Effect of Cultivar on the Response of Barley and Wheat to Chloride Fertilizers

Results of 1991 Field Trials

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Introduction:

Results of preliminary cultivar trials conducted in 1990 suggested that cultivars of wheat and barley commonly grown in Canada differ in their responsiveness to Cl^- fertilizer applications.

In order to confirm these observations, a factorial experiment consisting of four cultivars and three fertilizer treatments was conducted at Anola, Portage and the University of Manitoba for both barley and wheat. Barley cultivars grown were Bedford, Brier, Argyle and Heartland. Wheat cultivars grown were Katepwa, Roblin, Biggar and Marshall. Fertilizer treatments included a control, 50 kg Cl^- ha^{-1} as KCl and 50 kg Cl^- ha^{-1} as $CaCl_2$ (p.8). At all sites, soil Cl^- content measured less than 66 kg Cl^- ha^{-1} to 60 cm (p.9). Cl^- fertilization would be recommended for these sites according to current South Dakota soil test guidelines.

Results:

Results of 1991 field trials appear to have been significantly influenced by the environmental conditions which prevailed during the growing season. High levels of precipitation occurred early in the growing season followed by drier weather during the grain fill period. At Portage and the University of Manitoba, crop growth was excellent until midseason as evidenced by fairly high, uniform midseason dry matter yields. Unfortunately, high levels of disease and poor grain fill later in the season resulted in lower, more variable grain yields than had been anticipated. At Anola, excess moisture prior to midseason restricted crop growth and resulted in uneven crop development throughout the season.

1. Final Yield

a) Grain (p.10-11)

The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ did not significantly increase the grain yield of any of the barley cultivars tested at any of the field sites. At Portage, the application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly decreased the grain yield of Bedford barley. The reason for this decrease is not known.

The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly increased the grain yield of Biggar at Anola (~260 kg ha^{-1}) and at Portage (~400 kg ha^{-1}) and of Marshall at Anola (~310 kg ha^{-1}). The same trend was evident for Katepwa at the University of Manitoba (~250 kg ha^{-1}) but the effect was not statistically significant. At Portage, the application of 50 kg Cl^- ha^{-1} significantly decreased grain yield of Marshall; the same trend was apparent in Katepwa but the effect was not

significant. In Roblin at Portage, the application of 50 kg Cl^- ha^{-1} as KCl resulted in a significantly lower grain yield than the application of 50 kg Cl^- ha^{-1} as $CaCl_2$. No other significant effects of Cl^- on grain yield occurred. The reason for the unexpected decreases in grain yield of Marshall and of Katepwa at the Portage site is not known.

b) Straw (p.12-13)

The addition of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ significantly reduced the straw yield of Bedford barley at Portage. An accompanying significant decrease in grain yield for Bedford barley at Portage was also observed. No other significant effects of rate on straw yield of barley cultivars were noted. Straw yield for Argyle barley at Anola and Portage was found to be significantly higher in subplots treated with $CaCl_2$ than in subplots treated with KCl.

The addition of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ resulted in a significant decrease in straw yield of Katepwa wheat at Portage and at the University of Manitoba, of Roblin at Anola and at Portage and of Marshall at Portage. An accompanying significant reduction in grain yield was observed only in the Marshall at Portage.

2. Midseason Dry Matter Yields (p.14-15)

The application of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ did not have a significant effect on midseason dry matter yields for any of the barley cultivars tested at any of the sites.

The application of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ significantly decreased midseason dry matter yield of Roblin wheat at Anola and Portage. This deleterious effect of Cl^- was evident throughout the growing season; Cl^- applications were found to significantly decrease straw yield for Roblin at both these sites. No other significant effects of Cl^- on midseason dry matter yields were observed.

3. **Plant Nutrient Status (boot to heading stage)**

a) Chloride (p.16-17)

The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly increased the plant tissue Cl^- concentration for all barley cultivars at all field sites. Overall, KCl and $CaCl_2$ were equivalent in their ability to provide Cl^- to the plant. However, in Argyle at Anola, plant tissue samples taken from subplots treated with $CaCl_2$ were found to contain significantly higher concentrations of Cl^- than those taken from subplots treated with KCl. Very high plant tissue Cl^- concentrations observed at the Portage site were likely the result of the presence of a high soil Cl^- concentration at depth (p.9). The coefficient of variation for plant tissue Cl^- at the Portage site was very low as compared to Anola and the University of Manitoba. Also, at the Portage site, the overall increase in plant tissue Cl^- concentration from Cl^- applications was high.

The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly increased the plant tissue Cl^- concentration for all wheat cultivars at all field sites. As was the case with barley, high and consistent plant tissue Cl^- concentrations were observed at the Portage site. Overall, Cl^- sources were equivalent in their ability to provide Cl^- to the plant except for Biggar at the University of Manitoba. In Biggar at the University of Manitoba, plant tissue samples taken from subplots treated with $CaCl_2$ were found to contain significantly higher concentrations of Cl^- than those taken from subplots treated with KCl.

b) Nitrate (p.18-19)

The application of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ significantly reduced midseason plant tissue NO_3^- concentrations for Bedford and Brier barley at all three field sites. The application of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ significantly reduced plant tissue NO_3^- concentration for Argyle barley and for Heartland barley at Portage only. Cl^- applications tended to reduce plant tissue NO_3^- concentration for Heartland at Anola, but the effect was not significant.

The application of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ significantly reduced plant tissue NO_3^- concentrations for Katepwa wheat at Portage and at the University of Manitoba, for Roblin wheat at Anola and at Portage, for Marshall wheat at Anola and at Portage and for Biggar wheat at Portage only. Applications of Cl^- tended to decrease the plant tissue NO_3^- concentrations for Roblin at the University of Manitoba and for Biggar at Anola.

Studies conducted in the Northern Great Plains have demonstrated significant reductions in plant tissue NO_3^- concentrations for spring wheat and barley with the application of Cl^- containing fertilizers (Fixen et al., 1987; Goos et al., 1987). Increases in plant tissue N have often been associated with increases in plant disease (Huber and Watson, 1974). Thus, reductions in plant tissue NO_3^- concentrations by Cl^- may be important in the suppression of plant disease and thereby in consequent increases in grain yield. In the 1991 Manitoba field trials, significant reductions in plant tissue NO_3^- concentrations were observed for the wheat and barley cultivars grown. However, plant tissue NO_3^- concentrations were not consistently or significantly reduced by Cl^- applications for all cultivars or for all sites. In addition, significant reductions in plant tissue NO_3^- concentrations were not consistently associated with visible reductions in foliar disease, increases in grain yield or reductions in total N content of grain at maturity.

c) Potassium (p.20-21)

According to guidelines followed by the Manitoba Provincial Soil Testing Laboratory, plant tissue K concentrations were adequate across all treatments in both the barley and the wheat. (Concentrations of 1.5% to 3.0% in whole plant prior to filling are considered sufficient.) In general, concentrations did not differ significantly among fertilizer treatments which indicates that the probability of a K response is low and that responses to KCl were likely due to the Cl^- component of the applied fertilizer.

d) Manganese (p.22-23)

The application of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ significantly decreased plant tissue Mn concentration for Argyle at Anola and for Brier at the University of Manitoba. The same trend was apparent for Bedford at Portage, but the effect was not significant.

The effect of Cl^- on plant tissue Mn concentration for wheat was inconsistent. In Biggar wheat, the application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly decreased plant tissue Mn concentration at Anola and significantly increased plant tissue Mn concentration at Portage. The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly decreased plant tissue Mn concentration for Marshall at Anola and for Katepwa at Portage.

Beaton et al. (1988) suggested that the application of Cl^- containing fertilizers may increase plant available Mn and thereby suppress cereal diseases and increase grain yield. However, the effect of Cl^- fertilization on plant tissue Mn concentration does not appear to be an important factor influencing yield responses to Cl^- under Manitoba conditions. In the 1991 Manitoba field experiments conducted on neutral to basic soils (p.9), Cl^- applications most often either slightly

reduced or did not affect plant tissue Mn concentrations for wheat or barley. Cl^- applications were found to have negligible effects on midseason dry matter accumulations; thus, observed reductions in plant tissue Mn concentration cannot be attributed to a dilution effect.

e) Copper (p.24-25)

Overall, Cl^- fertilizer treatment did not have a significant effect on plant tissue Cu concentration for barley. For Bedford, the application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly decreased plant tissue Cu concentration at Anola, but significantly increased plant tissue Cu concentration at the University of Manitoba.

The application of Cl^- did not have a significant effect on plant tissue Cu concentration for any of the wheat cultivars at any site.

f) Zinc (p.26-27)

The application of Cl^- did not have a significant effect on plant tissue Zn concentration for any of the barley cultivars tested.

The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ resulted in a small but significant decrease in plant tissue Zn concentrations for Biggar and Marshall at Anola. No other significant effects of rate were observed. In Katepwa at Anola and in Biggar at the University of Manitoba, plant tissue samples taken from subplots treated with $CaCl_2$ were found to contain significantly lower concentrations of Zn than those taken from subplots treated with KCl.

g) Ammonium (p.28-29)

The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ did not have a significant effect on plant tissue NH_4^+ concentration for any of the wheat or barley cultivars tested.

In some instances, dramatic, significant differences in midseason plant tissue concentrations of Cl^-, NO_3^-, Mn, Zn and Cu were observed for different cultivars within a species. A combination of factors, including genetic differences and differences in the maturity of cultivars at time of sampling was likely responsible for the differences among cultivars.

4. Crop Development

Cl^- treatment did not have a visible effect on crop advancement for any of the barley cultivars tested.

At Portage and the University of Manitoba, the application of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ resulted in a visible advancement in the maturity of Biggar and Marshall. This trend was not observed at Anola, probably as a result of the high degree of variability in crop development.

