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ANNUAL REPORT TO PPI-1996

Chloride Fertilization on Yield and Development Rate of Several Wheat Varieties in Montana

Personnel

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Objectives

1. To determine the effect of Cl fertilization on grain yield, kernel weight, rate of kernel growth, and grain-fill duration in several spring and winter wheat cultivars under a wide range of environments.

2. To provide a Cl fertilizer recommendation program to Montana producers by developing a data-base on yield response frequency to Cl as affected by soil and plant Cl levels.

3. To determine the effect of Cl on leaf spots in susceptible wheat cultivars, and to verify the origin as being physiological or microbial.

4. To include a final report at the conclusion of this project to address each of the objectives

Specific results and conclusions for each objective

Objective 1

Winter wheat studies

Winter wheat yields and mature 1000 kernel weights were significantly increased by Cl fertilization (applied as 0-0-60 at seeding) at both the Forth Smith and Bighorn Mountain foothills sites (Table 1). The cultivar x Cl interaction was not significant for all measured parameters. Sierra and Manning were the top yielding cultivars at both locations. Manning was affected by lodging at Bighorn Mtn. foothills site. Growing season rain (April 1 to crop maturity) was excellent at both locations, 8.5" and 11.4" at Fort Smith and Bighorn Mtn, respectively.

Background soil Cl levels (0-24" depth) were 3.3 and 3.9 lb/a at the Forth Smith and Bighorn Mountain site, respectively, and well below the reported critical levels of Fixen et al. (1986). Hence, the large responses to Cl fertilizer observed at these sites were not surprising. The low background soil Cl levels were also reflected by the results from the plant tissue analyses. Control or Cl- plant Cl (head emergence stage) levels averaged 406 and 217 ppm at the Forth Smith and Bighorn Mountain sites, respectively, or well below the 1500 ppm critical level of Fixen et al. (1986). Fertilizer Cl (60 lbs/a Cl) greatly increased plant Cl levels (Table 1) as expected. The effects were not as large at the Bighorn Mountain site because of significant Cl

Table 1. Winter wheat grain yield, thousand kernel weight, and plant Cl in several winter wheat cultivars as affected by Cl fertilization (60 lbs/a) at Fort Smith (Greenwalt farm) and Bighorn Mountain foothills sites, Bighorn Co. 1995.

Cultivar	Chloride	Forth Smith			Bighorn Mountain		
	fertilizer	Yield	1000 KW	Plant Cl	Yield	1000 KW	Plant Cl
		bu/a	g	%	bu/a	g	%
Kestrel	+	88.4	31.8	.6009	90.7	32.0	.2053
	-	76.3	29.5	.0376	76.9	28.4	.0206
Manning	+	95.5	34.4	.5151	98.2	33.9	.2159
	-	90.2	32.4	.0415	87.9	31.0	.0220
Neeley	+	92.2	36.2	.6133	92.7	38.7	.1549
	-	85.6	33.6	.0404	86.9	35.2	.0220
Redwin	+	86.2	35.6	.6346	80.1	34.7	.1978
	-	77.1	33.7	.0436	77.1	31.9	.0245
Rocky	+	72.1	29.5	.4520	84.2	31.5	.1769
	-	66.4	27.3	.0376	75.5	28.2	.0209
Sierra	+	98.4	36.9	.5683	94.5	36.7	.1734
	-	86.1	34.8	.0436	87.9	33.5	.0209
Tiber	+	89.7	36.3	.5839	83.0	35.4	.2042
	-	84.8	34.0	.0347	74.2	32.0	.0213
Weston	+	76.7	42.9	.3882	90.0	39.5	.2014
	-	69.0	39.1	.0461	75.9	35.2	.0213
Average	+	87.4	35.4	.5546	89.2	35.3	.1912
	-	77.4	33.0	.0406	79.5	31.9	.0217
Prob > F	Cl- vs. Cl+	.0001	.0001	.0001	.0001	.0001	.0001

leaching losses during the winter months..

Fertilizer Cl rate studies were included at both locations. Chloride fertilizer rates required for maximum production were generally higher at Bighorn Mountain than Fort Smith (Figure 1). The higher requirements were probably due to Cl leaching losses and proportionately less soil and/or fertilizer Cl uptake by the plant.

