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Sugarcane Plant Nutrient Diagnosis[1]

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Introduction

A consistent soil testing program is a valuable best management practice (BMP) that allows sugarcane growers to make sound economic fertilization decisions. However, soil testing in Florida has two limitations. First, soil tests are either not available or are not calibrated for nitrogen and micronutrients. Second, soil samples are routinely taken only before sugarcane is planted, not in ratoon crops, because of problems in obtaining representative soil samples after banding of fertilizers in the furrow at planting and in later sidedress applications.

Use of leaf nutrient analysis in combination with visual evaluation of malnutrition symptoms can complement a growers soil testing program and add additional information that will improve decisions. Leaf analysis provides a picture of crop nutritional status at the time of sampling, while soil testing provides information about the continued supply of nutrients from the soil. Leaf analysis allows for early detection of nutritional problems and so enables the grower to add supplemental fertilizer to the current year's crop or to adjust next year's fertilizer application. It is also used to help diagnose a nutritional problem in a particular field or localized area of a field where poor growth or other symptoms have been observed. Although specific fertilizer recommendations are not provided for a given leaf nutrient analysis, deficiencies or imbalances indicate where additions or changes in the fertility program are needed. Leaf analysis and knowledge of visual symptoms can be used along with soil-test values and fertilizer and crop records to make improved decisions regarding fertilization.

Leaf Analysis Evaluation Methods

There are two methods for evaluating the nutrient status of sugarcane, the Critical Nutrient Level (CNL) approach and the Diagnosis and Recommendation Integrated System or DRIS. Leaf sampling and preparation procedures are discussed in a companion EDIS publication by Ezenwa et al. (2005) (http://edis.ifas.ufl.edu/SC076).

1. This document is SS-AGR-128, one of a series of the Agronomy Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. Original publication date July 2006. This publication is also a part of the Florida Sugarcane Handbook, an electronic publication of the Agronomy Department. For more information you may contact the editor of the Sugarcane Handbook, R. A. Gilbert (ragilbert@ufl.edu). Visit the EDIS Web Site at http://edis.ifas.ufl.edu.
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The CNL approach defines a nutrient concentration below which the nutrient is considered to limit production. It refers specifically to the concentration of a particular nutrient in a particular plant part at a specific stage of growth at which production losses reach 5 to 10%. For Florida sugarcane, the top visible dewlap (TVD) leaf blade is sampled during the grand growth period of June to August. When using this approach it is particularly important to collect leaf samples at the specified growth stage used for reference standards because nutrient contents change during the crop growth cycle. The CNL approach may also include using a nutrient's optimum range, defined as the range of concentration of a nutrient considered optimum for production. Within this range there should be no deficiency or excess of a given nutrient. Sugarcane leaf nutrient critical values and optimum ranges are given in Table 1.

DRIS calculates indices relative to zero by comparing leaf nutrient ratios with those found in a high-yielding population. In the mid-1980s a DRIS application for Florida sugarcane was developed (Elwali and Gascho, 1983; 1984). DRIS requires a large number of observations of plant tissue nutrient concentrations and associated crop yields which are used to define separate low- and high-yielding populations and are also used to determine nutrient ratio means for the high-yielding population. A calibration formula uses the means and standard deviations of the nutrient ratios to calculate relative indices for individual nutrients that can range from negative to positive and that when equal to zero indicate that the associated nutrient ratios are similar to those of the high-yielding test population. The more negative an index for a given nutrient, the more likely the nutrient is insufficient relative to other nutrients. A positive index indicates the nutrient is present in excess relative to other nutrients. The Nutrient Balance Index (NBI) can be calculated by adding the absolute value of all individual indices together. As the NBI increases, the more out of balance a leaf analysis is considered to be. DRIS incorporates a measure of the balance between nutrients and can indicate problems that are not as obvious with the CNL approach. It also has the advantage of not being as sensitive to the stage of growth as the CNL approach, which allows a wider time frame in which to collect samples. It is important to note that the use of one approach does not exclude the use of the other. DRIS is simply another valuable tool that can be used to examine nutrient balance, and offers additional interpretations beyond the evaluation of leaf nutrient concentrations alone.

