TROUBLESHOOTING FIELDS USING PLANT ANALYSIS

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Introduction

Plant analysis can be a useful tool for troubleshooting plant nutrition related crop production problems during the growing season. From a troubleshooting standpoint, plant analysis can confirm visual symptomology of nutrient deficiencies or toxicities, reveal early stages of nutrient deficiencies, and determine the availability of nutrients for which a reliable soil test does not exist or soil test calibration has not been completed. Plant analysis can also be used to assess a crop's response to applied nutrients, particularly where different treatments may have been applied in the same field (e.g., strips with and without sulfur addition).

Over the past several years, agronomists have become increasingly interested in using plant analysis to help troubleshoot problem fields or identify slight nutrient deficiencies that might hinder a producer from achieving high yields. This is evidenced by the fact that plant samples submitted to the UW Soil & Plant Analysis Lab doubled each year since 2007 (Table 1). While plant analysis sample submission has increased, the number of soil samples submitted in conjunction with plant samples has remained relatively steady since 2005. An analysis of some of the plant analysis data since 2005 revealed that plant analysis may not be well understood by some agronomists. Therefore, the objective of this paper is to describe the use and limitations of plant analysis for troubleshooting fields.

The Basics of Plant Analysis

As previously stated, plant analysis can detect nutrient deficiencies and assess a crop's response to applied nutrients. However, in order for plant analysis results to be a useful diagnostic tool a few guidelines must be followed.

First, take good notes. When visiting a field, take written notes describing any visual symptomology paying attention to where on the leaf and plant the symptoms occur. For example, yellowing of leaf margins on older leaves, new leaves appear ok. Also note where in the field the symptoms occur and if any pattern is apparent as you look across the landscape. Sketch a map of the affected area noting drainage, topography, soil color, soil texture, and other features that might affect plant growth. Photographs including close-ups and panoramas can be very useful to document how a field looked at a particular point in time. In panoramic photos, try to include a landmark (such as a house, telephone pole, grove of trees, etc.) that will be visible as the crop continues to develop. This can be useful when

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you go back to the field to make sure you are looking at the same areas. If possible, you could leave a flag or other marker or use GPS to mark the boundaries of the abnormal and normal areas.

Table 1. Number of plant samples submitted to the lab in various crop categories along with the number of soil samples submitted to the UW Soil and Plant Analysis Lab from June 1 through August 31 in each year from 2005 through 2009.

	Year				
Crop or Soil	2005	2006	2007	2008	2009
	Number of observations, n				
Alfalfa	23 (5, 18)†	59 (4, 55)	21 (10, 11)	13 (6,7)	47 (20, 27)
Corn	69 (32, 37)	114 (39, 75)	86 (24, 62)	111(37,74)	567 (119, 448)
Soybean	19 (15, 4)	28 (13, 15)	34 (19, 15)	135 (24, 111)	230 (39, 191)
All vegetables	25 (16, 9)	2 (1, 1)	14 (5, 9)	33 (7, 26)	30 (13, 17)
Cranberry	84 (0, 84)	53 (0, 53)	54 (18, 36)	93 (2, 91)	236 (3, 233)
Grape	15 (0,15)	17 (2, 15)	19 (2, 17)	49 (1, 48)	40 (2, 38)
Fruit, other	161 (6, 155)	39 (3, 36)	57 (8, 49)	132 (4, 128)	40 (3, 37)
Other‡	19 (12, 7)	12 (10, 2)	7 (3, 4)	55 (13, 42)	65 (11, 54)
Total Crop	415	324	292	621	1255
Total Soil	275	243	169	287	245

† Total number of samples followed by the number of samples identified as being abnormal and normal in appearance, respectively, in parenthesis where appropriate.
‡ Other includes wheat and other small grains, forage legumes other than alfalfa, tobacco, trees, grasses, and unreported crops.

In addition to assessing the plant's foliage, look at the plant's roots by carefully digging up a plant or two. If the crop is a legume, determine if nodules are present and active (inside of nodule is pink). Also look for signs of soil compaction, which include pancaked roots, overly thickened roots, roots that are gnarled, poor soil structure and/or stunted plant growth. Other information that should be noted include: weather conditions throughout the growing season along with current growing conditions; crop management practices (planting date, hybrid/variety, tillage, pest management, etc.); and field history (crop rotation, manure application, past problems, etc.). All of this information can be helpful in interpreting plant analysis results and making a decision on what can be done to remedy the problem. Sometimes the most challenging diagnostic situations are those where background information is either incomplete or inaccurate.

