

Understanding the Soil Test Report

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UNDERSTANDING THE SOIL TEST REPORT

WHAT IS A SOIL TEST?

A soil test chemically extracts and measures the elements essential to plant nutrition. It also measures soil acidity and pH. These factors are indicators of lime requirement, nutrient availability, and the potential of the soil to produce crops.

The NCDA&CS Agronomic Division carries out two types of soil tests: predictive and diagnostic. The predictive test focuses on the fertilization necessary to optimize yields. The diagnostic test focuses on identifying specific deficiencies or excesses that are interfering with optimal plant growth.

Predictive Soil Testing

Lime and fertilizer recommendations in North Carolina are based on field experiments conducted across a variety of soil types and cropping sequences. The rates suggested are designed to eliminate fertility as a limiting factor in optimum crop production.

Other factors that have a strong impact on yield are soil moisture; planting date; variety; weed, insect, disease, and nematode pressure; soil compaction; etc. If any of these factors are less than optimum, reduced yields result. Optimum production requires reasonable management of all the factors involved in the overall crop production scheme.

Continuous field calibration research is essential to determine fertility requirements dictated by changes in farming practices and cropping sequences. These studies are being conducted by North Carolina State University researchers in conjunction with the NCDA&CS agronomists.

The North Carolina soil test uses the Mehlich-3 extractant. Results may or may not agree with other state or private laboratories depending on their

method of extraction and other laboratory variables. Growers are encouraged to use a laboratory that is supported by field research within their state.

Diagnostic Soil Testing

Problem soil samples are handled separately from the routine samples. In addition to the routine analyses, levels of nitrate nitrogen (NO_3-N) and soluble salts ($SS-I$) may be determined.

Problem soil sample test results are reviewed by an agronomist. The agronomist makes appropriate comments regarding the cause of the problem and any recommended treatment.

Plant analysis, in conjunction with a diagnostic soil test, is the best way to ascertain a nutrient problem. It is also wise to collect soil and plant samples from both “good” and “bad” areas for comparison purposes. Soil and plant samples from the same vicinity should be labeled the same to facilitate comparison.

ASSISTANCE AVAILABLE

An effort has been made to report soil test results and recommendations in a manner that can be understood by growers. NCDA&CS agronomists and North Carolina Cooperative Extension personnel are available to assist growers in the interpretation and implementation of the results. The fertilizer industry will also help growers interpret their soil test reports and address their fertilizer needs.

In essence, a soil test recommendation is a lime and fertilizer prescription that is ultimately filled by local agri-supply dealers. Without soil test results, fertilizer suppliers are somewhat handicapped in advising farmers of their lime and fertilizer needs. If they make general fertilizer recommendations without a soil test, undue criticism may be levied toward their product if crop response is poor.

THE REPORT

The heading contains the report number, date, grower's name and address, and a list of other people receiving a copy of the report. Each sheet contains field information, applied lime history, recommendations, and test results for up to five soil samples. The **Agronomist Comments** section may contain a discussion of test results. Interpretive information about the index system is also enclosed as a cover sheet with all soil test reports.

Agronomist Comments

This section is located on the first page of the soil test report above the **Field Information** section. Reports for diagnostic samples provide helpful comments and discussion.

Field Information

This section contains the *Sample No.*, which is the same identification number that you provided on your soil sample information form.

Applied Lime

If you indicated that lime was applied within 12 months prior to your current sample, this information has been used to determine the residual lime credit (RC). Residual lime credit is calculated only if you provided the date and rate of application on the sample information form. For an explanation of the residual credit calculation and its impact on your lime recommendation, refer to the section titled **LIME** later in this document.

Test Results

The abbreviated headings that appear in the **Test Results** section of the soil test report are explained briefly in Figure 1. Detailed explanations follow under the appropriate headings.

Many of the nutrients are reported as indices. Table 1 relates these indices to general nutrient availability and indicates the likelihood of crop response to fertilization. Table 2 shows micronutrient application rates by soil type, nutrient, and application method.

