1991

PROGRESS REPORT TO POTASH AND PHOSPHATE INSTITUTE

TITLE: Effect of chloride fertilization on yield and development rate of several winter wheat varieties in Montana.

PROJECT LEADER:

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OBJECTIVES:

1. To determine the effect of chloride fertilization on grain yield, spike stage development and grain-fill duration in several winter wheat cultivars.

2. To determine if Cl fertilizer responses in winter wheat are affected by cultivar selection.

3. To increase existing knowledge on the mechanism by which chloride improves small grain yields.

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

WORK PLAN:

Field experiments were established at 3 locations in south central Montana where soil Cl levels in the upper 24" tested below 30 lbs/a (Table 1). Each study site consisted four replications of 12 treatments, including six winter wheat cultivars ('Redwin', 'Cree', 'Neeley', 'QT-542', 'Weston', and 'Manning') and two Cl levels (0 and 40 lbs/a) in factorial arrangement. The treatments were arranged as a split-plot design with varieties as the main-plots and Cl level as sub-plots. Since there were only two Cl levels, the sub-plots were situated side-by-side as paired-plots. Winter wheat was seeded at a rate of 60 lbs/a in 12" rows. Individual plots were 6' wide and approximately 28' long. Chloride was applied as KCl (0-0-60) in a band approximately 4" to the side and 2" below the seed row. To maintain a uniform level of K over the study, K_2SO_4 (0-0-52-18) was applied to the control or O Cl plots. Nitrogen was band applied with KCl or K_2SO_4 urea (46-0-0) at a rate of 80 lbs/a. Phosphorus, 30 lbs P_2O_5/a, was placed with the seed as triple superphosphate.

To determine the effect of Cl on kernel size and development rate, subsamples of wheat kernels were collected at several dates during grain-filling at Garryowen and Lodgegrass. At Garryowen, 100-120 of the earliest developing spikes with extruded anthers from central florest were tagged in each plot to mark the beginning of anthesis. Although cultivar selection and Cl affected plant development overall, within each sub-plot tagged spikes collectively represented a population of spikes which reached anthesis on the same day. After tagging, sub-samples of 20 tagged spikes were collected at one week intervals beginning on June 24 and ending on July 15. At Lodgegrass, random samples of 20 prominent spikes were collected at one week intervals beginning on July 1 and ending on July 29. Comparison of chloride effects on kernel development at this site are from a spike population with a more variable date of anthesis initiation. After collecting the spikes, samples were dried at 70°C, hand-threshed, and thousand kernel weights determined by counting and weighing 200 kernels.

Table 1. Soil series descriptions, seeding dates, and background soil Cl levels at several depths as determined by potentiometric titration with 0.01 $AgNO_3$.

Location	Series	Classification	Depth feet	Soil Cl ppm
Lodgegrass	Farnuf	Fine-loamy, mixed	0-1	1.2
		Typic Agriborolls	1-2	1.4
			2-3	2.0
			3-4	5.0
Garryowen	Richfield	Fine, montmorillonitic,	0-1	1.3
		mesic	1-2	1.6
		Aridic Agriustolls	2-3	1.4
			3-4	2.9
Huntley	Lohmiller	Fine, montmorillonitic,	0-1	1.1
		calcareous, mesic	1-2	1.8
		Ustic Torrifluvents	2-3	3.1
			3-4	6.1

RESULTS AND DISCUSSION:

The 1991 growing season was characterized by well above normal rainfall during April, May, and June. This is reflected by the extremely high yields at all sites. At Huntley a hail-storm during the ripening stages resulted in some shattered heads and fracture stems. Chloride fertilizer resulted in a significant yield improvement over control plots at Garryowen and Lodgegrass, but not at the Huntley (Table 2). At all locations the cultivar x K source interaction was not significant indicating the Cl response was not affected by cultivar selection. In general, the response from Cl was modest at both the Garryowen and Lodgegrass averaging less than 3 bu/a. Test weight was measured at the Cl yield responsive sites, Garryowen and Lodgegrass, and found to be increased ($P < 0.10$) by chloride (Table 3).

Due to the extremely wet spring foliar diseases were common in 1991. At the Garryown site symptoms of tanspot developed in Redwin and Manning early in June. For these two varieties Cl resulted in a dramatic decrease in the disease symptoms at the boot stage. The disease suppression effects from Cl diminished with time however and were not nearly apparent after July 1. Plants samples were collected at two dates (June 6 and June 17) for assessment of disease severity and intensity. At present this disease assessment work has not been performed. Symptoms of leaf rust were apparent in all varieties at the Lodgegrass site by the ripening stages. Though there was no clear effect from Cl on disease severity, leaf blade samples were collected (July 15) for assessment of disease severity and intensity. Plant samples from both the Garryowen and Lodgegrass sites are currently in cold storage (< 0 °C).

