AB-10

Optimal Time and Placement of Fertilizer on Winter Wheat

AARI Project 95M611

1995 Summary Report

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1.0 Introduction

In the early 1980's, over 450,000 acres of winter wheat was grown annually in southern Alberta. However, because of drought conditions, poor fall weather and low grain prices, winter wheat acreage has dropped to less than 100,000 acres annually, in the last few years.

However, with improved fall moisture conditions in 1992 and 1993 and with the release of A.C. Readymade, a new winter wheat variety with up to a 20% yield advantage over spring wheat, there is a renewed interest in growing winter wheat.

Most farmers would also like to apply all their fertilizer while direct seeding rather than broadcasting nitrogen in the following spring. However, with fall applied nitrogen there is a risk of reduced winter survival. Producers need to know if fall applied and/or seed-placed nitrogen fertilizer will significantly affect plant populations, over-winter hardiness, weed competition, crop yield and crop quality.

2.0 Objective

The objective of this project is to examine the effects of conventional versus direct seeding to establish winter wheat, and to determine the effects of seed-placed fertilizer in the fall versus broadcast fertilizer in the spring. Results will be used to develop recommendations for best management practices for winter wheat production.

3.0 Materials and Methods

3.1 Experimental Design, Location and Treatments

Anhydrous opener experiment

This experiment was carried out at 3 locations near Barons, Bow Island and Pincher Creek. Readymade winter wheat was grown at all sites. This experiment was arranged as a split plot with 3 main plots (openers) and 4 sub plots (fertilizer rates) with 4 replications (Table 1). The two openers were a dutch and flexicoil. The dutch opener consists of a front fertilizer knife and a backswept knife for seed application. Fertilizer is placed approximately one inch to the side and one inch below the seed. The flexicoil opener consists of front fertilizer knife followed by a pair row seed blade, which actually forms a single band of seed approximately 2.5 inches wide except in moist soil where two distinct rows may form. Fertilizer is placed approximately one inch directly below the seed band. Phosphate was placed with the seed at 30 kg/ha P_2O_5.

Optimal Time and Placement of Fertilizer

This experiment were carried out at 5 locations near Barons, Bow Island, High River, and Pincher Creek. Readymade winter wheat was grown at all sites. Each site was divided into two experiments, core 1 and core 2. Core 1 was arranged as a split plot with 3 main plots (seed placement widths) and 9 sub plots (fertilizer rates) with 4 replications (Table 1). The three seed placement widths were band, 10% Seedbed Utilization (SBU) and 50% SBU. Band placement applied N fertilizer, using the 10% SBU opener, banding the fertilizer at a 3 to 4 inch depth, followed by seeding. The direct seeded 10% SBU treatment placed the seed and fertilizer together in a 1 inch band. The 50% SBU treatment applied the fertilizer and seed together in a 4 inch spread pattern. Phosphate, when applied, was placed with the seed.

Core 2 was arranged with 2 main plots (seed placement widths) and 9 sub plots (fertilizer treatments) with 4 replications. This portion of the experiment examined time of N application. Nitrogen was applied as a fall/spring split or spring only. Fall N was placed with the seed, while spring N was broadcast applied at the end of March. Phosphate was fall applied with the seed (Table 1).

All plots were seeded with a 10 row, 8 inch row spaced, plot air seeder. All plots were seeded directly into standing stubble except for the band placement treatments. Following seeding hanging harrows, rotary harrow and crowfoot packer were used to pack the seedbed.

Table 1 - Core 1 and 2 fertilizer and seed placement treatments.

Anhydrous Opener			Optimal Time and Placement of Ferilizer						
			Core 1 Treatments			Core 2 Treatments			
(kg/ha)		Opener	(kg/ha)		Seed placement width	(kg/ha)			Seed placement width
N	P_2O_5		N	P_2O		N fall	N spring	P_2O_5	
0	30	Dutch	0	0	Band	0	0	20	Narrow
30AA	30	Flexi	0	20	Narrow	0	30AN	20	4"
60AA	30		30AN	0	4"	30AN	30AN	20	
90AA	30		30AN	20		0	60AN	20	
			60AN	20		0	90AN	20	
			90AN	20		0	30U	20	
			30U	20		30U	30U	20	
			60U	20		0	60U	20	
			90U	20		0	90U	20	

AA- Anhydrous ammonia (82-0-0)
AN - Ammonium nitrate (34.5-0-0).
U - Urea (46-0-0).

3.2 Seeding, Spraying and Harvest dates

Table 2 lists all seeding, spraying and harvest dates, as well as total growing season precipitation.

Table 2 - Seeding, spraying, harvest dates and rainfall.

