LaMotte

Model AST Series

Instruction Manual

Professional Soil Testing Outfits

Model AST-5 • Code 5410
Model AST-15 • Code 5412-01

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INTRODUCTION

This instruction manual was written for use with LaMotte's AST Series Soil Test Kits. The Model AST-5 (5410) includes tests for pH, Nitrogen, Phosphorus, Potassium, and Humus. The AST-15 (5412-01) contains all of the tests included with Model AST-5, plus Calcium and Magnesium, Ammonia Nitrogen, Manganese, Aluminum, Nitrite Nitrogen, Sulfur, Chloride, Ferric Iron, and Copper. Instructions for all tests are included in this manual.

ACCESSORIES

QUANTITY	CONTENTS	CODE
1	Brush, Test Tube	0514
1	Spoon, 0.5 g	0698
1	Demineralizer Bottle	1155
100	Soil Sample Bags	0615-J
2 x 50	Soil Test Report Forms	1626
1	AST Instruction Manual	36071
1	*Improving Soil Sampling Accuracy*	36150
1	*A Study of Soil Science*	1530
1	*LaMotte Soil Handbook*	1504

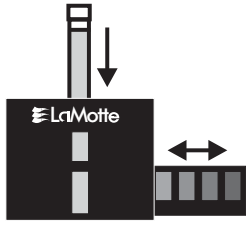
To reorder individual reagents or test kit components, use the specified code numbers.

Read the Demineralizer Bottle Instruction Manual before proceeding. This will be the source of all deionized water used in the tests.

TEST METHODS

pH, Nitrate Nitrogen, Ammonia Nitrogen, Nitrite Nitrogen, Phosphorus, Iron, and Sulfur test results are determined using an Octa-Slide Viewer. In this method, the color or turbidity of the reacted sample is matched to plastic color standards mounted in a black color bar.

The Octa-Slide Viewer should be held so non-direct light enters through the back of the viewer. With sample tube inserted at top, slide the Octa-Slide bar through the viewer and match with color standard.



Humus, Aluminum and Manganese test results are determined using a color chart. After the reaction is performed on a spot plate, the resulting color is matched to a printed color standard on a laminated chart.

The Copper test result is determined by a simple drop count. A standard solution is added a drop at a time to an unreacted sample until it matches the color of a reacted sample.

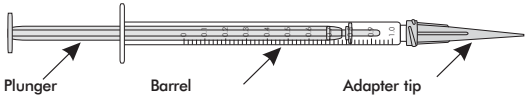
The Potassium test uses a Double Tube to measure the turbidity of the sample formed by the reacted potassium.

Calcium, Magnesium, and Chloride test results are determined using a Direct Reading Titrator, where small amounts of a titrant are added to the sample until a specified color change occurs.

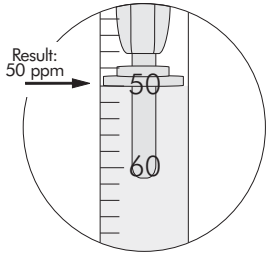
USE OF THE DIRECT READING TITRATOR

The Direct Reading Titrator consists of a plastic barrel, a plastic plunger, and a plastic adapter tip. The adapter tip reduces the size of the drops that are dispensed, increasing the precision of the test results. Detailed instructions for the use of the Direct Reading Titrator are provided on page 6.

see next page



1. Fill the test tube to the specified line with the water sample.
2. Add the reagents as specified in the instructions for the individual test method. Cap the tube with the special test tube cap. Mix by swirling gently.
3. Depress the plunger of the Titrator to expel air.
4. Insert the adapter tip into the special plastic plug in the titrating solution bottle.
5. Invert the bottle. Hold the bottle and the Titrator firmly together. Slowly pull out the plunger until the large ring on the plunger is opposite the zero (0) line on the scale.
6. If an air bubble appears in the Titrator barrel or the adapter tip, partially fill the barrel and pump the titration solution back into the inverted reagent bottle to expel the bubble. Repeat this pumping action until the bubble disappears.
7. Turn the bottle right-side-up and remove the Titrator.
8. Insert the adapter tip into the opening in the test tube cap. Slowly depress the plunger to dispense the titrating solution. Gently swirl tube to mix.
9. Continue adding the titrating solution until the specified color change occurs. If the color change has not occurred when plunger reaches the bottom of the scale, refill the Titrator to the zero (0) line. Continue the titration until the color change occurs.



10. Read the test result directly from the scale where the large ring on the plunger meets the Titrator barrel. If the Titrator was refilled to reach the final color change, add the total amounts of titrant used to determine the final test result.
11. If no additional tests are to be made, discard the titrating solution in the Titrator. DO NOT return the titrating solution to the reagent bottle. Thoroughly rinse the Titrator and the titration tube. DO NOT remove the plunger or the adapter tip from the Titrator.

SAMPLE DILUTION TECHNIQUES

In some tests the sample color may be darker than the darkest color standard. When this occurs, the original sample must be diluted so an accurate measurement can be made. Multiply the reading by the appropriate dilution factor.

EXAMPLE: Measure 5 mL of the sample into a graduated cylinder. Fill to the 10 mL line with deionized or distilled water. The sample has been diluted by one-half, and the dilution factor is therefore 2. Run the test procedure, and multiply the reading by 2 to obtain the final result.

