9	---	97 mm	86 mm	97 mm
	Aug. 7	122 mm	---	97 mm	94 mm
	Aug. 26	91 mm	89 mm	---	71 mm
		213 mm	186 mm	183 mm	262 mm
Lentils	July 8	---	89 mm	79 mm	84 mm
	Aug. 6	127 mm	---	102 mm	112 mm
	Aug. 19	119 mm	89 mm	---	81 mm
		246 mm	178 mm	181 mm	277 mm

All plots including dryland received approximately a 25 mm irrigation on May 12 to ensure uniform germination. In addition all treatments of Dry Beans received a 30 mm irrigation to aid emergence; and on May 28 all treatments of lentils (reseeded) received a 25 mm irrigation.

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 AutoAnalyzer II System.

In addition to the yields obtained by manual sampling, total plot yields were determined by Hege combine. The Hege combine operation was done in late September and hence, some shelling had occurred.

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 clearly shows the response of all of the pulse crops to irrigation water applications. The yields obtained were lower than those in 1980 but it must be remembered that in 1980 specific sites of high plant population were selected for sampling because of poor plant stands and poor germination. The yields found in the present work, however, were larger for all the pulse crops than those found in previous research conducted from 1976 to 1978[1]. Maximum yields in the present work for the pulse crops under irrigation were fababeans 6100 kg/ha, peas 3700 kg/ha, dry beans 2400 kg/ha and lentils 2700 kg/ha in comparison to previous work where irrigated yields over a three year period were fababeans 4119 kg/ha, peas 2189 kg/ha, dry beans 1930 kg/ha and lentils 1736 kg/ha.

There were yield differences between irrigation scheduling treatments for all the pulse crops. The most significant yield reduction occurred for Water C where the third irrigation application was missed. This resulted in yield reductions for fababeans, peas and

[1] Soil-Plant Nutrient Research Reports for 1976, 1977 and 1978. Department of Soil Science, University of Saskatchewan, Saskatoon, Sask.

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

Water schedule	Plants/ hectare (X 1000)	Hege combine yield kg/ha	Yield Grain -- kg/ha --	Yield Straw -- kg/ha --	Grain[1] % protein	Straw % N	% P[2] Grain	% P[2] Straw	% K[2] Grain	% K[2] Straw
					Fababeans					
A	166	3655	6167	7139	28.6	0.54	0.645	0.144	1.16	1.35
B	166	3464	6058	6038	30.9	0.66	0.656	0.156	1.17	1.35
C	123	2648	4804	4997	30.5	0.69	0.647	0.153	1.10	1.44
D	123	2931	5173	5881	29.8	0.66	0.642	0.150	1.16	1.29
Dryland	129	465	1634	1822	30.0	0.66	0.618	0.129	1.07	2.46
					Peas					
A	-	2161	3193	2872	24.9	1.05	0.449	0.084	1.20	1.08
B	-	2839	3652	3073	24.4	1.08	0.450	0.105	1.16	1.02
C	-	2612	3126	2497	25.5	0.84	0.44	0.072	1.14	1.08
D	-	2963	3705	2924	24.9	0.96	0.468	0.087	1.20	1.26
Dryland	-	356	1691	1522	23.2	0.78	0.44	0.075	1.05	1.65
					Dry Beans					
A	-	1304	2390	2039	16.6	0.75	0.612	0.174	1.68	2.22
B	-	909	1880	1442	16.3	0.66	0.656	0.180	1.68	2.01
C	-	906	1985	1718	15.9	0.66	0.639	0.225	1.67	1.95
D	-	839	1850	1647	15.8	0.69	0.642	0.222	1.67	2.10
Dryland	-	244	759	664	21.1	0.66	0.630	0.144	1.64	1.95
					Lentils					
A	1304	1773	2715	2513	22.7	1.23	0.445	0.168	1.01	1.29
B	1126	2181	2763	4343	30.0	1.35	0.588	0.180	1.17	1.65
C	1003	2381	2455	4019	27.2	1.41	0.534	0.201	1.14	1.56
D	1027	2611	2765	3871	26.3	1.44	0.533	0.201	1.10	1.53
Dryland	1187	1050	1957	1806	23.0	0.66	0.419	0.051	0.95	1.56

