Annual Progress Report Regarding University of Manitoba Chloride Research Project for 1989/90

Assessing the Chloride Fertilizer Requirements of Barley and Wheat Grown on Manitoba Soils

D.N. Flaten and R.M. Mohr

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Project Leader: Dr. Don Flaten, Director, School of Agriculture

Cooperators: Ms. Ramona Mohr, Graduate Student (M.Sc.)
Dr. Claude Bernier, Plant Science Dept.
Dr. Geza Racz, Soil Science Dept.

Locations of Research: Soils were sampled from across Southern Manitoba; field trials were located at Anola, Carman, Darlingford, Portage and Winnipeg

Objectives: #1 - Assess Chloride Fertility Status of Manitoba Soils
#2 - Determine Effects of Chloride on Growth and Yield of Barley and Wheat

Results and Conclusions:

#1 - Assessment of Chloride Fertility Status of Manitoba Soils

In the initial phase of the experiment conducted in 1988, 800 soil samples were taken from 160 sites across southern Manitoba. Samples were taken to a depth of 120 cm from various soil types, textures and slope positions. These samples were then analyzed for extractable chloride using a $AgNO_3$ titration procedure.

Soil chloride concentrations varied greatly among sites. Chloride concentrations in the top 60 cm ranged from a high of 1262 kg/ha in a St. Claude fine sandy loam to a low of 1.2 kg/ha in a Stockton loamy fine sand and a Souris loamy fine sand. Within sites chloride concentration also showed a high degree of variability. At one site chloride levels ranged from 16 to 1262 kg/ha over a distance of 0.5 km. Landscape position and depth in the profile did not have a consistent effect on chloride concentration. There was a higher frequency of low chloride levels in medium to coarse textured soils than in fine textured soils with the coarse textured soils being most variable in chloride concentration.

Further analysis of the soil sample information will be conducted to investigate relationships between chloride and soil type, texture, drainage, toposequence and depth. A study of differences between methods of analysis for Cl may also be conducted.

#2 - Determination of the Effects of Chloride Fertilization on the Growth and Yield of Barley and Wheat

Field Trials

In the second phase initiated in 1989, field trials were established at five sites, one site on campus which rated high and four sites off campus which rated low to very low in chloride (the ratings are estimated according to the South Dakota guidelines of <66 kg/ha to 60 cm for low and <33 kg/ha to 60 cm for very low).

Two small sites sown to Katepwa wheat were established at Anola and Darlingford. Each trial consisted of five replicates of seven fertilizer treatments. Treatments included three fertilizer rates (0, 25, 50 kg/ha Cl) using two sources of broadcast fertilizer (KCl and NaCl). The seventh treatment was a seedrow application of 25 kg/ha Cl as KCl. Grain yield and quality were measured at these sites.

Three larger sites were also established at Portage, Carman and the Point of the University campus. At Carman and Portage the experiment consisted of six replicates of 14 treatments arranged as a split plot design with Bedford barley and Katepwa wheat as main plots. Treatments consisted of three fertilizer rates (0, 25, 50 kg/ha Cl) with two sources of broadcast fertilizer (KCl and NaCl) and two disease inoculation treatments (with and without common root rot inoculum). Two additional treatments consisting of 25 kg/ha Cl as KCl (seedrow placement), with and without inoculation treatments were included. A similar design was used at the Point. However, in place of main plots of wheat and barley, main plots consisted of Bedford barley treated with common root rot inoculum and Bedford barley treated with spot blotch inoculum. Measurements taken at these three larger sites included plant counts at the one to three leaf stage, disease severity ratings at early heading and again at milky to mealy ripe stage, plant nutrient levels at the early heading stage, grain yield and grain quality measures.

The effect of chloride fertilization on wheat and barley was inconsistent in 1989. Plant counts, especially in wheat, were reduced by common root rot inoculum. There was no consistent effect of chloride on the severity of common root rot or spot blotch at any individual site. Chloride concentrations in plant tissue differed greatly with chloride treatment, but grain yield and quality responses to chloride fertilization were either very small or nonexistent, regardless of disease inoculation (Tables 1 to 8). Thus one can assume that, for these trials in 1989, the economic returns from chloride fertilizer were negative.

Environmental conditions of the 1989 growing season may well have had a significant effect on the results obtained. Conditions were such that disease development occurred rapidly early in the season but was brought to an abrupt halt by the hot, dry conditions which followed. If, in fact, a yield response to chloride application is a function of the disease suppressant action of chloride, the large influence which environment exerted on disease development may well have dominated over the relatively small influence of chloride.