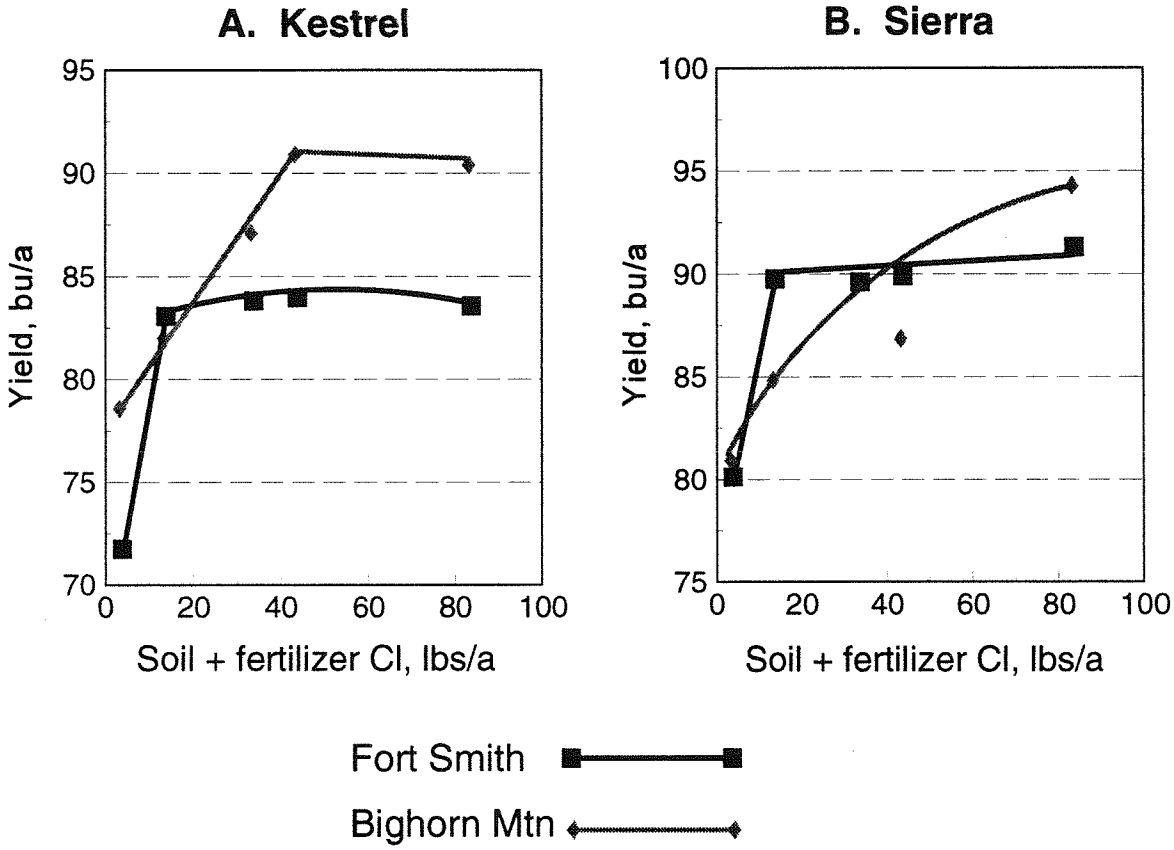

Figure 1. Kestrel and Sierra winter wheat yields as affected by soil (0-24" depth) + fertilizer Cl at Forth Smith and Bighorn Mountain sites. 1995.

Spring wheat studies

Spring wheat yields were improved by Cl fertilization at the Molt but did not improve yield at Lodgegrass (Table 2). Background soil Cl (0-24" depth) levels were 3.9 and 15.8 lbs/a Cl at Molt and Lodgegrass, respectively. Considerable soil Cl, i.e. 20.8 lbs/a, was present in the 24-36" depth at Lodgegrass. Hence, it was not surprising that Cl fertilization did not increase yield at this site. The yield response to Cl fertilization at Molt was somewhat surprising, since sulfur deficiency symptoms where apparent early in the season. At this site Cl- plots, which had received K-sulfate, were visibly greener than the Cl+ (KCl) treatments. Chloride fertilization increased thousand kernel weight at both sites. In previous studies thousand kernel responses to Cl have sometimes been observed without an accompanying yield responses.

Table 2. Spring wheat grain yield, thousand kernel weight, and plant Cl in several winter wheat cultivars as affected by Cl fertilization (60 lbs/a) at Lodgegrass (Murdock farm-Bighorn Co) and Molt (Leuthold farm, Stillwater Co.), 1995.