Because of the large number of calculations required to determine DRIS indices, a computer program is required. An Excel spreadsheet programmed for sugarcane DRIS calculations is available at the EREC website (http://erec.ifas.ufl.edu/). At the EREC web site homepage, the Sugarcane DRIS Calculator is listed under the heading EREC Extension. Click on the DRIS Calculator and you will have the option of opening or saving the Excel spreadsheet programmed for the calculations. The nutrient concentrations required for the calculations are nitrogen, phosphorus, potassium, calcium, magnesium, iron, manganese, zinc, and copper. Questions about the DRIS spreadsheet can be directed to Mabry McCray (jmmccray@ufl.edu).

A cooperative research effort is being made between IFAS scientists and Florida sugarcane growers to use leaf nutritional analysis to improve growers fertility programs. This includes tests of fertilizer supplements to a current years crop based on DRIS indices of leaf samples taken in the spring. As improvements are made in our ability to use sugarcane leaf nutritional data, updates will be made available in EDIS.

References and Further Reading

Anderson, D. L. and J. E. Bowen. 1990. Sugarcane Nutrition. Potash and Phosphate Institute, Atlanta, GA.

Beaufils, E. R. 1973. Diagnosis and Recommendation Integrated System (DRIS). A general scheme of experimentation based on principles developed from research in plant nutrition. Soil Sci. Bull. 1, Univ. of Natal, Pietermaritzburg, South Africa. 132 pp.

Elwali, A. M. O. and G. J. Gascho. 1983. Sugarcane response to P, K, and DRIS corrective treatments on Florida Histosols. Agron. J. 75: 79-83.

Elwali, A. M. O. and G. J. Gascho. 1984. Soil testing, foliar analysis, and DRIS as guides for sugarcane fertilization. Agron. J. 76: 466-470.

Ezenwa, I. V., J. M. McCray, P. R. Newman, and R. W. Rice. 2005. Sugarcane leaf tissue sample preparation for diagnostic analysis. Florida Cooperative Extension Service Pub. SS-AGR-259. http://edis.ifas.ufl.edu/SC076.

Rice, R. W., R. A. Gilbert, and R. S. Lentini. 2002. Nutritional requirements for Florida sugarcane. Florida Cooperative Extension Service Pub. SS-AGR-228. http://edis.ifas.ufl.edu/SC028.

Samuels, G. 1969. Foliar Diagnosis for Sugarcane. Adams Press, Chicago. 362 pp.

Table 1. Sugarcane leaf nutrient critical values and optimum ranges.

Nutrient	Critical Value	Optimum Range
	%	%
Nitrogen (N)	1.80	2.00-2.60
Phosphorus (P)	0.19	0.22-0.30
Potassium (K)	0.90	1.00-1.60
Calcium (Ca)	0.20	0.20-0.45
Magnesium (Mg)	0.12	0.15-0.32
Sulfur (S)	0.13	0.13-0.18
Silicon (Si)	0.50	>0.70
	mg/kg	mg/kg
Iron (Fe)	-----	50-105
Manganese (Mn)	-----	12-100
Zinc (Zn)	15	16-32
Copper (Cu)	3	4-8
Boron (B)	4	15-20
Molybdenum	0.05	-----

From Anderson and Bowen (1990), except for Si values (J. M. McCray, unpublished data). All values are from Florida except S and Mo, which are from Louisiana.

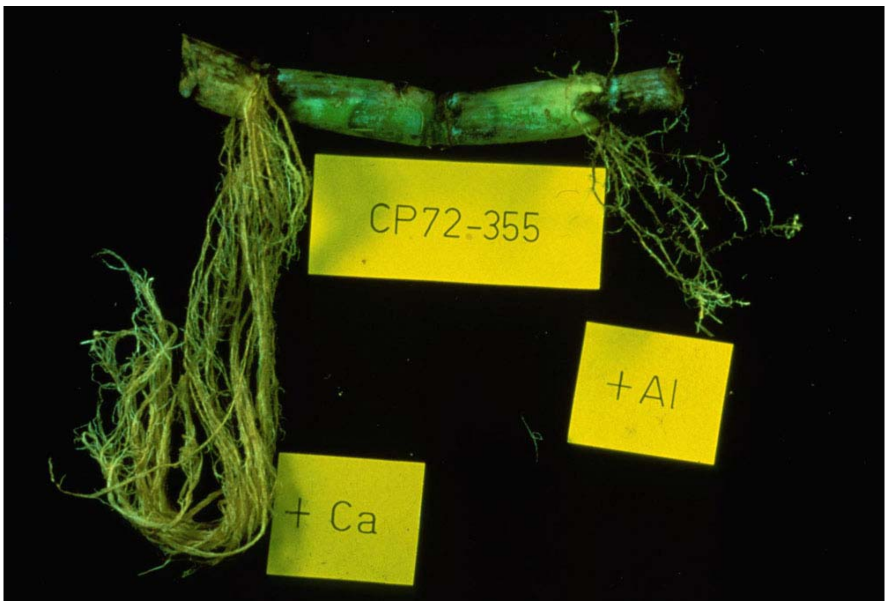
Field Identification of Nutritional Problems

