# Nutrient Concentrations and Balance in Corn Tissue

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**Introduction -** Tissue testing is a well-established science that has a growing data base. Interpretation of tissue testing results is based on and referenced to historical results (chemical concentrations) from studies where crops were considered to have an adequate supply of all nutrients. Information about weather (temperature and water) and soils (pH, CEC, etc.) is lost when tissue concentration data are extracted from the various reports. Compiled reference concentrations for a given nutrient and crop results in a range of adequacy values that are typically based on relative yield for a given study. For example, tissue concentrations that result in 95-100% of maximum yield are typically considered "***sufficient***" or adequate, yields that are 80-95% of maximum yield are considered "***low***", and yields that are <80% of maximum are considered "***deficient***". Nutrient concentrations that are considerably greater than the "***sufficient***" range are considered "***high***" and could be toxic or result in other problems because of nutrient interactions within plants.

The focus of this research was to begin assessing if and how tissue concentrations in modern high-yielding corn hybrids might have changed over time and if existing reference concentrations are still appropriate. More specifically, how do sufficiency-ranges change with growth stage, hybrid, and geographical location (basically origin of topsoil)?

**Methods -** Irrigated corn hybrid demonstration plots at Shelton and York, Nebraska were used in the second year of this study. The Shelton study (14 hybrids) was managed by a local Pioneer HiBred representative and the York study (16 hybrids) was managed by Pioneer staff at the York Research Station. Three additional Pioneer studies at York, NE (irrigated) and Johnston, IA and Bloomington, IL (both rainfed) involved two hybrids that were fertilized at five N rates (0, 50%, 70%, 100%, and 130% of recommended). Studies in Iowa and Illinois involved four replications.

All plots were sampled at silking (VT growth stage) by removing the ear leaf from 12 representative leaves. Samples were dried and ground before sending to A&L Great Plains Lab for analyses

**Results -** Even though there was considerable variability in nutrient concentrations across hybrids at Shelton (i.e., B, Mn, and Cu), Mg was the only nutrient found to be potentially low (mean 0.14%, range 0.12 to 0.20%) at VT with a CV of 16% across hybrids. Ear-leaf Mg concentrations across hybrids at York also had a CV of 16%, but none of the samples were deemed deficient according to industry guidelines (equal to or greater than 0.13%). Figure 1 illustrates the variability in ear-leaf Mg concentrations at the Shelton location. Even though some of the ear-leaf Mg concentrations were considered to be "low", the average yield was 259 bu/A (range from 241 to 279 bu/A) and yield was poorly correlated with Mg concentration ($r^2$ = 0.19).

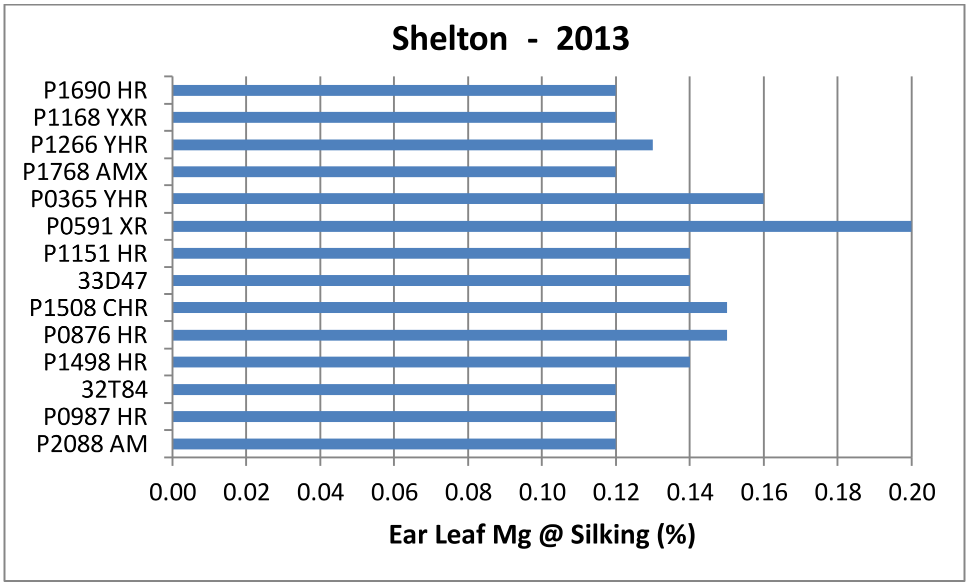


Figure 1. Ear-leaf Mg concentrations for fourteen corn hybrids at Shelton, NE in 2013. Values between 0.9 and 0.13% are considered "low".

