CROP INSIGHTS

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University/Pioneer Research[1] Update:

Influence of Potassium Fertilizer on Corn Stalk Strength

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Key Findings of CMRA[1] Research Project

- Stalk performance is known to vary widely among corn hybrids, but little is known about genetic variation in the effects of plant nutrients on stalk strength.
- Due to its physiological functions, potassium (K) is expected to play an important role in maintaining strong stalks until harvest.
- Field studies in eastern Nebraska from 2000 to 2003 found that stalk diameter, stalk moisture content, and stalk density were the key determinants of stalk strength.
- Increased K supply improved stalk strength in some hybrids, typically by reducing stalk drydown between physiological maturity and harvest.
- Researchers concluded that spatial variation in nutrient supply within a field could be managed to some extent through site-specific hybrid planting and variable-rate fertilizer application.

Corn stalk diameter varies by hybrid and plant density.

Introduction

Stalk strength varies widely among corn hybrids and may also be affected by crop management practices, including plant density and soil fertility. Due to its physiological functions, potassium (K) is expected to play an important role in maintaining strong stalks until harvest, but its effect on stalk strength has not been studied widely for modern corn hybrids and at varying plant densities. In Nebraska, potassium effects on corn were last studied in the 1970s and early 1980s, mostly on coarse-textured soils that had been converted to growing irrigated corn.

Differences among hybrids in stalk performance are well documented, but little is known about genetic variation in the effects of plant nutrients on stalk strength. The period from physiological maturity (black layer) to harvest is of particular interest because it affects late-season standability, and has not been widely investigated.

Primary Research Objective

The primary objective of this study was to investigate the effects of potassium supply and plant density on corn stalk strength across hybrids differing in stalk performance. The study was conducted by Drs. Achim Dobermann and Charles Shapiro of the University of Nebraska-Lincoln.

Study Description

In 2000 and 2001, a field experiment was established on a sandy soil (Valentine sand) under center-pivot irrigation in Pierce County, northeast Nebraska. In 2000, the experiment was conducted in a sloping field in a randomized complete block split-plot design with hybrid as main plots and K rates as subplots (5 replicates, 20 x 50 foot plot size, 8 rows per plot). Hybrids tested were Pioneer® brand 33G27, 34R07 and 3489. Potassium rates were 0, 76 and 152 lb K_2O/A.

In 2001, the experiment was continued at the same site with a modified design to accommodate six corn hybrids by splitting the original 8-row K plots by half. Potassium rates and all other field management practices were the same as in 2000. The six hybrids were chosen based on differences in stature, stalk strength score, stalk rot resistance score and maturity: Pioneer 34R07 and 33A14 for low stalk strength (score 3 to 4), Pioneer 34B24 and 33P67 for medium stalk strength (score 5), and Pioneer 34G13 and 33G30 for high stalk strength (score 7).

In 2003, field experiments with irrigated corn were conducted at three sites in Nebraska to evaluate stalk strength characteristics in four fertility x plant density treatments. It was assumed that dense stands produce thinner stalks and have greater stress, particularly if nutrient supply is insufficient to support the greater crop demand. To help create a range in stalk strength characteristics at each site., plant density (2 levels) and nutrient input (2 levels) were varied. Treatments in 2003 were:

Table 1. Fertility and plant density treatments at three experimental locations in 2003.

Treatment	N	P_2O_5	K_2O	Plant Density
	Lbs/A			*Plants/A*
Normal fertilizer rate, normal plant density	150 or 200	41	0	24-30,000
Normal fertilizer rate, high plant density	150 or 200	41	0	30-35,000
High fertilizer rate, normal plant density	250 or 300	82	86	24-30,000
High fertilizer rate, high plant density	250 or 300	82	86	30-35,000

Treatment normal fertility-normal density represented a currently recommended best management practice and is similar to average Nebraska farmer practices. Treatment high fertility-high density represented a maximum yield management practice with high input of fertilizers and increased plant population. All sites were irrigated and soils included Ovina-Thurman lS at Bellwood, Nora-Crofton siL at Brunswick, and Kennebec/Alcester siL at Concord.