SOIL CLASS

Each soil sample is classified as mineral (MIN), mineral-organic (M-O), or organic (ORG). These classifications are made based on the humic matter percent (*HM%*) and weight/volume ratio (*W/V*). Each soil class has a different target pH: 6.0–6.5 for MIN soils, 5.5 for M-O soils, and 5.0 for ORG soils.

Mineral soils require a higher pH to neutralize exchangeable aluminum so that plant growth is not affected. Since M-O and ORG soils contain less exchangeable aluminum due to their lower mineral content, a lower pH can be maintained without any detrimental effects to crop production. In addition, since M-O and ORG soils have much higher buffering capacity, it is not economically feasible or agronomically practical to apply lime at rates sufficient to raise the soil pH to 6.0.

Table 1. Crop Response to Fertilization as Related to Soil Test Levels

Index	Nutrient Status	Response* to Applied				
		P	K	Mn	Zn	Cu
0–10	Very Low	VH	VH	VH	VH	VH
11–25	Low	H	H	H	H	H
26–50	Medium	M**	M**	N	N	N
51–100	High	N	L/N	N	N	N
100+	Very High	N	N	N	N	N

* Crop response to fertilizer is expected to be very high (VH), high (H), medium (M), low (L) or none (N).

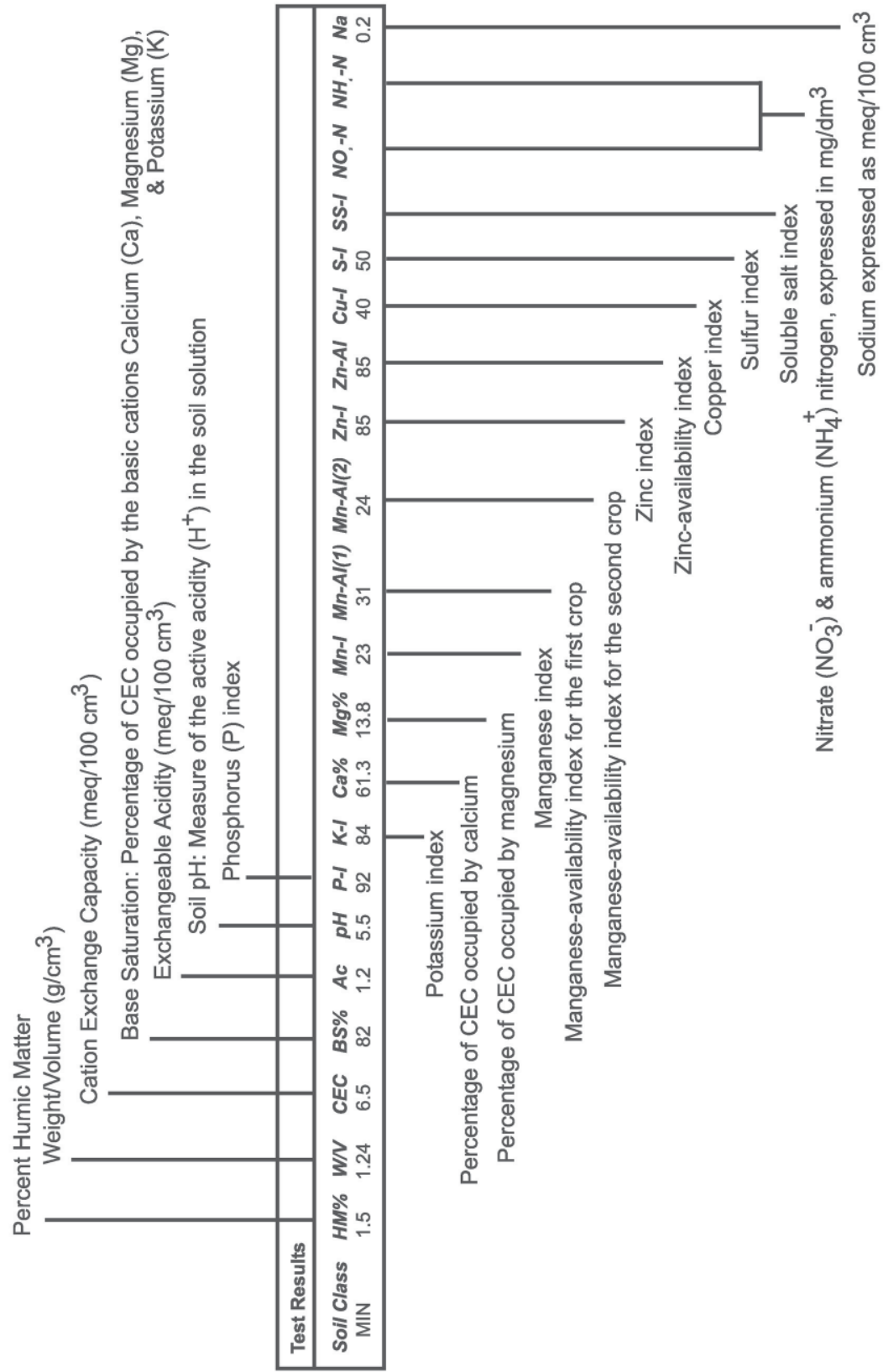
** Response decreases as soil test index increases.