The following table provides dilution factors for several sample sizes:

Size Of Sample	Distilled Water To Bring Volume To 10 mL	Multiplication Factor
10 mL	0 mL	1
5 mL	5 mL	2
2.5 mL	7.5 mL	4
1 mL	9 mL	10
0.5 mL	9.5 mL	20

NOTE: It is important to use pipets and graduated cylinders to make accurate dilutions.

UNITS OF MEASURE

All tests in the AST kits measure the concentration of the nutrients that are available to the plants. The tests are conducted on soil extract, the liquid formed by removing the nutrients from the soil. Since extraction procedures remove varying amounts of nutrients, the test is dependent upon the time and extracting solution used.

Test results are expressed in the following terms:

Parts Per Million (ppm)	Pounds Per Acre† (lb/acre)	Low To High
Calcium	Nitrate Nitrogen	Manganese
Magnesium	Phosphorus	Aluminum
Copper	Potassium	Humus
Sulfur	Ammonia Nitrogen	
Chloride	Nitrate Nitrogen	
Iron		

†Pounds per acre represents the number of pounds of soil in an acre to a depth of 6 inches, or 2,000,000 pounds. Conversion from pounds to acre to parts per million, or vice versa, can be accomplished using the following equations:

ppm x 2 = lb/acre

lb/acre x 0.5 = ppm

FERTILIZER APPLICATIONS

Test results should not be the only consideration when establishing a fertilizer program. Soil composition, drainage, climate, previous fertilizer programs, and the type of plant must also be considered when determining the type and amount of fertilizer needed. The following table offers quick-reference general guidelines to correlate soil test results and fertilizer application rates. These guidelines can be supplemented by the information in the *LaMotte Soil Handbook* (Code 1504). Consult your local agricultural extension services for advice on establishing a fertilizer program specific to your area.

General Guidelines For Fertilizer Application Rates

Nitrogen		Phosphorus		Potash (K_2O)	
Test Result	Add (lbs/acre)	Test Result	Add (lbs/acre)	Test Result	Add (lbs/acre)
10	220	10	260	100	180
20	180	25	220	140	150
40	130	50	180	180	130
60	110	75	150	220	110
100	90	100	130	300	90
150	40	150	90	400	70

SOIL SAMPLING PROCEDURES

Detailed soil sampling procedures are described in the *LaMotte Soil Handbook* (Code 1504) and in *Improving Soil Sampling Accuracy* (Code 36150).

The following procedure is recommended for sampling greenhouse soils.

1. Collect soil before watering.
2. Remove any mulch covering the soil. Use a soil sampling tube or spoon to take a sample from the entire plant rooting surface, top to bottom. Take 8 to 10 samples from the area.
3. Thoroughly mix the individual samples to form a composite sample. Spread the mixed composite sample on a sheet of paper or plastic to dry.

   NOTE: A composite sample insures representative test results.
4. Sift the dried sample through a 10 mesh wire screen or 2 mm sieve. Collect the soil. Discard particulate which remains on top of screen.

HOW TO USE A FUNNEL AND FILTER PAPER

A funnel and filter paper are used in the preparation of soil filtrate and plant tissue extracts, and to filter the soil extract for the Phosphorus in Alkaline Soils, Chloride, and Humus procedures.

1. Fold a piece of filter paper (0465) in half. Fold in half again.
2. With pointed end at the bottom, gently push corners together to form a cone.

   NOTE: There should be three layers on one side of the opening and one layer on the opposite side.
3. Place in funnel (0459). Place funnel in container for collecting filtrate.
4. Pour liquid through the funnel and filter paper to filter solution.

pH

pH is a measure of alkalinity or acidity. The pH of soil ranges from 3.5 to 11.0, but research has found plants grow best in the range of 5.0 to 8.5. In soils with low pH, some nutrients may reach toxic levels, and the activity of soil microbes may be drastically reduced. Soils with a high pH generally have a lower availability of micro-nutrients, and some nutrients may not be present at sufficient levels.

A distilled water extraction procedure with a Flocculating Reagent provides a clear liquid extract, to which *Wide Range Indicator is added. The resulting color is matched to a color standard to determine the pH.

QUANTITY	CONTENTS	CODE
500 mL	Tricon Flocculating Reagent	5941-L
30 mL	*Wide Range Indicator	*2218-G
1	Test tube, plastic, w/cap	0106
1	Spoon, 0.5 g, plastic	0698
1	Pipet, 1.0 mL, plastic	0354
1	Octa-Slide Viewer	1100
1	pH Wide Range Octa-Slide Bar	3424

***WARNING:** Reagents marked with an * are considered to be potential health hazards. To view or print a Material Safety Data Sheet (MSDS) for these reagents go to www.lamotte.com. To obtain a printed copy, contact LaMotte by e-mail, phone or fax.

PROCEDURE

Read Use of the Octa-Slide Viewer on page 5 before proceeding.

1. Fill a test tube (0106) to 5 mL line with Tricon Flocculating Reagent (5941).
2. Use the 0.5 g spoon (0698) to add 3 level measures of the soil sample. Cap and slowly invert back and forth for one minute to mix. Wait for soil particles to settle.
3. Use a pipet (0354) to fill another tube (0106) to the 2.5 mL line with the clear solution above the settled soil particles.
4. Add 6 drops of *Wide Range Indicator (2218). Cap and mix.
5. Insert test tube into Octa-Slide Viewer (1100). Slide the pH Wide Range Octa-Slide Bar (3424) into the viewer. Match sample color to a color standard. Record as pH.

