Spring Wheat Response to Chloride Applications in Southwestern North Dakota

Patrick M. Carr, Glenn B. Martin, and Burt A. Melchior
North Dakota State University
Dickinson Research Extension Center
Dickinson, ND

Research Summary

Previous research demonstrated disease suppression and yield benefits of chloride (Cl) applications on spring barley in western North Dakota. The objective of this study was to determine if similar benefits resulted when Cl was applied to spring wheat. Fifteen spring wheat (*Triticum* spp.) cultivars and two Cl treatments (0 and 40 lb/acre as KCl) were arranged factorially in a randomized complete block and replicated four times. The cultivars differed in heading date, plant height, and grain yield in both years ($P < .05$). Chloride applications reduced the days to heading and reduced plant height but had no effect on grain yield. Kernel weight and Cl concentration of plant tissue increased with the application of Cl. Results of this study support previous research at Dickinson and suggest that grain yield generally is unaffected by applications of Cl at this location, although kernel weight may increase.

Introduction

Previous research indicated that applications of Cl increase yield and kernel plumpness in barley, and reduces disease incidence at Dickinson (R. Jay Goos, personal communication, 1998). Similar research in Montana and South Dakota demonstrated a beneficial response to Cl applications in 69% of cases where soil Cl levels in the 0- to 2-ft depth were < 30 lb/acre (Engel et al., 1994).

Fixen (1993) suggested that cultivar selection affects grain yield response to applications of Cl in wheat. A cultivar x Cl interaction generally did not occur, however, for winter wheat grown in Montana (Engel et al., 1994. The objective of this study was to determine if a grain yield response to Cl could be demonstrated, and if a spring wheat cultivar x Cl interaction occurred.

Materials and Methods

Thirteen hard red spring wheat (*Triticum aestivum* L. emend. Thell.) and two durum (*Triticum turgidum* L.) cultivars were included in the study, based on characteristics discussed by Goos et al. (1996).

The cultivars were sown at 1.2 million live seed/acre with a small-plot seeder in sandy loam soils that contained <30 lb/acre Cl in the 0- to 2-ft depth in 1999 and 33 lb/acre in 2000[1].

Chloride was incorporated as KCl (0-0-60-50) at 40 lb/acre in 6 ft x 27 ft plots 7 days (d) prior to sowing each cultivar. Cultivars also were sown in plots where no Cl was applied. The cultivar and Cl treatments were arranged as a 2 x 15 factorial in a randomized complete block and replicated 4 times.

Nitrogen as ammonium nitrate (34-0-0) and phosphorus as triple superphosphate (0-45-0) were applied for a yield goal of 40 bu/acre, based on soil test results. Herbicides provided excellent weed control in both years of the study.

Plants were excised at the soil surface at the flag leaf emergence/early boot stage, dried at 50^{o}C, and the Cl content determined by wet chemistry methods (AgVISE Laboratories, Northwood, ND).

The date of heading in each plot was recorded during the heading period. Attempts to quantify foliar disease were made but were abandoned when "firing' from dry conditions made it impossible to distinguish leaf chlorosis and necrosis resulting from pathogenic and non-pathogenic origins.

Grain was harvested mechanically in 1999, but not before plots were damaged by hail. Approximately 30% of the heads in plots shattered because of hail before grain could be harvested The study was not damaged by hail in 2000.

Grain test weight and kernel weight, and chloride concentration of plant tissue and grain, were determined from subsamples collected from plots in 2000. Test weight, kernel weight, and chloride concentration were not determined in 1999, since plots were damaged before grain was harvested.

Data were analyzed using the ANOVA procedure from SAS. Spring wheat cultivars and Cl treatments were considered fixed effects and replicates were considered random. The study was not analyzed across years since data were damaged from hail in 1999. Mean comparisons were made using a protected LSD to separate treatments where *F*-tests indicated that significant differences existed.

Results and Discussion

An application of Cl reduced the time from emergence to heading by an average of 1 day across the 15 cultivars in 1999 (Table 1). Plants in plots receiving Cl headed 50 d after emergence while plants in plots where no Cl was applied headed on average in 51 d. There was a 5-d range among the cultivars in heading dates. Butte 86 and Kulm headed only 48 d after emergence, while Marshall, Renville, and Verde headed 53 d after emergence. An interaction between the application of Cl and spring wheat cultivars did not occur for heading date.

The application of Cl reduced plant height by an average of 1 in across the 15 cultivars in 1999 (Table 1). Average plant height was 31 in when no Cl was applied and 30 in when Cl was applied. Cultivar height ranged from 27 in for Marshall to 34 in for Trenton. An interaction between spring wheat cultivars and Cl fertilizer did not occur.