Site	Seeding Date	Spraying Date[1]	Harvest Date
Barons	Oct. 26	June 2	Sept.26
Bow Island	Oct. 26	June 1	Aug. 29
High River	Oct. 21	June 2	Oct. 16
Pincher Creek	Oct.21	June2	Oct.24

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3.3 Data Collection and Analysis

Rainfall was recorded on a weekly basis. Plant populations (plants/m^2) were measured at the 2-4 leaf stage.

After harvest the following data was collected on all treatments:

1) % moisture
2) grain yield
3) bushel weight
4) grain protein
5) days to maturity

An area of 9.72 m^2 was harvested with a plot combine, to determine yield. Yields were adjusted to 14%. All four replicates were used to arrive at a mean for each treatment.

4.0 Results

4.1 Soil Fertility and Soil Moisture

Table 3 describes soil moisture, growing season and average precipitation. Soil samples were taken in the fall of 1994 (Table 4).

Table 3. Available soil moisture (mm), soil temperature at seeding, growing season and average annual precipitation (mm).

Depth (cm)	Barons		Bow Island		High River		Pincher Creek	
	Av.	%	Av.	%	Av.	%	Av.	%
0-5	6.3	79	3.7	37	9.6	96	11.8	100
5-10	5.6	70	5.6	56	7.1	71	10.1	100
10-15	5.7	71	5.1	51	5.2	52	10.5	100
15-30	14.5	61	14.6	49	1.3	4	19.3	66
30-45	2	8	7.9	26	2.5	7	4.4	15
45-60	0	0	3.1	10	3.2	9	2.9	10
60-75	0	0	0	0	.2	.5	4.6	16
75-90	0	0	0	0	1.4	4	7.5	26
Total Available	34.2		40		30.4		71.1	
Rainfall[1] (mm)	210.8		161.4		220.7		391.2	
Average[2] (mm)	223.5		188		218.4		251.5	

1. Growing season precipitation (Date of seeding to Harvest).
2. Average rainfall - Measured from May 1 to Aug. 31 - 30 year average.

Table 4. Mean soil analysis in lbs/ac.

Location	Depth Inches	N03-MA[1]	NO_3-NOR[2]	P-MA	P-NOR	K	SO_4-S	pH	E.C.	Soil Texture
Barons	0-6	4.0		18.0	18.0	692	4.4	7.3	.4	Sandy Clay
	6-12	2.0		2.0	6.0	340	3.6			Loam
	12-24	4.0		0			8.0			
	24-36	0		0						
	Total	10		20	24	1032	16.0			
Bow Island	0-6	4.0		18.0	20	372	5.8	7.0	.4	clay loam
	6-12	0.0		2.0	10	328	3.6			
	12-24	4.0		0			6.8			
	24-36	4.0		0						
	Total	12.0		20	30	1000	16.2			
High River	0-6	4.0		32.0	32	606	13.2	6.4	.4	clay loam
	6-12	2.0		2.0	8	258	4.4			
	12-24	4.0		0			544.0			
	24-36	4.0		0						
	Total	14.0		34.0	40	864	561.6			
Pincher	0-6	56.0		14.0	22.0	866	13.8	6.8	1.2	Heavy Clay
Creek	6-12	6.0		0	4.0	648	6.0			
	12-24	8.0		0			7.2			
	24-36	8.0		0						
	Total	78.0		14.0	26.0	1514	27.0			

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4.2 Site Overview

Soil moisture conditions were low at Bow Island and very good at all the other sites.

Soil nitrogen levels were extremely low at Barons, Bow Island and High River and high at Pincher Creek. The stand at Barons was thin and variable across treatments which resulted in high variability.

4.3 Anhydrous Opener Experiment

Opener - Pincher Creek was the only site to have a significant response to opener. At all of the sites the Flexi opener yielded the highest (Table 5, Figure 1).
Fertilizer - All sites had a highly significant response to fertilizer. Yields increases ranged from 11% to 209% increase over check treatment (Table 5, Figure 1).

Table 5. Mean yield and statistical anaylsis of Annhydrous Opener experiment.

Treatment	Yield (kg/ha)		
Opener	Barons	Bow Island	Pincher Creek
Dutch	1997	1916	3113 b
Flexi	2161	1925	4769 a
Fertilizer			
0	1048 a†	1105 a	3658 b
30	1641 b	1645 b	3500 b
60	2532 c	2321 c	4117 a
90	3095 d	2611 d	4489 a
Significance			
Opener	.16	.92	.02
Fertilizer	.0001	.0001	.0001
O X F	.10	.001	.02

† For each factor, means followed by the same letter within a column are not significantly different at the 5% level using Duncan's Multiple Range test.