The remainder of the 2013 study followed up on observations made in 2012 at York, NE showed an apparent increase in micro-nutrient concentrations with an increase in ear-leaf N concentrations. Five fertilizer N rates at three locations were used in 2013 to create a range in soil N availability for two Pioneer brand hybrids (P33D53 and P1498). The Nebraska location was under sprinkler irrigation while the Iowa and Illinois locations were both rainfed. Yields increased with ear-leaf N concentration (N-rate) as expected.

The yields ranged from 39 to 196 bu/A across these three locations for P33D53 (Figure 2) and from 44 to 190 bu/A for P1498 (Figure 3). Data in Figures 2 and 3 illustrate that not only did N rate affect yield, but so did the apparent availability of water. Seasonal rainfall amounts are not available for the Iowa and Illinois locations. It should be noted that the commonly accepted sufficiency-level for ear-leaf N concentration at silking is 2.75%. Water deficit had a strong influence on ear-leaf N concentration in Iowa and Illinois even though the highest fertilizer N rate was 30% higher than recommended for maximum yield at these locations. Also note that the zero-N rate treatment under irrigation in Nebraska yielded 68 and 84% of the maximum yield for P33D53 and P1498, respectively. Hybrid P1498 is an AquaMax hybrid that typically performs quite well under limited water conditions. This characteristic is commonly attributed to a more extensive rooting system. Data in Figure 3 indicate that the rooting system of P1498 was also more effective in extracting N from soil than P33D53 (Figure 2).

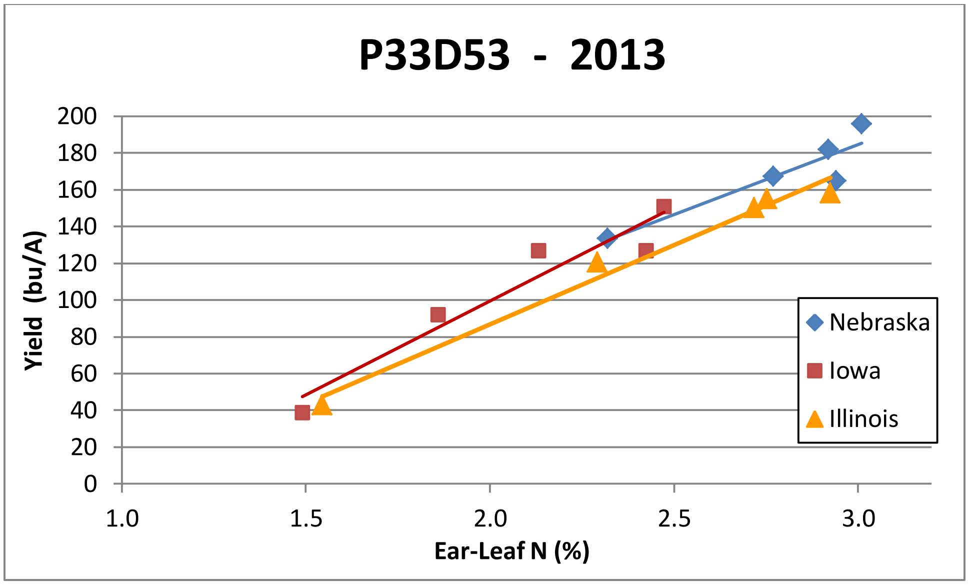


Figure 2. Effect of ear-leaf N concentration at silking on corn yield for P33D53 at three locations in 2013.