Hail damaged plots before grain was harvested in 1999, and a difference in yield resulting from the application of Cl was not detected (Table 1). There was a difference in yield among spring wheat cultivars. Yield ranged from 18.9 bu/acre the durum cultivar Monroe to 23.5 bu/acre for the hard red spring wheat cultivar Amidon. An interaction between Cl application and wheat cultivar did not occur.

Days from emergence to heading and plant height both were reduced by the application of Cl in 2000 (Table 2), as in 1999 (Table 1). Days from emergence to heading were reduced by an average of 2 d across the 15 cultivars (Table 2). Plant heightwas reduced by 1 in across the 15 cultivars, as in 1999.

Spring wheat cultivars differed in days from emergence to heading and plant height in 2000 (Table 2). Days from emergence to heading ranged from 56 for Kulm to 61 for Amidon and Marshall (Table 2). Plant height ranged from 24 in for Marshall to 32 in for Amidon. An interaction between Cl fertilizer and cultivar did not occur for either days to heading or plant height.

The application of Cl did not affect spring wheat yield in 2000 (Table 2). Yield averaged 35.1 bu/acre across plots where Cl was not applied and 35.0 bu/acre in plots receiving Cl. Failure of the Cl fertilizer to increase yield is consistent with previous research at Dickinson by Goos et al. (1996).

Yield responses occur in soils where Cl levels (0- to 2-ft) range from 30 to 60 lb/acre only approximately 31% of the time (Engel et al., 1994). The field at Dickinson where the study occurred in 2000 contained 33 lb/acre in the 0- to 2-ft depth, slightly more than the upper threshold of soils considered to be responsive to Cl fertilizer (30 lb/acre). Chloride levels of plant tissue in untreated plots, however, averaged only 0.07% at the flag leaf/early boot growth plant growth stage (Table 2), less than what is believed to be the critical level for Cl in wheat tissue (0.15%) (Engel et al., 1994). This suggests that the plant-soil environment favored a yield response from the application of Cl fertilizer at Dickinson, but no response occurred.

Previous research indicates that applications of Cl fertilizer may not produce a wheat yield response (Mohr et al., 1992; Engel and Grey, 1991). Yield increases by spring wheat only occur about 69% of the time in low-Cl soils (Engel et al., 1994). This suggests that soil levels may not accurately predict yield responsiveness to Cl applications in some environments. More work is needed to develop a reliable predictor of wheat responsiveness to Cl fertilizer applications.

Spring wheat cultivars differed in grain yield in 2000 (Table 2). Yields ranged from 30.2 for Monroe to 39.2 for Amidon. Grain chloride levels also differed between cultivars, as did plant tissue chloride levels at the flag leaf/early boot stage.

A significant interaction occurred between cultivar and Cl treatment for Cl tissue concentration at the flag leaf/early boot plant growth stage (Table 3). Increases in Cl concentration were smallest for Teal and Guard. Guard has been identified as a non-responder to Cl fertilizer applications (Goos et al., 1996). Increases in Cl concentration from applications of Cl were largest for Kulm and Marshall. Marshall has been identified as a responder to Cl fertilizer (Goos et al., 1996).

Grain test weight was unaffected by applications of Cl fertilizer in 2000, but kernel weight was increased (Table 2). Other research indicates that kernel weight increased following applications of Cl (Engel et al., 1994). Results of this research and past studies indicate that kernel weight can be increased by applications of Cl fertilizer at Dickinson and in similar soil-plant environments.

Acknowledgements

The authors gratefully thank the Foundation for Agronomic Research and Agrium, Inc., for their financial support of this study.

Literature Cited

Engel, R.E., J. Eckhoff, and R.K. Berg. 1994. Grain yield, kernel weight, and disease responses to winter wheat cultivar and chloride fertilization. Agron. J. 86:891-896.

Engel, R.E., and W.E. Grey. 1991. Chloride fertilizer effects on winter wheat inoculated with *Fusarium culmorum*. Agron. J. 83:204-208.

Fixen, P.E. 1993. Crop responses to chloride. Adv. Agron. 50:107-150.

Goos, R.J., B.E. Johnson, D. Zhang, and P. Carr. 1996. Annual report to the Foundation for Agronomic Research. Chloride x variety trials.

Mohr, R.M., D.N. Flaten, and C.C. Bernier. 1992. The effect of chloride fertilizer on wheat and barley. Proc. Manitoba Soc. Soil Sci., 35th Winnipeg, MB. 6-7 Jan.

[1] The original intent was to conduct the study only in 1999; however, a hail storm necessitated repeating the study in 2000. We were unable to locate a field containing < 33 lb Cl/acre among the several fields tested.

Table 1. Days to heading, plant height, and grain yield of fifteen spring wheat cultivars receiving no Cl (Minus) and 40 lb/acre (Plus) at Dickinson, North Dakota, in 1999.