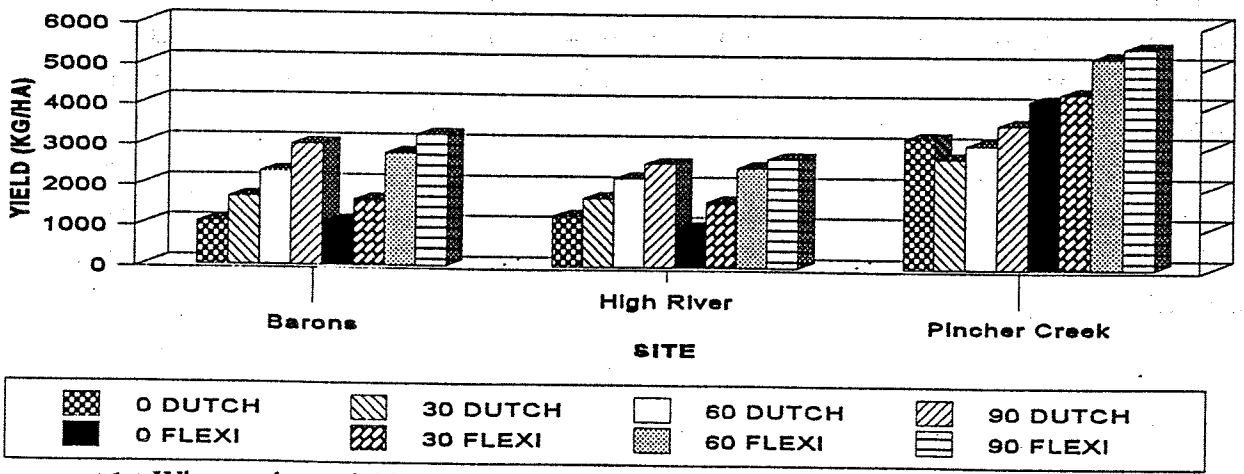

Figure 1. Winter wheat yield response to anhydrous ammonia and two openers at Barons, High River and Pincher Creek.

4.4 Optimal Time and Placement of Fertilizer

4.41 Core 1 - Yield and plant populations

Yield

Placement - There were five locations: Barons, Bow Island, High River and Pincher Creek. At Barons, High River and Pincher Creek the band treatment performed the poorest followed by the 10% SBU, with the 50% SBU yielding the highest. At Bow Island there were no differences between placements (Table 6, Figure 2 to 5).

Fertilizer - All sites had a highly significant response to fertilizer. Phosphate often provided a yield increase, but was not significant. Ammonium nitrate often outperformed the same rate of urea, especially at high rates of nitrogen (Table 6, Figure 2 to 5).

Plant Populations

Placement - The only site to have a significant difference in plant counts was at High River, where the band was lowest followed by the 10% SBU and the 50% SBU (Table 6).

Fertilizer - Plant populations showed no clear trends across fertilizer treatments (Table 6).

Table 6 - Mean yield, plant counts and statistical analysis of Core 1 experiments at Barons, Bow Island, High River and Pincher Creek.

	Core 1						
Treatment	Barons		Bow Island		High River		Pincher Creek
Placement	Yield (kg/ha)	plt/ m^2	Yield (kg/ha)	plt/ m^2	Yield (kg/ha)	plt/ m^2	Yield (kg/ha)
Band	1645 b†	84	2552	86	4187 b	44 c	2614
10% SBU	1963 a	73	2419	73	4799 a	67 b	2779
50% SBU	2099 a	72	2505	84	4927 a	78 a	2956
Fertilizer							
0+0	1231 cf	74	1398 c	96 ab	4290 bc	66 ab	2565 bc
0+20	1205 f	80	1350 c	84 bc	4082 c	74 a	2677 abc
30AN+0	1516 def	70	2463 b	101 a	4550 ab	61 ab	2511 bc
30AN+20	1756 cde	84	2529 b	81 bcd	4734 a	61 ab	2302 c
60AN+20	2604 a	78	3103 a	84 bc	4921 a	63 ab	2849 abc
90AN+20	2409 ab	67	3115 a	86 abc	5007 a	68 a	3198 a
30U+20	1905 bcd	78	2445 b	73 cde	4738 a	67 ab	2894 ab
60U+20	2159 abc	79	2966 b	65 de	4845 a	62 ab	3146 a
90U+20	2448 ab	81	3097 b	59 e	4572 ab	50 b	3198 a
Significance							
Placement	.005	.07	.17	.11	.003	.0025	.11
Fertilizer	.0001	.86	.0001	.0001	.0002	.09	.008
PXF	.63	.98	.09	.005	.05	.06	.8
CV	31.8	36.9	13.9	23.4	10.6	26.8	21.7

† For each factor, means followed by the same letter within a column are not significantly different at the 5% level using Duncan's Multiple Range test.