5. Foliar Disease

After heading, a cursory assessment of foliar disease was conducted for two of the three wheat plots. At the University of Manitoba, the application of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ resulted in a visible reduction in the severity of foliar disease for Marshall in 6 of 6 replicates and for Roblin in 4 of 6 replicates. In neither case did these visible reductions in foliar disease significantly increase grain yield. Cl^- did, however, significantly increase thousand kernel weight for these cultivars, possibly through the

suppression of foliar disease. Cl^- applications did not result in a consistent visible reduction in foliar disease for Katepwa or Biggar wheat. However, Cl^- tended to increase grain yield for Katepwa at the University of Manitoba. At Portage, a cursory assessment of foliar disease was conducted for only Marshall and Katepwa wheat. Cl^- applications did not appear to affect foliar disease severity at the Portage site. Very high levels of foliar disease pressure at Portage as compared to the University of Manitoba may have overcome the disease suppressive effects of Cl^-.

6. Grain Quality Measures

a) Thousand Kernel Weight (p.30-31)

The addition of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly decreased the thousand kernel weight of Heartland barley at the University of Manitoba. Cl^- application also tended to decrease thousand kernel weight for Heartland barley at Portage and for Brier barley at Anola and the University of Manitoba. No other significant effects of Cl^- treatment on thousand kernel weight were observed for barley.

The addition of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly increased the thousand kernel weight of Biggar at Anola and at Portage, of Marshall at Anola and at the University of Manitoba and of Roblin at the University of Manitoba. In three of the five cases, Cl^- also produced a significant increase in grain yield. Increases in thousand kernel weight may-have contributed to the observed increases in grain yield.

b) Hectolitre Weights (p.32-33)

The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly decreased hectolitre weight for Bedford, Brier and Argyle barley at the Anola site only. However, slight, statistically insignificant decreases in hectolitre weight of Bedford, Brier and Argyle at Portage and of Heartland at the University of Manitoba were also observed. No other significant effects of Cl^- on hectolitre weight of barley were observed.

The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly increased the hectolitre weight for Biggar at Anola and at Portage and for Marshall at Anola. In all cases, Cl^- had also significantly increased thousand kernel weight and grain yield. The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly decreased the hectolitre weight of Roblin at Portage. No other significant effects of Cl^- were observed.

c) Barley Kernel Plumpness (p.34-35)

The application of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly decreased the percentage of plump kernels for Brier and Argyle at Anola and for Heartland at Portage and the University of Manitoba. Slight, statistically insignificant reductions in the percentage of plump kernels were also observed in Brier at Portage and at the University of Manitoba and in Heartland at Anola.

The addition of 50 kg Cl^- ha^{-1} as KCl or $CaCl_2$ significantly increased the percentage of thin kernels for Brier and Heartland at the University of Manitoba. The same trend was apparent for Brier and Heartland at Portage, but the effects were not significant. In contrast, Cl^- applications significantly decreased the percentage of thin kernels for Brier at Anola.

Overall, the addition of Cl^- appeared to decrease the proportion of plump kernels and increase the proportion of thin kernels for the cultivars Brier and Heartland. Cl^- applications appeared to have

little or no effect on the cultivars Bedford and Argyle.

d) Total N Content of Grain (p.36-37)

The application of 50 kg Cl^- ha^{-1} significantly reduced total N content in grain for Bedford barley at Anola and for Brier barley at Portage. In both cases, the addition of Cl^- had also significantly reduced midseason plant tissue NO_3^- concentration. Reductions in midseason plant tissue NO_3^- concentration by Cl^- did not, however, appear to consistently result in a significant reduction in total N content of the grain. For the Brier at Portage, the reduction in total N content was due primarily to the effect of the KCl treatment not the $CaCl_2$ treatment. Applications of KCl resulted in a significantly lower total N content in grain for Brier at Portage and for Argyle at Anola than applications of $CaCl_2$. The same trend was apparent in Argyle at the University of Manitoba, but the effect was not significant.

The application of 50 kg Cl^- ha^{-1} as either KCl or $CaCl_2$ resulted in a significant reduction in total N content of grain for Biggar at Portage. The same trend was evident for Marshall at Anola but the effect was not significant. In both cases, these changes in total N were equivalent to approximately 0.5% protein. In both cases, Cl^- had significantly decreased midseason plant tissue NO_3^- concentration and had significantly increased grain yield, thousand kernel weight and hectolitre weight. As was the case with barley, reductions in midseason plant tissue NO_3^- concentration by Cl^- did not consistently result in a significant reduction in total N content of grain. However, results appear to suggest that a reduction in total N of grain was most likely when both a highly significant reduction in midseason plant tissue NO_3^- concentration and a significant increase in grain yield occurred. Reductions in total N of grain did not appear to have a deleterious effect on thousand kernel weight or hectolitre weight.

Summary:

Field trials were conducted in 1990 and 1991 to determine the effect of cultivar on the response of barley and wheat to chloride fertilizers.

Overall, the wheat cultivars tested showed yield responses to Cl^- applications more frequently than the barley cultivars tested. Of the wheat cultivars tested, Marshall, Biggar and Roblin were found to respond more frequently to Cl^- than Katepwa. Cl^- significantly increased grain yield of Biggar and Marshall in two of four field experiments and of Roblin in one of four field experiments. The frequency of yield response to Cl^- was very low in the barley cultivars tested. A significant increase in the grain yield of Heartland was observed in one of four field experiments; the addition of Cl^- did not significantly increase grain yield for any of the other barley cultivars tested in any of the four field experiments conducted. The observed yield responses did not appear to be dependent upon a suppression of disease by Cl^-. The high degree of variability evident in the responses observed among sites and among years suggests that environmental conditions may have had a strong influence on crop response.

The application of Cl^- consistently and significantly increased midseason plant tissue Cl^- concentration for all cultivars of wheat and barley in 1990 and 1991. Application of Cl^- did not significantly reduce plant tissue NO_3^- concentration for barley or wheat in 1990, however, Cl^- applications resulted in significant reductions in plant tissue NO_3^- concentrations for wheat and barley in 1991. Cl^- applications did not have a consistent and significant effect on midseason plant tissue concentrations of K, Mn, Cu, Zn or NH_4^+ for wheat or barley.

Cl^- applications did not appear to affect crop development in barley. Cl^- applications appeared to advance

the maturity of the wheat cultivars Biggar and Marshall.

In several instances, visible reductions in foliar disease were observed for certain of the cultivars. Significant increases in grain yield were not generally associated with these reductions in disease, however increases in thousand kernel weight were occasionally observed.

In the wheat trials, significant increases in thousand kernel weight and hectolitre weight most often occurred in conjunction with a significant increase in grain yield. In general, effects of Cl^- on grain quality of barley were nonexistent or deleterious; decreases in hectolitre weight and in the percentage of plump kernels were observed most frequently in the cultivars Brier and Heartland.

Slight reductions in total N content of wheat grain by Cl^- tended to occur when Cl^- both significantly decreased midseason plant tissue NO_3^- concentration and significantly increased grain yield. In barley, Cl^- did not have a consistent, significant effect on total N content of grain.

References

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Appendix I

Methods and Materials for 1991 Field Trials

Methods and Materials:

A factorial experiment consisting of four cultivars and three fertilizer treatments was conducted at Anola, Portage and the University of Manitoba for both barley and wheat. Plots were established on soils testing less than 66 kg Cl^- ha^{-1} to 60 cm; Cl^- fertilization would have been recommended according to current South Dakota soil test guidelines. Fertilizer treatments included a control, 50 kg Cl^- ha^{-1} as broadcast KCl and 50 kg Cl^- ha^{-1} as broadcast $CaCl_2$. A randomized complete block design using six replications was employed. Subplots consisted of 6 drill rows 6 m in length.

'Bedford', 'Brier', 'Heartland' and 'Argyle' barley (*Hordeum vulgare* L.) were grown. All cultivars of barley grown were recommended for Manitoba in 1991. Bedford, Brier and Heartland are 6-row feed cultivars. Argyle is a 6-row barley suitable for malting or feed purposes. 'Katepwa', 'Roblin', 'Biggar' and 'Marshall' wheat (*Triticum aestivum* L.) were grown. Katepwa, Roblin and Biggar were recommended cultivars in Manitoba in 1991. Katepwa and Roblin are high quality Canadian Western Red Spring wheats while Biggar is a red, medium quality Canadian Prairie Spring wheat. Marshall, which is not recommended for Manitoba, is a popular American semi-dwarf hard red spring wheat; it was included because studies conducted in the Northern United States have demonstrated Marshall to be especially responsive to Cl^- fertilizer applications.

All cultivars were sown to achieve a stand density of 250 germinated seeds per m^2 based on thousand kernel weight and germination percentage of each seedlot. Cl^- fertilizers were hand broadcast immediately after planting at Portage and several days after planting at the University of Manitoba and at Anola. Commercial grade KCl and $CaCl_2$ were applied at all sites.

Basal applications of macronutrients were made as required. At all sites, 100 kg N ha^{-1} as ammonium nitrate was hand broadcast in the spring prior to seeding. At Portage, the ammonium nitrate was incorporated prior to seeding. At Anola and the University of Manitoba, the crop was seeded directly without any additional spring tillage. At all sites monoammonium phosphate was placed with the seed at time of seeding at a rate of 13 kg P ha^{-1} and 7 kg N ha^{-1}. Approximately two weeks after seeding a further 25 kg N ha^{-1} as ammonium nitrate was hand broadcast at Anola.

Alleys and border areas were seeded to wheat or barley in order to reduce edge effects. Herbicides were applied at recommended rates for the control of weeds.

Sites were sampled at midseason and maturity. The midseason harvest corresponded to approximately the boot to heading stage for the majority of cultivars of wheat and barley. At or near the time of midseason harvest, crop advancement was recorded using the Feekes scale. At midseason, the shoot portion of plants was harvested from 0.5 m of three drill rows from two areas within each subplot. Samples were oven dried at 68°C, weighed to determine dry matter yield and ground with a Wiley mill to pass a 2 mm sieve. Plant tissue concentrations of Cl^-, NO_3^-, NH_4^+, K^+, Cu^{2+}, Mn^{2+} and Zn^{2+} were determined. Cl^- was determined by $AgNO_3$ titration procedure. NO_3^- and NH_4^+ were determined by steam distillation. K, Cu, Mn and Zn were determined by atomic absorption on a nitric perchloric digest.