Growth Chamber Studies

A pair of growth chamber studies was initiated in late January 1990 to investigate the effect of chloride fertilization on yield, disease pressure and nutrient uptake in Bedford barley grown in a controlled environment using soil very low in chloride (0.8 mg/kg).

The studies are being conducted concurrently in the same chamber. One study is designed primarily to examine the effect of chloride fertilization on plant nutrition, the other to concentrate on the effect of chloride on the severity of common root rot. Treatments in the nutrition study include 0, 5, 10, 20 and 40 mg Cl per kg soil. In the disease study, treatments include 0 and 40 mg Cl per kg soil, either with or without common root rot inoculum incorporated into the soil. For both studies, a midseason harvest at the boot stage (approx. Feekes Stage 10) was taken and grain yield will be determined at maturity. Root samples will also be taken at the soft dough stage for the disease study.

The barley crop is being grown to maturity, so the experiment is still in progress. However, some midseason measurements have been completed (Table 9). Chloride fertilization appeared to advance the maturity of the barley by a few days and may have increased dry matter yields slightly. Midseason moisture contents were not affected by treatment. The height of plants and the number of tillers were relatively unaffected by treatment and did not conform to a pattern that could be explained by the treatments.

Changes planned for 1990/91:

Overall, the plans for 1990/91 are very similar to those for 1989/90. The same five field locations will be used to assess the yield and disease response to chloride fertilizer on Katepwa wheat and Bedford barley. Further analyses of plant and soil samples gathered in 1989 are also planned.

Several changes are proposed for the upcoming year, including the introduction of a preliminary experiment to evaluate the effect of wheat and barley varieties on response to chloride fertilizer and some adjustments to budgetary expenditures to assist with a third year of field trials.

a) Effect of Cultivar on Yield Response to Chloride Fertilizer

The lack of a chloride response in the University of Manitoba trials may be due to varieties of wheat and barley being used. Researchers in South Dakota have noticed a significant difference between the chloride responses of Marshall and Guard varieties of spring wheat. So far, in experiments with American barley varieties, these researchers have been unable to identify a similar, significant interaction between variety and response to chloride fertilizer. There is no information in the literature describing a differential response of Canadian wheat and barley cultivars to chloride fertilizer.

Two simple field trials, one using four varieties of spring wheat (Katepwa, Roblin, Marshall and Biggar) and the other with four varieties of spring barley (Bedford, Heartland, Brier and Argyle) are planned for 1990. Treatments will include 0 and 50 kg/ha of chloride fertilizer applied as either KCl or NaCl. The wheat variety trial will be located at Anola on a field low in chloride and with a history of continuous wheat production. The barley variety trial will be located at Portage on a wheat stubble field with very low chloride levels.

b) Adjustments to Accommodate Third Year of Field Trials (1991)

The original plans for the chloride project included one year of gathering soil samples and only two years of field trials. Since the last progress report (June 1989) there have been some significant cost savings in the budget as a result of Ms. Mohr's ability to attract prestigious scholarships. The inconclusive results of 1989 and the availability of some "carryover" of funds into next year has encouraged the idea of extending the project into a third year of field testing. To accommodate such a proposal will require a significant quantity of funds because Ms. Mohr (supported now entirely by NSERC scholarship) will have completed her M.Sc. by that time, and a research associate or technician will have to be hired to replace her. A revised budget projection is as follows:

<u>Financial Plans for 1989/90 and 1990/91</u>

	Proj.	Actual
ADJUSTED NET CARRYOVER TO 1989/90	$8950	$8932
1989/90 Income		
Central Canada Potash	$1000	($2000?)
Cominco Fertilizers	2500	2500
Kalium Chemicals	2000	2000
Potash and Phosphate Inst. of Canada	5000	5000
Potash Corp. of Saskatchewan	5000	5000
Sherritt-Gordon Mines Ltd.	5000	5000
Western Canadian Fertilizer Assn.	1000	1000
Western Coop Fertilizers Ltd.	6000	6000
Total income	$27500	$28500
1989/90 Expenses		
Salaries		
Graduate Student	$12000	$7269
Summer Ass't. (.5 soils/.5 plant)	7000	7172
Benefits and Pay Levy		280
Overtime - Technicians		600
Supplies and Travel	11000	$13821
Total expenses	$30000	$29142
NET CARRYOVER TO 1990/91	$6450	$8290