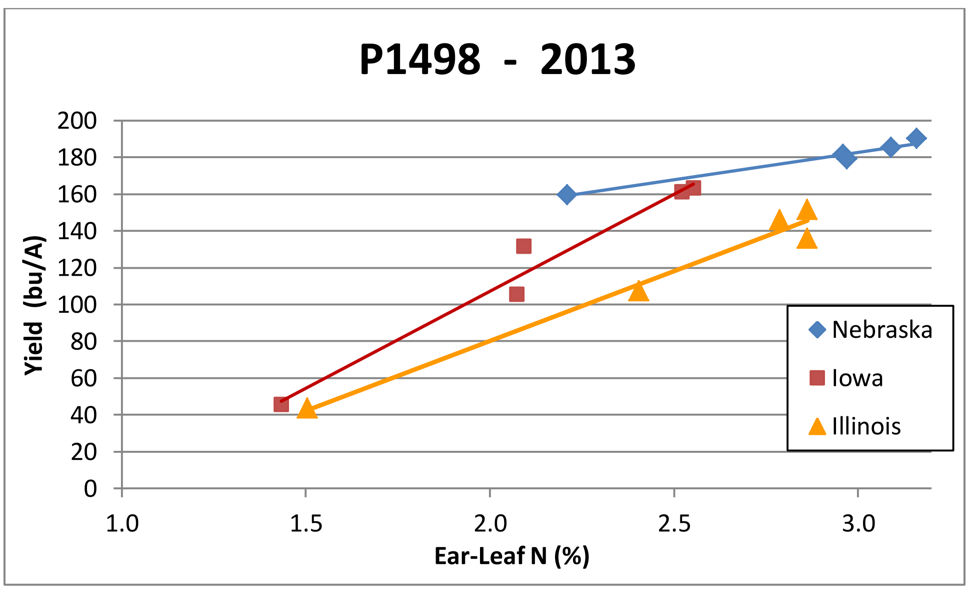


Figure 3. Effect of ear-leaf N concentration at silking on corn yield for P1498 at three locations in 2013.

The effect of ear-leaf N concentration on nutrient concentrations is illustrated in Figures 4, 5, and 6. Data from Iowa are used to illustrate these relationships. While the slope of the relationships between ear-leaf N concentration and that of the various nutrient concentrations was unique for each element, the two hybrids performed similarly. The relationships for Iowa were linear in all cases, and generally similar for Illinois. Relationships between ear-leaf N versus P, K, and S were insignificant.

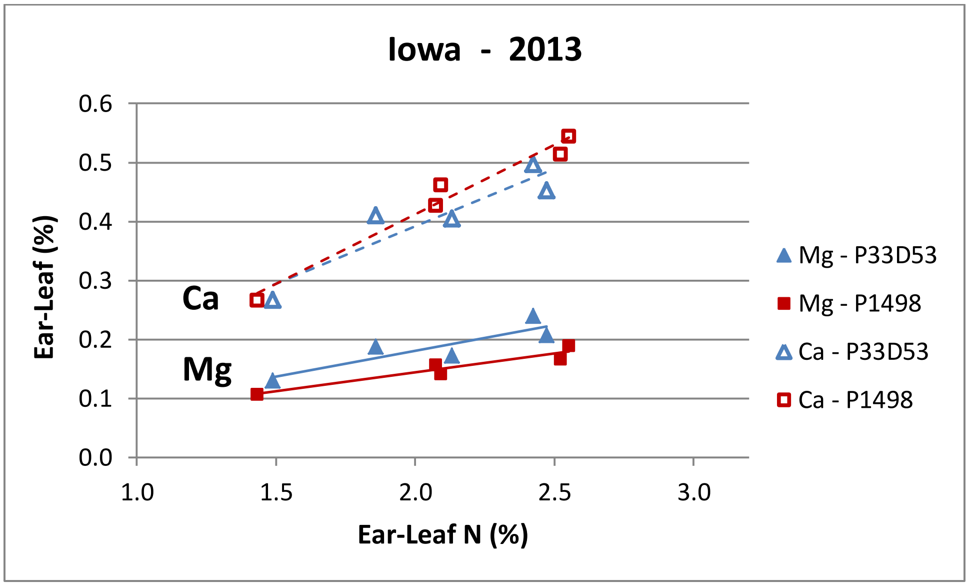


Figure 4. Effect of ear-leaf N concentration on Mg and Ca concentrations at silking for two Pioneer brand hybrids in Iowa in 2013.