The date of anthesis, measured as the appearance of anthers in the central florets of each spike, appeared to be advanced by approximately 1 day for all cultivars at both the Garryowen and Lodgegrass sites. At Garryowen a count of 'Weston' spikes on June 10, 11, 12, and 14 indicated that 0.0, 9.1, 29.4, and 69.8% of the control spikes had anthers extruding from the central florets, respectively. Whereas 0.0, 20.4, 40.0, and 85.7% of the Cl spikes had anthers extruding from the central florets as these respective dates.

At all dates sampled during grain-filling, Cl significantly increased winter wheat kernel weights (Table 4 and 5). Differences in kernel weights from Cl at Garryowen could not be attributed to an advancement in anthesis date. Although Cl enhanced the date of anthesis initiation overall, the spikes sampled were from a population of spikes that reached anthesis on the same day.

Chloride increased the kernel-fill rate at both Garryowen and Lodgegrass. Analysis of variance of kernel weight data over the linear-phase of kernel fill, day 175 to 189 (June 24-July 08) at Garryowen and day 182 to 203 (July 1-22) at Lodgegrass, indicated that the time linear * ksource interaction was significant at the 0.0001 and 0.0045 probability levels, respectively. Time-kernel weight regressions equations for Cl and control were solved simulanteously and indicate that the rate of grain-fill over the linear-phase was increased approximately 7 and 5% by Cl at Garryowen and Lodgegrass, respectively (Figs. 1 and 2).

Physiological maturity (PM) was estimated by assuming the kernel-fill rates continued to remain linear until the kernel reached its maximum weight. Extrapolating the regression lines in Figs. 1 and 2 until they intercept the kernel weights observed at the final sampling (day 196 at Garryowen, day 210 at Lodgegrass) provided a estimate of PM date. Estimated PM dates for Cl and controls plots were identical at Garryowen (day 190.0). At Lodgegrass PM occurred on day 203.4 and 204.4 for Cl and control plots, respectively. The later PM dates and longer grain-fill duration at Lodgegrass reflect the cooler temperatures and higher moisture conditions found at this site. The one day difference in PM may reflect the fact that KCl enhanced the date of anthesis initiation by one day and spikes sampled at this site were selected randomly, and were not selected for uniformity in plant development.

Table 2. Winter wheat yield as affected by K fertilizer source (potassium sulfate vs. potassium chloride) and selection. Garryowen, Lodgegrass, and Huntley site, 1991

Cultivar	K fertilizer source *	Yield and location Garryowen	Lodgegrass	Huntley	$\bar{x}$	
			bu/a			
QT 542	0-0-60	54.0	85.0	71.9	69.5	−1.1
	0-0-52-18	54.4	86.8	69.2	70.6	
Weston	0-0-60	47.0	82.2	57.5	64.6	+1.7
	0-0-52-18	47.2	78.5	57.6	62.9	
Neeley	0-0-60	52.6	84.2	57.2	68.4	+3.3
	0-0-52-18	49.1	81.0	56.2	65.1	
Manning	0-0-60	51.6	80.9	65.0	66.3	+3.7
	0-0-52-18	49.5	75.6	61.2	62.6	
Redwin	0-0-60	49.6	80.0	56.7	64.8	+2.9
	0-0-52-18	47.0	76.8	57.7	61.9	
Cree	0-0-60	46.7	70.7	50.7	58.7	+3.5
	0-0-52-18	44.0	66.4	50.2	55.2	
Means	0-0-60	50.3	80.6	60.2		
	0-0-52-18	48.5	77.6	58.7		

Summary statistics

Source	df	Prob > F	LSD (.05)
Garryowen			
Cultivar(C)	5	0.0162	4.7
K source(K)	1	0.0471	
C x K	5	0.672	
Lodgegrass			
Cultivar(C)	5	0.0001	3.4
K source(K)	1	0.0051	
C x K	5	0.3591	
Huntley			
Cultivar(C)	5	0.0001	5.1
K source(K)	1	0.3027	
C x K	5	0.3928	

Table 3. Winter wheat test weight yield as affected by K fertilizer source (potassium sulfate vs. potassium chloride) and selection. Garryowen and Lodgegrass sites, 1991

Cultivar	K fertilizer source #	Test weight and location	
		Garryowen	Lodgegrass
QT 542	0-0-60	60.2	62.4
	0-0-52-18	59.5	61.9
Weston	0-0-60	61.0	63.1
	0-0-52-18	60.4	62.6
Neeley	0-0-60	60.4	61.5
	0-0-52-18	59.4	61.5
Manning	0-0-60	61.0	60.4
	0-0-52-18	60.5	59.9
Redwin	0-0-60	61.2	62.3
	0-0-52-18	60.9	62.4
Cree	0-0-60	60.7	61.5
	0-0-52-18	60.1	61.0
Means	0-0-60	60.7	61.8
	0-0-52-18	60.1	61.5