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

[2]Oven-dry basis

lentils. Missing the first irrigation (Water A) also resulted in a reduced yield for peas. For dry beans, missing the second irrigation (Water B) and receiving all irrigation applications (Water D) resulted in the lowest yields.

Hege combine yields showed similar trends as the hand sampling yields, however, the yields were lower. This could be expected since some shelling of the crops occurred before Hege combine yields were obtained.

The overall yield relationship to the different irrigation schedules for the present work was similar to that found in 1980[2]. Some differences occurred between the two years work. In 1980 fababeans and lentils had a reduced yield when the first irrigation was missed (Water A) as well as when the third irrigation was missed (Water C) but in the present work only a yield reduction was observed for Water C. Dry beans in 1980 had a yield reduction when the third irrigation was missed (Water C) which was not observed in the present work.

Grain/straw ratios for the pulse crops grown under irrigation were greater than 1 for dry beans and peas, approximately 1 for fababeans and less than 1 for lentils. Under dryland all the pulse crops had a grain/straw ratio of approximately 1. There were no differences in grain/straw ratios for the different irrigation scheduling treatments for each crop.

Grain protein content was greater under dryland than irrigation for dry beans, the same under dryland and irrigation for fababeans and greater under irrigation than dryland for peas and lentils. These results are similar to those found in the 1980 and in previous research

---

[2] 1980 Soil-Plant Nutrient Research Report. Department of Soil Science, University of Saskatchewan, Saskatoon, Sask.

with the exception that grain protein of fababeans under irrigation is usually greater than dryland. This was also found in 1980 with the difference from the previous research being attributed to the higher protein content of the fababeans under dryland.

Straw nitrogen content was greater under irrigation than dryland for peas and lentils and approximately the same under irrigation as dryland for fababeans and dry beans. This work showed some differences in straw nitrogen content from the work in 1980 where dry bean and lentil straw nitrogen content was greater under dryland than irrigation. However, the present work tends to agree with previous research conducted on pulse crops from 1976 to 1978 where it was found that straw nitrogen content was generally greater under irrigation than dryland. No trends were observed between the different irrigation scheduling treatments and straw nitrogen content.

Grain phosphorus content was greater under irrigation than dryland for fababeans, dry beans and lentils and approximately the same under irrigation and dryland for peas. Only lentils showed the same trend as in 1980 whereas fababeans, peas and dry beans showed the opposite trend as in 1980. Water B (missed the second irrigation) had the highest grain phosphorus content for fababeans, dry beans and lentils whereas in 1980 Water C (missed the third irrigation) had the highest grain phosphorus content for fababeans, peas and dry beans. Differences in phosphorus grain content could possibly reflect the different water stresses placed on the pulse crops by the irrigation scheduling treatments. The plant growth stage at which a water stress is applied may also be important since the water scheduling treatment where phosphorus content was the highest changed from Water C in 1980 to Water B in 1981.

Straw phosphorus content was greater under irrigation than dryland for all the pulse crops. This was different than reported in 1980 for dry beans and lentils where the opposite was found. No relationship between straw phosphorus content and the irrigation scheduling treatments was observed, the same as in 1980.

The potassium content of the grain of the pulse crops was greater under irrigation than dryland for fababeans, peas and lentils and approximately the same under irrigation and dryland for dry beans. Straw potassium content was greater under dryland than irrigation for fababeans and peas, the same under dryland and irrigation for lentils and greater under irrigation than dryland for dry beans. These results were similar to those found in 1980 with the exception of straw potassium content. The much higher potassium content of fababean straw observed in 1980 was also observed in 1981. As in 1980, dry beans had the highest potassium content in both the grain and straw and as well, the straw potassium content was greater than the grain potassium content for all the pulse crops.