Table 2. Recommended Micronutrient Rates*

Soil Class	Banded		Broadcast			Foliar Spray		
	Mn	Zn	Mn	Zn	Cu	Mn	Zn	Cu
MIN	3	3	10	6	2	1/2	1/2	1/4
M-O	3	3	10	6	4	1/2	1/2	1/4
ORG	3	3	10	6	6	1/2	1/2	1/4

* Rates = lb element per acre.

Figure 1. Explanation of Soil Test Results



HUMIC MATTER (*HM%*)

The humic matter percent represents a percentage of the soil organic matter that is soluble in a dilute alkaline solution (NaOH). The *HM%* is reported in g/100 cm³ and is a measurement of humic and fulvic acid components of the soil. This portion of the total organic matter represents the chemically active organic fraction used in determining lime rates.

The relative humic matter content may or may not represent the total organic matter content of a soil. For example, sandy soils have a very low organic matter content and a correspondingly low *HM%*. In contrast, organic soils may have in excess of 50% organic matter with a *HM%* of less than 10. This implies that most of the organic matter in ORG soils has not been decomposed to the humic and fulvic acid fractions. In a general sense, *HM%* is related to the weight/volume ratio (*W/V*): that is, as the *W/V* increases, the *HM%* usually decreases.

WEIGHT/VOLUME RATIO (*W/V*)

The weight/volume ratio, expressed in g/cm³, is used to classify the sample's soil type. For example, a very sandy soil may have a *W/V* of 1.50 g/cm³, whereas that of an organic soil may be as low as 0.5 g/cm³. Soils high in clay fall within these two extremes. *W/V* is generally inversely related to the cation exchange capacity (*CEC*) of the soil: that is, soils with a high *W/V* generally have a low *CEC*.

CATION EXCHANGE CAPACITY (*CEC*)

The cation exchange capacity is a relative measure of the nutrient-holding capacity of a soil. It is measured in meq/100 cm³. *CEC* is determined by summation of the extractable calcium, magnesium, potassium, and exchangeable acidity (*Ac*).

The *CEC* of North Carolina soils ranges from low (less than 2.0 meq/100 cm³) for sandy soils to as high as 25 meq/100 cm³ for clay and organic soils.

A high *CEC* is desirable because nutrients are less subject to leaching and adequate quantities of nutrient reserves can be maintained. However, sandy soils, by nature, have a low *CEC*, and little can be done to change this phenomenon. The *CEC*

will vary with changes in soil pH, organic matter, and clay content.

BASE SATURATION (*BS%*)

The base saturation is an expression of the portion of the *CEC* that is occupied by basic cations, principally calcium, magnesium, and potassium. *BS%* and *pH* are directly correlated: as *pH* increases, so does *BS%*. A higher base saturation also corresponds to a lower level of soil acidity.

EXCHANGEABLE ACIDITY (*Ac*)

Exchangeable acidity represents that portion of the *CEC* that is occupied by hydrogen (H⁺) and aluminum (Al⁺⁺⁺) and is expressed as meq/100 cm³. Exchangeable acidity is one of the measurements used in calculating the lime recommendation.