AN - Ammonium nitrate.

U - Urea.

plt/m^2 - plants per square metre.

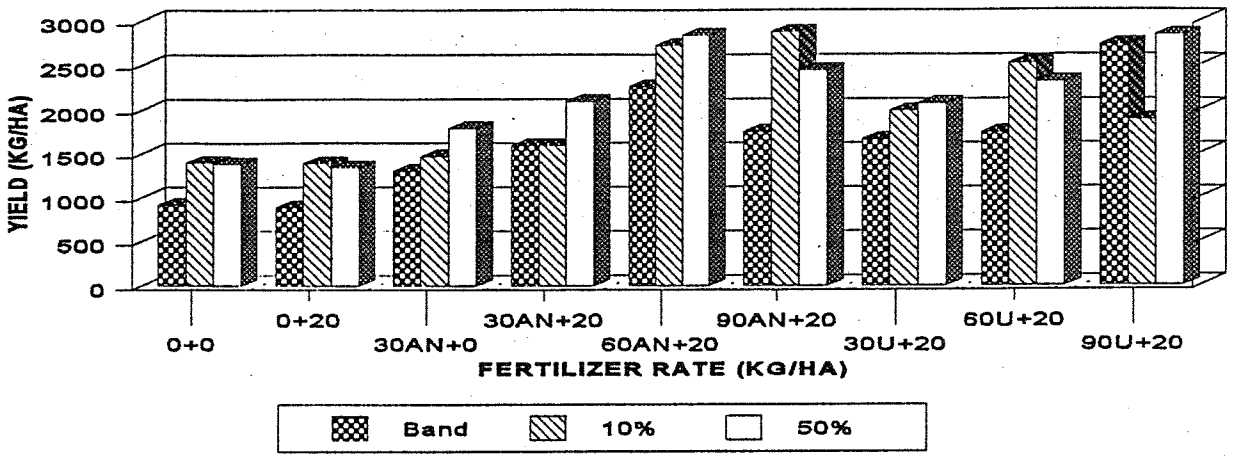

Figure 2. Winter wheat yield response to Core 1 treatments at Barons.

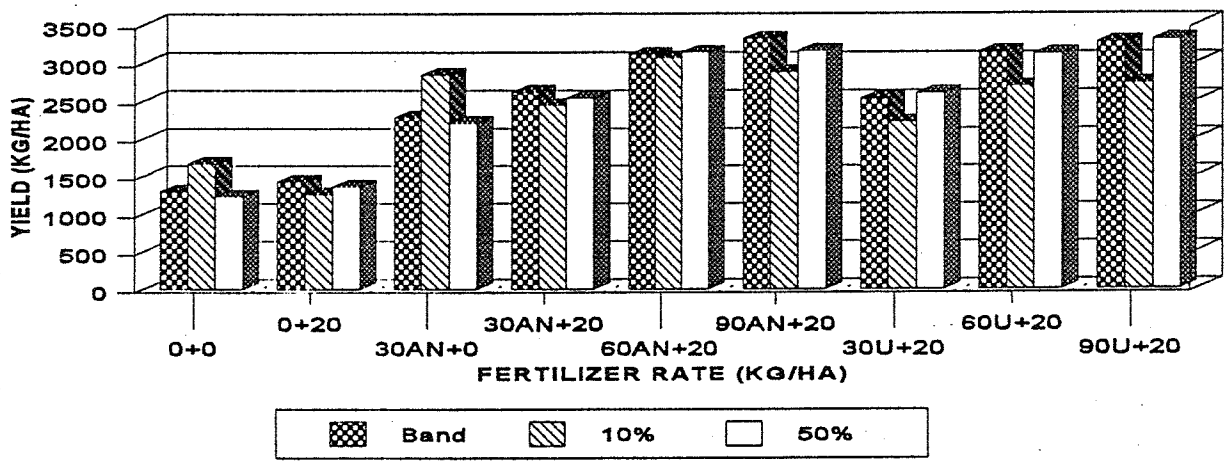

Figure 3. Wheat yield response to Core 1 treatments at Bow Island.

