Does Potassium or Chloride Play a Dominant Role in Suppression of Corn Stalk Rot?

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Corn stalk rot is a serious and widespread disease in the main corn production areas of China. Previous research has indicated that KCl plays a significant role in suppression of corn stalk rot. This study compared the effects of K and Cl nutrition, and showed that K played an important role in the suppression of the disease.

Stalk rot is a disease of increasing importance to corn production in China. The average annual yield loss in China due to stalk rot infection is approximately 20% and in individual fields may reach 50%. Potassium has long been the nutrient most associated with plant disease reduction. Potassium fertilizer application is one of the few effective measures to suppress corn stalk rot. A 12-year fixed site field trial in Jilin Province showed that KCl application decreased the incidence of corn stalk rot by 48% (Liu et al., 2007). However, insuff cient attention has been paid to the question of which element in KCl plays the dominant role in the suppression of corn stalk rot…an inadequacy addressed by this research.

Jilin is designated the "Corn Belt" of China due to its top ranking in annual sown area (Jia, 2004). A field experiment was conducted in the Gongzhuling region of Jilin in 2005 using a set of treatments consisting of a check (CK) and six combinations of K and Cl (K120, K240, K120Cl90, K240Cl180, Cl90, and Cl180) laid out in a randomized complete block design with four replicates. All treatments had equal applications of N and P. Plot area was 40 m^2. Soil pH and nutrient status at the 0 to 20 cm depth are shown in **Table 1**. Available nutrients in the soil were determined by ASI soil analysis methods (PPI/PPIC Beijing Office, 1992). Based on soil test results, applications of S, Zn, and Cu were done before sowing, at rates of 20, 10, and 1.0 kg/ha, respectively. Since soil Ca concentration was abundant and crops in the region have not responded to Ca fertilization, $CaCl_2$ was used to evaluate the effect of Cl on corn yield and disease severity. Potassium chloride was used to study the combined effect of K and Cl. Potassium nitrate was used to study the effect of K alone. The amounts of fertilizer used in the treatments are given in **Table 2**. The study used two commercial corn hybrids including Jidan 180, which is moderately resistant to stalk rot, and Jidan 327, which is considered susceptible to stalk rot. The plant density was 50,000 plants/ha. The incidence of corn stalk rot was investigated prior to harvest.

The treatment created obvious differences in growth between resistant and susceptible varieties at plant jointing stage (see photos). Prior to harvest of both varieties, significant reductions in stalk rot incidence, as well as yield increases, occurred in response to K and KCl, but not to Cl alone (**Table 3**). All K and KCl treatments reduced disease severity by 50 to 64%, and increased yield by 13 to 23% in Jidan 327. In Jidan 180, stalk rot was decreased by 44 to 60% and yield was increased by 20 to 29% compared to the CK. Thus, stalk rot was more effectively suppressed in the susceptible variety, but yield was enhanced to a larger degree with the resistant variety.

No signif cant differences in disease incidence and yield were observed between the two fertilization rates of KCl and Cl. Stalk rot was reduced with the addition of K, regardless of source.

For Jidan 180, when K (as KNO_3) application increased from 120 to 240 kg/ha, stalk rot incidence was unaffected, but grain yield decreased. The degree of yield loss in other K and KCl supplying treatments

Effects of K, Cl and KCl on the growth of Jidan 180 (top) and Jidan 327 (bottom) corn hybrids at jointing stage.

Abbreviations and notes for this article: K= potassium; Cl = chloride; KCl = potassium chloride; KNO_3 = potassium nitrate; K_2SO_4 = potassium sulfate; S = sulfur; Zn = zinc; Cu = copper; Ca =calcium; N = nitrogen; P = phosphorus; ASI = Agro Services International.

Table 1. Initial soil characteristics at the experimental site, Jilin.

OM, %	N-NH_4	P	K	Ca	Mg	S	B	Fe	Mn	Cu	Zn	Cl	pH_{H2O}
	mg/kg			g/kg		mg/kg							
2.4	8.6	5.9	42.4	3.0	0.4	12.9	1.8	102.5	12.8	2.7	1.0	30.2	5.8

Table 2. Nutrient application rates for the set of treatments.