	Days to Heading	Height	Grain yield
	--days from emergence--	--in--	--bu/ac--

Chloride (lb/ac)			
Minus	51	31	21.6
Plus	50	30	22.4
Wheat cultivar			
2375	51	29	22.8
Amidon	52	33	23.5
Butte86	48	31	20.9
Domain	50	32	17.7
Grandin	50	30	21.6
Guard	49	29	22.7
Hamer	50	27	22.2
Kulm	48	31	21.6
Marshall	53	27	22.8
Monroe	51	33	18.9
Renville	53	32	22.0
Russ	50	30	25.5
Teal	50	33	22.1
Trenton	51	34	21.9
Verde	53	28	23.7
Mean	51	31	22.0
CV (%)	1.9	3.8	13.7
Chloride (Cl)	*[1]	*	NS
Cultivar (C)	*	*	*
Cl x C	NS	NS	NS

[1]* = significant at *P*<0.05; NS = not significant

Table 2. Days to heading, plant height, grain yield, test weight, kernel weight, and leaf and grain chloride level of fifteen hard red spring wheat cultivars receiving no Cl (Minus) and 40 lb/acre (Plus) at Dickinson, North Dakota, in 2000.

	Days to Heading	Plant height	Grain			Chloride Level	
			Yield	Test weight	Weight	Leaf	Grain
	-- d --	--in--	--bu/ac--	--lbs/bu--	-kernels/lb-	------------%-----------	
Chloride (lb/ac)							
Minus	60	28	35.1	61.1	12,779	0.06	0.03
Plus	58	27	35.0	61.1	12,072	0.57	0.06
Wheat cultivar							
2375	58	26	36.1	60.9	12,055	0.30	0.04
Amidon	61	32	39.2	60.8	12,368	0.34	0.05
Butte86	57	29	35.9	61.8	11,737	0.27	0.04
Domain	58	30	34.2	60.4	14,140	0.37	0.05
Grandin	58	27	31.5	61.4	11,296	0.29	0.04
Guard	56	24	32.2	61.4	13,477	0.25	0.05
Hamer	60	25	30.9	61.5	11,383	0.35	0.04
Kulm	56	28	34.3	62.6	12,260	0.38	0.06
Marshall	61	24	35.2	61.2	12,953	0.41	0.05
Monroe	59	28	30.2	60.2	11,251	0.36	0.04
Renville	62	29	37.7	61.3	12,072	0.28	0.05
Russ	57	28	38.4	61.3	12,123	0.30	0.03
Teal	58	29	34.4	59.1	14,261	0.20	0.04
Trenton	60	30	37.3	61.4	12,741	0.32	0.06
Verde	60	27	37.8	61.9	12,270	0.32	0.04

Mean	59	28	35.0	61.1	12,426	0.35	0.04
CV (%)	2.5	6.0	7.5	0.8	8.8	15.8	22.5
Chloride (Cl)	*[1]	*	NS	NS	*	*	*
Cultivar (C)	*	*	*	*	*	*	*
Cl x C	NS	NS	NS	NS	NS	*	NS

[1]* = significant at *P*<0.05; NS = not significant

Table 3. Chloride (Cl) concentration in wheat plant tissue in plots where no Cl (Minus) and 40 lb/acre (Plus) as KCl were applied at Dickinson, lb Cl/acre (Plus) as KCl were applied at Dickinson, North Dakota in 2000.

Cultivar	KCl treatment	Cl	Plus - Minus
		%	
2375	Minus	0.07	
2375	Plus	0.52	0.45
Amidon	Minus	0.05	
Amidon	Plus	0.63	0.58
Butte 86	Minus	0.03	
Butte 86	Plus	0.52	0.49
Domain	Minus	0.08	
Domain	Plus	0.66	0.58
Grandin	Minus	0.08	
Grandin	Plus	0.51	0.43
Guard	Minus	0.07	
Guard	Plus	0.43	0.36
Hamar	Minus	0.06	
Hamar	Plus	0.63	0.57
Kulm	Minus	0.05	

Kulm	Plus	0.72	0.67
Marshall	Minus	0.09	
Marshall	Plus	0.74	0.66
Monroe	Minus	0.07	
Monroe	Plus	0.66	0.59
Renville	Minus	0.05	
Renville	Plus	0.50	0.45
Russ	Minus	0.06	
Russ	Plus	0.55	0.49
Teal	Minus	0.05	
Teal	Plus	0.36	0.31
Trenton	Minus	0.09	
Trenton	Plus	0.55	0.46
Verde	Minus	0.08	
Verde	Plus	0.57	0.49
Average	Minus	0.07	
	Plus	0.57	
	Plus-Minus		0.50

[Back to 2001 Annual Report Index] [Back to Agronomy Reports]

[DREC Home] [Contact DREC] [Top of Page]