Visual symptoms of nutrient deficiencies and toxicities can often be the first sign that a particular field or location within a field has a nutritional problem. Recognizing these visual symptoms is an important step toward taking corrective action. Further evaluation may be pursued with detailed leaf and soil sampling. The pictures of visual symptoms included in this document are from the publication “Sugarcane Nutrition”, by D. L. Anderson and J. E. Bowen (1990). These photographs are from various researchers from sugarcane growing areas around the world. The elements included are arranged alphabetically.

Aluminum (Al)

CREDITS: D. L. Anderson

Figure 1. Aluminum toxicity does not directly show up on the leaves, but in the root system. Damage to the root system by Al toxicity resembles injury symptoms caused by nematodes. Few lateral roots form and those roots that are present have abnormally thickened tips. Plants become highly susceptible to moisture stress. On acid soils, land-forming operations or erosion can expose acid subsoils. Aluminum toxicity might be found with soil pH less than 5.2 and can be alleviated by liming, which increases soil pH and adds Ca.



CREDITS: D. L. Anderson

Figure 2. Calcium added to the soil helps to alleviate the effects of Al toxicity, particularly if accompanied by an appropriate pH increase.

Boron (B)

CREDITS: D. L. Anderson

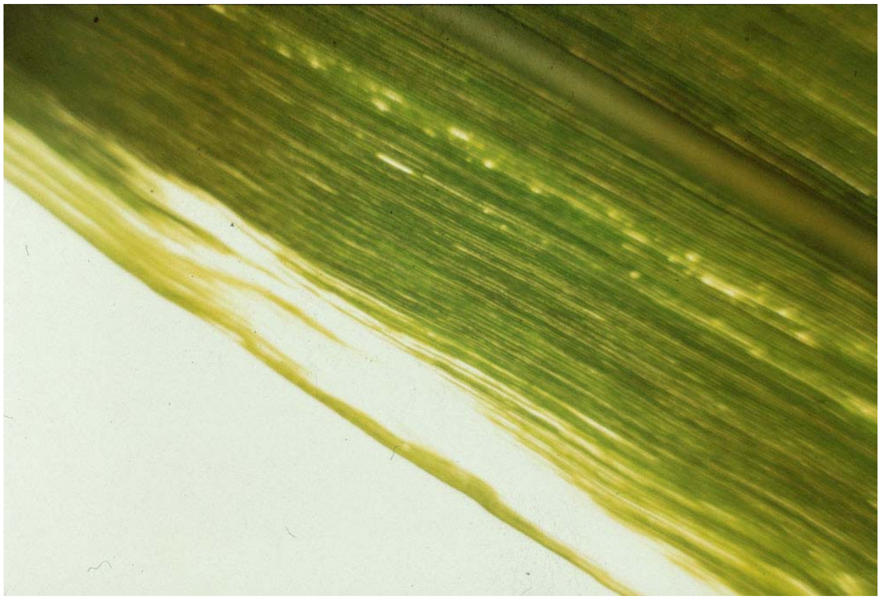
Figure 3. The symptoms of B deficiency appear on young leaves of sugarcane. Apical meristem may or may not remain alive. Immature leaves have varying degrees of chlorosis, but they do not wilt.

CREDITS: J. Orlando Filho

Figure 4. Boron-deficient plants have distorted leaves, particularly along the leaf margins on immature leaves. Immature leaves may not unfurl from the whorl when B deficiency is severe.