Cultivar	Chloride	Lodgegrass			Molt		
	fertilizer	Yield	1000 KW	Plant Cl	Yield	1000 KW	Plant Cl
		bu/a	g	%	bu/a	g	%
Amidon	+	54.8	35.1	.8807	36.4	30.7	-
	-	53.0	34.6	.2322	32.9	30.3	-
Lew	+	49.1	34.3	.8792	31.8	36.1	-
	-	49.3	33.0	.2351	30.4	33.8	-
Marshall	+	47.9	34.9	.9987	40.0	31.5	-
	-	46.0	35.2	.2815	38.0	29.3	-
McNeal	+	55.2	35.4	.7374	-	-	-
	-	57.8	34.1	.2177	-	-	-
Newana	+	49.8	33.9	.8041	31.9	33.7	.4875
	-	52.5	33.4	.1549	31.1	30.1	.0429
Pondera	+	53.3	30.8	.6605	35.6	33.3	-
	-	51.5	30.4	.2365	33.7	29.9	-
Rambo	+	53.2	37.8	.8324	38.3	36.1	-
	-	52.3	37.1	.2914	37.2	33.1	-
Average	+	51.9	34.6	0.8276	35.6	33.9	-
	-	51.8	34.0	0.2356	33.9	31.1	-
Prob > F	Cl- vs. Cl+	NS	.0281	.0001	.0001	.0001	.0001

Objective 2

Plant Cl vs. relative yield

Whole plant Cl - relative yield (% maximum yield Cl+ treatments) relationships for 225 cultivar x site x year episodes indicate that tissue analyses at head emergence are diagnostic for evaluating plant Cl status. Whole plant Cl concentrations < 0.10 % are inadequate or deficient in Cl at approximately 70% of the cultivar x site x year episodes. Response to Cl fertilization decreases dramatically, to 29%, within the 0.10 to 0.40 range. Whole plant Cl concentrations above 0.40% at head emergence are associated with adequate Cl nutrition.

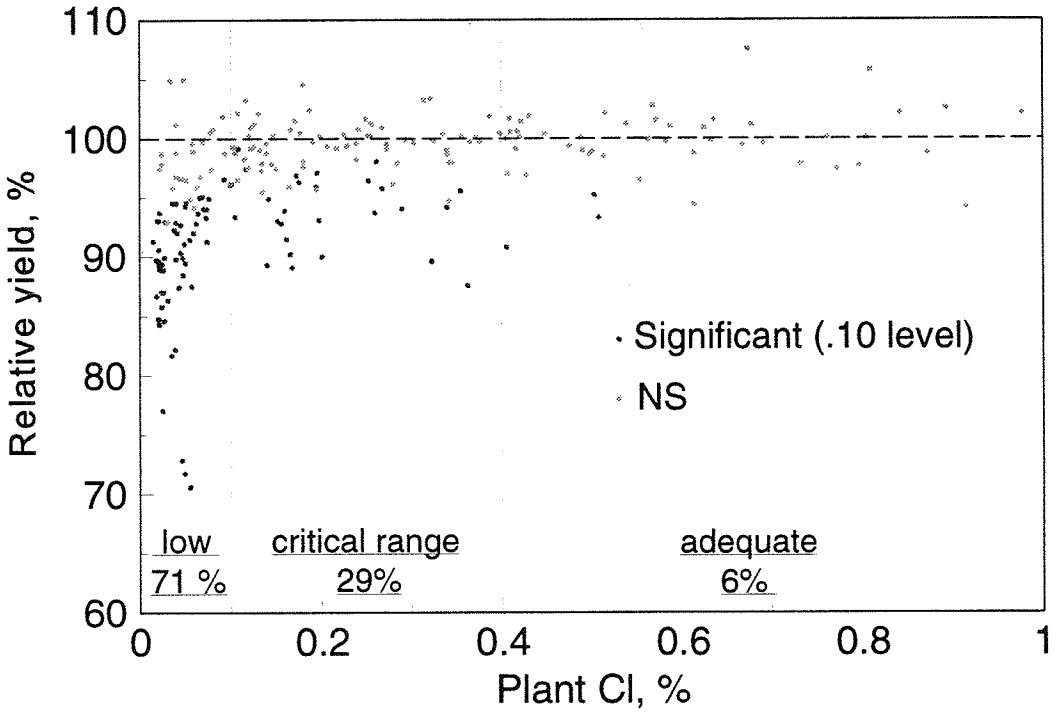

Figure 2. Whole plant Cl - relative yield relationships for wheat. Montana research (1988-1995).