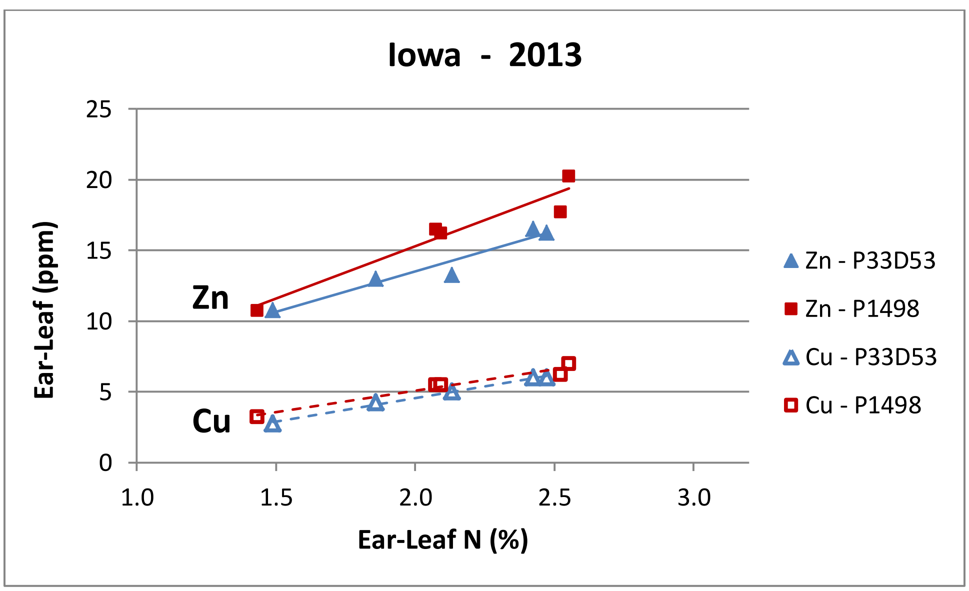


Figure 5. Effect of ear-leaf N concentration on Zn and Cu concentrations at silking for two Pioneer brand hybrids in Iowa in 2013.

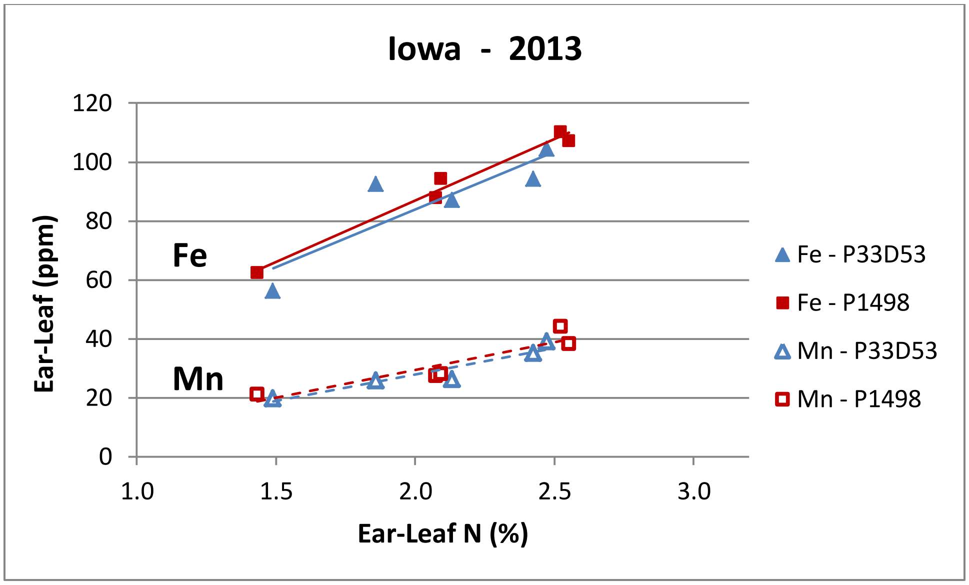


Figure 6. Effect of ear-leaf N concentration on Fe and Mn concentrations at silking for two Pioneer brand hybrids in Iowa in 2013.

The above relationships in Figures 4, 5, and 6 for Iowa compliment the data from the Illinois and Nebraska locations. In general, nutrient concentrations increased as ear-leaf N concentration increased up to the point of N adequacy (i.e., 2.75% N). Figures 7-12 illustrate that nutrient concentrations tended to reach a plateau when ear-leaf N concentrations exceeded 2.75% N. Perhaps these plateau concentrations could serve as reference values when using the DRIS approach for assessing nutrient adequacy.