After heading, a cursory assessment of foliar diseases was conducted for the wheat plots at the University of Manitoba and at Portage. Only the cultivars Katepwa and Marshall were rated at the Portage site. This rating system were purely subjective, not quantitative. Foliar diseases present were neither identified nor differentiated from one another.

Final harvest consisted of removing the shoot portion of plants from 3 m of two inside drill rows from each subplot. Samples were cut by hand approximately 1 inch from the soil surface. Samples were air dried, then threshed using a stationary thresher. Grain yield, straw yield, thousand kernel weight, hectolitre weight and barley kernel plumpness were determined. Hectolitre weight and kernel plumpness were determined according to methods outlined by the Canadian Grain Commission (1984). Thousand kernel weight was based on a random subsample of 200 kernels per subplot. Grain samples were then ground with a Wiley mill to pass a 2 mm sieve. Total nitrogen of grain samples was determined by the conventional Kjeldahl method.

Appendix II

Soil Characterization

Physical and Chemical Characteristics of Soils Used in 1991 Field Trials

Characteristic	Depth (cm)	Site		
		Anola	Portage	University of Manitoba
Legal Location		NE23-10-6E	SE7-11-8W	-
Texture		silty clay	clay loam	clay
pH	0 to 15	7.8	6.7	7.6
Organic C (%)	0 to 15	6.0	4.0	3.3
	15 to 30	3.9	3.1	3.2
Carbonates (% CO_3)	0 to 15	4.3	0.1	1.7
	15 to 30	10.9	0.4	2.9
NO_3^--N (mg kg^{-1})	0 to 60	8	8	13
	60 to 120	9	33	26
$NaHCO_3$-extr. P (mg kg^{-1})	0 to 15	7	11	80
	15 to 30	2	3	62
CH_3COONH_4-extr. K (mg kg^{-1})	0 to 15	408	196	441
	15 to 30	288	125	421
SO_4^{2-}-S (mg kg^{-1})	0 to 60	5	105	3
	60 to 120	30	1289	5
Cl^- (mg kg^{-1})	0 to 15	3.1	1.3	2.9
	15 to 30	4.4	1.1	2.6
	30 to 60	6.2	1.9	1.8
	60 to 90	2.6	23.0	2.0
	90 to 120	2.1	16.7	2.1
(kg ha^{-1})	0 to 60	39.7	12.3	18.3
	60 to 120	18.5	158.8	16.3
DTPA-extr. Cu (mg kg^{-1})	0 to 15	1.7	0.9	2.6
	15 to 30	2.3	1.0	2.8
DTPA-extr. Mn (mg kg^{-1})	0 to 15	9	22	19
	15 to 30	5	12	19
DTPA-extr. Zn (mg kg^{-1})	0 to 15	1.1	3.2	2.4
	15 to 30	0.4	2.7	2.4
DTPA-extr. Fe (mg kg^{-1})	0 to 15	20	35	25
	15 to 30	24	23	26

Appendix III

Results of 1991 Chloride Field Trials

Effect of Chloride Fertilizer on Grain Yield of Four Barley Cultivars

Treatment			Grain Yield (kg ha^{-1})		
kg ha^{-1} Cl$^-$ Applied	Cl$^-$ Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means0					
0	-	Bedford	2273	4582	3214
50	KCl	Bedford	2178	3490	3395
50	$CaCl_2$	Bedford	2300	3281	3321
0	-	Brier	1997	3565	2930
50	KCl	Brier	1872	3836	3095
50	$CaCl_2$	Brier	1983	3657	2770
0	-	Argyle	2062	4364	2661
50	KCl	Argyle	2211	4196	3217
50	$CaCl_2$	Argyle	2479	4839	2819
0	-	Heartland	1597	4829	2670
50	KCl	Heartland	1522	4652	3039
50	$CaCl_2$	Heartland	1484	4238	3021
Group Means					
0	-		1982	4335	2869
50	KCl		1946	4044	3186
50	$CaCl_2$		2061	4004	2983
LSD (P=0.05)			ns	ns	ns
		Bedford	2250	3784	3310
		Brier	1950	3686	2931
		Argyle	2251	4466	2899
		Heartland	1534	4573	2910
LSD (P=0.05)			193	416	ns

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.26
Treatment (T)		2	0.37	0.14	0.31
C*T		6	0.42	0.01 **	0.97
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.47	0.56	0.86
0 vs 50 Cl (both sources)	Bedford	1	0.81	0.0003 **	0.69
KCl vs $CaCl_2$	Brier	1	0.51	0.62	0.44
0 vs 50 Cl (both sources)	Brier	1	0.63	0.56	0.99
KCl vs $CaCl_2$	Argyle	1	0.11	0.08	0.34
0 vs 50 Cl (both sources)	Argyle	1	0.06	0.62	0.32
KCl vs $CaCl_2$	Heartland	1	0.82	0.25	0.97
0 vs 50 Cl (both sources)	Heartland	1	0.52	0.22	0.32
C.V. (%)			14.5	15.1	23.8

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Grain Yield of Four Wheat Cultivars

Treatment			Grain Yield (kg ha^{-1})		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	1137	3542	1980
50	KCl	Katepwa	1128	3204	2264
50	$CaCl_2$	Katepwa	1084	3150	2205
0	-	Roblin	1433	3325	2814
50	KCl	Roblin	1434	2984	2947
50	$CaCl_2$	Roblin	1505	3461	2919
0	-	Biggar	1484	2528	1379
50	KCl	Biggar	1648	2956	1192
50	$CaCl_2$	Biggar	1847	2904	1377
0	-	Marshall	1423	4140	2387
50	KCl	Marshall	1669	3643	2665
50	$CaCl_2$	Marshall	1797	3862	2361
Group Means					
0	-		1369	3384	2140
50	KCl		1470	3197	2267
50	$CaCl_2$		1558	3344	2215
LSD (P=0.05)			102	ns	ns
		Katepwa	1116	3299	2149
		Roblin	1457	3256	2893
		Biggar	1660	2796	1316
		Marshall	1629	3882	2471
LSD (P=0.05)			118	250	235

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.0001 **
Treatment (T)		2	0.002 **	0.20	0.46
C*T		6	0.05 *	0.03 *	0.55
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.67	0.80	0.77
0 vs 50 Cl (both sources)	Katepwa	1	0.73	0.06	0.15
KCl vs $CaCl_2$	Roblin	1	0.49	0.03 *	0.89
0 vs 50 Cl (both sources)	Roblin	1	0.68	0.59	0.50
KCl vs $CaCl_2$	Biggar	1	0.06	0.81	0.37
0 vs 50 Cl (both sources)	Biggar	1	0.004 **	0.04 *	0.59
KCl vs $CaCl_2$	Marshall	1	0.21	0.32	0.14
0 vs 50 Cl (both sources)	Marshall	1	0.0009 **	0.04 *	0.48
C.V. (%)			12.1	11.3	15.9

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Straw Yield of Four Barley Cultivars

Treatment			Straw Yield (kg ha^{-1})		
kg ha^{-1} Cl$^-$ Applied	Cl$^-$ Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	4988	5679	6187
50	KCl	Bedford	4987	5092	6060
50	$CaCl_2$	Bedford	4967	4762	6184
0	-	Brier	4767	5689	7579
50	KCl	Brier	4551	5553	7098
50	$CaCl_2$	Brier	4346	5965	7269
0	-	Argyle	4517	6018	6096
50	KCl	Argyle	4509	5448	6295
50	$CaCl_2$	Argyle	5360	6510	6360
0	-	Heartland	5032	5476	5868
50	KCl	Heartland	4631	5624	6310
50	$CaCl_2$	Heartland	4724	4996	6566
Group Means					
0	-		4826	5715	6433
50	KCl		4669	5429	6441
50	$CaCl_2$		4849	5558	6595
LSD (P=0.05)			ns	ns	ns
		Bedford	4981	5178	6144
		Brier	4555	5735	7315
		Argyle	4795	5992	6250
		Heartland	4796	5366	6248
LSD (P=0.05)			ns	416	496

ANOVA		df	Pr > F		
Cultivar (C)		3	0.09	0.001 **	0.0001 **
Treatment (T)		2	0.39	0.29	0.70
C*T		6	0.04 *	0.01 **	0.70
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.94	0.36	0.78
0 vs 50 Cl (both sources)	Bedford	1	0.96	0.02 *	0.86
KCl vs $CaCl_2$	Brier	1	0.47	0.26	0.69
0 vs 50 Cl (both sources)	Brier	1	0.20	0.82	0.29
KCl vs $CaCl_2$	Argyle	1	0.004 **	0.005 **	0.88
0 vs 50 Cl (both sources)	Argyle	1	0.09	0.90	0.54
KCl vs $CaCl_2$	Heartland	1	0.74	0.09	0.55
0 vs 50 Cl (both sources)	Heartland	1	0.15	0.60	0.13
C.V. (%)			10.3	11.2	11.4

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Straw Yield of Four Wheat Cultivars

Treatment			Straw Yield (kg ha^{-1})		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	4084	6407	7020
50	KCl	Katepwa	3917	5726	6509
50	$CaCl_2$	Katepwa	3698	5818	6624
0	-	Roblin	4624	6209	6782
50	KCl	Roblin	4060	5448	6707
50	$CaCl_2$	Roblin	4010	5867	6785
0	-	Biggar	3904	6944	6531
50	KCl	Biggar	4083	6757	6763
50	$CaCl_2$	Biggar	4354	6290	6519
0	-	Marshall	4471	6640	6695
50	KCl	Marshall	4424	6016	6990
50	$CaCl_2$	Marshall	4506	6199	6923
Group Means					
0	-		4271	6550	6757
50	KCl		4121	5987	6742
50	$CaCl_2$		4142	6043	6713
LSD (P=0.05)			ns	282	ns
		Katepwa	3900	5984	6717
		Roblin	4232	5841	6758
		Biggar	4114	6664	6604
		Marshall	4467	6285	6869
LSD (P=0.05)			339	326	ns