Total aboveground nitrogen, phosphorus and potassium uptake by the pulse crops grown under different irrigation water schedules are presented in Table 1.1.6. All of the pulse crops had greater nitrogen, phosphorus and potassium uptake under irrigation than dryland as would be expected since they also had greater yields under irrigation than dryland. No definite trends were observed relating nitrogen, phosphorus or potassium uptake and the different irrigation water schedules.

Total aboveground nitrogen uptake was greatest for fababeans and was followed in order by peas > lentils > dry beans, the same as found for 1980. The large total aboveground nitrogen uptake for the

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

Water schedule	N			P			K		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
	kg/ha								
				Fababeans					
A	282.4	38.6	321.0	39.8	10.3	50.1	71.5	96.4	167.9
B	299.9	39.9	339.8	39.7	9.4	49.1	70.9	81.5	152.4
C	234.4	34.5	268.9	31.1	7.6	38.7	52.8	72.0	124.8
D	246.8	38.8	285.6	33.2	8.8	42.0	60.0	68.2	128.2
Dryland	77.3	12.0	89.3	10.1	2.4	12.5	17.4	44.8	62.2
				Peas					
A	127.1	30.2	157.3	14.3	2.4	16.7	38.3	31.0	69.3
B	142.4	33.2	175.6	16.4	3.2	19.6	42.4	31.3	73.7
C	127.5	21.0	148.5	13.8	1.8	15.6	35.6	27.0	62.6
D	147.5	28.1	175.6	17.3	2.5	19.8	44.5	36.8	81.3
Dryland	62.7	11.9	74.6	7.4	1.1	8.5	17.8	25.1	42.9
				Dry Beans					
A	63.6	15.3	78.9	14.6	3.5	18.1	40.2	45.3	85.5
B	47.9	9.5	57.4	12.3	2.6	14.9	31.6	30.0	61.1
C	50.6	11.3	61.9	12.7	3.9	16.6	33.1	33.5	66.6
D	46.6	11.4	58.0	11.9	3.7	15.6	30.9	34.6	65.5
Dryland	25.7	4.4	30.1	4.8	1.0	5.8	12.4	12.9	25.3
				Lentils					
A	99.0	30.9	129.9	12.1	4.2	16.3	27.4	32.4	59.8
B	132.6	58.6	191.2	16.2	7.8	24.0	32.3	71.7	104.0
C	106.8	56.7	163.5	13.1	8.1	21.2	28.0	62.7	90.7
D	116.0	55.7	171.7	14.7	7.8	22.5	30.4	59.2	89.6
Dryland	72.0	11.9	83.9	8.2	1.0	9.2	18.6	28.2	46.8

fababeans, peas and lentils considering the low soil NO_3^--N level 0-60 cm (Table 1.1.1) at the beginning of the experiment indicates the high potential for nitrogen fixation that these crops have.

The total aboveground uptake of phosphorus and potassium for the pulse crops was of the order fababeans > lentils > peas > dry beans.

The seasonal water use for the pulse crops under the different irrigation water schedules is presented in Table 1.1.7. A greater total water use was found for each crop under irrigation than dryland. In conjunction with this greater total water use under irrigation, there was also an increase in yield for all the pulse crops.

Total water use for the pulse crops followed the order fababeans and peas > lentils > dry beans and followed the order of the amounts of water applied as irrigation applications. Generally, the yield of the pulse crops followed their water use patterns with the greatest yield occurring for the fababeans. As well, the amount of the aboveground plant material produced per unit of water used (water use efficiency) followed the order fababeans > lentils > peas > dry beans.