CREDITS: J. E. Bowen

Figure 5. In B deficiency, the apical meristem may die.



CREDITS: J. E. Bowen

Figure 6. Translucent lesions ("water sacks") along leaf margins may occur as B deficiency progresses.

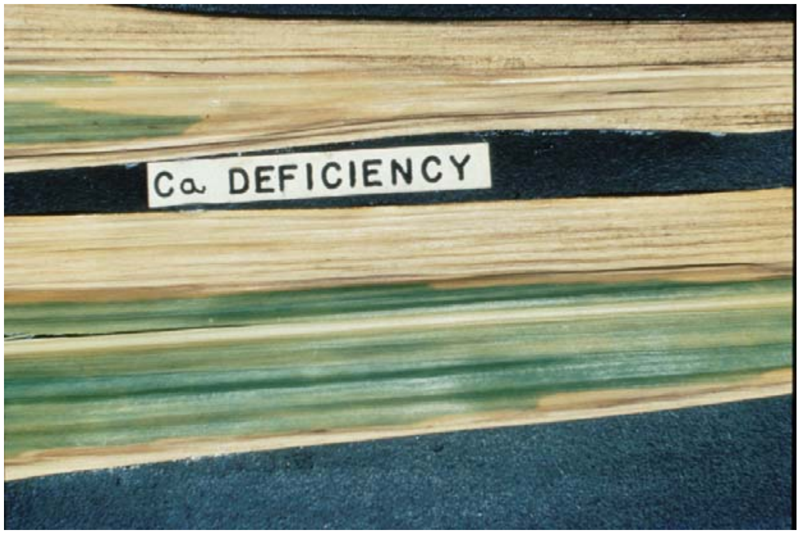
CREDITS: G. J. Gascho

Figure 7. In cases of severe B deficiency, young sugarcane plants tend to be brittle and bunched with many tillers.

CREDITS: J. E. Bowen

Figure 8. Leaf margins become chlorotic with B toxicity.

Calcium (Ca)



CREDITS: G. Samuels

Figure 9. The effects of Ca deficiency on older leaves are localized with mottling and chlorosis. Older leaves may have a "rusty" appearance and may die prematurely.

CREDITS: G. Samuels

Figure 10. Spindles often become necrotic at the leaf tip and along margins when Ca deficiency is acute. Immature leaves are distorted and necrotic. However, Ca deficiency is uncommon.

Chlorine (Cl)

CREDITS: J. E. Bowen

Figure 11. Chlorine deficiency and toxicity are hard to identify in the field. Chlorine deficiency causes abnormally short roots and increases the number of lateral roots. Chlorine toxicity will also cause abnormally short roots with very little lateral branching (from left to right: 0, 1, and 100 ppm Cl). Neither Cl deficiency nor toxicity are likely in commercially-grown sugarcane in Florida.

CREDITS: J. E. Bowen

Figure 12. Chlorine deficiency and toxicity in young leaves (from left to right: 0 and 100 ppm Cl).

Copper (Cu)

CREDITS: G. J. Gascho

Figure 13. Copper deficiency generally appears first in young leaves. Green splotches are an early symptom.

CREDITS: D. L. Anderson

Figure 14. Apical meristems remain alive, but internode elongation will be greatly reduced when Cu deficiency is severe.

CREDITS: J. Orlando Filho

Figure 15. General vigor and tillering are reduced under Cu deficiency.

Iron (Fe)

CREDITS: D. L. Anderson

Figure 16. Iron deficiency is first evident on young leaves. Symptoms of Fe deficiency often occur adjacent to unaffected plants. Young plants may overcome symptoms as the plant matures and the root system develops.

CREDITS: J. Orlando Filho

Figure 17. Iron deficiency occurs on high pH calcareous soils found in Brazil.

CREDITS: D. L. Anderson

Figure 18. On high pH calcareous soils found in Barbados, Fe deficiency is found adjacent to healthy maturing cane plants. Damage to the root system due to insects or adverse soil conditions (i.e., salts) give this deficiency unusual spatial characteristics.

Magnesium (Mg)

CREDITS: D. L. Anderson

Figure 19. Magnesium deficiency is first evident on older leaves. Red necrotic lesions result in a "rusty" appearance.