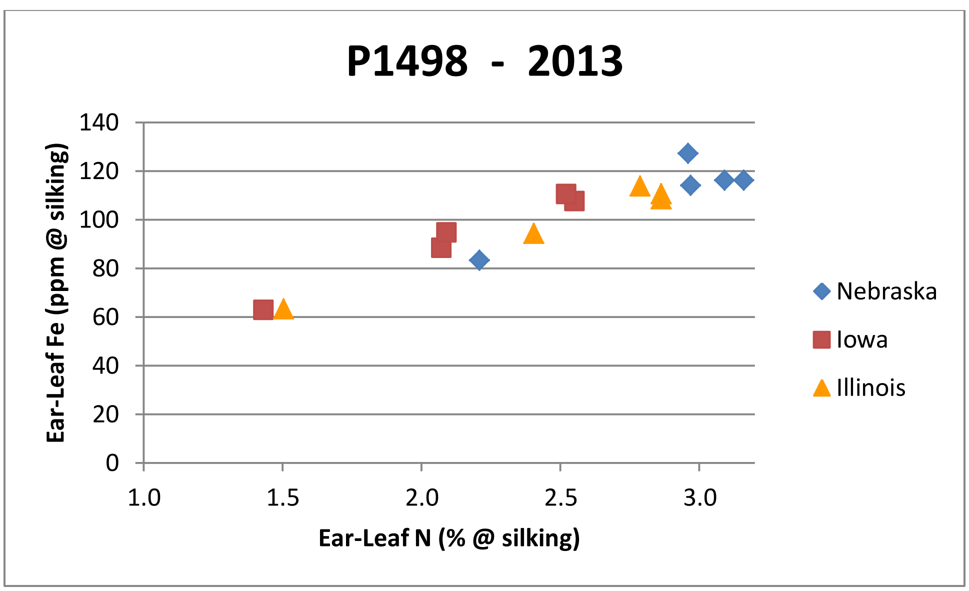


Figure 7. Effect of ear-leaf N concentration on Fe concentration at silking for P1498 at three sites in 2013.

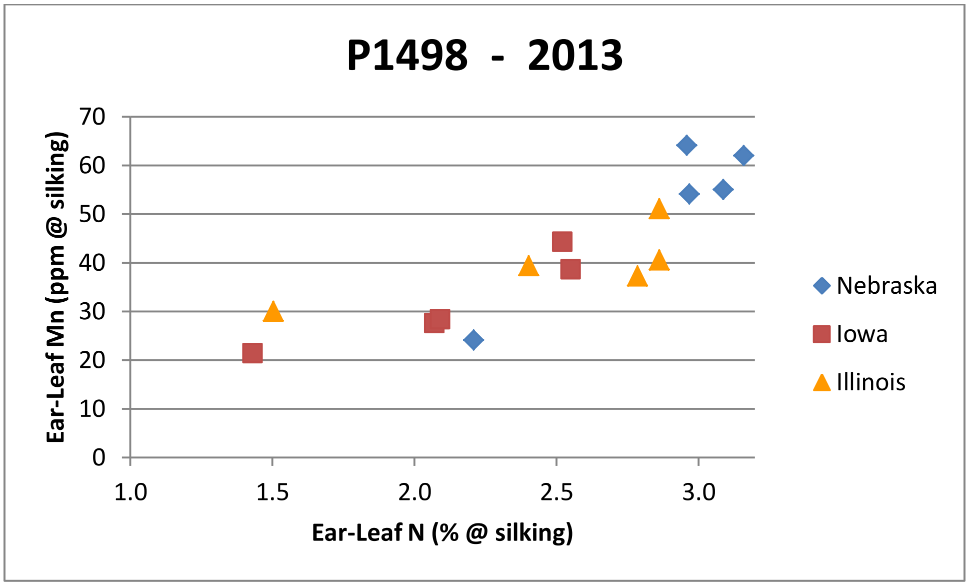


Figure 8. Effect of ear-leaf N concentration on Mn concentration at silking for P1498 at three sites in 2013.