CURRENT *pH*

The *pH* is a measure of the active acidity in the soil solution. The *pH* value alone does not determine how much lime is required but is used in conjunction with exchangeable acidity (*Ac*) in determining lime rates. The *pH* determination is useful for indicating when too much lime has been applied and for evaluating micronutrient availability, particularly manganese.

PHOSPHORUS (*P-I*) & POTASSIUM (*K-I*) INDICES

Levels of phosphorus and potassium are reported as indices. The index ranges are as follows: 0–10 is very low; 11–25 is low; 26–50 is medium; 51–100 is high; and 100+ indicates very high levels of these nutrients.

When levels are low, plants will respond to addition of these nutrients. At medium levels, plant response will depend on particular crop needs. At high nutrient levels, a favorable crop response to fertilization is not generally expected. Soil test indices above 100 are very high, and no fertilization is recommended, except for high value crops.

The fertilizer recommendation is based on the soil test results and varies depending on the crop to be grown. Refer to Table 1 for P and K ratings and crop response to fertilizer at given soil test levels.

CALCIUM (*Ca%*) & MAGNESIUM (*Mg%*) PERCENTS

Levels of calcium and magnesium are reported as percentages of the *CEC*. For example, if the *Ca%* is 62, then 62% of the soil's capacity to hold nutrients is occupied by Ca. Seldom is Ca low enough in the soil to cause a deficiency. Peanuts are an exception, and in this case, landplaster (CaSO_4) is a good source of supplemental Ca. In general, Ca is the predominant cation in most soils. Ca determination is essential to calculate the *CEC* and to evaluate the relationship among Ca, Mg and K.

The *Mg%* value determines whether Mg should be added to the soil. Dolomitic lime or a Mg fertilizer are both good sources. Multiplying *Mg%* by *CEC* gives you the amount of Mg present in meq/100 cm³. The following guidelines are useful in evaluating the Mg status of a soil:

1. If there is at least 0.5 meq/100 cm³, Mg application is not necessary.
2. If there is less than 0.5 meq/100 cm³ and *Mg%* is less than 10%, apply Mg.
3. If there is less than 0.5 meq/100 cm³ but more than 0.25 meq/100 cm³ and *Mg%* is greater than 10%, Mg application is not necessary.
4. If there is no more than 0.25 meq/100 cm³, Mg application is necessary. Usually 25–30 lb of Mg per acre are suggested when needed.

Additional information regarding magnesium is provided in the \$ *Note*.

MANGANESE INDEX (*Mn-I*)

This index is a measure of Mn levels in the soil. Since Mn availability is very closely associated with soil pH, a Mn-availability index (*Mn-AI*) is calculated, depending on crop sensitivity to this element.

MANGANESE AVAILABILITY INDEX (*Mn-AI*)

Two manganese indices are given when recommendations for a second crop are included. *Mn-AI(1)* is the manganese availability index for

the first crop; *Mn-AI(2)* applies to the second crop. *Mn-AI* values decrease as soil pH increases. Values above 25 are considered sufficient for most crops if the pH is below 6.0.

If *Mn-AI* is 25 or below and a rate is shown for the first crop, the reader is referred to the \$ *Note* for suggestions on manganese application. This notation is designed to bring this nutrient to your attention in the event it was not applied to the first crop.

ZINC INDEX (*Zn-I*)

This index is a measure of Zn levels in the soil. Zn availability is also influenced by soil pH. Unlike Mn availability, Zn availability is not based directly on pH. Zinc availability depends on the target pH of the soil class.

ZINC AVAILABILITY INDEX (*Zn-AI*)

The zinc availability index is based on soil class as follows: $1.0 \times \text{Zn-I}$ for MIN soils, $1.25 \times \text{Zn-I}$ for M-O soils, and $1.66 \times \text{Zn-I}$ for ORG soils. The critical *Zn-AI* is 25; above this index level, zinc is considered sufficient for most crops.

COPPER INDEX (*Cu-I*)

The *Cu-I* is a measure of plant-available copper in the soil. Adjustments in its availability are not made as they are for Mn and Zn.

