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. Compiling 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 - Corn hybrid demonstration plots were selected for this preliminary study because in all likelihood the fields would be considered to have adequate levels of all nutrients and would be well managed. Secondly, fields or study areas would have been planted in randomized strips that are at least four-rows wide with uniform nutrient applications. Such demonstration plots are typically not replicated at a given location but are replicated many times within a region or state.

Three study sites were made available for sampling. Each of these locations contained predominantly Pioneer brand corn hybrids (14 to 25 hybrids at each location). At the Shelton location the plants were sampled at the V3-4, V8, and VT growth stages, while at the other sites they were sampled at only the VT growth stage or a few days later. Only the Shelton and York locations were irrigated. The York location included a study where two hybrids had been growing on plots that had received 0, 50, 70, 100, and 130% of the recommended N fertilizer rate for the past 7 years.

All plant tissue samples were dried and ground before submitting to Ward Laboratories for analyses.

Results - Only selected analyses will be included in this report in that additional years of data are needed to confirm the observations. In terms of changes in nutrient concentration over time, the entire corn plants (V3-4), uppermost expanded leaves (V8), or the ear leaf (VT) were sampled. The average concentration across hybrids decreased over time as the plant growth rate increased. Even though there was considerable variability in concentrations of some nutrients (Zn, Fe and Cu), Mg was the only nutrient found to be potentially deficient at VT with a CV of 18% across hybrids. Figure 1 illustrates that Mg concentration in corn ear leaves varied considerably more in a relative sense than N concentration (CV of 18% for Mg versus 5% for N) at the VT growth stage (Fig. 1).

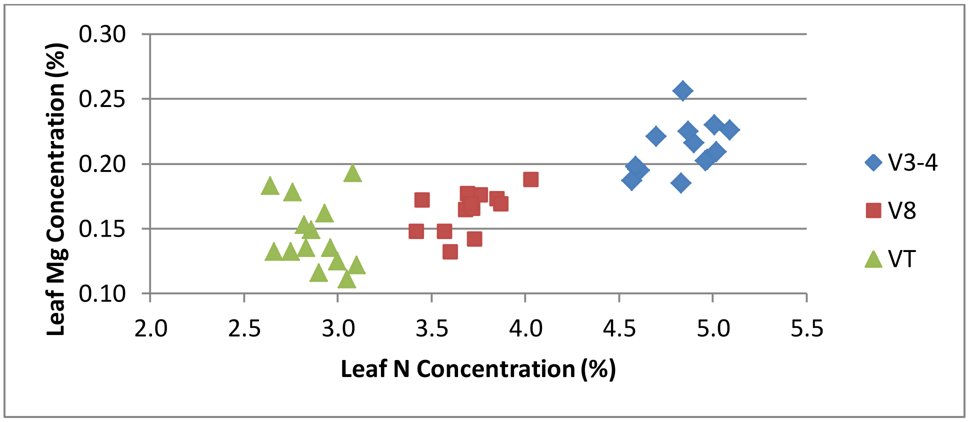

Figure 1. Tissue N and Mg concentrations for fourteen corn hybrids for three growth stages at Shelton, NE in 2012.

The major differences in nutrient concentrations at VT across locations related to Mn and Mg. The ear-leaf Mn concentrations were generally the highest at Lincoln and the lowest at York (Figure 2). This trend is attributed to differences in soil mineralogy between locations.

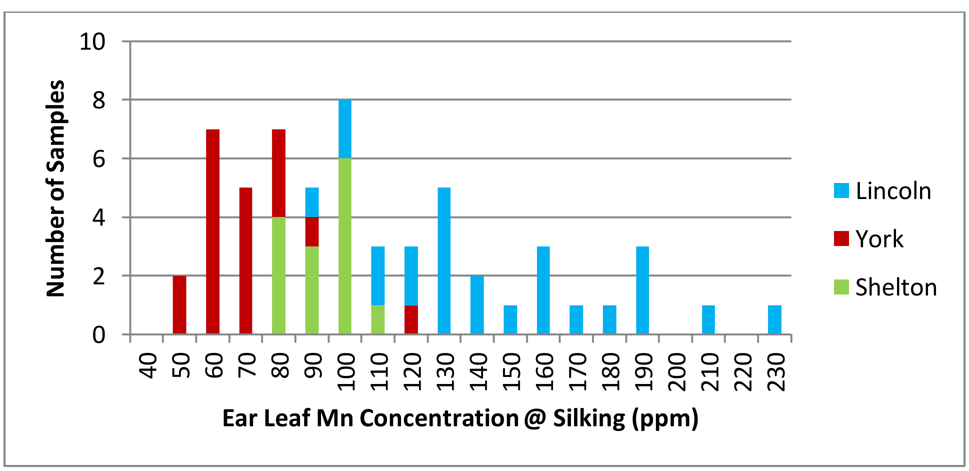

Figure 2. Differences in ear-leaf Mn concentrations at VT for a variety of corn hybrids at Lincoln (n=25), York (n=19) and Shelton (n=14).