ANOVA		df	Pr > F		
Cultivar (C)		3	0.01 **	0.0001 **	0.27
Treatment (T)		2	0.54	0.0002 **	0.93
C*T		6	0.23	0.46	0.22
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.46	0.74	0.62
0 vs 50 Cl (both sources)	Katepwa	1	0.28	0.01 **	0.03 *
KCl vs $CaCl_2$	Roblin	1	0.87	0.14	0.74
0 vs 50 Cl (both sources)	Roblin	1	0.02 *	0.03 *	0.86
KCl vs $CaCl_2$	Biggar	1	0.36	0.10	0.29
0 vs 50 Cl (both sources)	Biggar	1	0.22	0.09	0.58
KCl vs $CaCl_2$	Marshall	1	0.78	0.52	0.77
0 vs 50 Cl (both sources)	Marshall	1	0.98	0.03 *	0.20
C.V. (%)			12.1	7.9	5.9

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Dry Matter Yield of Four Barley Cultivars

Treatment			Midseason Dry Matter Yield (kg ha^{-1})		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	4965	5156	7115
50	KCl	Bedford	4668	5009	6890
50	$CaCl_2$	Bedford	4818	4856	6990
0	-	Brier	4371	4649	7171
50	KCl	Brier	4843	4671	7227
50	$CaCl_2$	Brier	4553	4837	7449
0	-	Argyle	4197	4490	6621
50	KCl	Argyle	4200	4597	6262
50	$CaCl_2$	Argyle	4499	4771	6805
0	-	Heartland	4315	4509	6349
50	KCl	Heartland	4034	4765	6421
50	$CaCl_2$	Heartland	4465	4806	6321
Group Means					
0	-		4462	4701	6814
50	KCl		4436	4760	6700
50	$CaCl_2$		4584	4817	6891
LSD (P=0.05)			ns	ns	ns
		Bedford	4817	5007	6998
		Brier	4589	4719	7282
		Argyle	4298	4619	6563
		Heartland	4271	4693	6364
LSD (P=0.05)			367	ns	358

ANOVA		df	Pr > F		
Cultivar (C)		3	0.01 **	0.08	0.0001 **
Treatment (T)		2	0.61	0.69	0.47
C*T		6	0.52	0.72	0.78
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.64	0.57	0.75
0 vs 50 Cl (both sources)	Bedford	1	0.42	0.34	0.52
KCl vs $CaCl_2$	Brier	1	0.36	0.54	0.48
0 vs 50 Cl (both sources)	Brier	1	0.24	0.65	0.54
KCl vs $CaCl_2$	Argyle	1	0.35	0.52	0.08
0 vs 50 Cl (both sources)	Argyle	1	0.58	0.41	0.75
KCl vs $CaCl_2$	Heartland	1	0.18	0.88	0.75
0 vs 50 Cl (both sources)	Heartland	1	0.81	0.24	0.94
C.V. (%)			12.2	9.8	7.9

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Dry Matter Yield of Four Wheat Cultivars

Treatment			Midseason Dry Matter Yields (kg ha^{-1})		
kg ha^{-1} Cl$^-$ Applied	Cl$^-$ Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	2756	3968	5474
50	KCl	Katepwa	2700	3915	5612
50	$CaCl_2$	Katepwa	2719	4031	5552
0	-	Roblin	3544	4815	6393
50	KCl	Roblin	3118	4353	6090
50	$CaCl_2$	Roblin	2781	4434	6412
0	-	Biggar	2447	3234	4575
50	KCl	Biggar	2747	3706	4709
50	$CaCl_2$	Biggar	2428	3334	4531
0	-	Marshall	2990	3803	4978
50	KCl	Marshall	3128	3571	5406
50	$CaCl_2$	Marshall	2968	3587	4971
Group Means					
0	-		2934	3955	5355
50	KCl		2923	3886	5454
50	$CaCl_2$		2724	3846	5367
LSD (P=0.05)			ns	ns	ns
		Katepwa	2725	3971	5546
		Roblin	3148	4534	6298
		Biggar	2540	3425	4605
		Marshall	3029	3654	5118
LSD (P=0.05)			357	282	284

ANOVA		df	Pr > F		
Cultivar (C)		3	0.005 **	0.0001 **	0.0001 **
Treatment (T)		2	0.32	0.67	0.68
C*T		6	0.49	0.21	0.39
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.95	0.64	0.81
0 vs 50 Cl (both sources)	Katepwa	1	0.86	0.98	0.61
KCl vs $CaCl_2$	Roblin	1	0.28	0.74	0.19
0 vs 50 Cl (both sources)	Roblin	1	0.03 *	0.05 *	0.51
KCl vs $CaCl_2$	Biggar	1	0.31	0.13	0.47
0 vs 50 Cl (both sources)	Biggar	1	0.60	0.18	0.83
KCl vs $CaCl_2$	Marshall	1	0.61	0.95	0.08
0 vs 50 Cl (both sources)	Marshall	1	0.83	0.29	0.33
C.V. (%)			18.7	10.8	7.9

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Cl^- Concentration for Four Cultivars of Barley

Treatment			Midseason Plant Tissue Cl^- Concentration ($\mu g\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	1477	8219	882
50	KCl	Bedford	6957	15349	8033
50	$CaCl_2$	Bedford	7163	15503	7697
0	-	Brier	1823	7992	850
50	KCl	Brier	8644	17758	7637
50	$CaCl_2$	Brier	7858	18616	7208
0	-	Argyle	1238	8624	1025
50	KCl	Argyle	7638	19018	9432
50	$CaCl_2$	Argyle	9465	18207	8855
0	-	Heartland	1631	8683	886
50	KCl	Heartland	8819	15954	8609
50	$CaCl_2$	Heartland	8477	16187	9362
Group Means					
0	-		1542	8380	911
50	KCl		8014	17020	8428
50	$CaCl_2$		8241	17128	8280
LSD (P=0.05)			881	929	770
		Bedford	5199	13024	5537
		Brier	6109	14789	5232
		Argyle	6114	15283	6437
		Heartland	6309	13608	6286
LSD (P=0.05)			ns	1073	889

ANOVA		df	Pr > F		
Cultivar (C)		3	0.14	0.0003 **	0.02 *
Treatment (T)		2	0.0001 **	0.0001 **	0.0001 **
C*T		6	0.25	0.05 *	0.43
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.82	0.87	0.66
0 vs 50 Cl (both sources)	Bedford	1	0.0001 **	0.0001 **	0.0001 **
KCl vs $CaCl_2$	Brier	1	0.38	0.36	0.58
0 vs 50 Cl (both sources)	Brier	1	0.0001 **	0.0001 **	0.0001 **
KCl vs $CaCl_2$	Argyle	1	0.04 *	0.39	0.46
0 vs 50 Cl (both sources)	Argyle	1	0.0001 **	0.0001 **	0.0001 **
KCl vs $CaCl_2$	Heartland	1	0.70	0.80	0.33
0 vs 50 Cl (both sources)	Heartland	1	0.0001 **	0.0001 **	0.0001 **
C.V. (%)			25.7	11.3	22.7

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Chloride Concentration for Four Wheat Cultivars

Treatment			Midseason Plant Tissue Cl^- Concentration ($\mu g\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	1122	3597	1003
50	KCl	Katepwa	5890	10462	7434
50	$CaCl_2$	Katepwa	5314	10459	8039
0	-	Roblin	980	3077	781
50	KCl	Roblin	4823	8214	5609
50	$CaCl_2$	Roblin	4752	8619	5849
0	-	Biggar	1022	5999	1082
50	KCl	Biggar	7164	13366	9378
50	$CaCl_2$	Biggar	7382	13561	10830
0	-	Marshall	1301	5027	967
50	KCl	Marshall	6332	12390	7698
50	$CaCl_2$	Marshall	6994	12969	7747
Group Means					
0	-		1106	4425	958
50	KCl		6052	11108	7530
50	$CaCl_2$		6110	11402	8116
LSD (P=0.05)			657	445	630
		Katepwa	4109	8173	5492
		Roblin	3518	6637	4079
		Biggar	5189	10975	7096
		Marshall	4876	10129	5470
LSD (P=0.05)			758	514	728

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0002 **	0.0001 **	0.0001 **
Treatment (T)		2	0.0001 **	0.0001 **	0.0001 **
C*T		6	0.07	0.003 **	0.0003 **
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.38	0.99	0.34
0 vs 50 Cl (both sources)	Katepwa	1	0.0001 **	0.0001 **	0.0001 **
KCl vs $CaCl_2$	Roblin	1	0.91	0.37	0.70
0 vs 50 Cl (both sources)	Roblin	1	0.0001 **	0.0001 **	0.0001 **
KCl vs $CaCl_2$	Biggar	1	0.74	0.66	0.02 *
0 vs 50 Cl (both sources)	Biggar	1	0.0001 **	0.0001 **	0.0001 **
KCl vs $CaCl_2$	Marshall	1	0.32	0.20	0.94
0 vs 50 Cl (both sources)	Marshall	1	0.0001 **	0.0001 **	0.0001 **
C.V. (%)			25.7	8.6	19.7

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Nitrate Concentration for Four Barley Cultivars

Treatment			Midseason Plant Tissue NO_3^- Concentration ($\mu g\ N\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	1019	4712	5982
50	KCl	Bedford	428	3247	4863
50	$CaCl_2$	Bedford	641	3451	4647
0	-	Brier	1310	6661	6946
50	KCl	Brier	1035	5422	4939
50	$CaCl_2$	Brier	758	5213	6240
0	-	Argyle	787	6071	7839
50	KCl	Argyle	471	4822	8559
50	$CaCl_2$	Argyle	974	4832	8029
0	-	Heartland	1164	5553	5942
50	KCl	Heartland	961	4406	5668
50	$CaCl_2$	Heartland	698	4378	6000
Group Means					
0	-		1070	5749	6677
50	KCl		724	4474	6007
50	$CaCl_2$		768	4468	6229
LSD (P=0.05)			233	418	ns
		Bedford	696	3803	5164
		Brier	1035	5765	6042
		Argyle	744	5242	8142
		Heartland	941	4779	5870
LSD (P=0.05)			270	483	758