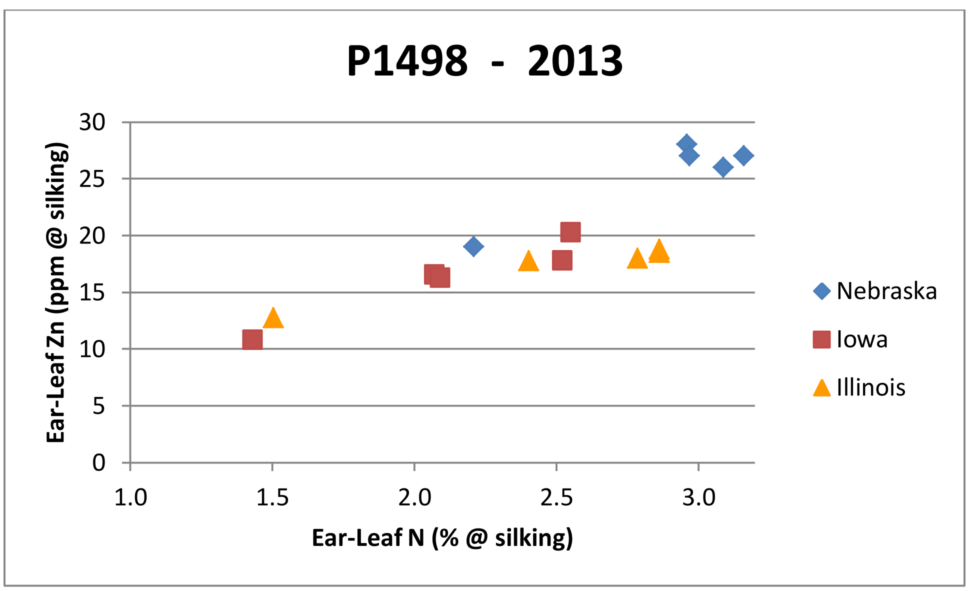


Figure 9. Effect of ear-leaf N concentration on Zn concentration at silking for P1498 at three sites in 2013.

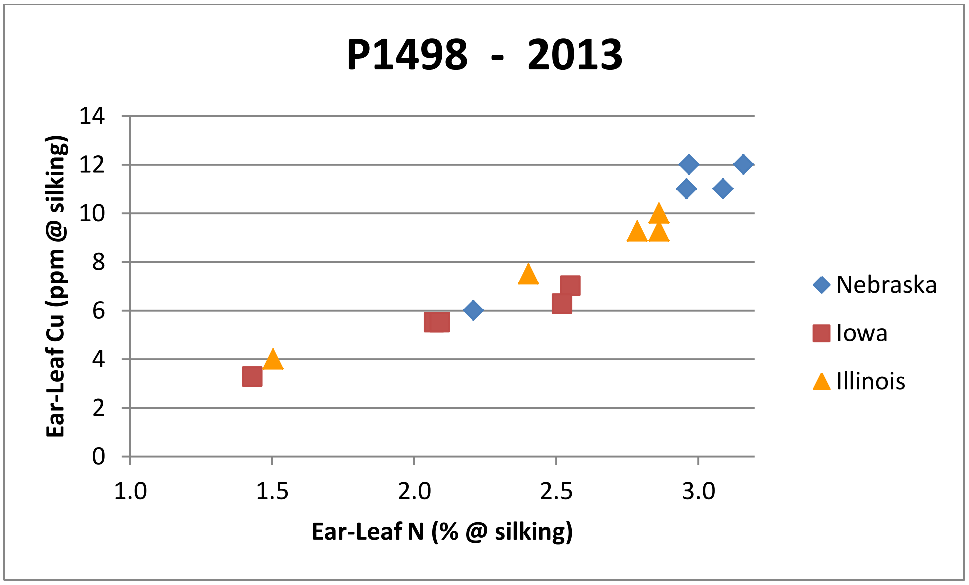


Figure 10. Effect of ear-leaf N concentration on Cu concentration at silking for P1498 at three sites in 2013.