   NOTE: Liming tables are found in the *LaMotte Soil Handbook* (Code 1504).

EXTRACTION

The following procedures are used to extract the soil filtrate needed for the Nitrate Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Ammonia Nitrogen, Nitrite Nitrogen, Copper, Manganese, Iron, and Aluminum tests. Separate extraction procedures are used for the Chloride, Sulfur, pH, and Humus tests. Consult the *LaMotte Soil Handbook* (Code 1504) for information on sampling and preparation of soil for testing.

*Acid Extracting Solution (6361) is used to prepare Melich 1 extracting solution. After dilution (performed during the extraction procedure) the resulting solution is 0.05N Hydrochloric Acid and 0.025N Sulfuric Acid.

NOTE: The Single Test Procedure will provide sufficient extract to do one of each of the tests in the Model AST-5 (5410). The Multiple Test Procedure should be used with the AST-15 (5412-01).

QUANTITY	CONTENTS	CODE
500 mL	*Acid Extracting Solution	*6361-L
60 mL	Charcoal Suspension	5638-H
100	Filter Papers	0465
1	Funnel	0459
1	Pipet, 1.0 mL, plastic	0354
1	Test Tube, 5-10-15 mL, plastic, w/cap	0701
1	Spoon, 1 g, plastic	0697
1	Graduated Cylinder, glass, 100 mL	0419
1	Bottle, glass, 100 mL, w/cap	0990
1	Spoon, 0.5 g	0698

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SINGLE TEST PROCEDURE

1. Use the 1.0 mL pipet (0354) to add 1 mL of *Acid Extracting Solution (6361) to the test tube (0701). Dilute to the 15 mL line with deionized water.
2. Use the 1 g spoon (0697) to add 3 measures of soil. Add 0.5 mL of Charcoal Suspension (5638). Cap and shake for five minutes.
3. Use funnel and filter paper to filter mixture (see How to Use a Funnel and Filter Paper, page 10). Collect the filtrate. Use this liquid as the extract for the Nitrate Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Ammonia Nitrogen, Nitrite Nitrogen, Copper, Manganese, and Aluminum tests.

MULTIPLE TEST PROCEDURE

1. Use the 1.0 mL pipet (0354) to add 5 mL of *Acid Extracting Solution (6361) to the 100 mL graduated cylinder (0419). Dilute to 75 mL line with deionized water. Pour into 100 mL bottle (0990).
2. Use the soil measure (1165) to add 15 grams of soil. Add 2 mL of Charcoal Suspension (5638). Cap and shake for 5 minutes.
3. Use funnel and filter paper to filter mixture (see How to Use a Funnel and Filter Paper, page 10). Collect the liquid. Use this liquid as the extract for the Nitrate Nitrogen, Phosphorus, Potassium, Calcium, Magnesium, Ammonia Nitrogen, Nitrite Nitrogen, Copper, Manganese, and Aluminum tests.

NEUTRALIZATION OF SOIL FILTRATE

The extract used for the Calcium, Magnesium, Ammonia Nitrogen, Copper and Iron tests must be neutralized before proceeding with the test. Neutralization can be accomplished using the following procedure.

QUANTITY	CONTENTS	CODE
30 mL	*Sodium Hydroxide Solution, 15%	*7886WT-G
1	pH Hydrion Test papers, 4.5-7.5	2953

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PROCEDURE

Add *Sodium Hydroxide Solution, 15% (7886) to the soil filtrate, one drop at a time, until the pH test paper (2953) indicates that the pH is between 6.0 and 7.0.

NITRATE NITROGEN

Nitrogen, in the form of nitrate, is an important element in plant growth. It is found in plant proteins, chlorophyll, nucleic acids, and other plant structures, and adequate levels result in larger plants which produce greater, more tender, yields. Since nitrogen is readily absorbed by the plants, or leached from the soil, levels may change rapidly.

Cadmium in the *Nitrate Reducing Reagent reduces nitrate to nitrite ions, which produce a red dyestuff through a diazotization reaction. *Mixed Acid Reagent supplies the acid necessary for the reaction to occur. The resulting color is matched to a color standard to determine the nitrate nitrogen level.

QUANTITY	CONTENTS	CODE
500 mL	*Mixed Acid Reagent	*V-6278-L
2 x 10 g	*Nitrate Reducing Reagent	*V-6279-D
1	Test Tube, plastic, w/cap	0106
1	Spoon, 0.1 g, plastic	0699
1	Nitrate Nitrogen Octa-Slide Bar, 2.5-100ppm	3422

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PROCEDURE

Read Use of the Octa-Slide Viewer on page 5 before proceeding.

1. Fill a test tube (0106) to 5 mL line with soil extract.
2. Dilute to 10 mL line with *Mixed Acid Reagent (V-6278).
3. Use the 0.1 g spoon (0699) to add 2 measures of *Nitrate Reducing Reagent (V-6279). Cap and invert 50-60 times in one minute to mix. Wait 10 minutes.