CREDITS: D. L. Anderson

Figure 20. The "rusty" appearance can spread across all leaves and may also result in premature dropping of older leaves.

CREDITS: D. L. Anderson

Figure 21. Under severe Mg deficiency, the stalk may become stunted and severely "rusted" and brown. Internal browning of the stalk may also occur.

Manganese (Mn)

CREDITS: J. Orlando Filho

Figure 22. Manganese deficiency first appears on younger leaves. Interveinal chlorosis occurs from the leaf tip toward the middle of the leaf.

CREDITS: D. L. Anderson

Figure 23. Under severe Mn deficiency, the entire leaf becomes bleached.

Molybdenum (Mo)

CREDITS: J. E. Bowen

Figure 24. Molybdenum deficiency is seen on older leaves. Short longitudinal chlorotic streaks on the apical one-third of the leaf. Symptoms are similar to mild infections of Pokkah Boeng disease (http://edis.ifas.ufl.edu/SC004).

Nitrogen (N)

CREDITS: D. L. Anderson

Figure 25. Older leaves first show N deficiency. Symptoms become generalized over the whole plant and older leaves die back. Young leaves are pale-green and stalks are slender when under long-term N deficiency stress.

CREDITS: J. E. Bowen

Figure 26. Internode growth is reduced with N deficiency.

CREDITS: P. Bosshart

Figure 27. With N deficiency, leaf sheaths prematurely separate from the stalk. Note pale-green to yellow color.

Phosphorus (P)

CREDITS: D. L. Anderson

Figure 28. Older leaves first show symptoms of P deficiency. Leaf reddening usually occurs with P deficiency when the plant is young and when growing temperatures are <10°C (50°F).

CREDITS: D. L. Anderson

Figure 29. Phosphorus deficiency causes short and slender stalks. Older leaves prematurely die back (note leaf sheaths).

Potassium (K)

CREDITS: D. L. Anderson

Figure 30. Older leaves first show symptoms of K deficiency. The symptoms appear as localized mottling or chlorosis.

CREDITS: D. L. Anderson

Figure 31. Red discoloration of upper surfaces of the midrib is characteristic of K deficiency. Insect feeding damage on the midrib may be misconstrued as K deficiency.

CREDITS: D. L. Anderson

Figure 32. Under moderate K deficiency, young leaves remain dark green and stalks become slender.

CREDITS: D. L. Anderson

Figure 33. Long-term K deficiency stress may affect meristem development indicated by spindle distortion and a "bunched top" or "fan" appearance.

Sodium (Na)

CREDITS: D. L. Anderson

Figure 34. High concentration of Na^{+} in the soil and resulting accumulation in the plant adversely affects root and shoot growth. Leaf tips and margins will dry out and have a scorched appearance. Excessive Na levels in soil or plants would not be expected in commercial sugarcane growing areas in Florida.

CREDITS: M. K. Schon

Figure 35. With high Na, sugarcane leaves may be broad, but under excessively high concentrations the chlorophyll content decreases, lowering the net photosynthesis per unit leaf area. Under these conditions, leaves may have a pale-green to yellowish-green appearance. High Na is associated with high Cl levels.

Silicon (Si)

CREDITS: J. E. Bowen

Figure 36. Silicon deficiency symptoms of cane grown on sand media under drip-irrigation. In the field, symptoms appear as minute circular white leaf spots (freckles) and are more severe on older leaves.

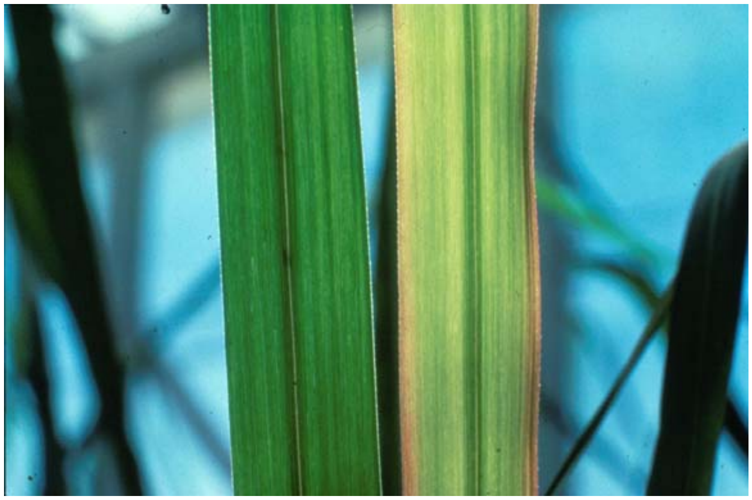
Sulfur (S)