Measurements in all years included (1) soil organic matter, pH, Bray P_1, and K by two extraction methods (ammonium acetate and sodium tetraphenyl borate) at two soil depths (2) grain yield, dry matter and nutrient uptake (N, P, K) in stems, leaves, cobs, and grain, and (3) stalk strength at physiological maturity and harvest (about 3 weeks later).

For each stalk, fresh and dry weight, moisture content, ear height and the number of internodes were measured. Measurements of diameter (digital caliper) and stalk strength (maximum load needed to break the stalk) were conducted for the first and fourth internodes below the ear using an Instron 4411 instrument (Figure 1).

Results

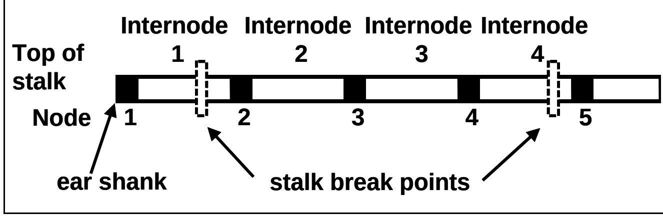
What determines corn stalk strength?

Stalk diameter, moisture content, and stalk density were the key determinants of stalk strength. Any management practice that increases any one of these characteristics will increase stalk strength and resistance to lodging. In summary, thick, shorter stalks with sufficient moisture content are harder to break than thinner, tall stalks that have dried down more rapidly after physiological maturity.

Do corn hybrids differ in their stalk strength and response to K application?

Yes, but assessing differences among hybrids requires that comparisons are made in a uniform environment, particularly with regard to soil fertility and nutrient supply. This was difficult to achieve in the hybrid x K rate comparisons conducted at Pierce in 2000 and 2001 because spatial soil variability was significant.

Figure 1. Location of corn stalk internodes used to measure breaking strength.



Potassium application increased moisture content, diameter and strength of stalks collected at maturity and at harvest in 33G27, but not in the other hybrids tested in 2000 (Figure 2). Compared to 3489 and 34R07, stalks of 33G27 lost less moisture and maintained their diameter from maturity to harvest, resulting in sustained stalk strength. Four out of six hybrids tested in 2001 (data not presented) demonstrated increasing stalk moisture content with increasing K application, just like 33G27 the previous year.

In general, hybrids with the highest stalk strength scores (33G30, 33G27 and 34G13) also had the best performance in stalk strength measurements. These hybrids were characterized by higher stalk density, greater stalk diameter and moisture content, and less dry-down of stalks after maturity. Stalk strength was further increased by K application or higher soil K levels in these hybrids. These effects were not observed consistently for hybrids with low or medium stalk strength scores (e.g., 34R07 in both 2000 and 2001).

Do hybrids with greater stalk strength yield less than hybrids with lower stalk strength scores?

Probably not. In 2000, Pioneer 33G30 had both the best stalk strength and grain yield performance. In 2001, stalk strength decreased in the order:
34G13 = 33G30 > 34R07 = 34B24 > 33P67 > 33A14,

whereas grain yield followed the order:
33P67 (194 bu) > 34B24 (189 bu) > 33G30 (185 bu) > 33A14 (182 bu) >34R07 (173 bu) > 34G13 (163 bu).

This could indicate that some hybrids with excellent stalk strength (e.g., 34G13) may yield somewhat lower than hybrids with poorer stalk strength, but full conclusions cannot be reached from a single-location experiment.

Figure 2a. Influence of potassium application rate on the stalk diameter of three corn hybrids.