Second, when troubleshooting a field, obtain plant samples from both abnormal and normal parts of the field AND take soil samples that correspond to these areas. The reason to sample normal and abnormal parts of the field is to compare the results. Nutrient concentrations for a crop may vary somewhat by hybrid/variety, soils, and local growing conditions. Thus, comparing an abnormal sample to a good sample for the same field may be more useful than using sufficiency range interpretation categories alone. Soil samples from the abnormal and normal areas are extremely helpful in assessing if the diagnosed nutrient deficiency is related to low availability of the nutrient in the soil or weather or field conditions that limited nutrient uptake. An example of this is where soil compaction has limited potassium uptake and resulted in potassium deficiency even though the soil test level is optimum throughout both the normal and abnormal areas. This is also an example of why assessing at plant roots and weather conditions are useful. Another example is where plant analysis reveals manganese toxicity and the soil test reveals that the pH is 4.8. Without the soil test, you might assume low pH is a problem but you would not know for certain.

Third, sample the appropriate part of the plant for a given growth stage and collect an adequate number of samples. The concentration of nutrients in plant tissue generally decreases as the crop becomes more mature. Sufficiency ranges and to some extent DRIS indices were developed based on a specific plant part sampled at a specific growth stage.

Sampling the incorrect plant part for a growth stage will lead to inaccurate interpretation of the plant analysis. In addition, a sample should be comprised of tissue taken from an adequate number of plants such that the sample is representative of the area and enough tissue is collected for the lab to analyze. Table 2 outlines the plant parts to sample at each growth stage and the number of plants that should comprise one sample. The growth stages for each crop listed in Table 2 are the only ones for which there is an interpretation of the plant analysis results. If a crop growth stage is not listed in Table 2, then a plant analysis interpretation is not available.

Fourth, place the sample in a paper envelope and send to the laboratory. Placing plant samples in a plastic bag is not acceptable. If soil has splashed onto plant tissue brush it off, but do not wash the leaves, before placing the sample in the bag. Clearly label samples and fill out sample submission forms completely. Failure to fill out a sample submission form completely or accurately can result in incorrect interpretations. Contact your laboratory in advance to obtain more information on how the lab would like samples submitted.

Fifth, review plant and soil analysis results in conjunction with field notes. Ask yourself if the plant analysis interpretations make sense based on your field assessment. If your answer to this is no or you aren’t sure, then contact your local County Extension office and/or soil fertility specialist for assistance.

Table 2. Plant part to sample and number of plants that comprise one sample for crop growth stages that have plant analysis interpretations. From UW Soil & Plant Analysis Lab's plant sample submission form.

Field Crops	Stage of Growth		Plant Part Sampled		Number of Plants
Alfalfa	1	Bud to first flower	A	Top 6 inches	30-40
Alfalfa hay	2	Harvest	B	Whole plant	15-20
Barley	12	Prior to heading	L	Newest fully developed leaf	30-40
Beans, dry lima	8	Prior to or at initial flowering	H	4th petiole and leaflet or 4th petiole only	20-25
Beans, snap	8	Prior to or at initial flowering	H	4th petiole and leaflet or 4th petiole only	20-25
Beans, soy	8	Prior to or at initial flowering	H	4th petiole and leaflet or 4th petiole only	20-25
Birdsfoot trefoil	1	Bud to first flower	A	Top 6 inches	30-40
Brome grass	12	Prior to heading	L	Newest fully developed leaf	30-40
Canary grass	12	Prior to heading	L	Newest fully developed leaf	30-40
Clover, red	1	Bud to first flower	A	Top 6 inches	30-40
Clover, red hay	2	Harvest	B	Whole plant	15-20
Crown vetch	1	Bud to first flower	A	Top 6 inches	30-40
Corn, field	3	12 inches	C	Whole plant	10-15
	4	Pre-tassel	D	Leaf below whorl	15-20
	5	Tassel to silk	E	Ear leaf	15-20
	6	Ensiled/chopped	F	Whole plant	10-15
Corn, sweet	7	Tassel to silk	G	Ear leaf	15-20
Oats	12	Prior to heading	L	Newest fully developed leaf	30-40
Orchard grass	12	Prior to heading	L	Newest fully developed leaf	30-40
Peas, canning	8	Prior to or at initial flowering	H	4th petiole and leaflet or 4th petiole only	20-25
Peas, chick	8	Prior to or at initial flowering	H	4th petiole and leaflet or 4th petiole only	20-25
Potato	9	Prior to or at initial flowering	I	4th petiole and leaflet or 4th petiole only	40-50
	10	Tuber bulking	J	4th petiole and leaflet or 4th petiole only	40-50
Rye	12	Prior to heading	L	Newest fully developed leaf	30-40
Sorghum, grain	13	Prior to heading	M	2nd fully developed leaf	15-20
Sorghum, sudan	14	Prior to heading	N	Newest fully developed leaf	15-20
Triticale	12	Prior to heading	L	Newest fully developed leaf	30-40
Wheat	11	Tillering	K	Newest fully developed leaf	30-40
Wheat	12	Prior to heading	L	Newest fully developed leaf	30-40