CREDITS: J. E. Bowen

Figure 37. Young leaves affected by SO_2 toxicity. Symptoms are mottled chlorotic streaks running the full length of the leaf blade. Toxicity occurs in active volcanic regions of the world.

CREDITS: J. E. Bowen

Figure 38. Leaf tips and margins may become necrotic within 3 to 7 days after SO_2 exposure.



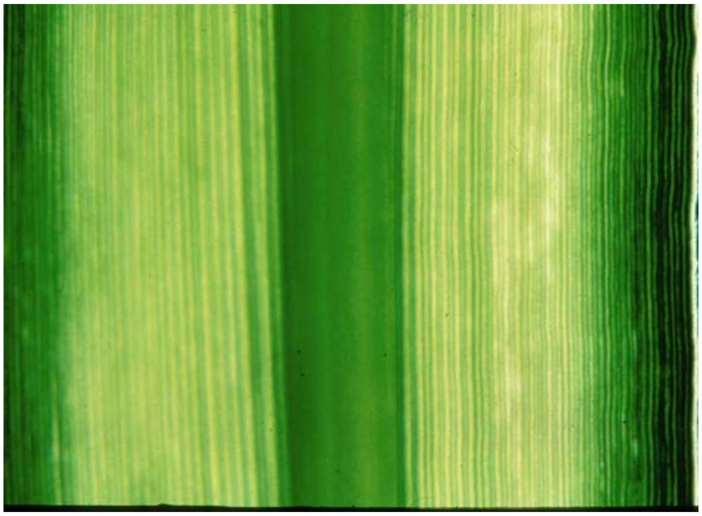
CREDITS: A. Hurney

Figure 39. Sulfur-deficient leaf (right), with symptoms of chlorosis and purple leaf margins contrasted with a healthy leaf (left) treated with ammonium sulfate.

CREDITS: A. Hurney

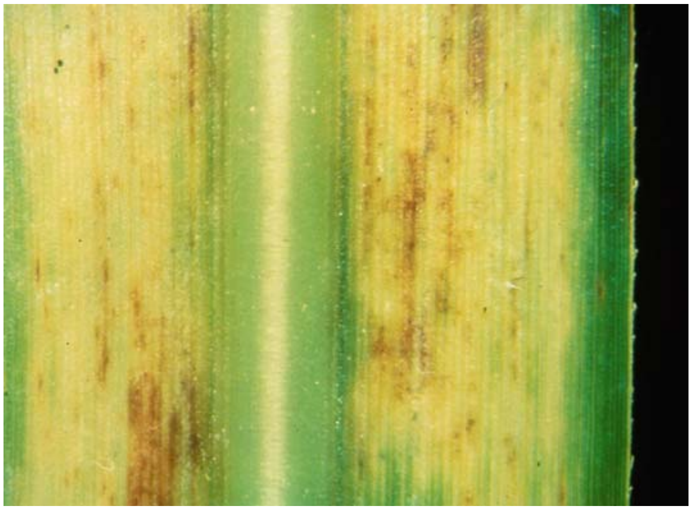
Figure 40. Sulfur deficiency in a sandy soil in North Queensland, Australia. Leaves are narrower and shorter than normal; stalks are slender.

Zinc (Zn)



CREDITS: J. Reghenzani

Figure 41. Zinc deficiency is first evident on the younger leaves. A broad band of yellowing in the leaf margin occurs. The midrib and leaf margins remain green except when the deficiency is severe.



CREDITS: J. Reghenzani

Figure 42. Red lesions are often noticed. The lesions may be associated with a fungus which prefers to grow in Zn deficient tissues.

CREDITS: J. Reghenzani

Figure 43. The severity of Zn deficiency can be highly variable. Symptoms are increased with liming and when low Zn subsoils are exposed to the surface.