In the case of ear-leaf Mg concentrations, the highest values were obtained at the Lincoln location and the lowest at Shelton. Ten of the fourteen hybrids at Shelton were considered to be Mg deficient. Yet, yields at Shelton ranged from 229 to 294 bu/acre, which were quite good considering the hot weather experienced during the 2012 growing season. This raises the question as to whether the "sufficiency" criteria for Mg that are used to evaluate tissue concentrations are appropriate. It should be noted that the Shelton site is irrigated with water that is quite "hard". Perhaps the apparent low Mg concentrations were because of high crop demand. Another possibility is that the Ca concentration in soil dominated over Mg uptake and thereby influenced the tissue concentrations (0.46% for Ca compared to 0.14% for Mg). The Ca versus Mg concentration relationship in ear leaves was not significant (positive relationship with $r^2 = 0.23$). The relationship between ear leaf Mg concentration and yield was not significant ($r^2 = 0.006$), but perhaps worth pursuing in conjunction with other nutrients.

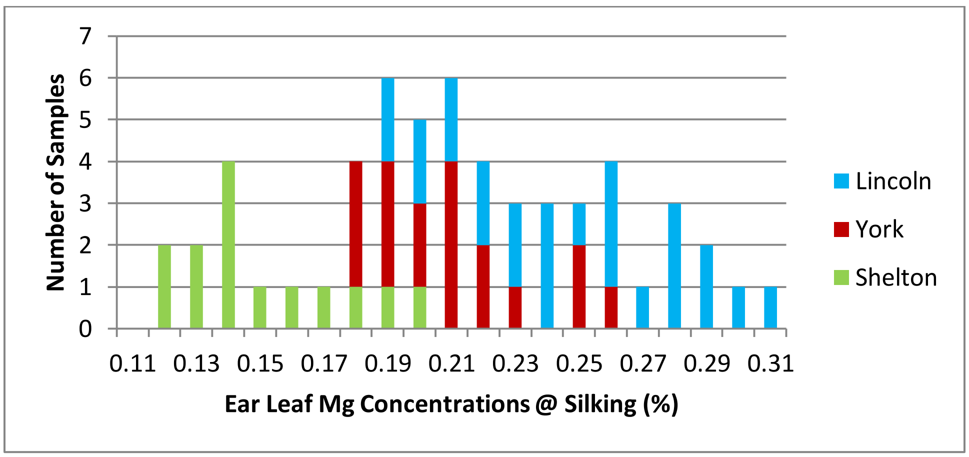

Figure 3. Differences in ear-leaf Mg concentrations at VT for a variety of corn hybrids at Lincoln (n=25), York (n=19) and Shelton (n=14).

The most interesting nutrient uptake results were obtained from the N rate study at York. Both hybrids (termed left and right) had similar results in terms of nutrient concentrations in most cases. First, it should be noted that N fertilizer application rates only establish a range in plant N uptake that is not likely to be proportional to the rates applied. The most obvious observation was that as leaf N concentration increased, so did the concentrations of most nutrients. In the case of N, its leaf concentration peaked out at the 100% N rate (Figure 4). This indicates the appropriateness of the fertilization strategy. The leaf K concentration peaked out at about the 70% N rate while the leaf P concentration was virtually unaffected by N fertilizer rate (Figure 4). In contrast, ear-leaf Zn concentration increased nearly linearly with fertilizer N rate (Figure 5). The effect of fertilizer N rate on ear-leaf Fe concentration was not all that obvious using the scale in Figure 5.

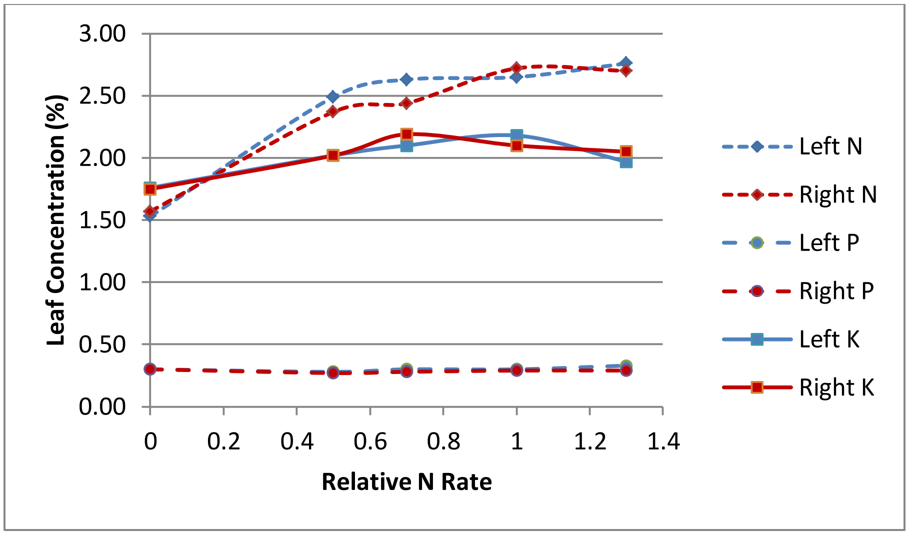

Figure 4. Ear-leaf N, P and K concentrations at silking for two corn hybrids (left and right) fertilized at 0, 50, 70, 100 and 130% of the recommended N rate for plots receiving the same treatments for seven years.

