TISSUE TESTING FOR FIELD CROPS REQUIRES CAUTIOUS USE AND INTERPRETATION

Antonio Mallarino, Professor, Department of Agronomy, Iowa State University
John Sawyer, Professor, Department of Agronomy, Iowa State University

In-season plant tissue testing can be useful in diagnosing nutrient deficiencies in field crops, but it must be used with caution. Extra care is needed this year given the unusual crop planting and growing conditions.

Iowa State University (ISU) Extension and Outreach has research-based interpretations for in-season tissue testing only for phosphorus (P) and potassium (K) in corn and soybean, and for sulfur (S) in alfalfa. Interpretations and guidelines for using the end-of-season cornstalk nitrate test are in ISU Extension and Outreach publication CROP 3154. There are no interpretations for other nutrients or crops due to lack of research, infrequent deficiency that precludes meaningful test calibration, or research results show tissue testing is an unreliable diagnostic tool.

As is the case for soil testing, use of tissue testing as a reliable diagnostic tool requires field research to correlate nutrient concentrations with crop yield response. Establishing reliable tissue test interpretations is even more difficult than for soil testing, however, because tissue nutrient concentrations vary greatly with the crop growth stage and the plant part sampled, and may also vary across hybrids or varieties and growing conditions. For example, effects of drought or plant diseases on plant growth and nutrient uptake often result in tissue nutrient concentration (increase) or dilution (decrease) in tested plant material.

Tissue Testing for Phosphorus and Potassium in Corn and Soybean

Last year the new ISU Extension and Outreach publication CROP 3153 "Phosphorus and Potassium Tissue Testing in Corn and Soybean" provided the first-ever ISU sampling and interpretation guidelines for using tissue testing for P and K in corn and soybean. As both crop yields and interest in tissue testing have increased in recent years, extensive field research was conducted during the last decade to determine the value of tissue testing for these nutrients. Publication CROP 3153 provides sampling guidelines and interpretations for an early-season test and a mid-season test, as well as research results used to establish the guidelines.

For the early season test, sample the entire aboveground corn or soybean plant by cutting plants one inch from ground level at the V5-V6 growth stage. For the mid-season test in corn, sample the blade portion of the leaf opposite and below the primary ear at the R1 (silking) growth stage. For the mid-season test in soybean, sample the three top trifoliate leaves with leaflet borders not touching (including the trifoliate leaf petioles) at the R2-R3 stage growth stage. To ensure the tests results represent the collection area, each sample should be a composite from at least ten corn or soybean plants. That is, ten plants at the V5-V6 stage, ten corn ear-leaf blades at the R1 stage, or three trifoliate soybean leaves from ten plants at the R2-R3 stage.

Tissue test interpretations in Table 1 are from publication CROP 3153. Test results in the Low category indicate likely P or K deficiency, whereas test results in the High category indicate a high probability of P or K supply beyond amounts needed to maximize yield. A test result in the High category does not indicate nutrient supply that reduces yield, since fertilization did not cause yield decreases even for the highest observed concentrations.

Table 1. Interpretation categories of P and K tissue tests for corn and soybean based on two growth stages and plant parts.

Nutrient	Crop	Stage	Plant Part	Low	Sufficient	High
				--- Nutrient Concentration (%) ---		
Phosphorus	Corn	V5-V6	Plant†	< 0.48	0.48-0.58	≥ 0.59
		R1	Ear leaves‡	< 0.25	0.25-0.32	≥ 0.33
	Soybean	V5-V6	Plant†	< 0.33	0.33-0.41	≥ 0.42
		R2-R3	Trifoliate leaves§	< 0.35	0.35-0.42	≥ 0.43
Potassium	Corn	V5-V6	Plant†	< 2.5	2.5-3.8	≥ 3.9
		R1	Ear leaves§	< 1.4	1.4-2.0	≥ 2.1
	Soybean	V5-V6	Plant†	< 1.9	1.9-2.7	> 2.8
		R2-R3	Trifoliate leaves§	< 1.8	1.8-2.5	> 2.6

† Cut one inch from ground level.
‡ Blade of the leaf opposite and below the primary ear.
§ Top three trifoliate leaves with untouching leaflet border per plant including petioles.