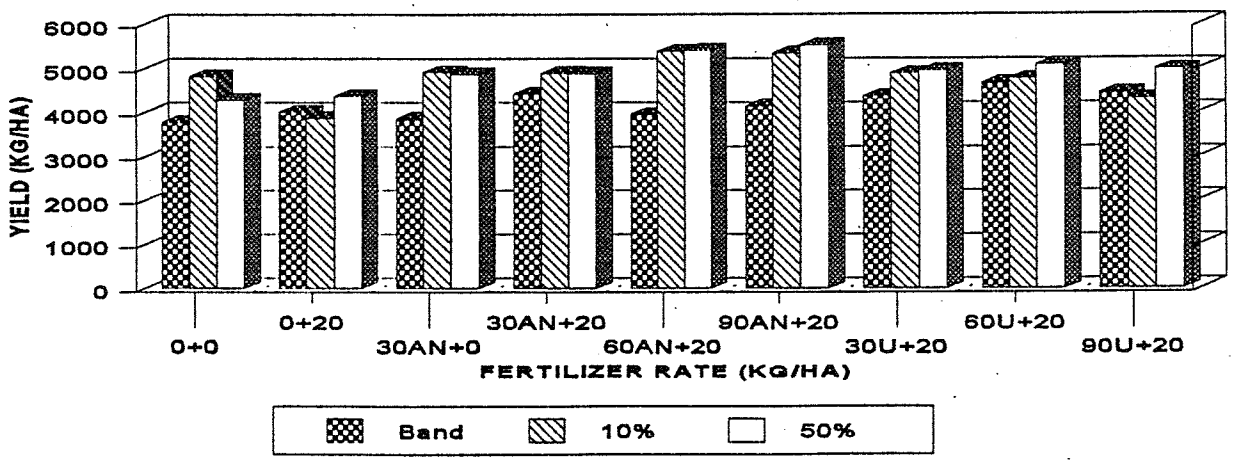

Figure 4. Winter wheat yield response to Core 1 treatments at High River.

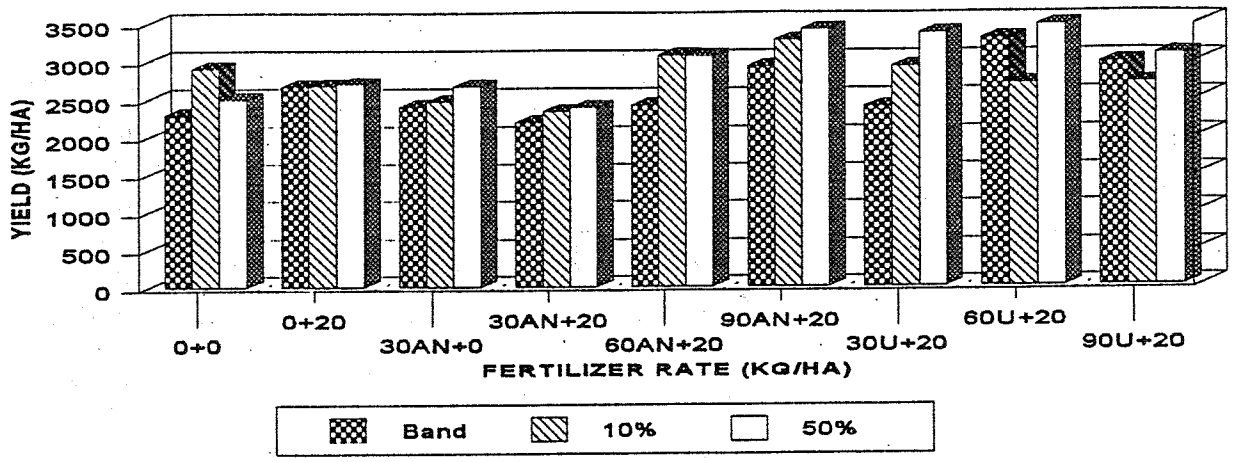

Figure 5. Winter wheat yield response to Core 1 treatments at Pincher Creek.

4.42 Core 2 - Yield and plant populations

Yield

Placement - There were four locations: Barons, Bow Island, High River and Pincher Creek. Pincher Creek was the only site to have a significant difference in placement. The 50% SBU outperformed the 10% SBU (Table 7, Figure 6 to 9).

Fertilizer - Response to fertilizer was significant to highly significant. The 30/30AN split outperformed the 60AN treatment at all sites except Barons, although these differences were not significant. The 30/30U split often performed poorer than the 60U treatment except at Bow Island. Again these differences were not significant (Table 7, Figure 6 to 9).

Plant Populations

Placement - There were no significant differences between placement treatments. The 10% SBU at Bow Island yielded the lowest (Table 7).

Fertilizer - Plant populations showed no clear trends across fertilizer treatments (Table 7).

Table 7 - Mean yield, plant counts and statistical analysis of Core2 experiments at Barons, Bow Island, High River and Pincher Creek.