Summary statistics

Source	df	Prob > F	LSD (.05)
Garryowen			
Cultivar(C)	5	0.0105	0.673
K source(K)	1	0.0011	
C x K	5	0.8766	
Lodgegrass			
Cultivar(C)	5	0.0001	0.597
K source(K)	1	0.0802	
C x K	5	0.7396	

Table 4. Winter wheat kernel weights from the earliest flowering spikes at several dates during the ripening stages. Garry Owen site, 1991.

Cultivar	K fertilizer source	Thousand kernel weights			
		Date			
		06-24	07-01	07-08	07-15
		gms			
QT 542	0-0-60	11.7	23.3	33.0	32.6
	0-0-52-18	10.9	21.0	31.1	30.3
Weston	0-0-60	11.9	25.7	39.4	40.2
	0-0-52-18	11.2	24.0	36.2	36.4
Neeley	0-0-60	8.6	19.9	33.3	35.9
	0-0-52-18	7.3	18.1	31.1	33.8
Manning	0-0-60	9.8	20.5	32.0	35.8
	0-0-52-18	8.5	18.1	29.8	31.9
Redwin	0-0-60	8.5	18.1	30.6	33.1
	0-0-52-18	7.7	17.3	29.4	31.4
Cree	0-0-60	9.2	21.8	34.6	34.3
	0-0-52-18	8.4	20.2	31.2	33.2
Means	0-0-60	9.9	21.5	33.8	35.3
	0-0-52-18	9.0	19.8	31.5	32.8

Summary statistics

ANOVA within sampling dates

Source	df	Prob > F			
Cultivar(C)	5	0.0001	0.0001	0.0001	0.0001
K source(K)	1	0.0001	0.0001	0.0001	0.0001
C x K	5	0.190	0.364	0.357	0.158

Table 4 .... continued

ANOVA over sampling dates 06-24, 07-01, and 07-08

Source	df	SS	Prob > F
Cultivar(C)	5	567.8	0.0001
K source(K)	1	102.6	0.0001
C x K	5	4.79	0.4341
Time (T)	2	12881.6	0.0002
Time linear (Tl)	1	12876.3	0.0001
C x T	10	95.84	0.0001
C x Tl	5	81.00	0.0001
K x T	2	12.33	0.0001
K x Tl	1	12.26	0.0001
C x K x T	10	5.94	0.2860
C x K x Tl	5	3.85	0.1721

Table 5. Winter wheat kernel weights at several dates during the ripening stages. Lodgegrass site, 1991.

Cultivar	K fertilizer source	Thousand kernel weight				
		Date				
		07-01	07-08	07-15	07-22	07-29
				gms		
QT 542	0-0-60	11.7	22.7	34.6	39.8	39.5
	0-0-52-18	10.0	22.4	32.2	37.7	38.8
Weston	0-0-60	10.3	22.5	36.2	44.7	46.8
	0-0-52-18	8.8	21.1	32.8	42.7	44.5
Neeley	0-0-60	7.6	17.3	30.6	40.4	41.6
	0-0-52-18	6.5	14.2	27.0	37.9	41.5
Manning	0-0-60	10.0	19.4	29.9	38.7	41.9
	0-0-52-18	8.0	19.4	27.6	37.1	39.3
Redwin	0-0-60	6.7	16.0	27.1	37.2	38.6
	0-0-52-18	6.7	15.5	24.3	34.5	38.2
Cree	0-0-60	7.1	17.2	30.2	38.2	38.5
	0-0-52-18	5.7	15.0	27.9	35.3	37.8
Means	0-0-60	8.9	19.2	31.4	39.8	41.2
	0-0-52-18	7.6	17.9	28.6	37.5	40.0

Summary statistics

ANOVA within sampling dates

Source	df	Prob. > F				
Cultivar(C)	5	.0001	.0001	.0001	.0001	.0001
K source(K)	1	.0001	.0252	.0001	.0001	.0060
C x K	5	.1539	.5254	.8240	.9100	.2445

Table 5 .... continued

ANOVA over sampling dates 07-01, 07-08, 07-15, and 07-22

Source	df	SS	Prob > F
Cultivar(C)	5	1007.7	0.0001
K source(K)	1	175.1	0.0001
C x K	5	7.21	0.6734
Time (T)	3	25420.7	0.0001
Time linear (Tl)	1	25348.9	0.0001
C x T	15	248.7	0.0001
C x Tl	5	134.9	0.0001
K x T	3	21.34	0.0044
K x Tl	1	12.97	0.0045
C x K x T	15	16.98	0.7424
C x K x Tl	5	4.82	0.4302