Tissue Testing for Sulfur in Alfalfa

Publication CROP 3072 "Sulfur Management for Iowa Crop Production" provides guidelines for S management in corn, soybean, and alfalfa as well as interpretations for using S tissue testing in alfalfa. Extensive Iowa research during the last decade showed that tissue testing for S is not a reliable diagnostic tool in corn and soybean, but it is a useful tool in alfalfa. In fact, S tissue testing for alfalfa is recommended whereas S soil testing is not.

As with other nutrients or crops, the S tissue test for alfalfa was calibrated for a specific growth stage and plant part. Sample the top six inches of alfalfa plants at the bud stage before harvest including stem, leaves, and any buds or flowers. To represent an area reliably, each sample should be a composite of at least 15 plants. An S concentration of 0.22-0.25 percent indicates adequate S levels and unlikely alfalfa response to applied S. Lower S concentrations indicate a high probability of response to S application. Higher test results indicate an S supply higher than needed to maximize alfalfa dry matter yield, but the research has not shown yield reductions for these higher levels.

Tissue Testing for Micronutrients in Corn and Soybean

In spite of extensive field research in Iowa for decades, no tissue test interpretations for micronutrients in corn or soybean has been possible due to usually adequate soil supply and very infrequent or lack of yield response to fertilization in trials across the state. This was also the case in numerous trials with both crops conducted as recently as 2012 to 2015. In corn, there was no yield increase at any of 47 trials from boron, manganese, zinc or their mixture when applied to the soil or foliage (copper was applied in ten trials). Only very few and isolated corn zinc deficiencies have been reliably documented in Iowa and neighboring areas of surrounding states. In soybean, there was one yield increase and one yield decrease in 63 trials from boron, copper, manganese, or zinc or their mixture when applied to the soil or foliage (copper was applied in 46 trials). Soybean response to iron was not evaluated because although deficiency chlorosis is common in calcareous (high pH) soils, reported yield responses to iron fertilization in Iowa and the region have been infrequent and small.

The lack of yield response and the observed tissue test results strongly suggest that that "sufficiency ranges" for tissue tests published elsewhere are too high for most micronutrients and would encourage unneeded fertilization in many fields. Therefore, the only ISU Extension and Outreach guidelines for micronutrients are for zinc in corn and sorghum, and include only soil-test interpretation (see publication PM 1688, A General Guide for Crop Nutrient and Limestone Recommendations in Iowa).

Use Tissue Testing Wisely

- Tissue testing for P and K in corn and soybean can be useful but does not substitute for recommended soil testing and interpretations in making fertilization decisions.
- Tissue testing for S is useful in alfalfa managed for hay but is not reliable to diagnose S status in corn and soybean.
- Sample the plant parts at the growth stage that research used to develop interpretations.
- No reliable tissue test interpretations for micronutrients could be developed due to infrequent deficiency and yield response. Research suggests that most interpretations used elsewhere recommend unnecessary fertilization in many Iowa fields.
- A potentially useful approach for tissue testing is when there are areas within a field that look normal and areas with poor growth or symptoms that could be related to nutrient supply. In such situations, collect and analyze both soil and plant tissue from normal and poor areas and compare results to previous information. Use of tissue testing alone can be misleading because stress caused by drought, excess moisture, pests or diseases, or severe deficiency of other nutrients can influence plant growth and nutrient uptake, nutrient concentrations, and thus result incorrect interpretations.

Additional Online Resources

- Iowa State University Soil Fertility website
- Micronutrients for Soybean Production in the North Central Region
- Nutrient Deficiencies and Application Injuries in Field Crops