	Core 2						
Treatment	Barons		Bow Island		High River		Pincher Creek
Placement	Yield (kg/ha)	plt/ m^2	Yield (kg/ha)	plt/ m^2	Yield (kg/ha)	plt/ m^2	Yield (kg/ha)
10% SBU	2038	79	2272	78	4900	77	2862 b
50% SBU	2059	79	2305	85	4889	77	3230 a
Fertilizer							
0 + 20	1467 c†	80 abc	1094 e	89 ab	4486 c	76	2568 c
30AN+20	1517 c	89 ab	2026 d	91 ab	4611 bc	82	2908 abc
30/30AN+20	2194 abc	59 c	2802 a	71 b	4842 abc	73	3278 ab
60AN+20	2314 ab	71 bc	2579 ab	81 ab	4713 bc	77	2920 abc
90AN+20	2645 a	74 abc	2915 a	89 ab	5070 ab	63	3382 a
30U+20	1716 bc	83 abc	1780 d	70 b	4791 abc	84	3213 ab
30/30U+20	1799 bc	78 abc	2589 ab	70 b	4842 abc	66	3162 abc
60U+20	2155 abc	79 abc	2257 bc	69 b	5159 ab	91	3305 a
90U+20	2661 a	99 a	2596 ab	105 a	5293 a	81	2681 bc
Significance							
Placement	.09	.95	.65	.23	.95	.89	.04
Fertilizer	.0018	.05	.0001	.02	.02	.46	.03
PXF	.42	.45	.82	.46	.13	.6	.88
CV	30.8	27.5	14.3	26.9	9.9	33.2	17.7

† For each factor, means followed by the same letter within a column are not significantly different at the 5% level using Duncan's Multiple Range test.
AN - Ammonium nitrate.
U - Urea.
plt/m^2 - plants per square metre.

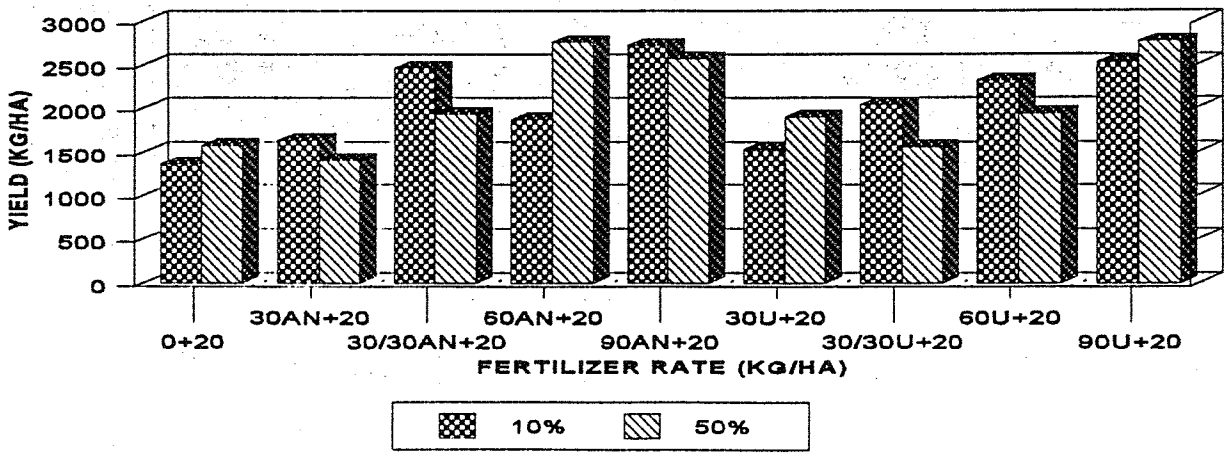

Figure 6. Winter wheat yield response to Core 2 treatments at Barons.