Whole plant Cl - soil Cl relationships

Most of the field sites were uniformly low in Cl (< 1.0 ppm) at all depths (0-48"). The Cl- treatment typically had plant Cl concentrations < 0.10%. Hence, it was not possible from these treatments alone to develop a meaningful regression relationship between soil Cl and plant Cl, or to determine the relative importance of soil Cl positioned at different depths in the profile. The relationship between fertilizer + soil Cl (0-24") and plant Cl provides some insight into the quantity of Cl necessary to ensure adequate nutrition. In most cases this relationship was described by the quadratic model in Curve 1 (Figure 3). Assuming a plant Cl > 0.40% ensures adequate nutrition (upper end of critical plant Cl range) a 34 kg/ha critical soil Cl level can be defined from the curve. One exception to this relationship occurred at the Bighorn Mountain site in 1995. Chloride leaching resulted in proportionately less soil + fertilizer Cl uptake by the plant.

Hence, the shape of curve 2 was considerable flatter than curve 1.

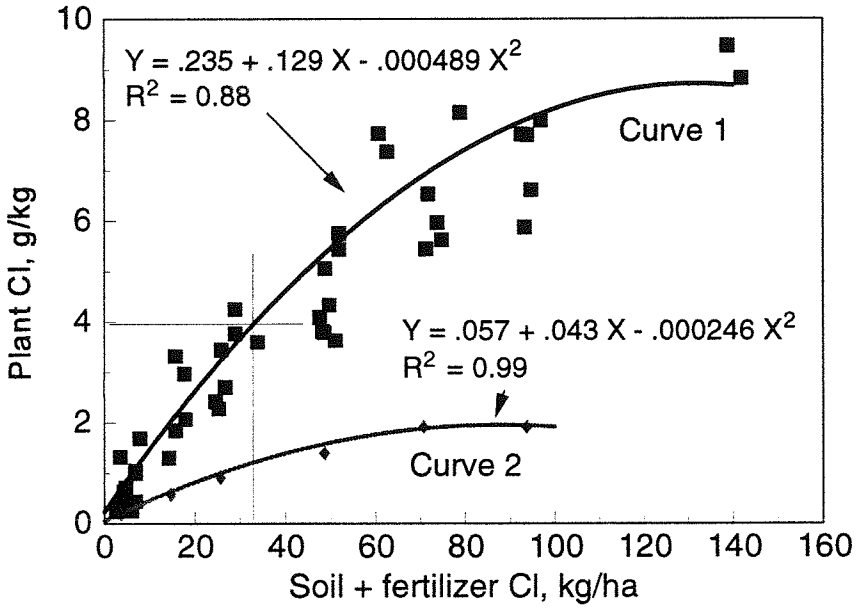

Figure 3. Soil (0-30 cm depth) + fertilizer Cl - whole plant at head emergence. Montana research 1988 -1995. Curve 2 = Bighorn Mountain foothill site, 1995. Curve 1 = all other sites.

Objective 3

- see enclosed manuscript draft to be submitted to Soil Sci. Soc. Am. J.

Title: A chloride deficient leaf spot syndrome of wheat.

Planned changes for next year.

Project will not be continue in 1996.

Can PPI/FAR cite data ?

Yes

Give a brief economic analysis of any observed responses.

Application of chloride containing fertilizers can potentially increase yield and economic return to wheat growers. A critical soil Cl level of 30 lbs/a (0-24") or 34 kg/ha is adequate for maximum production. Fertilizer Cl applications required to achieve maximum yields are frequently < 20 lbs/a Cl. Chloride fertilizer, sold as 0-0-62, is currently priced at $.16 - $.17/lb (U.S. dollars). Hence, the material cost of correcting or preventing Cl deficiency in wheat is comparatively small. In addition, a large percentage of applied fertilizer Cl may be available to succeeding wheat crops under dryland conditions. Only small amounts of Cl are removed in the grain (<3 lbs/a) even under high yield (70 bu/a) potentials. Chloride in the wheat straw should be recycled and released to the soil as the residue decomposes. Also, rainfall is comparatively low in the West. Under most conditions leaching events are infrequent even though Cl is mobile in soils.

Interpretative statement

Agronomists have historically believed that chloride deficiency in the field was rare or unknown. However, new research from Montana has revealed that wheat yields are frequently improved by Cl fertilization. Soil and plant analyses provide important diagnostic tools in response prediction. Significant yield responses to Cl fertilizer are observed in 70% of the cultivar x site x year episodes where whole plant Cl levels are < 0.10%. Response frequency drops to 29% at plant Cl range of 0.10 to 0.40%. Few responses to Cl fertilizer are observed at plant Cl levels > 0.40%. A soil Cl level of 30 lbs/a (0-24") appears to be critical for ensuring adequate Cl nutrition.

References

Fixen, P.E., G.W. Buchenau, R.H. Gelderman, T.E. Schumacher, J.R. Gerwing, and F.A. Cholick. 1986. Influence of soil and applied chloride on several wheat parameters. Agron. J. 78:736-740.