Fababeans, peas and lentils had their greatest total water use where no water stress was applied during the growing season (Water D) while dry beans had their greatest total water use where a water stress was applied during the growing season (Water C). This indicates that where water was available for use by the pulse crops throughout the entire growing season (Water D) the greatest water use occurred. However, none of the pulse crops had their greatest yield associated with their greatest total water use but, as was noted in 1980, high yields were generally associated with high total water use for the pulse crops.

Table 1.1.7 Seasonal water use of pulse crops under different irrigation watering schedules (1981).

Crop	Water schedule	Rain	Irrigation	ΔS*	Total water use**
		---------- mm	----------		
Fababean	A	143	351	-85	409
	B	143	360	-129	374
	C	143	366	-68	441
	D	143	458	-147	454
	X	135	25	-23	137
Peas	A	135	337	-138	334
	B	135	335	-73	397
	C	135	305	-19	421
	D	135	401	-75	461
	X	135	25	33	193
Dry Beans	A	135	238	-130	243
	B	143	211	-103	251
	C	143	208	-43	308
	D	143	287	-181	249
	X	135	55	16	206
Lentils	A	135	271	-128	278
	B	143	203	-67	279
	C	143	206	-116	233
	D	143	302	-140	305
	X	135	25	-18	142

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

**Total water use = rainfall + irrigation + ΔS

The reasons for the observed effects of the irrigation watering schedules on the growth of the pulse crops is still not fully clear after two years research. A water stress appears to be required in order to produce maximum yields with a water stress later in the growing season causing the greatest yield reduction. The exact nature of this water stress in producing the high yields is not known at this time but, as stated in conjunction with the 1980 research it could possibly be do to physiological plant growth stage when irrigation water is applied or alternatively when an irrigation application is missed. Whether it is due to an irrigation water application knocking off flower blossoms, a missed irrigation application causing a water stress on the plants which in turn causes the plants to set seed or some other cause is not known. Further research will be required to fully elucidate these effects.

1.2 The effect of annual legume crops on the yield 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 perennial 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[1]. Less well known is the residual nitrogen contribution of annual legume crops, such as fababeans, to subsequent cereal crops.

A research project was initiated in 1980 to determine the residual nitrogen contribution of annual legume crops on subsequent cereal crop yields under irrigation. This work indicated that a significant nitrogen contribution to cereal crops from a previous fababean crop was present in only one site out of three sites tested. Therefore, it was considered necessary to try and further document the residual nitrogen contribution of fababeans to subsequent annual cereal crops.

OBJECTIVE

To obtain further documentation of the residual nitrogen contribution of annual legume crops to subsequent cereal crops.

---

[1] Soil-Plant Nutrient Research Reports for 1977, 1978 and 1979. Department of Soil Science, University of Saskatchewan, Saskatoon, Sask.

EXPERIMENTAL METHODS

Three sites were selected in the spring of 1981 for this experiment as indicated in Table 1.2.1. All three sites had grown fababeans the previous year.

The results of the analyses of soil samples taken prior to seeding for the three sites are presented in Table 1.2.2. All three sites had a medium soil NO_3^--N level in the 0-60 cm, and according to the present Nutrient Requirement Guidelines for Saskatchewan under irrigation a strong response to nitrogen fertilization would be expected. Phosphorus levels (0-15 cm) were low and both K and SO_4^{2-}-S were considered adequate.

Fielder soft wheat was seeded at the Murray and Niska sites while Neepawa hard wheat was seeded at the Duncan site. All pre-seeding tillage and seeding operations were as conducted by the co-operating farmer. Phosphorus was applied at a rate of 30 to 35 kg P_2O_5/ha with the seed by the co-operating farmer.

The experimental plot established at each site was a randomized complete block design with seven treatments replicated six times. The fertilizer 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 co-operating farmer. All three sites had flood type irrigation.

At harvest yield samples were taken from all treatments by clipping at the soil surface 3 rows by 3 meters for the Murray and

Table 1.2.1 Farm co-operator, legal location and soil type for the cereal crop nitrogen correlation experiment on annual legume stubble.