   NOTE: At the end of 10 minutes an undissolved portion of *Nitrate Reducing Reagent may remain in the test tube. This will not affect test results.
4. Invert the sample once to mix. Insert test tube into the Octa-Slide Viewer (1100). Slide the Nitrate Nitrogen Octa-Slide Bar (3422) into viewer. Match sample color to a color standard. Record as lb/acre Nitrate Nitrogen.

   NOTE: If sample color is darker than the highest color standard, the sample must be diluted (see Sample Dilution Techniques, page 7) and the test repeated.

AMMONIA NITROGEN

Fertile soil will give low ammonia nitrogen readings, unless nitrogenous fertilizer has recently been added. The rapid disappearance of ammonia after fertilizer application indicates the ammonia has been transformed to the more available nitrogen compounds, such as nitrate. In less fertile forest soils ammonia is the most available form of nitrogen.
Nessler's Reagent (*Ammonia Nitrogen Reagent #2) reacts in direct proportion with the ammonia in the sample to form a reddish-brown color. The resulting color is matched to a color standard to determine the ammonia nitrogen concentration.

QUANTITY	CONTENTS	CODE
2 x 30 mL	Ammonia Nitrogen Reagent #1	4797WT-G
2 x 30 mL	*Ammonia Nitrogen Reagent #2	*4798PS-G
1	Test tube, plastic, w/cap	0106
1	Pipet, 0.5 mL, plastic	0353
1	Ammonia Nitrogen Octa-Slide Bar, 10-80 ppm	3425

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PROCEDURE

Read Use of the Octa-Slide Viewer on page 5 before proceeding.

1. Fill a test tube (0106) to 5.0 mL line with neutralized soil extract.

   NOTE: See Neutralization of Soil Extract, page 15.
2. Add 6 drops of Ammonia Nitrogen Reagent #1 (4797). Cap and mix.
3. Use a 0.5 mL pipet (0353) to add 0.5 mL of *Ammonia Nitrogen Reagent #2 (4798). Cap and mix. Wait 5 minutes.
4. Invert the sample once to mix. Insert test tube into the Octa-Slide Viewer (1100). Slide the Ammonia Nitrogen Octa-Slide Bar (3425) into viewer. Match sample color to a color standard. Record as lb/acre Ammonia Nitrogen.

   NOTE: If sample color is darker than the highest color standard, the sample must be diluted (see Sample Dilution Techniques, page 7) and the test repeated

NITRITE NITROGEN

Nitrites are formed as an intermediate step in the transformation of ammonia to nitrate. This transformation is aided by well drained and aerated by soil, so these soils often have low nitrite levels. Toxic levels of nitrites may be found in poorly aerated soil, or in soils with high nitrate levels, where a portion of the nitrate nitrogen decomposes to form nitrite.

Nitrite reacts with sulfanilamide in the *Color Developing Reagent through a diazotization reaction to produce a pink azo dye. The resulting color is matched to a color standard to determine the nitrite nitrogen concentration.

QUANTITY	CONTENTS	CODE
500 mL	*Mixed Acid Reagent	*V-6278-L
2 x 10 g	*Color Developing Reagent	*V-6281-D
1	Test Tube, plastic, w/cap	0106
1	Spoon, 0.1g, plastic	0699
1	Nitrite in Soil Octa-Slide Bar, 0.5-25 lb/acre	3481

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PROCEDURE

Read Use of the Octa-Slide Viewer on page 5 before proceeding.

1. Fill test tube (0106) to 2.5 mL line with soil extract. Dilute to 5 mL line with deionized water.
2. Dilute to 10 mL line with *Mixed Acid Reagent (V-6278).
3. Use the 0.1 g spoon (0699) to add 2 measures of *Color Developing Reagent (V-6281). Cap and mix for one minute. Wait 5 minutes.
4. Invert the sample once to mix. Insert test tube into the Octa-Slide Viewer (1100). Slide the Nitrite in Soil Octa-Slide Bar (3481) into viewer. Match sample color to a color standard. Record as lb/acre Nitrite Nitrogen.

   NOTE: If sample color is darker than the highest color standard, the sample must be diluted (see Sample Dilution Techniques, page 7) and the test repeated.

PHOSPHORUS

Phosphorus is an important element for both plants and animals. It is contained in the nucleus of the plant cell, which controls cell division and growth, and has an important role in energy storage and chemical transfer within the plant. Phosphorus is also important to fruiting and seed production.

Phosphorus reacts with molybdate in *VM Phosphate Reagent to form a phospho-molybdate compound. Reduction with stannous chloride in the *Reducing Reagent produces a molybdenum blue color. The resulting color is matched to a color standard to determine the phosphorus concentration.

QUANTITY	CONTENTS	CODE
2 x 60 mL	*VM Phosphate Reagent	*4410-H
5 mL	*Reducing Reagent	*6405-C
2 x 60 mL	*Special NF Phosphorus Extracting Solution	*6362-H
60 mL	Charcoal Suspension	5638-H
1	Test Tube, 5-10-15 mL, plastic, w/cap	0701
100	Filter Papers	0465
1	Funnel	0459
1	Test tube, plastic, w/cap	0106
1	Pipet, 1.0 mL, plastic	0354
1	Pipet, 0.5 mL, plastic	0353
1	Pipet, plain	0352
1	Spoon, 1 g, plastic	0697
1	Phosphorus Octa-Slide Bar, 15-150 lb/acre	3423

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PROCEDURE

Read Use of the Octa-Slide Viewer on page 5 before proceeding.