ANOVA		df	Pr > F		
Cultivar (C)		3	0.05 *	0.0001 **	0.0001 **
Treatment (T)		2	0.008 **	0.0001 **	0.12
C*T		6	0.13	0.99	0.09
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.36	0.63	0.74
0 vs 50 Cl (both sources)	Bedford	1	0.02 *	0.0004 **	0.04 *
KCl vs $CaCl_2$	Brier	1	0.24	0.62	0.05 *
0 vs 50 Cl (both sources)	Brier	1	0.05 *	0.0005 **	0.02 *
KCl vs $CaCl_2$	Argyle	1	0.04 *	0.98	0.42
0 vs 50 Cl (both sources)	Argyle	1	0.75	0.001 **	0.43
KCl vs $CaCl_2$	Heartland	1	0.26	0.95	0.61
0 vs 50 Cl (both sources)	Heartland	1	0.10	0.002 **	0.85
C.V. (%)			47.3	14.7	18.0

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Nitrate Concentration for Four Wheat Cultivars

Treatment			Midseason Plant Tissue NO_3^- Concentration ($\mu g\ N\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	1621	4432	6970
50	KCl	Katepwa	1536	2971	5100
50	$CaCl_2$	Katepwa	1065	2629	5411
0	-	Roblin	1993	2843	4770
50	KCl	Roblin	1189	2227	3699
50	$CaCl_2$	Roblin	1057	2078	3417
0	-	Biggar	2375	6045	7248
50	KCl	Biggar	1410	5168	7453
50	$CaCl_2$	Biggar	2045	4450	5300
0	-	Marshall	2082	4718	4743
50	KCl	Marshall	1111	3227	4533
50	$CaCl_2$	Marshall	1206	3195	4627
Group Means					
0	-		2018	4509	5933
50	KCl		1312	3398	5196
50	$CaCl_2$		1343	3088	4689
LSD (P=0.05)			405	267	756
		Katepwa	1407	3344	5827
		Roblin	1413	2383	3962
		Biggar	1943	5221	6667
		Marshall	1466	3713	4634
LSD (P=0.05)			ns	308	873

ANOVA		df	Pr > F		
Cultivar (C)		3	0.07	0.0001 **	0.0001 **
Treatment (T)		2	0.001 **	0.0001 **	0.007 **
C*T		6	0.46	0.05 *	0.16
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.25	0.21	0.68
0 vs 50 Cl (both sources)	Katepwa	1	0.36	0.0001 **	0.01 **
KCl vs $CaCl_2$	Roblin	1	0.74	0.58	0.71
0 vs 50 Cl (both sources)	Roblin	1	0.02 *	0.004 **	0.07
KCl vs $CaCl_2$	Biggar	1	0.12	0.009 **	0.006 **
0 vs 50 Cl (both sources)	Biggar	1	0.07	0.0001 **	0.19
KCl vs $CaCl_2$	Marshall	1	0.81	0.91	0.90
0 vs 50 Cl (both sources)	Marshall	1	0.01 **	0.0001 **	0.80
C.V. (%)			44.9	12.6	24.8

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Potassium Concentration for Four Barley Cultivars

Treatment			Midseason Plant Tissue K Concentration (%)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	1.81	2.18	2.70
50	KCl	Bedford	1.67	2.20	2.66
50	$CaCl_2$	Bedford	1.66	2.10	2.86
0	-	Brier	1.77	2.41	2.80
50	KCl	Brier	1.90	2.36	2.98
50	$CaCl_2$	Brier	1.87	2.31	2.98
0	-	Argyle	1.93	2.38	2.91
50	KCl	Argyle	2.02	2.44	2.70
50	$CaCl_2$	Argyle	2.02	2.39	2.88
0	-	Heartland	1.73	2.33	2.83
50	KCl	Heartland	1.78	2.23	3.01
50	$CaCl_2$	Heartland	1.87	2.46	3.02
Group Means					
0	-		1.81	2.33	2.81
50	KCl		1.84	2.31	2.84
50	$CaCl_2$		1.85	2.31	2.93
LSD (P=0.05)			ns	ns	ns
		Bedford	1.71	2.16	2.74
		Brier	1.85	2.36	2.92
		Argyle	1.99	2.40	2.83
		Heartland	1.79	2.34	2.95
LSD (P=0.05)			0.10	0.12	ns

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0007 **	0.24
Treatment (T)		2	0.58	0.93	0.43
C*T		6	0.19	0.34	0.81
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.97	0.31	0.32
0 vs 50 Cl (both sources)	Bedford	1	0.06	0.72	0.73
KCl vs $CaCl_2$	Brier	1	0.72	0.63	0.99
0 vs 50 Cl (both sources)	Brier	1	0.14	0.38	0.31
KCl vs $CaCl_2$	Argyle	1	0.92	0.68	0.38
0 vs 50 Cl (both sources)	Argyle	1	0.24	0.71	0.46
KCl vs $CaCl_2$	Heartland	1	0.34	0.04 *	0.93
0 vs 50 Cl (both sources)	Heartland	1	0.20	0.90	0.28
C.V. (%)			8.3	7.7	11.8

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Potassium Concentration for Four Wheat Cultivars

Treatment			Midseason Plant Tissue K Concentration (%)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	2.20	2.34	2.42
50	KCl	Katepwa	2.26	2.35	2.42
50	$CaCl_2$	Katepwa	2.23	2.22	2.52
0	-	Roblin	2.12	2.27	2.29
50	KCl	Roblin	2.25	2.21	2.29
50	$CaCl_2$	Roblin	2.21	2.07	2.22
0	-	Biggar	2.48	2.43	2.66
50	KCl	Biggar	2.35	2.23	2.62
50	$CaCl_2$	Biggar	2.29	2.30	2.43
0	-	Marshall	2.39	2.52	2.48
50	KCl	Marshall	2.38	2.41	2.51
50	$CaCl_2$	Marshall	2.42	2.30	2.49
Group Means					
	-		2.30	2.39	2.46
	KCl		2.31	2.30	2.46
	$CaCl_2$		2.29	2.22	2.41
LSD (P=0.05)			ns	ns	ns
		Katepwa	2.23	2.30	2.45
		Roblin	2.19	2.19	2.27
		Biggar	2.37	2.32	2.57
		Marshall	2.40	2.41	2.49
LSD (P=0.05)			0.17	ns	0.13

ANOVA		df	Pr > F		
Cultivar (C)		3	0.05 *	0.28	0.0002 **
Treatment (T)		2	0.95	0.26	0.61
C*T		6	0.85	0.98	0.49
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.83	0.52	0.39
0 vs 50 Cl (both sources)	Katepwa	1	0.72	0.78	0.62
KCl vs $CaCl_2$	Roblin	1	0.80	0.50	0.53
0 vs 50 Cl (both sources)	Roblin	1	0.42	0.45	0.69
KCl vs $CaCl_2$	Biggar	1	0.65	0.73	0.09
0 vs 50 Cl (both sources)	Biggar	1	0.22	0.36	0.17
KCl vs $CaCl_2$	Marshall	1	0.77	0.56	0.84
0 vs 50 Cl (both sources)	Marshall	1	0.95	0.34	0.81
C.V. (%)			11.4	15.1	8.0

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Manganese Concentration for Four Barley Cultivars

Treatment			Midseason Plant Tissue Mn Concentration ($\mu g\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	17.6	25.7	44.5
50	KCl	Bedford	17.2	23.1	45.0
50	$CaCl_2$	Bedford	17.7	24.4	39.2
0	-	Brier	16.6	23.9	73.8
50	KCl	Brier	14.8	22.7	45.4
50	$CaCl_2$	Brier	16.8	23.7	56.9
0	-	Argyle	20.5	25.6	47.4
50	KCl	Argyle	18.2	26.3	43.7
50	$CaCl_2$	Argyle	18.1	25.8	42.5
0	-	Heartland	16.5	23.7	42.5
50	KCl	Heartland	15.3	23.4	37.4
50	$CaCl_2$	Heartland	15.7	23.1	39.8
Group Means					
0	-		17.8	24.7	52.1
50	KCl		16.4	23.9	42.9
50	$CaCl_2$		17.1	24.2	44.6
LSD (P=0.05)			ns	ns	ns
		Bedford	17.5	24.4	42.9
		Brier	16.1	23.4	58.7
		Argyle	18.9	25.9	44.5
		Heartland	15.8	23.4	39.9
LSD (P=0.05)			1.5	1.5	9.5

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0003 **	0.003 **	0.001 **
Treatment (T)		2	0.10	0.39	0.07
C*T		6	0.73	0.68	0.27
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.75	0.33	0.49
0 vs 50 Cl (both sources)	Bedford	1	0.91	0.07	0.73
KCl vs $CaCl_2$	Brier	1	0.13	0.41	0.17
0 vs 50 Cl (both sources)	Brier	1	0.52	0.52	0.003 **
KCl vs $CaCl_2$	Argyle	1	0.95	0.72	0.88
0 vs 50 Cl (both sources)	Argyle	1	0.04 *	0.71	0.55
KCl vs $CaCl_2$	Heartland	1	0.75	0.82	0.77
0 vs 50 Cl (both sources)	Heartland	1	0.35	0.71	0.59
C.V. (%)			13.1	9.0	30.7

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Manganese Concentration for Four Wheat Cultivars

Treatment			Midseason Plant Tissue Mn Concentration ($\mu g\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	18.7	40.9	42.1
50	KCl	Katepwa	17.6	35.4	49.0
50	$CaCl_2$	Katepwa	16.2	35.7	39.1
0	-	Roblin	15.2	26.1	34.8
50	KCl	Roblin	14.9	24.5	34.8
50	$CaCl_2$	Roblin	15.2	26.4	30.9
0	-	Biggar	26.4	35.0	51.4
50	KCl	Biggar	21.3	39.0	51.2
50	$CaCl_2$	Biggar	23.3	42.6	50.2
0	-	Marshall	27.0	39.5	54.4
50	KCl	Marshall	22.1	41.8	49.3
50	$CaCl_2$	Marshall	23.2	43.8	49.0
Group Means					
0	-		21.8	35.4	45.7
50	KCl		19.0	35.2	46.1
50	$CaCl_2$		19.5	37.1	42.3
LSD (P=0.05)			1.4	ns	ns
		Katepwa	17.5	37.3	43.4
		Roblin	15.1	25.7	33.5
		Biggar	23.7	38.9	50.9
		Marshall	24.1	41.7	50.9
LSD (P=0.05)			1.6	2.8	4.5