Fruits	Stage of Growth		Plant Part Sampled		Number of Plants
Apple	15	Current season's shoots	O	Fully developed leaf at midpoint of new shoots	10-20
Cherry	15	Current season's shoots	O	Fully developed leaf at midpoint of new shoots	10-20
Cranberry	18	Aug 15 to Sept 15	R	Current season's growth above berries	35-50
Raspberry	17	Aug 10 to Sept 4	Q	6th & 12th leaf blade and petiole from trifoliate	10-20
Strawberry	16	At renovation before mowing	P	Fully developed leaflets and petioles	10-20

Vegetables	Stage of Growth		Plant Part Sampled		Number of Plants
Cabbage	22	Midseason	V	Wrapper leaf	10-20
Cauliflower	20	Midseason	T	Youngest mature leaves	10-20
Carrots	20	Midseason	T	Youngest mature leaves	10-20
Celery	20	Midseason	T	Youngest mature leaves	10-20
Ginseng	20	Midseason	T	Youngest mature leaves	10-20
Lettuce	22	Midseason	V	Wrapper leaf	10-20
Onion	19	Midseason	S	Tops, no white	10-20
Pepper	23	Prior to or at early fruit development	W	Petiole and leaflet	10-20
Tomato	21	Midseason	U	Newest fully developed leaf	10-20

Limitations of Plant Analysis

Plant analysis is not without limitations. In fact many of the guidelines in the previous section are based on these limitations. The ability to remediate a nutrient deficiency identified by plant analysis is another limitation. For example, the deficiency may have already caused yield loss; the crop may not respond to additional nutrients at the growth stage tested; the crop may be too large for nutrient application; and/or the weather may be unfavorable for fertilization and/or for crop to benefit. In these situations, plant analysis can be a decision making guide for the next season's crop.

Analyzing plant analysis data from samples submitted to the UW Soil and Plant Analysis Lab from 2005 through 2009 suggests that there are a few areas for improvement in sampling for plant analysis. First, the percentage of plant samples submitted with corresponding soil samples has decreased over the past couple years (Table 1). Second, the percentage of plant samples submitted as normal, as opposed to abnormal, in 2009 was 57%, 79%, and 83% for alfalfa, corn, and soybean, respectively. Without surveying everyone who submitted plant samples, the first two points suggest that agronomists are sampling fields looking for potential problems or sample submission forms were not filled out accurately. When looking for potential problems care must be taken not to over interpret nutrient concentrations that might fall just below the sufficiency range and assessing the bigger picture (economics and temporal/weather patterns effect on nutrient availability) is important in determining if remedial action is required. Third, a large percentage of soybean samples submitted in 2009 were submitted from mid-July thorough late-August. The appropriate sampling time for soybean is prior to or at initial flowering (R1). It is very likely that these soybeans were beyond R1 and thus, the interpretation of the plant analysis would be inaccurate.

Summary

Plant analysis can be a very helpful diagnostic tool when used properly. Thoroughly researching field history and assessing the present problem are just as important as taking samples properly to obtain a correct diagnosis. Failure to follow plant analysis sampling guidelines may result in inaccurate interpretation of results. Plant analysis is not a substitute for a consistent soil sampling program followed by appropriate lime and nutrient applications.

For additional information on plant analysis see:

Kelling, K.A., S.M. Combs, and J.B. Peters. 2000. Sampling for plant analysis. UW Soil and Plant Analysis Lab. http://uwlab.soils.wisc.edu/madison/index.htm?../forms.htm&contents.asp

Kelling, K.A., S.M. Combs, and J.B. Peters. 2000. Using plant analysis as a diagnostic tool. New Horizons in Soil Science. No.6-2000. Dept. of Soil Science, Univ. of Wisconsin-Madison.

Schulte, E.E., K.A. Kelling, J.B. Peters, and S.M. Combs. 2000. Plant analysis interpretations used in the revised Wisconsin program. New Horizons in Soil Science. No.7-2000. Dept. of Soil Science, Univ. of Wisconsin-Madison.