Farmer Co-Operator	Legal Location	Soil Type	Previous Crop
Murray	SE22-29-7-W3	Elstow loam	Fababeans
Niska	NE23-27-7-W3	Bradwell very fine sandy loam	Fababeans
Duncan	NW8-29-7-W3	Asquith sandy loam	Fababeans

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

Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^=$-S
			kg/ha*			
		Niska (Bradwell - very fine sandy loam)				
0-15	7.4	0.6	35	13	433	19
15-30	7.6	0.4	13	5	357	16
30-60	7.9	0.4	16	4	580	41
60-90	8.2	0.4	27	4	600	48+
90-120	8.3	0.5	29	4	633	41
		Murray (Elstow - loam)				
0-15	7.5	0.7	25	11	703	24+
15-30	7.7	0.8	10	4	267	24+
30-60	8.2	1.5	20	4	453	48+
60-90	8.2	3.5	20	8	793	48+
90-120	8.2	4.3	20	12	840	48+
		Duncan (Asquith - sandy loam)				
0-15	7.8	1.1	27	12	737	24+
15-30	8.0	0.8	13	5	303	24+
30-60	8.3	0.9	19	5	440	48+
60-90	8.5	1.3	17	4	460	48+
90-120	8.9	0.5	16	4	493	48+

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

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

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

*N applied as ammonium nitrate (34-0-0)

Niska sites and 2 m^2 for the Duncan site. 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 replicates of each treatment and ground. Replicates of all grain samples for each treatment were bulked and ground. Total nitrogen, phosphorus and potassium content of the grain and straw were determined by wet digestion and colorimetric analysis using a Technicon Auto-Analyzer II system.

RESULTS AND DISCUSSION

The results for the effect of nitrogen fertilization on the yield and nutrient content of soft wheat and hard wheat grown on fababean stubble are indicated in Table 1.2.4. At all three sites both grain yield and straw yield appeared to show a small response to the applied fertilizer nitrogen but only the grain yield for the Murray site showed a significant response. As well, grain protein content and straw nitrogen content of the Fielder soft wheat at the Murray and Niska sites increased with increasing rates of applied nitrogen. Grain protein of the Neepawa hard wheat decreased while straw nitrogen content increased with increasing rates of applied nitrogen at the Duncan site.

These results indicate that there was not enough available nitrogen present in the soil at all three sites to produce the maximum yield. Response to applied nitrogen fertilization was observed even though only grain yields at the Murray site showed a significant response. However, a larger yield response to the applied nitrogen would have been expected considering the levels of NO_3^--N present in

Table 1.2.4 The effect of nitrogen fertilization on the yield and nutrient content of cereal crops grown on fababean stubble.