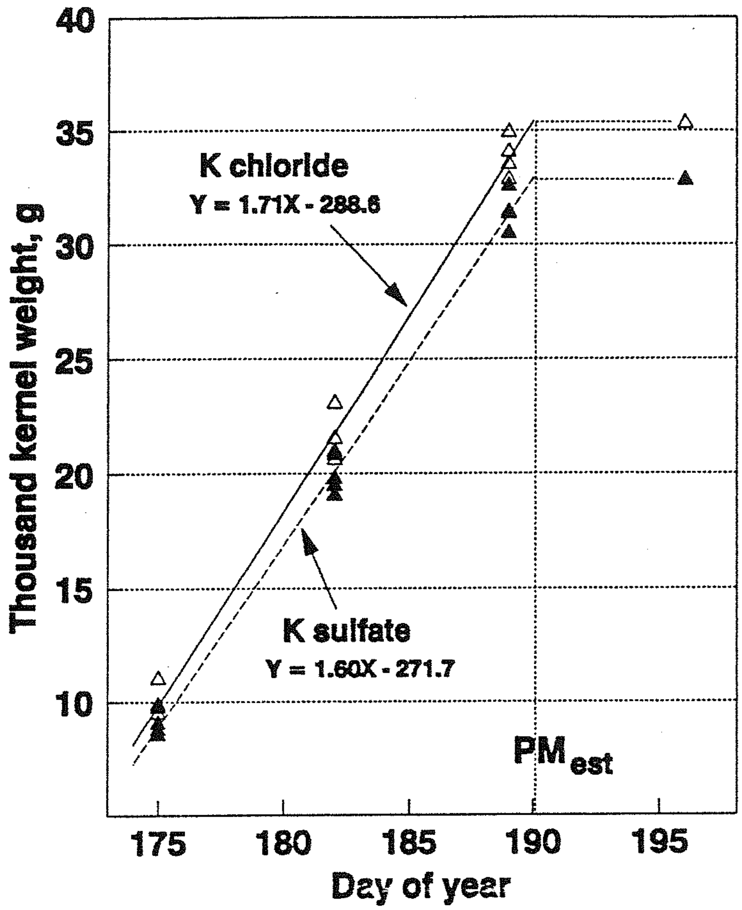

Figure 1. Effect of chloride on thousand kernel weight at several dates during grain-filling. Garryowen, Montana. 1991. PMest = physiological maturity estimate.

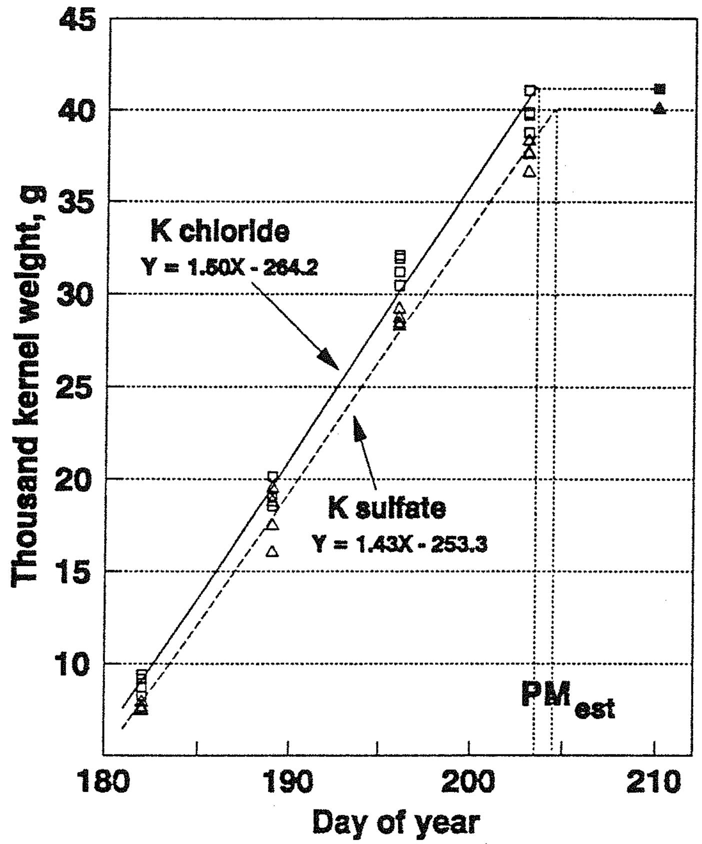

Figure 2. Effect of chloride on thousand kernel weight at several dates during grain-filling. Lodgegrass, Montana. 1991. PMest = physiological maturity estimate.