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.0001 **
Treatment (T)		2	0.0002 **	0.24	0.11
C*T		6	0.09	0.02 *	0.42
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.32	0.93	0.01 **
0 vs 50 Cl (both sources)	Katepwa	1	0.12	0.01 **	0.56
KCl vs $CaCl_2$	Roblin	1	0.78	0.45	0.32
0 vs 50 Cl (both sources)	Roblin	1	0.91	0.76	0.56
KCl vs $CaCl_2$	Biggar	1	0.15	0.15	0.81
0 vs 50 Cl (both sources)	Biggar	1	0.001 **	0.009 **	0.82
KCl vs $CaCl_2$	Marshall	1	0.44	0.41	0.92
0 vs 50 Cl (both sources)	Marshall	1	0.0006 **	0.13	0.12
C.V. (%)			11.8	11.9	15.1

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Copper Concentration for Four Barley Cultivars

Treatment			Midseason Plant Tissue Cu Concentration ($\mu g\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	4.56	5.97	6.21
50	KCl	Bedford	3.69	5.94	6.93
50	$CaCl_2$	Bedford	3.73	5.59	7.06
0	-	Brier	3.40	5.55	7.09
50	KCl	Brier	3.95	6.06	6.61
50	$CaCl_2$	Brier	3.68	6.11	7.11
0	-	Argyle	4.55	7.10	7.71
50	KCl	Argyle	4.28	6.59	7.98
50	$CaCl_2$	Argyle	4.59	6.19	7.41
0	-	Heartland	3.66	5.21	6.42
50	KCl	Heartland	4.12	5.30	6.48
50	$CaCl_2$	Heartland	4.07	5.39	6.58
Group Means					
0	-		4.04	5.96	6.86
50	KCl		4.01	5.97	7.00
50	$CaCl_2$		4.02	5.82	7.04
LSD (P=0.05)			ns	ns	ns
		Bedford	3.99	5.83	6.73
		Brier	3.68	5.91	6.94
		Argyle	4.47	6.62	7.70
		Heartland	3.95	5.30	6.49
LSD (P=0.05)			0.52	0.86	0.51

ANOVA		df	Pr > F		
Cultivar (C)		3	0.03 *	0.03 *	0.0001 **
Treatment (T)		2	0.99	0.90	0.69
C*T		6	0.25	0.88	0.33
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.92	0.65	0.75
0 vs 50 Cl (both sources)	Bedford	1	0.03 *	0.75	0.04 *
KCl vs $CaCl_2$	Brier	1	0.54	0.95	0.27
0 vs 50 Cl (both sources)	Brier	1	0.30	0.41	0.54
KCl vs $CaCl_2$	Argyle	1	0.49	0.59	0.20
0 vs 50 Cl (both sources)	Argyle	1	0.77	0.28	0.96
KCl vs $CaCl_2$	Heartland	1	0.91	0.91	0.83
0 vs 50 Cl (both sources)	Heartland	1	0.27	0.84	0.78
C.V. (%)			19.3	21.7	10.9

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Copper Concentration for Four Wheat Cultivars

Treatment			Midseason Plant Tissue Cu Concentration ($\mu g\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	3.92	4.88	5.70
50	KCl	Katepwa	3.56	4.97	5.86
50	$CaCl_2$	Katepwa	3.43	4.23	5.92
0	-	Roblin	3.25	3.70	4.06
50	KCl	Roblin	3.14	3.84	4.54
50	$CaCl_2$	Roblin	3.05	3.74	4.11
0	-	Biggar	4.65	6.58	6.39
50	KCl	Biggar	3.97	6.17	7.17
50	$CaCl_2$	Biggar	4.20	5.81	6.48
0	-	Marshall	3.88	4.75	5.08
50	KCl	Marshall	3.54	4.54	5.75
50	$CaCl_2$	Marshall	3.39	5.07	5.62
Group Means					
0	-		3.93	4.98	5.31
50	KCl		3.55	4.88	5.83
50	$CaCl_2$		3.52	4.71	5.53
LSD (P=0.05)			0.35	ns	0.40
		Katepwa	3.64	4.69	5.83
		Roblin	3.14	3.76	4.24
		Biggar	4.28	6.19	6.68
		Marshall	3.60	4.79	5.48
LSD (P=0.05)			0.40	0.56	0.46

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.0001 **
Treatment (T)		2	0.04 *	0.54	0.04 *
C*T		6	0.94	0.51	0.82
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.72	0.13	0.88
0 vs 50 Cl (both sources)	Katepwa	1	0.17	0.51	0.57
KCl vs $CaCl_2$	Roblin	1	0.80	0.83	0.29
0 vs 50 Cl (both sources)	Roblin	1	0.61	0.84	0.44
KCl vs $CaCl_2$	Biggar	1	0.51	0.46	0.09
0 vs 50 Cl (both sources)	Biggar	1	0.07	0.17	0.22
KCl vs $CaCl_2$	Marshall	1	0.66	0.29	0.76
0 vs 50 Cl (both sources)	Marshall	1	0.17	0.90	0.09
C.V. (%)			16.5	17.3	12.4

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Zinc Concentration for Four Barley Cultivars

Treatment			Midseason Plant Tissue Zn Concentration ($\mu g\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	10.0	20.5	24.8
50	KCl	Bedford	8.5	18.9	25.6
50	$CaCl_2$	Bedford	9.2	21.2	24.1
0	-	Brier	9.3	19.9	29.4
50	KCl	Brier	9.6	20.8	29.3
50	$CaCl_2$	Brier	8.9	19.6	27.5
0	-	Argyle	10.9	21.7	28.6
50	KCl	Argyle	10.3	19.9	31.6
50	$CaCl_2$	Argyle	12.9	22.6	27.4
0	-	Heartland	11.8	23.1	27.4
50	KCl	Heartland	11.8	21.5	25.7
50	$CaCl_2$	Heartland	11.1	23.1	26.7
Group Means					
0	-		10.5	21.3	27.5
50	KCl		10.1	20.3	28.0
50	$CaCl_2$		10.5	21.6	26.4
LSD (P=0.05)			ns	ns	ns
		Bedford	9.2	20.2	24.8
		Brier	9.3	20.1	28.7
		Argyle	11.3	21.4	29.2
		Heartland	11.6	22.6	26.6
LSD (P=0.05)			1.7	2.0	2.8

ANOVA		df	Pr > F		
Cultivar (C)		3	0.007 **	0.05 *	0.01 **
Treatment (T)		2	0.77	0.27	0.39
C*T		6	0.61	0.75	0.81
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.63	0.18	0.53
0 vs 50 Cl (both sources)	Bedford	1	0.39	0.78	0.98
KCl vs $CaCl_2$	Brier	1	0.62	0.48	0.46
0 vs 50 Cl (both sources)	Brier	1	0.96	0.87	0.63
KCl vs $CaCl_2$	Argyle	1	0.08	0.12	0.09
0 vs 50 Cl (both sources)	Argyle	1	0.58	0.79	0.69
KCl vs $CaCl_2$	Heartland	1	0.64	0.36	0.68
0 vs 50 Cl (both sources)	Heartland	1	0.78	0.61	0.59
C.V. (%)			24.7	13.9	15.3

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Zinc Concentration for Four Wheat Cultivars

Treatment			Midseason Plant Tissue Zn Concentration ($\mu g\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	11.1	25.0	26.5
50	KCl	Katepwa	11.2	24.1	23.9
50	$CaCl_2$	Katepwa	10.2	22.7	25.7
0	-	Roblin	10.2	18.9	18.9
50	KCl	Roblin	10.4	17.8	17.9
50	$CaCl_2$	Roblin	9.9	18.0	18.1
0	-	Biggar	13.9	30.3	33.9
50	KCl	Biggar	12.8	29.0	37.6
50	$CaCl_2$	Biggar	12.6	28.8	33.9
0	-	Marshall	12.3	24.5	26.1
50	KCl	Marshall	11.8	23.9	26.8
50	$CaCl_2$	Marshall	11.0	23.2	24.9
Group Means					
0	-		11.9	24.7	26.4
50	KCl		11.5	23.7	26.5
50	$CaCl_2$		10.9	23.2	25.7
LSD (P=0.05)			0.5	1.2	ns
		Katepwa	10.8	23.9	25.4
		Roblin	10.1	18.2	18.3
		Biggar	13.1	29.4	35.1
		Marshall	11.7	23.8	25.9
LSD (P=0.05)			0.6	1.4	1.7

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.0001 **
Treatment (T)		2	0.002 **	0.05 *	0.47
C*T		6	0.43	0.98	0.08
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.04 *	0.27	0.22
0 vs 50 Cl (both sources)	Katepwa	1	0.37	0.15	0.19
KCl vs $CaCl_2$	Roblin	1	0.34	0.89	0.88
0 vs 50 Cl (both sources)	Roblin	1	0.94	0.32	0.49
KCl vs $CaCl_2$	Biggar	1	0.74	0.86	0.02 *
0 vs 50 Cl (both sources)	Biggar	1	0.009 **	0.18	0.16
KCl vs $CaCl_2$	Marshall	1	0.12	0.55	0.20
0 vs 50 Cl (both sources)	Marshall	1	0.03 *	0.38	0.86
C.V. (%)			7.7	9.0	10.0

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Ammonium Concentration for Four Barley Cultivars

Treatment			Midseason Plant Tissue NH_4^+ Concentration ($\mu g\ N\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	298	2158	1020
50	KCl	Bedford	226	2031	1203
50	$CaCl_2$	Bedford	243	2620	954
0	-	Brier	345	2790	1732
50	KCl	Brier	472	3459	1533
50	$CaCl_2$	Brier	328	2738	1837
0	-	Argyle	382	2574	1634
50	KCl	Argyle	431	2892	2036
50	$CaCl_2$	Argyle	465	4018	1649
0	-	Heartland	371	3098	1418
50	KCl	Heartland	411	3395	1411
50	$CaCl_2$	Heartland	541	3248	1919
Group Means					
0	-		349	2655	1451
50	KCl		385	2944	1546
50	$CaCl_2$		394	3156	1590
LSD (P=0.05)			ns	ns	ns
		Bedford	256	2270	1059
		Brier	381	2995	1701
		Argyle	426	3161	1773
		Heartland	441	3247	1582
LSD (P=0.05)			82	674	375