SULFUR INDEX (*S-I*)

A value for *S-I* is given, but no rate for sulfur application is recommended. S is rarely lacking in piedmont or mountain soils due to their high clay content. Under normal growing conditions, S is also sufficient on organic soils.

S, however, does leach very readily from sandy topsoils. It accumulates in the subsoil where it is still available for crop use. Therefore, the S content in the plow layer alone is not a good indicator of the S status in the soil.

If the *S-I* for the plow layer of deep sandy soils is less than 25, however, there is a high probability that S should be included in the fertilizer. A rate of 20–25 lb of S per acre should satisfy most crop requirements.

SOLUBLE SALT INDEX (*SS-I*)

The *SS-I* represents the relative content of fertilizer salts within a soil. The results are expressed in 10^{-5} mho/cm, which is a measure of electrical conductivity.

This assessment is made on soil tested from greenhouses or problem fields. For greenhouse soils, the effect of soluble salts in different media is explained in the Notes included with the report. For problem field soils, an interpretive comment is provided only if salt levels are abnormally high.

NITRATE NITROGEN (NO_3-N)

This test gives an indication of the level of available nitrogen at the time of sampling. It is performed only for greenhouse and some problem field soils. Since nitrogen leaches very readily and fluctuates considerably with rainfall and soil texture, NO_3-N has little predictive value for field soil samples. Test results are reported in mg/dm^3 , which is equivalent to parts/million on a volume basis.

AMMONIUM NITROGEN (NH_4-N)

This test is performed at the discretion of a staff agronomist. The values, when reported, are expressed as mg/dm^3 (parts per million on a volume basis).

SODIUM (*Na*)

Sodium is evaluated for all samples. Values less than 0.4 meq/100 cm^3 are inconsequential to plant nutrition. However, values greater than 0.4 to 0.5 meq/100 cm^3 on sandy soils may indicate that sodium accounts for 15 to 20% of the *CEC*. Such levels could interfere with plant uptake of calcium, magnesium, and potassium and also adversely affect soil structure.

Recommendations

Fertilizer and lime recommendations depend on the information supplied on the sample information form. Recommendations are given for "1st Crop" and "2nd Crop," depending on the crops specified on the sample information form.

When recommendations for two crops with different target pHs are requested, the lime recommendation given will be for the crop that is least acid tolerant. Therefore, the higher of two possible lime recommendations will be given.

Soil test calibration for micronutrients (boron, copper, manganese, and zinc) is not as well defined as for the primary and secondary nutrient elements. However, with the increased concern about maximizing yields through better management practices, micronutrients have gained more attention. Hence, research efforts to refine the calibration for micronutrient soil tests in relation to yields have increased. In addition, advances in laboratory instrumentation have led to more accurate determination of critical soil test levels.

LIME

Lime rates for field crops are expressed in tons/acre (T) or lb/1000 ft^2 (M) for small areas such as lawns and gardens. Rate calculation involves soil pH, exchangeable acidity (*Ac*), target pH, and residual lime credit (*RC*). The formula is

$$\text{tons lime / acre} = Ac \left[\frac{\text{target pH} - \text{current pH}}{6.6 - \text{current pH}} \right] - RC$$

RC is the amount of lime applied in the last 12 months that has not reacted with soil acidity. Residual credit for lime applied varies with soil type over time. *RC* is reduced by 8% per month for MIN soils and 16% per month for M-O and ORG soils. The *RC* is reduced at a greater rate for the latter two soils because they contain higher levels of acidity that increase the reaction rate of lime. The equation for determining *RC* is as follows:

$$RC = rate - (rate \times months \times reduction\ percentage)$$

where

- *rate* is amount of lime applied in tons/acre,
- *months* is the number of months between lime application and the current soil test,
- *reduction percentage* is 0.08 for MIN soils and 0.16 for M-O and ORG soils.

To convert tons/acre to lb/1000 ft², multiply tons/acre by 46. Example: 0.8 tons/acre × 46 = 36.8 lb/1000 ft².