1. Use a 1.0 mL pipet (0354) to add 1 mL of soil extract to a test tube (0106). Dilute to 5 mL line with deionized water.
2. Use a 0.5 mL pipet (0353) to add 0.5 mL of *VM Phosphate (4410). Cap and invert several times to mix. Wait 5 minutes.
3. Use the plain pipet (0352) to add 2 drops of *Reducing Reagent (6405). Cap and mix. Solution should turn blue in 10 seconds.
4. Invert the sample once to mix. Insert test tube into the Octa-Slide Viewer (1100). Slide the Phosphorus Octa-Slide (3423) into viewer. Match sample color to a color standard. Record as lb/acre Phosphorus.

   NOTE: If sample color is darker than the highest color standard, the sample must be diluted (see Sample Dilution Techniques, page 7) and the test repeated.

PHOSPHORUS IN ALKALINE SOILS

A special extraction procedure is used for determining the available phosphorus content of soils where the pH value is above 7.0.

1. Use the 1.0 mL pipet (0354) to add 1 mL of *Special NF Phosphorus Extracting Solution (6362) to the test tube (0701). Dilute to the 15 mL line with deionized water.
2. Use the 1 g spoon (0697) to add 3 measures of the soil sample. Add 0.5 mL of Charcoal Suspension (5638). Cap and shake for 5 minutes.
3. Use filter paper (0465) and funnel (0459) to filter solution (see How to Use a Funnel and Filter Paper, page 10). Collect the filtrate. Follow the Phosphorus procedure above.

POTASSIUM

Potassium is found in great supply as a component of common minerals, but slow solubility limits availability to plants. Although it is not part of the actual plant structure, potassium is important in many biochemical functions, including cell division and resistance to disease.

Potassium present in an alkaline solution combines with sodium tetraphenylboron in *Potassium TPB Solution, to form a potassium tetraphenylboron precipitate. The resulting turbidity is used to determine the potassium level.

QUANTITY	CONTENTS	CODE
250 mL	*Potassium TPB Solution	*3825-K
1	Double Tube, Potassium	0796
2	Pipets, 1.0 mL, plastic	0354

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PROCEDURE

1. Use a 1.0 mL pipet (0354) to add 2 mL of soil extract to the round tube (0796).
2. Use a second 1.0 mL pipet (0354) to add 2 mL of *Potassium TPB Solution (3825). Wait 5 minutes.
3. Dilute to top line with deionized water. Cap and shake to mix.
4. Remove the cap and slowly insert the square tube with the collar. The square tube will slide up and down through the collar and fill with liquid.
5. Viewing from above, lower the square tube into the solution until the black dot on the base can no longer be seen. Hold the round tube at the top to avoid blocking the light.
6. Read the level of the liquid level in the square tube. Record as lb/acre Potassium.

   NOTE: To convert to potash, multiply result by 1.2.

IRON

Only small quantities of iron are used by plants, but it is essential to growth as an activator in numerous enzyme systems. Since iron is more soluble in acidic solutions, it will be more available in soils with a low pH.

A bipyridal indicator, *Iron Reagent #2 Powder, reacts with iron at the proper pH to produce a pink color. The resulting color is matched to a color standard to determine the iron concentration.

QUANTITY	CONTENTS	CODE
30 mL	*Iron Reagent #1	*4450-G
10 g	*Iron Reagent #2 Powder	*V-4451-D
1	Test Tube, plastic, w/cap	0106
1	Spoon, 0.05 g, plastic	0696
1	Iron Octa-Slide Bar, 2.5-50 ppm	3479

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PROCEDURE

Read Use of the Octa-Slide Viewer on page 5 before proceeding.

1. Fill test tube (0106) to 5 mL line with neutralized soil extract.

   NOTE: See Neutralization of Soil Extract, page 15.
2. Add 5 drops of *Iron Reagent #1 (4450).
3. Use the 0.05 g spoon (0696) to add 1 measure of *Iron Reagent #2 (V-4451). Cap and mix until the powder has dissolved. Wait 5 minutes.
4. Invert the sample once to mix. Insert test tube into the Octa-Slide Viewer (1100). Slide the Iron Octa-Slide Bar (3479) into viewer. Match sample color to a color standard. Record as ppm Iron.

   NOTE: If sample color is darker than the highest color standard, the sample must be diluted (see Sample Dilution Techniques, page 7) and the test repeated.

SULFUR

Sulfur is essential to the formation of protein, and affects various aspects of plant metabolism. Plants which are deficient in sulfur can be distinguished by the pale green color and thin, reedy stems. The major sources of sulfur are fertilizers containing sulfate compounds, and atmospheric sulfur dioxide carried into the soil by precipitation.

*Sulfate Reagent contains barium chloride, which reacts with sulfur to form a barium sulfate precipitate. The resulting turbidity is matched to a standard to determine the sulfur concentration.

QUANTITY	CONTENTS	CODE
60 mL	Charcoal Suspension	5638-H
10 g	*Sulfate Reagent	*V-6277-D
1	Test Tube, 5-10-15 mL, w/cap	0701
1	Spoon, 1.0 g, plastic	0697
100	Filter Papers	0465
1	Funnel	0459
1	Test tube, sulfur, turbidity, plastic, w/cap	0106-WL
1	Sulfur Octa-Slide Bar, 0-100 ppm	3480

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PROCEDURE

Read Use of the Octa-Slide Viewer on page 5 before proceeding.