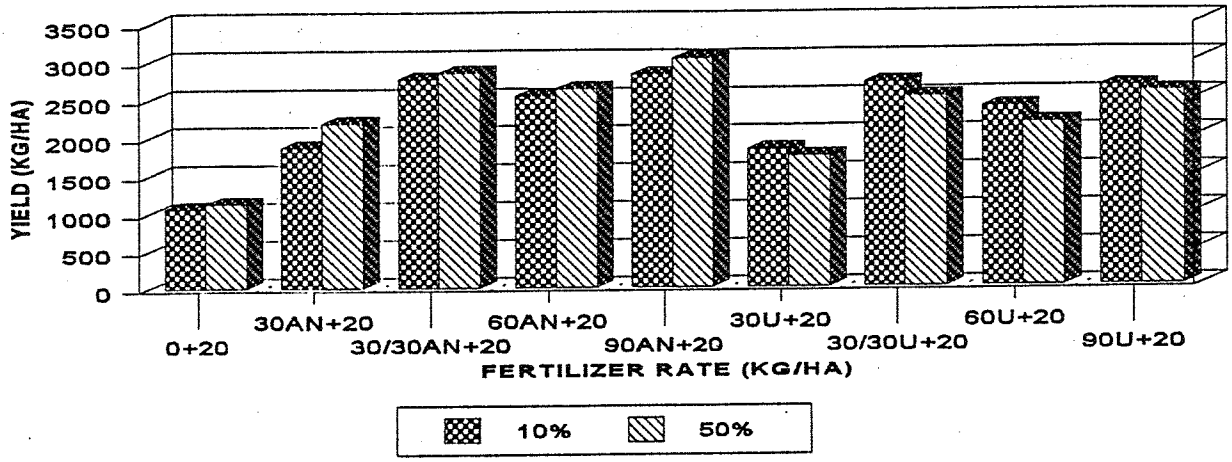

Figure 7. Winter wheat yield response to Core 2 treatments at Bow Island.

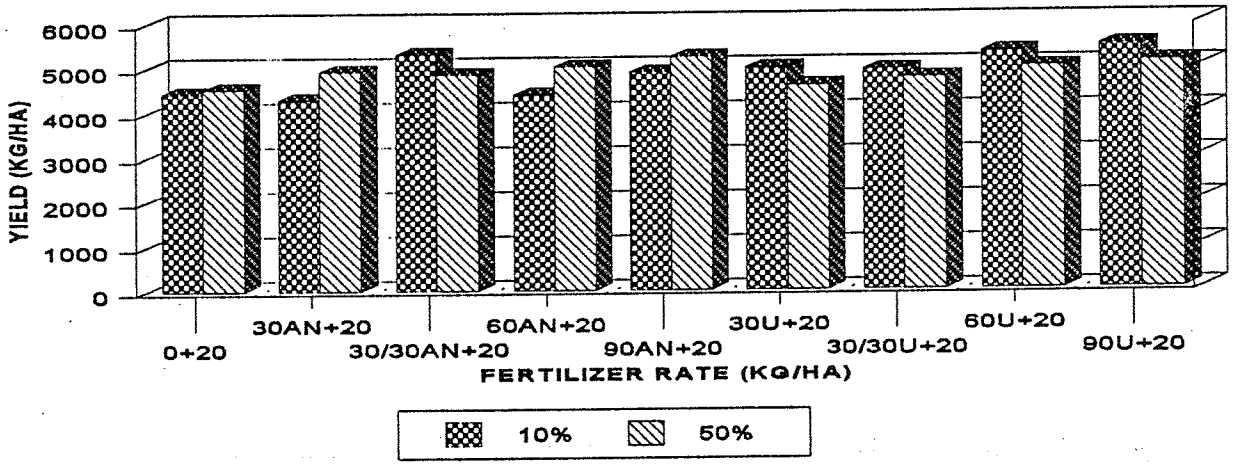

Figure 8. Winter wheat yield response to Core 2 treatments at High River.

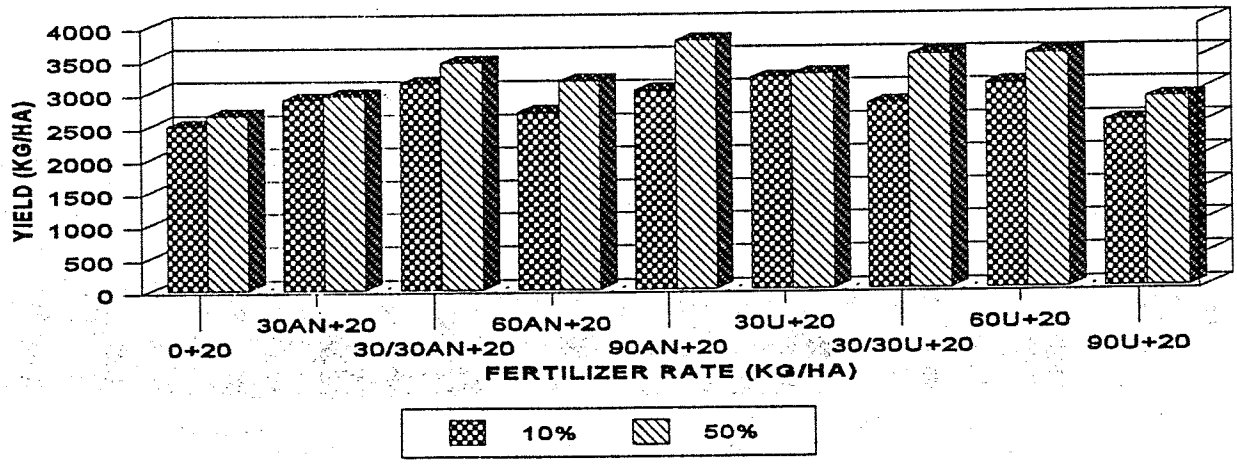

Figure 9. Winter wheat yield response to Core 2 treatments at High River.