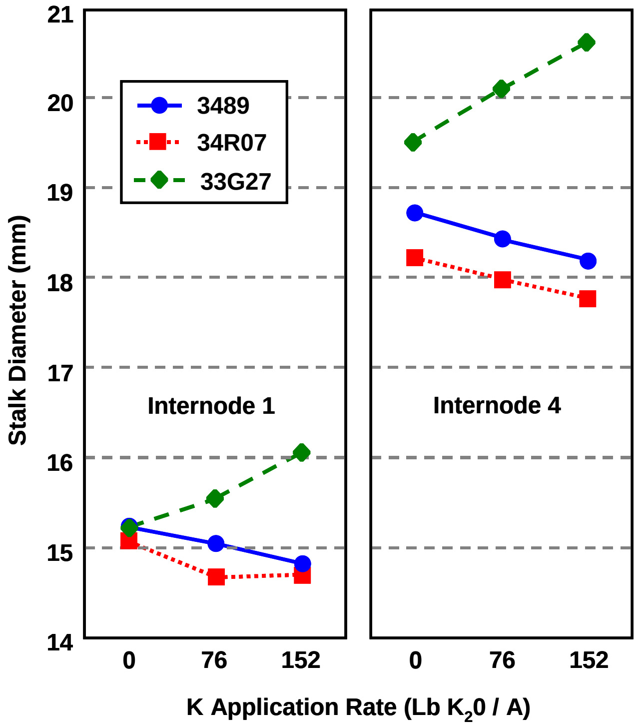
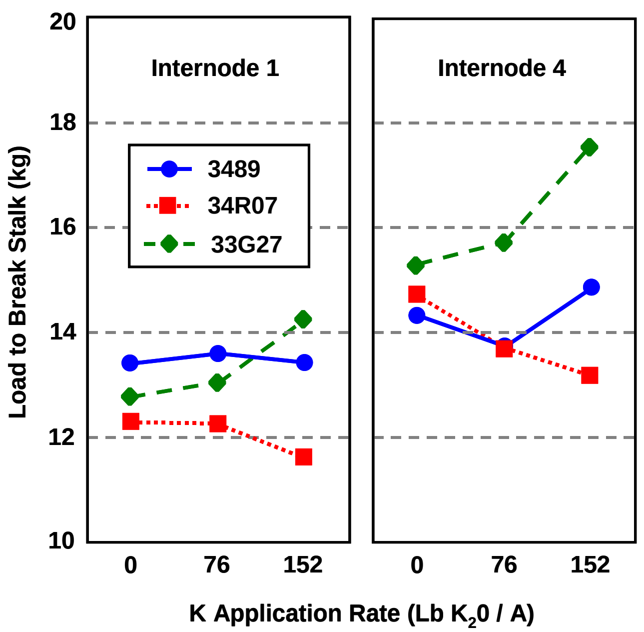


Figure 2b. Influence of potassium application rate on the stalk breaking strength of three corn hybrids.



Can stalk strength be managed through adjusting plant population and fertilizer rates?

Yes. Interactions of soil fertility, plant density, and fertilizer rate caused significant differences in plant dry matter partitioning at three sites in 2003. This affected corn stalks and traits that determine resistance to breakage measured in the laboratory.

Fertilizer application and plant density had opposite but not fully compensating effects on stalk strength. At both maturity and harvest, stalk density and, therefore, stalk strength increased in the order:

Normal fertility-high density < normal fertility-normal density = high fertility-high density < high fertility-normal density (data not presented).

Stalk moisture at maturity was not related to management, but at harvest, it increased with higher fertilizer rates or lower plant density. Interactions between plant density and nutrients provide excellent management opportunities, particularly at high plant density. In general, increasing plant density to levels in the 32 to 37,000 plants/A range causes thinner stalks that dry down faster from maturity to harvest and, therefore, are more prone to lodging at a very late stage. Providing additional plant nutrients, particularly N and K, partially compensates for this loss in stalk strength and <u>helps sustain strong stalks all the way to harvest</u>.