1. Fill the test tube (0701) to the 15 mL line with deionized water.
2. Use the 1.0 g spoon (0697) to add 3 measures of soil.
3. Add 0.5 mL of Charcoal Suspension (5638). Cap and shake for 5 minutes.
4. Use the filter paper (0465) and funnel (0459) to filter sample(see page 10, How to Use a Funnel and Filter Paper). Collect liquid. Use this liquid as the extract for the sulfur test.
5. Fill the tube (0106-WL) to the 5 mL line with soil extract. Dilute to 10 mL line with deionized water.
6. Use the 0.1 g spoon (0699) to add 1 measure of *Sulfate Reagent (V-6277). Cap and shake until the powder is dissolved. A white precipitate will form if sulfur is present. Wait 5 minutes.
7. Invert the sample once to mix. Insert test tube into the Octa-Slide Viewer (1100). Place tube in Viewer with printing facing away from operator. Slide the Sulfur Octa-Slide Bar (3480) into viewer. Match sample color to a color standard. Record as ppm Sulfur.

   NOTE: If sample turbidity is greater than the highest standard, the sample must be diluted (see Sample Dilution Techniques, page 7) and the test repeated.

COPPER

Copper acts as a catalyst in enzyme systems. In acidic soils, aluminum may compete with copper, resulting in decreased uptake by plants. The balance of copper with iron and molybdenum may be more important than the actual amounts present in the plant.

A Standard Color Solution is added to an untreated sample until it matches the color of the sample in which the copper has reacted with sodium diethyeldithiocarbamate in the Copper Reagent.

QUANTITY	CONTENTS	CODE
2 x 15 mL	*Copper 1 Reagent	*6446-E
2 x 15 mL	Copper 2 Reagent	6613-E
2	Test tubes, plastic, w/cap	0106
1	Sheet, white, plastic	32961

***WARNING:** Reagents marked with an * are considered to be potential health hazards. To view or print a Material Safety Data Sheet (MSDS) for these reagents go to www.lamotte.com. To obtain a printed copy, contact LaMotte by e-mail, phone or fax.

PROCEDURE

1. Fill two test tubes (0106) to the 10 mL line with neutralized soil extract.

   NOTE: See Neutralization of Soil Extract, page 15.
2. Add 5 drops of *Copper Reagent (6446) to one test tube. Cap and mix. Remove cap.
3. Hold both test tubes one-half inch above the white plastic sheet. The extract with the reagent will appear yellow if copper is present.
4. Add Copper 2 Reagent (6613) to the second, untreated sample, one drop at a time, with mixing, until the color of the two samples is the same. Count the number of drops added. Hold bottle vertically.
5. Multiply number of drops of Copper 2 Reagent used in Step 4 by 0.25. Record as ppm Copper.

1 ppm = 4 drops
2 ppm = 8 drops
3 ppm = 12 drops

CALCIUM & MAGNESIUM

Calcium is found in rapidly growing root tips, indicating that it is a necessary ingredient for cell division. It also tends to make cells more selective in their absorption of nutrients.

Magnesium is an ingredient in chlorophyll which makes plants green. It also aids in the formation of fats and oils, as well as phosphorus uptake.

The Schwarzenbach EDTA titration, used to determine calcium and magnesium levels, involves two separate titrations. The first titration determines the combined calcium and magnesium level, and the second titration indicates the calcium level only. Magnesium is determined by calculation.

QUANTITY	CONTENTS	CODE
30 mL	*Sodium Hydroxide Solution, 15%	*7886WT-G
30 mL	Calcium-Magnesium Inhibitor Reagent	3922-G
30 mL	*Calcium & Magnesium Buffer	*5126-G
2 x 15 mL	*CM Indicator Reagent	*6522-E
250 mL	Standard EDTA Reagent	5254-K
15 mL	*Inhibitor Solution	*9258-E
15 mL	*TEA Reagent	* 3921-E
30 mL	*Sodium Hydroxide Reagent w/Metal Inhibitors	*4259-G
100	Calcium Hardness Indicator Tablets	T-5250-J
1	pH Hydrion Test papers, 4.5-7.5	2953
1	Graduated Cylinder, glass, 25 mL	0417
1	Beaker, plastic, 50 mL	0944
1	Test Tube, 5-10-15 mL, glass, w/cap	0778
1	Direct Reading Titrator, 0-1000 Range	0384

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PROCEDURE

Read the Direct Reading Titrator instructions on page 6 before proceeding.

DILUTION OF SOIL EXTRACT

1. Use the graduated cylinder (0417) to transfer 10 mL of soil extract to a 50 mL beaker (0944).
2. Add 10 mL of deionized water. Mix and neutralize.

   NOTE: See Neutralization of Soil Extract, page 15.