N Applied (kg/ha)	Yield		Grain[1] % Protein	Straw[2] % N	Nitrogen Uptake			% P^2		% K^2	
	Grain -- (kg/ha) --	Straw			Grain ---- (kg/ha) ----	Straw	Total	Grain	Straw	Grain	Straw
				Murray - Fielder soft wheat							
0	4116	4070	10.2	0.39	85.2	15.9	101.1	0.369	0.072	0.390	2.94
28	3913	4319	10.5	0.51	83.4	22.0	105.4	0.333	0.099	0.345	3.03
56	5084	5589	10.5	0.57	108.3	31.9	140.2	0.351	0.057	0.372	3.27
84	4774	5043	11.2	0.60	108.9	30.3	139.2	0.333	0.063	0.363	3.18
112	5014	5218	11.4	0.75	115.8	39.1	154.9	0.393	0.051	0.366	3.39
168	5161	5751	11.4	0.69	119.2	39.7	158.9	0.294	0.048	0.345	3.54
224	5025	5911	11.5	0.90	117.6	53.2	170.8	0.315	0.045	0.360	3.78
L.S.D. (P = 0.05)	881										
				Niska - Fielder soft wheat							
0	5039	6458	11.7	0.51	119.4	32.9	152.3	0.429	0.090	0.426	3.03
28	5121	6744	11.8	0.60	122.9	40.5	163.4	0.378	0.072	0.375	3.36
56	5326	7365	11.7	0.72	126.2	53.0	179.2	0.369	0.069	0.375	3.45
84	5571	7633	12.0	0.69	135.4	52.7	188.1	0.390	0.057	0.396	3.39
112	5259	8316	12.0	0.75	127.8	62.4	190.2	0.351	0.054	0.366	3.66
168	5557	8145	11.7	0.90	131.7	73.3	205.0	0.324	0.060	0.342	3.54
224	5443	8373	12.4	0.96	137.2	80.4	217.6	0.396	0.054	0.378	3.63
L.S.D. (P = 0.05)	636										
				Duncan - Neepawa hard wheat							
0	3472	5111	15.7	0.45	110.4	23.0	133.4	0.459	0.069	0.429	2.34
28	3687	5192	15.2	0.39	113.9	20.3	134.2	0.450	0.036	0.372	2.34
56	3635	5488	15.1	0.48	111.2	26.3	137.5	0.462	0.054	0.381	2.40
84	3501	6014	14.5	0.48	102.9	28.9	131.8	0.474	0.042	0.381	2.31
112	3501	6045	14.3	0.48	101.8	29.0	130.8	0.492	0.042	0.390	2.34
168	3426	6057	14.2	0.72	98.7	43.6	142.3	0.462	0.048	0.396	2.82
224	3613	6159	13.6	0.66	99.7	40.6	140.3	0.474	0.039	0.396	2.58
L.S.D. (P = 0.05)	488										

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

[2] Oven-dry basis

the soil at seeding time. For the soil NO_3^--N levels present at seeding time at all three sites the yields obtained where no nitrogen was applied would not be possible on land continuously cropped to cereals under irrigation without additional nitrogen. Obviously, soil NO_3^--N mineralization occurred to a greater extent on the fababean stubble than occurs on cereal stubble under irrigation.

Thus, this work indicates that the residual nitrogen contribution of fababeans to subsequent cereal crops is significant but in some cases is not large enough to meet the total nitrogen requirement of the cereal crop.

A P P E N D I X

APPENDIX A. Selected tables of data from the 1981 irrigation experiments

Appendix Table A1. Grain nitrogen, phosphorus and potassium content of pulse crops grown under different irrigation water schedules.

Crop	Water schedule	Rep	% N	% P	% K
Fababeans	A	1 to 5	4.50	0.642	1.17
		6 to 10	4.65	0.648	1.14
	B	1 to 5	4.95	0.645	1.17
		6 to 10	4.95	0.666	1.17
	C	1 to 5	4.95	0.639	1.14
		6 to 10	4.80	0.654	1.05
	D	1 to 5	4.80	0.648	1.14
		6 to 10	4.74	0.636	1.17
	X	1 to 5	4.65	0.612	1.08
		6 to 10	4.80	0.624	1.05
Peas	A	1 to 5	4.20	0.438	1.20
		6 to 10	3.75	0.459	1.20
	B	1 to 5	3.90	0.438	1.14
		6 to 10	3.90	0.447	1.17
	C	1 to 5	3.96	0.438	1.14
		6 to 10	4.20	0.441	1.14
	D	1 to 5	3.90	0.462	1.20
		6 to 10	4.05	0.474	1.20
	X	1 to 5	3.69	0.432	1.05
		6 to 10	3.72	0.447	1.05
Dry Beans	A	1 to 5	2.64	0.579	1.56
		6 to 10	2.67	0.645	1.80
	B	1 to 5	2.73	0.690	1.74
		6 to 10	2.49	0.621	1.62
	C	1 to 5	2.55	0.642	1.68
		6 to 10	2.55	0.636	1.65
	D	1 to 5	2.49	0.636	1.62
		6 to 10	2.55	0.648	1.71
	X	1 to 5	3.36	0.624	1.62
		6 to 10	3.39	0.636	1.65

Appendix Table A1. Continued.