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.02 *	0.001 **
Treatment (T)		2	0.41	0.23	0.69
C*T		6	0.09	0.33	0.44
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.82	0.32	0.44
0 vs 50 Cl (both sources)	Bedford	1	0.31	0.74	0.84
KCl vs $CaCl_2$	Brier	1	0.05 *	0.22	0.35
0 vs 50 Cl (both sources)	Brier	1	0.37	0.54	0.87
KCl vs $CaCl_2$	Argyle	1	0.63	0.06	0.24
0 vs 50 Cl (both sources)	Argyle	1	0.29	0.09	0.46
KCl vs $CaCl_2$	Heartland	1	0.07	0.80	0.12
0 vs 50 Cl (both sources)	Heartland	1	0.09	0.66	0.38
C.V. (%)			32.8	34.6	36.7

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Midseason Plant Tissue Ammonium Concentration for Four Wheat Cultivars

Treatment			Midseason Plant Tissue NH_4^+ Concentration ($\mu g\ N\ g^{-1}$)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	460	1967	1082
50	KCl	Katepwa	561	1948	912
50	$CaCl_2$	Katepwa	285	1891	1147
0	-	Roblin	292	909	525
50	KCl	Roblin	221	1103	463
50	$CaCl_2$	Roblin	243	1094	516
0	-	Biggar	1056	4467	3085
50	KCl	Biggar	1075	4152	3763
50	$CaCl_2$	Biggar	979	4089	3237
0	-	Marshall	717	2913	1514
50	KCl	Marshall	570	2389	1265
50	$CaCl_2$	Marshall	522	2587	1309
Group Means					
0	-		631	2564	1551
50	KCl		607	2398	1601
50	$CaCl_2$		507	2415	1552
LSD (P=0.05)			ns	ns	ns
		Katepwa	435	1935	1047
		Roblin	252	1035	501
		Biggar	1037	4236	3362
		Marshall	603	2630	1362
LSD (P=0.05)			160	407	370

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.0001 **
Treatment (T)		2	0.17	0.59	0.94
C*T		6	0.75	0.81	0.42
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.05 *	0.87	0.47
0 vs 50 Cl (both sources)	Katepwa	1	0.76	0.88	0.85
KCl vs $CaCl_2$	Roblin	1	0.87	0.98	0.87
0 vs 50 Cl (both sources)	Roblin	1	0.62	0.54	0.90
KCl vs $CaCl_2$	Biggar	1	0.49	0.86	0.11
0 vs 50 Cl (both sources)	Biggar	1	0.81	0.26	0.14
KCl vs $CaCl_2$	Marshall	1	0.73	0.58	0.89
0 vs 50 Cl (both sources)	Marshall	1	0.16	0.17	0.42
C.V. (%)			41.1	24.8	35.4

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Thousand Kernel Weight of Four Barley Cultivars

Treatment			Thousand Kernel Weight (g/thousand kernels)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	23.7	29.7	28.1
50	KCl	Bedford	23.8	29.7	28.3
50	$CaCl_2$	Bedford	24.7	29.5	28.1
0	-	Brier	25.6	27.8	30.3
50	KCl	Brier	24.5	28.4	29.1
50	$CaCl_2$	Brier	24.5	27.4	26.3
0	-	Argyle	24.3	30.4	24.3
50	KCl	Argyle	24.3	30.1	27.1
50	$CaCl_2$	Argyle	23.9	29.7	24.3
0	-	Heartland	25.4	30.1	33.2
50	KCl	Heartland	25.3	29.3	29.8
50	$CaCl_2$	Heartland	24.7	29.0	29.0
Group Means					
0	-		24.7	29.5	29.0
50	KCl		24.5	29.3	28.6
50	$CaCl_2$		24.5	28.9	26.9
LSD (P=0.05)			ns	ns	1.5
		Bedford	24.1	29.6	28.2
		Brier	24.8	27.9	28.6
		Argyle	24.2	30.1	25.2
		Heartland	25.1	29.5	30.7
LSD (P=0.05)			0.9	0.9	1.8

ANOVA		df	Pr > F		
Cultivar (C)		3	0.07	0.0001 **	0.0001 **
Treatment (T)		2	0.74	0.27	0.02 *
C*T		6	0.54	0.91	0.08
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.23	0.79	0.88
0 vs 50 Cl (both sources)	Bedford	1	0.44	0.87	0.95
KCl vs $CaCl_2$	Brier	1	0.96	0.22	0.08
0 vs 50 Cl (both sources)	Brier	1	0.13	0.89	0.06
KCl vs $CaCl_2$	Argyle	1	0.66	0.66	0.07
0 vs 50 Cl (both sources)	Argyle	1	0.85	0.43	0.29
KCl vs $CaCl_2$	Heartland	1	0.46	0.71	0.63
0 vs 50 Cl (both sources)	Heartland	1	0.56	0.15	0.006 **
C.V. (%)			5.7	4.6	9.4

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Thousand Kernel Weight of Four Wheat Cultivars

Treatment			Thousand Kernel Weight (g/thousand kernels)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	18.4	28.1	23.1
50	KCl	Katepwa	19.6	28.0	24.2
50	$CaCl_2$	Katepwa	18.0	29.0	24.6
0	-	Roblin	22.5	33.0	27.8
50	KCl	Roblin	23.1	32.8	29.4
50	$CaCl_2$	Roblin	23.3	32.5	29.5
0	-	Biggar	20.3	19.3	14.7
50	KCl	Biggar	21.7	21.8	13.6
50	$CaCl_2$	Biggar	22.5	21.8	14.4
0	-	Marshall	16.6	26.6	19.7
50	KCl	Marshall	19.6	26.1	22.5
50	$CaCl_2$	Marshall	21.2	25.9	22.8
Group Means					
0	-		19.4	26.7	21.3
50	KCl		21.0	27.2	22.4
50	$CaCl_2$		21.2	27.3	22.8
LSD (P=0.05)			1.0	ns	0.9
		Katepwa	18.7	28.3	24.0
		Roblin	23.0	32.8	28.9
		Biggar	21.5	20.9	14.2
		Marshall	19.1	26.2	21.7
LSD (P=0.05)			1.2	0.8	1.1

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.0001 **
Treatment (T)		2	0.001 **	0.24	0.006 **
C*T		6	0.04 *	0.01 **	0.11
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.12	0.17	0.70
0 vs 50 Cl (both sources)	Katepwa	1	0.61	0.53	0.10
KCl vs $CaCl_2$	Roblin	1	0.88	0.67	0.91
0 vs 50 Cl (both sources)	Roblin	1	0.47	0.65	0.05 *
KCl vs $CaCl_2$	Biggar	1	0.41	0.97	0.36
0 vs 50 Cl (both sources)	Biggar	1	0.04 *	0.0001 **	0.37
KCl vs $CaCl_2$	Marshall	1	0.13	0.84	0.76
0 vs 50 Cl (both sources)	Marshall	1	0.0001 **	0.36	0.0006 **
C.V. (%)			8.6	4.5	7.3

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Hectolitre Weight of Four Barley Cultivars

Treatment			Hectolitre Weight (kg hL^{-1})		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	58.8	60.6	56.3
50	KCl	Bedford	57.2	59.5	56.6
50	$CaCl_2$	Bedford	57.1	59.6	55.8
0	-	Brier	53.8	51.1	49.2
50	KCl	Brier	52.0	50.7	48.9
50	$CaCl_2$	Brier	51.4	49.6	45.8
0	-	Argyle	56.2	56.9	49.2
50	KCl	Argyle	55.2	56.1	52.4
50	$CaCl_2$	Argyle	54.0	55.4	48.2
0	-	Heartland	56.9	54.2	57.2
50	KCl	Heartland	56.5	54.6	53.3
50	$CaCl_2$	Heartland	55.8	54.2	55.1
Group Means					
0	-		56.4	55.7	53.0
50	KCl		55.2	55.2	52.8
50	$CaCl_2$		54.6	54.7	51.2
LSD (P=0.05)			0.9	0.9	ns
		Bedford	57.7	59.9	56.2
		Brier	52.4	50.4	48.0
		Argyle	55.1	56.1	49.9
		Heartland	56.4	54.3	55.2
LSD (P=0.05)			1.0	1.0	2.3

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.0001 **
Treatment (T)		2	0.0003 **	0.08	0.16
C*T		6	0.86	0.78	0.20
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.87	0.90	0.68
0 vs 50 Cl (both sources)	Bedford	1	0.04 *	0.19	0.92
KCl vs $CaCl_2$	Brier	1	0.52	0.21	0.13
0 vs 50 Cl (both sources)	Brier	1	0.007 **	0.19	0.28
KCl vs $CaCl_2$	Argyle	1	0.15	0.44	0.04 *
0 vs 50 Cl (both sources)	Argyle	1	0.04 *	0.12	0.53
KCl vs $CaCl_2$	Heartland	1	0.42	0.61	0.36
0 vs 50 Cl (both sources)	Heartland	1	0.31	0.77	0.09
C.V. (%)			2.7	2.7	6.4

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Hectolitre Weight of Four Wheat Cultivars

Treatment			Hectolitre Weight (kg hL^{-1})		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	74.1	75.3	71.3
50	KCl	Katepwa	73.8	74.7	72.0
50	$CaCl_2$	Katepwa	74.8	74.4	71.4
0	-	Roblin	73.4	75.1	73.3
50	KCl	Roblin	73.8	73.8	73.1
50	$CaCl_2$	Roblin	73.8	73.7	73.4
0	-	Biggar	71.7	64.3	59.6
50	KCl	Biggar	73.1	65.2	56.8
50	$CaCl_2$	Biggar	74.3	66.6	58.4
0	-	Marshall	70.0	74.0	69.3
50	KCl	Marshall	72.6	73.7	72.0
50	$CaCl_2$	Marshall	72.7	73.4	69.6
Group Means					
0	-		72.3	72.2	68.4
50	KCl		73.3	71.9	68.5
50	$CaCl_2$		73.9	72.0	68.2
LSD (P=0.05)			1.0	ns	ns
		Katepwa	74.3	74.8	71.6
		Roblin	73.7	74.2	73.3
		Biggar	73.0	65.4	58.3
		Marshall	71.8	73.7	70.3
LSD (P=0.05)			1.1	0.9	1.5