5.0 Summary

Anhydrous Opener Experiment

At all sites the flexi yielded slightly higher than the dutch opener, but none of these differences were significant. All sites had a good response to nitrogen.

Optimal time and placement of fertilizer

Core 1- Generally the Band and the 10% treatments performed the poorest. Phosphate often increased yields. Ammonium nitrate often outperformed urea especially at the higher rates of nitrogen.

Core 2 - The 50% SBU performed better at the Pincher Creek site, while the other sites had no real differences. The 30/30AN split outperformed the 60AN treatment, while the 30/30U split was often poorer than the 60U treatment. This is likely because of volatilization resulting from the broadcasting of the 30U in the spring on the 30/30U treatment.

Acknowledgements

The authors gratefully acknowledge funding from the Alberta Agricultural Institute, the Potash Institute of Canada, Sherritt Ltd. and the Alberta Winter Wheat Producers Commision. We would also like to thank Zeneca and Dow Elanco for providing crop herbicides used in these trials.

APPENDIX

Table 1 - CORE 1 yield and plant populations.

Treatment	Yields (kg/ha)											
Fertilizer	Barons			Bow Island			High River			Pincher Creek		
(kg/ha)	Band	10%	50%	Band	10%	50%	Band	10%	50%	Band	10%	50%
0+0	917	1394	1383	1298	1667	1230	3781	4817	4275	2297	2904	2496
0+20	890	1386	1340	1428	1263	1361	4018	3865	4364	2664	2673	2697
30AN+0	1298	1467	1785	2280	2840	2207	3870	4917	4865	2403	2465	2667
30AN+20	1590	1589	2091	2615	2439	2533	4426	4895	4883	2186	2335	2387
60AN+20	2259	2719	2834	3111	3065	3135	3964	5384	5412	2419	3068	3063
90AN+20	1752	2875	2436	3315	2878	3155	4144	5353	5526	2924	3264	3407
30U+20	1660	1989	2066	2526	2217	2595	4372	4889	4955	2398	2927	3361
60U+20	1744	2518	2305	3140	2684	3112	4677	4770	5090	3281	2693	3465
90U+20	2730	1877	2836	3264	2726	3302	4440	4300	4978	2957	2688	3069
	Plants/m^2											
0+0	84	80	58	86	99	105	38	70	90			
0+20	94	74	73	73	84	95	43	88	92			
30AN+0	76	65	70	98	107	101	34	79	69			
30AN+20	95	73	87	97	65	82	47	66	71			
60AN+20	87	73	74	70	89	93	34	78	78			
90AN+20	63	70	67	101	82	75	41	77	87			
30U+20	83	84	69	83	56	80	61	63	76			
60U+20	101	67	71	90	38	67	51	62	72			
90U+20	82	76	86	80	37	60	45	36	69			

AN - Ammonium nitrate
U - Urea

Table 2 - CORE 2 yield and plant populations.

Treatment	Plants/m²							
Fertilizer	Barons		Bow Island		High River		Pincher Creek	
(kg/ha)	10% s	50%	10%	50%	10%	50%	10%	50%
0+0	1363	1571	1065	1125	4447	4527	2489	2649
30AN+20	1634	1401	1868	2186	4297	4925	2881	2936
30/30AN+20	2463	1926	2763	2841	5324	4855	3123	3433
60AN+20	1870	2759	2531	2627	4402	5025	2687	3154
90AN+20	2722	2569	2811	3020	4891	5249	3005	3760
30U+20	1536	1897	1831	1731	4997	4587	3185	3242
30/30U+20	2039	1560	2696	2510	4936	4750	2801	3523
60U+20	2321	1933	2363	2152	5334	4981	3086	3526
90U+20	2524	2765	2630	2563	5481	5107	2510	2853
	Plants/m²							
0+0	75	86	93	87	71	81		
30AN+20	91	88	103	80	92	74		
30/30AN+20	53	66	64	79	76	71		
60AN+20	61	81	70	93	85	70		
90AN+20	77	72	90	90	65	61		
30U+20	86	82	62	79	90	80		
30/30U+20	93	64	69	72	51	81		
60U+20	76	84	56	83	83	100		
90U+20	107	91	98	112	88	76		

AN - Ammonium nitrate
U - Urea