TITRATION A: CALCIUM & MAGNESIUM

1. Fill test tube (0778) to 5 mL line with diluted soil extract. Dilute to 10 mL line with deionized water.
2. Add 5 drops of Calcium-Magnesium Inhibitor Reagent (3922). Swirl to mix. Wait 5 minutes.
3. Add 5 drops of *Calcium & Magnesium Buffer (5126). Swirl to mix.
4. Add 10 drops of *CM Indicator Reagent (6522). Swirl to mix. Solution will turn red.
5. Fill the Direct Reading Titrator (0384) with Standard EDTA Reagent (5254). Insert Titrator tip into the center hole of the test tube cap.
6. While swirling the tube, slowly press the plunger to titrate sample until color changes from red to blue.
7. Read the result where the plunger tip meets the scale. Multiply by 5.16. Record as Value A.

TITRATION B: CALCIUM

1. Fill test tube (0778) to 5 mL line with diluted soil extract. Dilute to 10 mL line with deionized water.
2. Add 2 drops of *Inhibitor Solution (9258). Swirl to mix.
3. Add 2 drops of *TEA Reagent (3921). Swirl to mix.
4. Add 8 drops of *Sodium Hydroxide Reagent w/Metal Inhibitors (4259). Swirl to mix.
5. Add one Calcium Hardness Indicator Tablet (T-5250). Cap and swirl until tablet disintegrates. Solution will turn red.
6. Fill the Direct Reading Titrator (0384) with Standard EDTA Reagent (5254). Insert Titrator tip into the center hole of the test tube cap.
7. While swirling the tube, slowly press the plunger to titrate sample until color changes from red to blue, and does not revert to red for at least one minute.
8. Read the result where the plunger tip meets the scale. Multiply by 5.16. Record as Value B.

FINAL RESULTS

Calcium:

Value B x 0.4 = ppm Ca

Magnesium:

0.24 (Value A – Value B) = ppm Mg

NOTE: To obtain results in lb/acre, multiply results by 2.

CHLORIDE

No natural soil deficiencies of chloride are known to exist. Chloride-containing fertilizers may lead to excessive or even toxic levels. A high test reading, particularly where stunted growth has been observed, may indicate poisoning due to high levels.

This test is valuable on saline soils or when contamination from sea water or sea spray is suspected. Normal soils of humid regions rarely give readable test results, except when liberal amounts of chloride-containing fertilizers were recently applied.

Chloride is titrated with silver nitrate in *Chlorine Reagent 2S, after potassium dichromate in *Chloride Reagent #1 has been added as an indicator. The final result is read directly from the Titrator.

QUANTITY	CONTENTS	CODE
60 mL	Charcoal Suspension	5638-H
15 mL	*Chloride Reagent #1	*4504-E
2 x 60 mL	*Chloride Reagent 2S	*7624DR-H
1	Test Tube, 5-10-15 mL, w/cap	0701
1	Spoon, 1 g, plastic	0697
100	Filter papers	0465
1	Funnel	0459
1	Test Tube, 5-10-15 mL, w/cap	0778
1	Direct Reading Titrator, 0-1000 Range	0384

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PROCEDURE

Read the Direct Reading Titrator instructions on page 6 before proceeding. The Titrator is calibrated in ppm chloride. Each minor division on the Titrator scale equals 20 ppm.

1. Fill a clean test tube (0701) to 15 mL line with deionized water.
2. Use the 1 g spoon (0697) to add 3 measures of soil sample. Add 0.5 mL of Charcoal Suspension (5638). Cap and shake for 5 minutes.
3. Use funnel (0459) and filter paper (0465) to filter soil (see How to Use a Funnel and Filter Paper, page 10). Collect the soil filtrate. It will be used as the extract for the chloride test.

   NOTE: The extract may be slightly turbid. This will not interfere with the test result.
4. Fill the test tube (0778) to 10 mL line with soil extract.
5. Add 3 drops of *Chloride Reagent #1 (4504). Cap and mix. Solution should turn yellow.
6. Fill the Titrator (0384) with *Chloride Reagent 2S (7624). Insert Titrator into center hole of test tube cap.
7. While gently swirling the tube, slowly press plunger to titrate with *Chloride Reagent 2S until yellow color changes permanently to brick-red. Read result where plunger meets the scale. Record as ppm Chloride.
8. If the Titrator reaches the bottom mark on the scale before the color change occurs, refill and continue titration. Include original amount (1000 ppm) in final result.

ALUMINUM

All soils contain significant concentrations of aluminum, in the form of inorganic colloidal material and undecomposed minerals. In neutral, slightly alkaline, or slightly acid soils the aluminum is in inert combinations that do not affect plant growth. In more acidic soils, aluminum can form potentially toxic salts. A high test result indicates an undesirable acid soil. Plants which normally thrive on acid soils may fail in a soil with a high active aluminum test reading. A medium test result is tolerable to many plants, including grasses, corn, oats, potatoes, and tobacco; a low or negative aluminum result is preferable.

Aluminum reacts with hematein in the *Aluminum Test Solution to form a colored solution. The resulting color is matched to a color chart to determine the aluminum concentration.

QUANTITY	CONTENTS	CODE
30 mL	*Aluminum Test Solution	*5101-G
1	Pipet, transfer	0364
1	Spot Plate	0159
1	Pipet, transfer, plastic	0364
1	Stirring rod, plastic	0519
1	Aluminum in Soil Color Chart	1301

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PROCEDURE

1. Use pipet (0364) to add 2 drops of soil extract to the large depression on a spot plate (0159).
2. Add 2 drops of deionized water.
3. Use a clean pipet (0364) to add 1 drop of *Aluminum Test Solution (5101). Use a stirring rod (0519) to mix. Wait one minute.
4. Match sample color to a color standard on the Aluminum in Soil Color Chart (1301). Record result. Use chart below to convert reading to an approximate concentration. Record as ppm Aluminum.