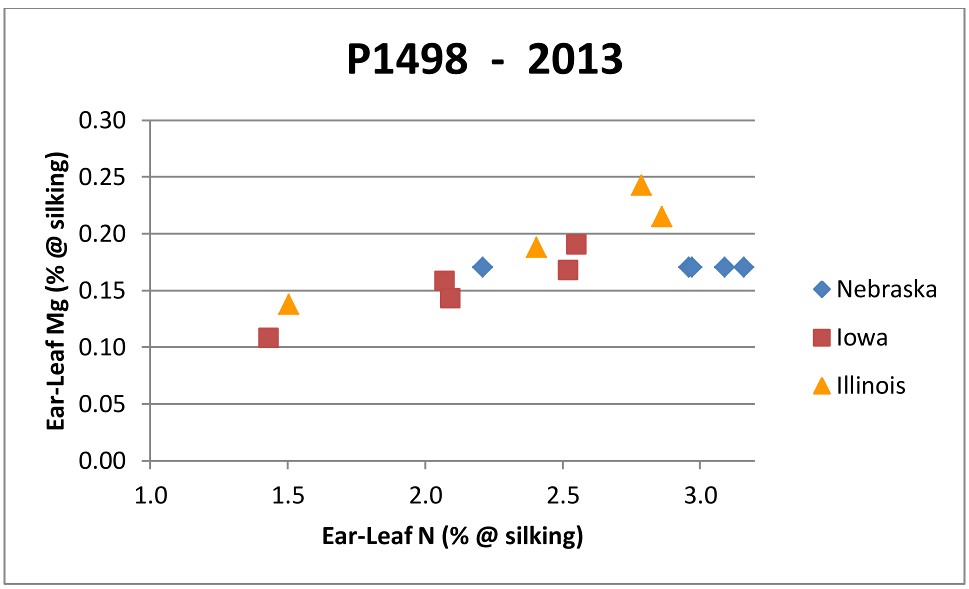


Figure 11. Effect of ear-leaf N concentration on Mg concentration at silking for P1498 at three sites in 2013.

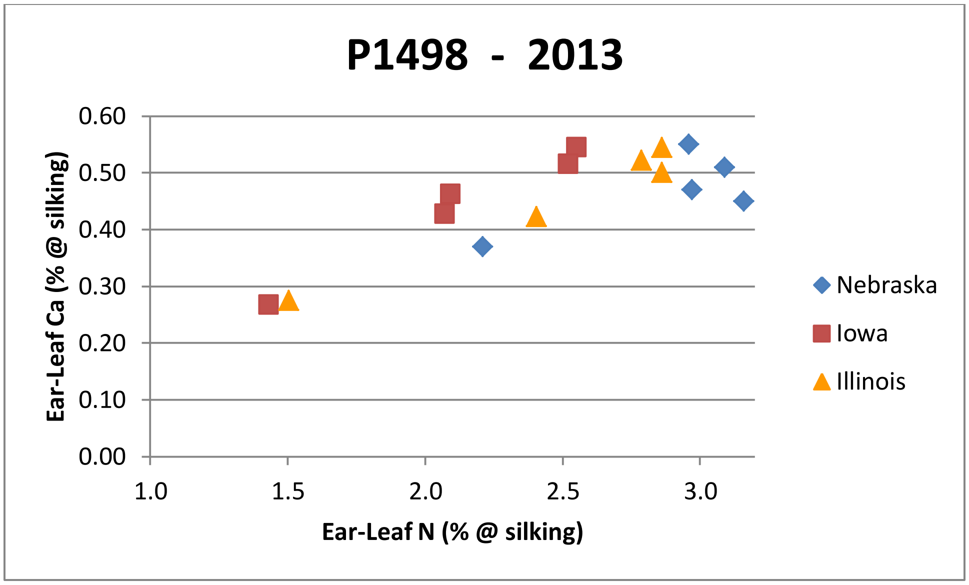


Figure 12. Effect of ear-leaf N concentration on Ca concentration at silking for P1498 at three sites in 2013.

One might be tempted to conclude that increasing fertilizer N rates should increase yields because it increases the concentrations of others nutrients. In fact, one might also conclude that a little extra N fertilizer (approaching the 130% N rate) might even compensate for small deficiencies in other nutrients. This conclusion is probably erroneous because when N ions (nitrate or ammonium) are taken up, plants must also take up a companion ion with the opposite net charge.

**Conclusions** - The second year of this study funded by the Fluid Fertilizer Foundation confirmed preliminary observations made in 2012. The take-home lesson might be that when evaluating tissue testing data, make sure the ear-leaf N concentrations are adequate before drawing conclusions about the adequacy of other nutrients.

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