NITROGEN (*N*)

Nitrogen is not routinely tested on field soils, but a range of suggested application rates (lb/acre) is given in the *N* column. These rates were established for each crop based on field research studies and observations. Supplemental N applications may be required under certain soil and climatic conditions. *Note 3*, which accompanies the soil test report for field crops, offers suggestions on conditions under which supplemental N may be needed.

PHOSPHATE (*P₂O₅*)

The rate or range of P₂O₅ recommended is based on the *P-I* value, soil type, and the specific crop requirement. Crop requirement is determined by rate studies on a number of different soils and cropping situations. Equations have been established to meet the majority of soil and crop conditions.

POTASH (*K₂O*)

The rate or range of potash recommended was established in the same manner as phosphate.

MAGNESIUM (*Mg*)

If the amount of magnesium in the soil sample is found to be below a pre-established critical level, a \$ will appear in the *Mg* column. The \$ refers the reader to the \$ *Note* enclosed with the soil test report. The note discusses options for applying secondary nutrients and micronutrients, including Mg. If lime is recommended for your soil, use of dolomitic lime will provide adequate Mg.

MANGANESE (*Mn*)

The need for manganese is evaluated for all crops on the basis of response similar to corn and soybeans. The availability of Mn is affected by soil pH, that is, as the soil pH increases, Mn availability decreases. This relationship has been established

and is used to calculate the Mn-availability index (*Mn-AI*). The critical *Mn-AI* value is 25.

A zero (0) will appear in the *Mn* column if the soil test level is considered adequate. A rate will be shown for corn, corn silage, sweet corn, soybeans, peanuts, small grains, and both flue-cured and burley tobacco when the *Mn-AI* is 25 or below.

If a rate is recommended for the first crop, a \$ appears on the line for the second crop. The \$ brings this nutrient element to your attention in case it was not applied to the first crop. When soil levels of Mn are low for crops without established response data, a \$ appears on the soil test report. This symbol refers you to the \$ *Note* for suggestions on supplemental manganese treatments.

COPPER (*Cu*)

A rate for copper will be recommended if the *Cu-I* value is 25 or below for specific crops that have been shown to respond to fertilization. Uniform broadcasting and thorough incorporation contribute to optimum Cu applications. If the *Cu-I* is 25 or below and data on crop response are lacking, refer to the \$ *Note*, which gives suggestions about Cu application.

If a rate is recommended for the first crop, a \$ will appear on the line for the second crop. The \$ brings this nutrient element to your attention in case it was not applied on the first crop. The \$ will appear when the *Cu-I* is 25 or below and when Cu response data are limited or unavailable. The \$ *Note* contains further information on rates of application and is sent out with each report that indicates a micronutrient deficiency.

A potential Cu toxicity is indicated whenever a C appears under *Cu* in the Recommendations section of your report. The C alerts the grower that the *Cu-I* is greater than 2000. The critical toxic level for Cu is 3000. If this notation appears on your soil test report, check the **Agronomist Comments** section for further information.

ZINC (*Zn*)

A rate for zinc may be given if the Zn-availability index (*Zn-AI*) is 25 or below. A rate is

given for specific crops that have shown a response to Zn. The current recommendation for Zn is 6.0 lb/acre broadcast or 3.0 lb/acre banded.

If a rate is recommended for the first crop, a \$ appears on the line for the second crop. The \$ brings this nutrient element to your attention in case it was not applied to the first crop. The \$ will appear when *Zn-AI* is 25 or below for crops on which data are limited or unavailable. The \$ *Note* provides further information on rates of application.

A potential zinc toxicity is indicated whenever a Z appears under *Zn* in the Recommendations section of your report. The Z alerts the grower

that the *Zn-I* is greater than 2000. The critical toxic level for Zn is 3000 for most crops. Peanuts are very sensitive to zinc, so growers are alerted when *Zn-I* = 300 or 500 (critical toxic level). If this notation appears on your soil test report, check the **Agronomist Comments** section for further information.

BORON (B)

Boron recommendations are made for crops that are known to respond to this micronutrient. Recommendations are based on field studies for various crops. Actual levels of B in the soil are not measured.