Crop	Water schedule	Rep	% N	% P	% K
Lentils	A	1 to 5	3.63	0.450	1.02
		6 to 10	3.63	0.444	0.99
	B	1 to 5	4.80	0.585	1.17
		6 to 10	4.80	0.591	1.17
	C	1 to 5	4.50	0.540	1.14
		6 to 10	4.20	0.528	1.14
	D	1 to 5	4.20	0.534	1.11
		6 to 10	4.20	0.531	1.08
	X	1 to 5	3.75	0.423	0.96
		6 to 10	3.60	0.414	0.93

Appendix Table A2. Spring soil analyses for the nitrogen correlation experiment after annual legumes.

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^=$-S
				-------	kg/ha		-------
			Murray				
1 and 2	0-15	7.3	0.6	26	14	700	24+
	15-30	7.6	0.4	12	4	270	24+
	30-60	8.2	1.5	20	4	520	48+
	60-90	8.2	3.9	20	8	840	48+
	90-120	8.2	4.4	20	12	880	48+
3 and 4	0-15	7.5	0.6	28	14	860	24+
	15-30	7.6	0.3	10	4	290	24+
	30-60	8.0	1.0	20	4	500	48+
	60-90	8.4	2.3	24	4	720	48+
	90-120	8.2	4.4	24	8	800	48+
5 and 6	0-15	7.6	0.9	20	6	550	24+
	15-30	7.8	1.7	8	4	240	24+
	30-60	8.3	1.9	20	4	340	48+
	60-90	8.1	4.4	16	12	820	48+
	90-120	8.1	4.2	16	16	840	48+
			Niska				
1 and 2	0-15	7.2	0.6	32	10	350	18
	15-30	7.6	0.4	14	4	260	15
	30-60	8.1	0.3	16	4	540	48+
	60-90	8.3	0.4	16	4	540	48+
	90-120	8.4	0.4	20	4	600	48+
3 and 4	0-15	7.8	0.7	24	8	720	24+
	15-30	8.0	0.4	12	4	280	24+
	30-60	8.3	0.3	20	4	400	48+
	60-90	8.5	0.3	20	4	420	48+
	90-120	8.8	0.4	16	4	560	48+

Appendix Table A2. Continued.

Rep	Depth (cm)	pH	Conductivity (mmhos/cm)	NO_3^--N	P	K	$SO_4^=$-S
				---------	kg/ha	---------	
5 and 6	0-15	7.5	0.6	30	10	440	21
	15-30	7.6	0.4	14	4	430	24+
	30-60	7.8	0.4	20	4	620	48+
	60-90	8.2	0.4	44	4	680	48+
	90-120	8.3	0.6	40	4	760	48+
			Duncan				
1 and 2	0-15	7.9	0.8	26	12	670	24+
	15-30	8.1	0.4	14	4	300	24+
	30-60	8.5	0.4	16	4	340	48+
	60-90	8.8	0.3	16	4	380	48+
	90-120	9.0	0.4	16	4	440	48+
3 and 4	0-15	7.8	0.7	24	8	720	24+
	15-30	8.0	0.4	12	4	280	24+
	30-60	8.3	0.3	20	4	400	48+
	60-90	8.5	0.3	20	4	420	48+
	90-120	8.8	0.4	16	4	560	48+
5 and 6	0-15	7.6	1.8	30	16	820	24+
	15-30	7.8	1.5	12	6	330	24+
	30-60	8.2	1.9	20	8	580	48+
	60-90	8.1	3.3	16	4	580	48+
	90-120	8.8	0.8	16	4	480	48+