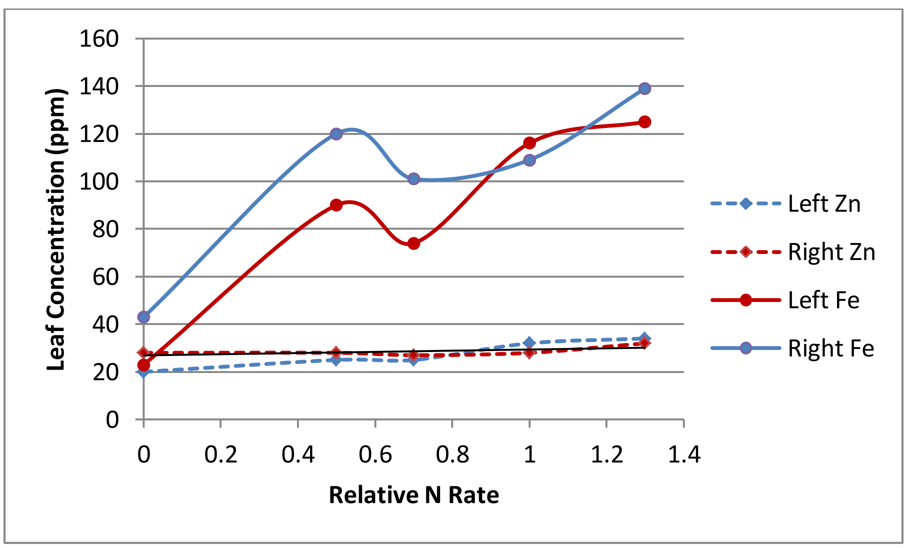

Figure 5. Ear-leaf Zn and concentrations versus leaf N concentration at silking for two corn hybrids (left and right) fertilized at 0, 50, 70, 100 and 130% of the recommended N rate for plots receiving the same treatments for seven years.

Rather than evaluating the uptake of micro-nutrients as a function of N fertilizer rate the relationships were developed using leaf N concentration data. In the case of Fe, Mn and Cu there was a general increase in concentrations with leaf N concentration (Figure 6). The slope of these relationships was largely determined by the concentrations at the lowest fertilizer N rate. The 50% N rate resulted in the greatest increase in the concentrations of all nutrients except for P and Mg.

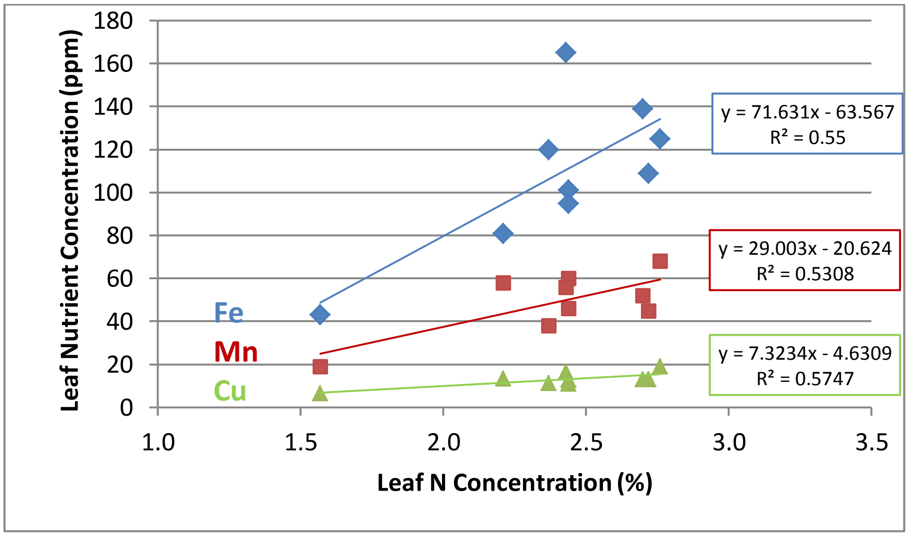

Figure 6. Ear-leaf Fe, Mn and Cu concentrations versus leaf N concentration at silking for two corn hybrids (left and right) fertilized at 0, 50, 70, 100 and 130% of the recommended N rate for plots receiving the same treatments for seven years.

One might be tempted to conclude that increasing fertilizer N rates should increase yields because it increases the concentrations of micro-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, it must also take up a companion ion with the opposite net charge.

Conclusions - This study does not yet merit very many conclusions because the samples were not collected from replicated plots. However, observations across hybrids indicated that the location of a study can influence soil properties that in turn affect nutrient uptake and tissue concentrations. More data are needed over a range of documented growing conditions to determine the appropriateness of existing tissue sufficiency levels.

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