	Original	Rev. Projected
1990/91 Income		
Central Canada Potash	$1000	$(1000?)
Cominco Fertilizers	2500	2500
Kalium Chemicals	2000	2000
Potash and Phosphate Inst. of Canada	5000	5000
Potash Corp. of Saskatchewan	5000	5000
Sherritt-Gordon Mines Ltd.	5000	5000
Western Canadian Fertilizer Assn.	1000	1000
Western Coop Fertilizers Ltd.	5000	5000
Total income	$26500	$26500
1990/91 Expenses		
Salaries		
Graduate Student	$12500	0
Summer Ass't. (.5 soils/.5 plant)	7500	1 soils $2000
		.5 plant 3750
Benefits and Pay Levy		300
Overtime - Technicians		700
Supplies and Travel	11950	14000
Total expenses	$31950	$20750
NET CARRYOVER TO 1991/92	$1000	$14040

	Projected
Carryover from 1990/91	$14040
1991/92 Income	
Central Canada Potash	$1000
Cominco Fertilizers	2500
Kalium Chemicals	2000
Potash and Phosphate Inst. of Canada	5000
Potash Corp. of Saskatchewan	5000
Sherritt-Gordon Mines Ltd.	5000
Western Canadian Fertilizer Assn.	1000
Western Coop Fertilizers Ltd.	5000
Total income	$26500
91/92	
1990/91 Expenses	
Salaries	
Research Associate (7 months)	$17340
Summer Ass't. (.5 soils/.5 plant)	8000
Benefits and Pay Levy	500
Overtime - Technicians	700
Supplies and Travel	14000
Total expenses	$40540
NET CARRYOVER TO 1992/93	0

Table 1. Grain yield of Katepwa wheat, as influenced by chloride fertilization and inoculation with common root rot (CRR).

#	Chloride Applied (kg/ha)	CRR Inoculum Applied	Cl Source and Placement	Grain Yield (kg/ha, 14% moisture)			
				Carman	Portage	Anola	Darlingford
1	0	No	KCl, B'cast	1944	3045	3095	1668
2	25	No	KCl, B'cast	1954	3045	3123	1895
3	50	No	KCl, B'cast	2224	3235	3308	1611
4	0	No	NaCl, B'cast	1855	2717	3026	1783
5	25	No	NaCl, B'cast	2234	2482	3197	1525
6	50	No	NaCl, B'cast	1895	3122	3344	1821
13	25	No	KCl, S'row	2004	2947	3309	2069
7	0	Yes	KCl, B'cast	1519	2645		
8	25	Yes	KCl, B'cast	1825	2892		
9	50	Yes	KCl, B'cast	1632	2640		
10	0	Yes	NaCl, B'cast	1991	2554		
11	25	Yes	NaCl, B'cast	1618	2991		
12	50	Yes	NaCl, B'cast	1625	2581		
14	25	Yes	KCl, S'row	1853	2865		

Table 2. Grain yield of Bedford barley, as influenced by chloride fertilization and inoculation with common root rot (CRR) or spot blotch (SB).

#	Chloride Applied (kg/ha)	CRR Inoculum Applied	Cl Source and Placement	Grain Yield (kg/ha, 14% moisture)			
				Carman	Portage	U of M-Point	
1	0	No	KCl, B'cast	2907	4478	4799	4315
2	25	No	KCl, B'cast	2970	4021	4761	4212
3	50	No	KCl, B'cast	3348	4413	4295	4352
4	0	No	NaCl, B'cast	3173	4242	4613	4465
5	25	No	NaCl, B'cast	2651	4521	4880	3994
6	50	No	NaCl, B'cast	2728	5136	4897	4845
13	25	No	KCl, S'row	2857	4340	4166	—
				CRR Studies			SB Study
7	0	Yes	KCl, B'cast	2646	4138	4335	4408
8	25	Yes	KCl, B'cast	3012	4314	4614	4533
9	50	Yes	KCl, B'cast	3060	4608	4704	4829
10	0	Yes	NaCl, B'cast	2706	4319	4624	4242
11	25	Yes	NaCl, B'cast	2864	3346	4687	4240
12	50	Yes	NaCl, B'cast	2935	4319	4451	4591
14	25	Yes	KCl, S'row	3183	3334	4471	—

Table 3. Chloride concentrations in Katepwa wheat at the boot stage, as influenced by chloride fertilization and inoculation with common root rot (CRR).