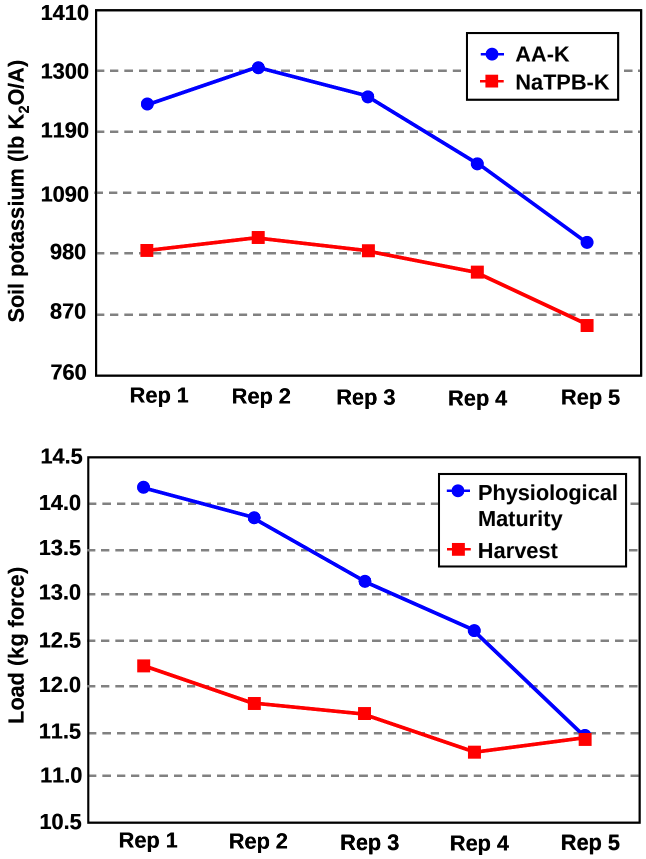
Does potassium application increase stalk strength and reduce lodging risk?

This question cannot be fully answered because response to potassium was confounded by spatial variability in soil K (2000 and 2001). However, there is evidence that K application may reduce the potential for lodging occurring after maturity by increasing stalk strength in certain hybrids. In 2000, stalk characteristics such as moisture content, diameter, stalk density and load to break increased with increasing K rate in 33G27, but not in 3489 or 34R07 (Figure 2). In 2001, K application increased stalk moisture content at harvest in four out of six hybrids tested (data not presented). Providing sufficient soil or fertilizer K is important for stalk strength because it slows down stalk drydown after maturity. This helps stalks sustain greater elasticity and strength until harvest.

Does stalk strength vary with changes in soil fertility in a field?

Yes. Strong relationships occurred between landscape position (soil type/soil fertility status) and stalk strength in the sloping field at Pierce, NE (Figure 3). On poorer (sandy) soil, stalks were thin and more brittle and they dried down much faster between maturity and harvest, causing significantly lower stalk strength and increased lodging risk.

Figure 3. Spatial variation in soil potassium levels and stalk breaking strength along the field slope at Pierce, NE. Elevation increased in the direction from Rep 1 (toeslope, more fertile loamy sand) to Rep 5 (hilltop position, very poor sand). AA-K and NaTPB-K refer to ammonium acetate and sodium tetraphenyl borate extractable K.



Such variations could be manageable to some degree through site-specific hybrid planting and variable-rate fertilizer application. Spatial variability in soil moisture and nutrient (N, K) supply has strong influence on stalk strength.

Is soil test potassium a useful index for identifying sites with potentially low corn stalk strength?

Yes, but this also depends on the distribution of available K in the soil profile. On the sandy soil at Pierce, NE (2000-2001), correlations between soil test K and grain yield, dry matter, K uptake, and stalk strength increased with increasing sampling depth. Correlations also increased when extraction methods that accounted for both exchangeable (AA-K) and readily avail-able non-exchangeable K fractions were used (NaTPB-K). This was because topsoil levels of exchangeable K were low and subsoil K contributed much to plant K uptake.

[1] The Pioneer Crop Management Research Awards **(CMRA)** Program provides funds for agronomic and precision farming studies by university and USDA cooperators throughout North America. The awards normally extend for three years and address crop management information needs of Pioneer agronomists, sales professionals and customers.