Treatment	$Ca(NO_3)_2$	$Ca(H_2PO_4)_2$	KNO_3		KCl		$CaCl_2$
	N	P_2O_5	K_2O	N	K_2O	Cl	Cl
CK	200	120	-	-	-	-	-
+ K_{120}	158	120	120	43	-	-	-
+ K_{240}	114	120	240	86	-	-	-
+ $K_{120}Cl_{90}$	200	120	-	-	120	91	-
+ $K_{240}Cl_{180}$	200	120	-	-	240	182	-
+ Cl_{90}	200	120	-	-	-	-	91
+ Cl_{180}	200	120	-	-	-	-	182

The corn leaves in the left rows received no K fertilizer and appeared dull gray-green, while the leaves in the right rows with K application were still green.

may have been partially influenced by stalk rot incidence, but it appears nutrient imbalance may have exerted a larger effect. Ash and Brown (1991) found a similar result showing that increased disease did not correlate with yield losses, but N fertilizer application rate had a large influence on the yield-loss relationship.

For both varieties, 120 kg K_2O/ha seemed most appropri-ate, and 240 kg K_2O/ha excessive, to maintain high yields at this site. No positive interactions between K and Cl were detected at the 120 kg/ha rate, but there was evidence that Cl may help to moderate the yield-dampering effects of the 240 kg K_2O/ha rate applied to Jidan 180.

Heckman (1998) found that the incidence of corn stalk rot was 67% lower with KCl application, compared to K_2SO_4 application at an equivalent K rate. This result suggests that Cl played an important role in the suppression of the disease. In contrast, this research indicates that Cl plays a less important role in stalk rot suppression than K. This inconsistency may be due to differences in nutrient status of the test soils. Sanogo and Yang (2001) reported that soil amendment with KCl when the soil was not deficient in K resulted in 36% decrease in the severity of soybean sudden death syndrome (SDS), a soil-born disease. Conversely, disease severity was increased by 43% with K_2SO_4 application, and by 45% with KNO_3, compared to the study's controls. Thus, Cl was helpful in reducing SDS and K application was not found beneficial. A comparison of the available K concentration (0 to 20 cm depth) between this research and Heckman's U.S. study finds the initial K fertility in the U.S. study to be 92 mg/kg, which is over twice the level measured in this work (**Table 1**). Additionally, soil Cl in the 0 to 30 cm soil layer was only 6 mg/kg (low) in Heckman's experiment, while this study's soil Cl concentration in 0 to 20 cm layer was 30 mg/kg. Therefore, under conditions of

Table 3. Effects of K and Cl- on the stalk rot incidence and yield of corn.

Treatment	Jidan 180				Jidan 327			
	Disease incidence, %	Disease control, %	Yield, kg/ha	Yield increase, %	Disease incidence, %	Disease control, %	Yield, kg/ha	Yield increase, %
CK	24.6 a[1]	-	7114 c	-	34.1 a	-	6925 c	-
K_{120}	13.7 b	44.4	9162 a	28.8	17.1 b	50.0	8544 a	23.4
K_{240}	12.4 b	49.6	8546 b	20.1	12.3 b	63.8	7839 ab	13.2
$K_{120}Cl_{90}$	10.8 b	55.9	8615 ab	21.1	13.8 b	59.7	8164 a	17.9
$K_{240}Cl_{180}$	9.9 b	59.8	9050 ab	27.2	12.4 b	63.6	8252 a	19.2
Cl_{90}	17.1 ab	30.3	7373 c	3.6	31.8 a	6.8	6340 c	-8.5
Cl_{180}	17.3 ab	29.8	7166 c	0.7	30.4 a	10.8	6509 c	-6.0

[1]*Means within a column followed by different letters are significantly different (LSD Test, $p<0.05$).*

Stalk lodging and ear dropping are the typical symptoms of corn stalk rot. Stalk rot in plots without K application (left) was more severe than that with K application (right) in September.

soil K deficiency and Cl sufficiency, the influence of K nutrition on corn stalk rot was much more strongly pronounced than the influence of Cl. Apparently the result is opposite under soil K sufficiency and Cl deficiency.

In conclusion, the role of K and Cl in disease suppression must be examined in conjunction with the soil nutrient status. Therefore, whether K or Cl play the dominant role in corn stalk suppression will depend on the K and Cl status of the soil. A well-balanced fertilization strategy is necessary for both yield increases and disease control.

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Visual Indicators of Potassium Deficiency in Corn