#	Chloride Applied (kg/ha)	CRR Inoculum Applied	Cl Source and Placement	Chloride Concentration (% in whole plant, dry wt. basis)	
				Carman	Portage
1	0	No	KCl, B'cast	0.31	0.20
2	25	No	KCl, B'cast	0.69	0.64
3	50	No	KCl, B'cast	0.79	0.77
4	0	No	NaCl, B'cast	0.41	0.22
5	25	No	NaCl, B'cast	0.62	0.66
6	50	No	NaCl, B'cast	0.81	0.82
13	25	No	KCl, S'row	0.67	0.59
7	0	Yes	KCl, B'cast	0.29	0.24
8	25	Yes	KCl, B'cast	0.60	0.56
9	50	Yes	KCl, B'cast	0.76	0.70
10	0	Yes	NaCl, B'cast	0.41	0.23
11	25	Yes	NaCl, B'cast	0.60	0.66
12	50	Yes	NaCl, B'cast	0.79	0.83
14	25	Yes	KCl, S'row	0.64	0.57

Table 4. Chloride concentrations in Bedford barley at the boot stage, as influenced by chloride fertilization and inoculation with common root rot (CRR) or spot blotch (SB).

#	Chloride Applied (kg/ha)	CRR Inoculum Applied	Cl Source and Placement	--- Chloride Concentration --- (% in whole plant, dry wt. basis)			
				Carman	Portage	U of M-Point	
1	0	No	KCl, B'cast	0.63	0.26	0.13	0.11
2	25	No	KCl, B'cast	1.11	0.67	0.62	0.40
3	50	No	KCl, B'cast	1.25	1.02	0.91	0.66
4	0	No	NaCl, B'cast	0.62	0.21	0.14	0.13
5	25	No	NaCl, B'cast	0.95	0.70	0.51	0.44
6	50	No	NaCl, B'cast	1.32	0.98	0.86	0.75
13	25	No	KCl, S'row	0.96	0.65	0.50	--
				---- CRR Studies ----			SB Study
7	0	Yes	KCl, B'cast	0.68	0.27	0.13	0.18
8	25	Yes	KCl, B'cast	0.97	0.65	0.57	0.43
9	50	Yes	KCl, B'cast	1.27	0.96	0.91	0.77
10	0	Yes	NaCl, B'cast	0.43	0.28	0.15	0.11
11	25	Yes	NaCl, B'cast	1.15	0.74	0.54	0.44
12	50	Yes	NaCl, B'cast	1.35	1.07	0.80	0.74
14	25	Yes	KCl, S'row	0.88	0.57	0.57	--

Table 5. Kernel size for Bedford barley, as influenced by chloride fertilization and inoculation with common root rot (CRR) or spot blotch (SB).

#	Chloride Applied (kg/ha)	CRR Inoculum Applied	Cl Source and Placement	---- % Plump Kernels ---- Carman	Portage	U of M-Point	
1	0	No	KCl, B'cast	8.0	10.2	60.8	55.8
2	25	No	KCl, B'cast	5.6	9.5	55.9	51.9
3	50	No	KCl, B'cast	8.2	8.6	53.1	57.0
4	0	No	NaCl, B'cast	5.9	10.8	59.5	58.6
5	25	No	NaCl, B'cast	5.7	10.4	54.6	49.5
6	50	No	NaCl, B'cast	5.5	11.6	57.9	51.8
13	25	No	KCl, S'row	5.7	8.7	45.8	—
				--- CRR Studies		----	SB Study
7	0	Yes	KCl, B'cast	4.8	6.6	56.8	49.7
8	25	Yes	KCl, B'cast	7.2	12.4	50.9	56.8
9	50	Yes	KCl, B'cast	5.3	8.8	58.1	55.2
10	0	Yes	NaCl, B'cast	4.5	8.6	57.3	56.4
11	25	Yes	NaCl, B'cast	4.4	7.6	53.3	48.5
12	50	Yes	NaCl, B'cast	6.0	8.0	51.1	51.5
14	25	Yes	KCl, S'row	6.1	10.7	51.4	—

#	Chloride Applied (kg/ha)	CRR Inoculum Applied	Cl Source and Placement	---- % Thin Kernels ---- Carman	Portage	U of M-Point	
1	0	No	KCl, B'cast	22.7	22.3	5.1	6.7
2	25	No	KCl, B'cast	26.3	23.9	6.5	7.3
3	50	No	KCl, B'cast	21.8	24.2	7.3	6.3
4	0	No	NaCl, B'cast	22.9	19.9	5.5	5.7
5	25	No	NaCl, B'cast	25.3	21.8	6.7	8.5
6	50	No	NaCl, B'cast	25.8	18.9	6.5	6.6
13	25	No	KCl, S'row	23.8	21.4	8.8	—
				--- CRR Studies		----	SB Study
7	0	Yes	KCl, B'cast	23.5	24.3	6.0	7.2
8	25	Yes	KCl, B'cast	21.4	19.3	7.3	6.5
9	50	Yes	KCl, B'cast	23.0	21.5	6.1	6.3
10	0	Yes	NaCl, B'cast	22.2	22.4	5.7	5.5
11	25	Yes	NaCl, B'cast	25.5	25.1	7.2	8.5
12	50	Yes	NaCl, B'cast	21.2	25.7	8.3	7.5
14	25	Yes	KCl, S'row	23.3	21.6	7.5	—

Table 6. Thousand kernel weight of Katepwa wheat, as influenced by chloride fertilization and inoculation with common root rot (CRR).