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0003 **	0.0001 **	0.0001 **
Treatment (T)		2	0.007 **	0.70	0.91
C*T		6	0.34	0.04 *	0.16
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.31	0.71	0.67
0 vs 50 Cl (both sources)	Katepwa	1	0.80	0.29	0.71
KCl vs $CaCl_2$	Roblin	1	1.00	0.86	0.83
0 vs 50 Cl (both sources)	Roblin	1	0.62	0.05 *	1.00
KCl vs $CaCl_2$	Biggar	1	0.25	0.07	0.25
0 vs 50 Cl (both sources)	Biggar	1	0.02 *	0.02 *	0.08
KCl vs $CaCl_2$	Marshall	1	0.89	0.71	0.08
0 vs 50 Cl (both sources)	Marshall	1	0.003 **	0.52	0.20
C.V. (%)			2.3	1.8	3.4

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Percentage of Plump Kernels for Four Barley Cultivars

Treatment			Percent Plump Kernels		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	18.9	30.3	32.0
50	KCl	Bedford	17.4	29.7	30.1
50	$CaCl_2$	Bedford	17.4	31.6	27.9
0	-	Brier	17.0	22.9	39.0
50	KCl	Brier	13.5	19.9	32.0
50	$CaCl_2$	Brier	10.7	18.3	27.4
0	-	Argyle	31.7	47.7	33.9
50	KCl	Argyle	29.4	45.0	45.3
50	$CaCl_2$	Argyle	25.4	44.4	26.3
0	-	Heartland	24.7	38.1	58.2
50	KCl	Heartland	22.4	32.7	42.1
50	$CaCl_2$	Heartland	20.0	31.6	46.4
Group Means					
0	-		23.1	34.8	40.8
50	KCl		20.7	31.8	37.4
50	$CaCl_2$		18.4	31.5	32.0
LSD (P=0.05)			2.1	ns	6.4
		Bedford	17.9	30.5	30.0
		Brier	13.7	20.4	32.8
		Argyle	28.8	45.7	35.2
		Heartland	22.4	34.1	48.9
LSD (P=0.05)			2.5	3.4	7.4

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.0001 **
Treatment (T)		2	0.0003 **	0.06	0.03 *
C*T		6	0.73	0.67	0.09
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.99	0.51	0.74
0 vs 50 Cl (both sources)	Bedford	1	0.40	0.89	0.59
KCl vs $CaCl_2$	Brier	1	0.21	0.59	0.48
0 vs 50 Cl (both sources)	Brier	1	0.01 **	0.15	0.10
KCl vs $CaCl_2$	Argyle	1	0.07	0.84	0.005 **
0 vs 50 Cl (both sources)	Argyle	1	0.03 *	0.24	0.73
KCl vs $CaCl_2$	Heartland	1	0.27	0.72	0.51
0 vs 50 Cl (both sources)	Heartland	1	0.07	0.02 *	0.01 **
C.V. (%)			17.9	15.6	30.2

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Percentage of Thin Kernels for Four Barley Cultivars

Treatment			Percent Thin Kernels		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	47.8	55.9	52.1
50	KCl	Bedford	46.6	55.3	48.2
50	$CaCl_2$	Bedford	46.9	53.7	55.5
0	-	Brier	48.6	53.4	40.6
50	KCl	Brier	44.2	57.2	45.5
50	$CaCl_2$	Brier	46.0	55.3	46.8
0	-	Argyle	47.7	43.5	41.1
50	KCl	Argyle	49.0	45.1	40.5
50	$CaCl_2$	Argyle	50.0	45.3	46.6
0	-	Heartland	48.5	47.3	30.1
50	KCl	Heartland	49.3	49.5	40.6
50	$CaCl_2$	Heartland	47.9	49.8	38.4
Group Means					
0	-		48.1	50.0	41.0
50	KCl		47.3	51.8	43.7
50	$CaCl_2$		47.7	51.0	46.8
LSD (P=0.05)			ns	ns	2.8
		Bedford	47.1	55.0	51.9
		Brier	46.3	55.3	44.3
		Argyle	48.9	44.7	42.7
		Heartland	48.5	48.9	36.4
LSD (P=0.05)			1.9	2.1	3.3

ANOVA		df	Pr > F		
Cultivar (C)		3	0.02 *	0.0001 **	0.0001 **
Treatment (T)		2	0.58	0.15	0.0005 **
C*T		6	0.17	0.45	0.02 *
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.85	0.36	0.01 **
0 vs 50 Cl (both sources)	Bedford	1	0.48	0.36	0.91
KCl vs $CaCl_2$	Brier	1	0.26	0.29	0.66
0 vs 50 Cl (both sources)	Brier	1	0.02 *	0.07	0.03 *
KCl vs $CaCl_2$	Argyle	1	0.56	0.91	0.04 *
0 vs 50 Cl (both sources)	Argyle	1	0.20	0.28	0.32
KCl vs $CaCl_2$	Heartland	1	0.39	0.88	0.44
0 vs 50 Cl (both sources)	Heartland	1	0.95	0.13	0.0003 **
C.V. (%)			5.9	6.1	11.1

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Total Nitrogen Content of Grain for Four Barley Cultivars

Treatment			Total N Content of Grain (%)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Bedford	2.05	1.85	2.36
50	KCl	Bedford	1.93	1.84	2.30
50	$CaCl_2$	Bedford	1.94	1.89	2.32
0	-	Brier	1.96	2.01	2.45
50	KCl	Brier	2.00	1.88	2.36
50	$CaCl_2$	Brier	1.92	1.98	2.44
0	-	Argyle	1.93	1.93	2.14
50	KCl	Argyle	1.91	1.93	2.00
50	$CaCl_2$	Argyle	2.01	1.94	2.19
0	-	Heartland	2.39	1.81	2.51
50	KCl	Heartland	2.36	1.83	2.41
50	$CaCl_2$	Heartland	2.34	1.87	2.42
Group Means					
0	-		2.08	1.90	2.36
50	KCl		2.05	1.87	2.27
50	$CaCl_2$		2.05	1.92	2.34
LSD (P=0.05)			ns	ns	ns
		Bedford	1.98	1.86	2.32
		Brier	1.96	1.96	2.41
		Argyle	1.95	1.93	2.11
		Heartland	2.36	1.84	2.45
LSD (P=0.05)			0.06	0.05	0.12

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.0001 **
Treatment (T)		2	0.37	0.06	0.16
C*T		6	0.10	0.29	0.91
Contrasts					
KCl vs $CaCl_2$	Bedford	1	0.92	0.22	0.82
0 vs 50 Cl (both sources)	Bedford	1	0.02 *	0.68	0.59
KCl vs $CaCl_2$	Brier	1	0.18	0.02 *	0.43
0 vs 50 Cl (both sources)	Brier	1	0.96	0.04 *	0.59
KCl vs $CaCl_2$	Argyle	1	0.05 *	0.70	0.07
0 vs 50 Cl (both sources)	Argyle	1	0.51	0.79	0.64
KCl vs $CaCl_2$	Heartland	1	0.75	0.46	0.93
0 vs 50 Cl (both sources)	Heartland	1	0.33	0.36	0.32
C.V. (%)			4.5	4.0	7.9

*, ** Significant at the 0.05 and 0.01 levels respectively.

Effect of Chloride Fertilizer on Total Nitrogen Content of Grain for Four Wheat Cultivars

Treatment			Total N in Grain (%)		
kg ha^{-1} Cl^- Applied	Cl^- Source	Cultivar	Anola	Portage	Univ. of Manitoba
Treatment Means					
0	-	Katepwa	2.35	2.06	2.43
50	KCl	Katepwa	2.32	2.06	2.38
50	$CaCl_2$	Katepwa	2.28	2.07	2.38
0	-	Roblin	2.44	2.26	2.52
50	KCl	Roblin	2.37	2.26	2.59
50	$CaCl_2$	Roblin	2.34	2.26	2.58
0	-	Biggar	2.13	2.34	2.20
50	KCl	Biggar	2.07	2.27	2.25
50	$CaCl_2$	Biggar	2.01	2.25	2.16
0	-	Marshall	2.30	2.25	2.12
50	KCl	Marshall	2.21	2.29	2.13
50	$CaCl_2$	Marshall	2.15	2.29	2.22
Group Means					
0	-		2.30	2.23	2.31
50	KCl		2.24	2.22	2.33
50	$CaCl_2$		2.20	2.22	2.33
LSD (P=0.05)			0.07	ns	ns
		Katepwa	2.32	2.06	2.39
		Roblin	2.39	2.26	2.56
		Biggar	2.07	2.29	2.20
		Marshall	2.22	2.28	2.15
LSD (P=0.05)			0.08	0.04	0.05

ANOVA		df	Pr > F		
Cultivar (C)		3	0.0001 **	0.0001 **	0.0001 **
Treatment (T)		2	0.01 **	0.85	0.62
C*T		6	0.99	0.30	0.07
Contrasts					
KCl vs $CaCl_2$	Katepwa	1	0.53	0.68	0.92
0 vs 50 Cl (both sources)	Katepwa	1	0.40	0.89	0.25
KCl vs $CaCl_2$	Roblin	1	0.68	0.73	0.86
0 vs 50 Cl (both sources)	Roblin	1	0.20	0.85	0.10
KCl vs $CaCl_2$	Biggar	1	0.37	0.57	0.07
0 vs 50 Cl (both sources)	Biggar	1	0.17	0.02 *	0.96
KCl vs $CaCl_2$	Marshall	1	0.43	0.95	0.06
0 vs 50 Cl (both sources)	Marshall	1	0.06	0.28	0.16
C.V. (%)			5.5	3.0	3.5

*, ** Significant at the 0.05 and 0.01 levels respectively.