#	Chloride Applied (kg/ha)	CRR Inoculum Applied	Cl Source and Placement	--- Thousand Kernel Wt --- (g/1000 kernels, 14% moisture) Carman	Portage	Anola	Darling-ford	Avg
1	0	No	KCl, B'cast	22.8	30.2	37.4	20.4	27.7
2	25	No	KCl, B'cast	22.1	30.3	32.2	20.3	26.2
3	50	No	KCl, B'cast	24.2	30.9	32.7	19.6	26.9
4	0	No	NaCl, B'cast	22.6	29.9	31.9	19.9	26.1
5	25	No	NaCl, B'cast	23.1	32.2	32.3	18.0	26.4
6	50	No	NaCl, B'cast	23.0	32.3	32.5	20.2	27.0
13	25	No	KCl, S'row	22.6	32.2	32.9	21.1	27.2
7	0	Yes	KCl, B'cast	23.3	31.8			27.6
8	25	Yes	KCl, B'cast	24.1	31.3			27.7
9	50	Yes	KCl, B'cast	23.6	31.9			27.7
10	0	Yes	NaCl, B'cast	24.9	32.3			28.6
11	25	Yes	NaCl, B'cast	24.4	32.9			28.6
12	50	Yes	NaCl, B'cast	24.8	33.2			29.0
14	25	Yes	KCl, S'row	25.2	33.1			29.2

Table 7. Thousand kernel weight of Bedford barley, as influenced by chloride fertilization and inoculation with common root rot (CRR) or spot blotch (SB).

#	Chloride Applied (kg/ha)	CRR Inoculum Applied	Cl Source and Placement	--- Thousand Kernel Wt. --- (g/1000 kernels, 14% moisture) Carman	Portage	U of M	Point	Avg
1	0	No	KCl, B'cast	30.3	29.5	35.7	34.3	32.5
2	25	No	KCl, B'cast	30.1	29.5	35.0	33.8	32.1
3	50	No	KCl, B'cast	30.2	29.1	34.7	35.1	32.3
4	0	No	NaCl, B'cast	29.8	29.1	34.8	34.7	32.1
5	25	No	NaCl, B'cast	29.4	28.9	34.5	35.0	32.0
6	50	No	NaCl, B'cast	29.1	30.7	35.4	34.2	32.3
13	25	No	KCl, S'row	29.5	29.5	33.9	—	31.0
				--- CRR Studies ---			SB Study	
7	0	Yes	KCl, B'cast	29.6	28.3	34.5	33.4	31.4
8	25	Yes	KCl, B'cast	30.1	30.6	33.6	35.3	32.4
9	50	Yes	KCl, B'cast	30.4	29.8	36.6	35.0	33.0
10	0	Yes	NaCl, B'cast	28.6	28.8	35.3	34.8	31.9
11	25	Yes	NaCl, B'cast	28.9	29.1	34.9	33.4	31.6
12	50	Yes	NaCl, B'cast	29.9	29.1	34.6	34.8	32.1
14	25	Yes	KCl, S'row	30.4	28.9	34.8	—	31.4

Table 8. Summary of preliminary measurements describing the effect of chloride fertilizer and inoculation with common root rot on the growth of Bedford spring barley grown in the growth chamber using soil very low in chloride.

#	Treatments: Chloride Applied (mg/kg)	Treatments: CRR Inoculum Applied	Feekes Stage	Fresh Wt (g/pot)	Dry Wt (g/pot)	%H2O (% of fresh wt)	Height (cm)
#1	0	No	10.00	59.6	10.5	82.3	69.4
#2	5	No	10.00	60.9	10.2	83.3	68.4
#3	10	No	10.02	62.2	10.3	83.4	67.6
#4	20	No	10.04	66.3	11.6	82.5	69.8
#5	40	No	10.06	65.9	12.2	81.4	69.2
#8	0	Yes	10.02	67.2	11.0	83.6	70.4
#11	40	Yes	10.08	64.4	11.4	82.3	70.2