Very Low	5 ppm
Low	10 ppm
Medium	30 ppm
High	80 ppm
Very High	125 ppm

MANGANESE

An essential element in the enzyme system of plants, manganese plays a role in metabolic reactions affecting germination, photosynthesis, and other vital aspects of plant development. Yellowing and stunted growth may indicate manganese deficiency.

Some insoluble manganese is present in all soils, and its solubility or availability is related to the pH. Calcareous soils, or soils which have been heavily limed, may be deficient in manganese, which can be corrected by applying manganese sulfate or another soluble manganese salt. Highly acid soils may have extremely high, even toxic, levels of manganese, which can be lowered by applying lime.

Since available manganese may be leached from the soil, or may be altered to less available forms by oxidation, tests should be performed just before planting and during plant growth. A positive test reading, even a very low reading, generally indicates sufficient available manganese to meet plant requirements. A high test reading is undesirable and indicates the need for lime.

Periodate oxidizes soluable manganous compounds to form permanganate.

QUANTITY	CONTENTS	CODE
10 g	Manganese Buffer Reagent	6310-D
30 mL	*Manganese Periodate Reagent	*6311-E
1	Spot Plate	0159
1	Pipet, transfer, plastic	0364
2	Spoons, 0.05 g	0696
1	Manganese in Soil Color Chart	1307-01

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PROCEDURE

1. Use a transfer pipet (0364) to add 10 drops of soil extract to the large depression on a spot plate.
2. Use the 0.05 g spoon (0696) to add one measure of Manganese Buffer Reagent (6310). Mix with a clean stirring rod (0519) until the powder dissolves.
3. Use the other 0.05 g spoon (0696) to add one measure of *Manganese Periodate Reagent (6311). Mix with a clean stirring rod for 20 seconds.

   NOTE: Immediately clean the spot plate to prevent staining.
4. Match the color in the spot plate to a color standard on the Manganese in Soil Color Chart (1307-01). Record as ppm Manganese.

Low	5 ppm
Medium	12 ppm
High	25 ppm
Very High	40 ppm

HUMUS

Humus consists of the complex remains of fresh plant and animal residue after extensive chemical and biological breakdown. It accounts for 60 to 70% of the total organic carbon in soil. It can modify the physical properties of soil, affecting the chemical and biological properties.

*Humus Screening Reagent Powder is EDTA, which extracts the humus from the soil. The resulting color is matched to a color standard to determine the humus concentration.

QUANTITY	CONTENTS	CODE
50 g	*Humus Screening Reagent Powder	*5119-H
2 x 60 mL	Soil Flocculating Reagent	5643WT-H
1	Extraction tube	0704
2	Spoon, 0.5 g, plastic	0698
100	F ilter Papers	0465
1	Funnel	0459
1	Humus Color Chart	1384

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PROCEDURE

1. Use the 0.5 spoon (0698) to add 8 level measures of soil to an extraction tube (0704).
2. Add deionized or tap water to 14 mL line. Cap and shake to mix.
3. Use the 0.5 g spoon (0698) to add 2 measures *Humus Screening Reagent Powder (5119). If necessary, add more water to bring level to 14 mL mark. Cap and mix vigorously for one minute.
4. Add 15 drops of Soil Flocculating Reagent (5643WT). Cap and mix gently. Allow the soil to settle for several minutes.
5. Use filter paper (0465) and funnel (0459) to filter mixture (see How to Use a Funnel and Filter Paper, page 10). Collect filtrate in a second extraction tube.
6. Match sample color of the filtrate to a color standard on the Humus Color Chart (1384). Record result. Use chart to convert result to a value.

Humus or Organic Matter in Soil

Humus Reading	1	2	3	4	5
Agricultural Soils	Low	Medium	High		
Garden Greenhouse Soils		Low	Medium	High	
Organic Soils			Low	Medium	High

GREEN PLANT TISSUE TESTS

Nutrient deficiencies during plant growth can be verified by using an extract prepared from fresh plant tissue. A procedure for testing nitrate nitrogen, phosphorus, and potassium in plant tissue is described below. Additional information on plant tissue testing is discussed in the *LaMotte Soil Handbook* (Code 1504).

These tests are meant to be used in a comparative manner. When testing plant tissue, it is important to compare tissue from healthy plants to tissue from the problem plants. Plants of the same species, the same age and grown in the same environment should be compared. Since test reactions vary from species to species, and even from environment to environment within a species, it is not possible to accurately quantify results. Relative values from very deficient to abundant have been assigned to the range of possible test reactions under each factor below.

PREPARATION OF TISSUE EXTRACT

1. Select a small lot of the leaf petioles or succulent portions of the stem. When testing problem plants, collect tissues from those areas where the abnormality is most visible.
2. Use a clean, sharp knife or razor blade to cut the material into small pieces, not more than 1/8" to 1/16" in length and thickness.
3. Fill a extraction vial (0701) half way with plant material.

   NOTE: Do not pack material into vial.
4. Use a 1 mL pipet (0354) to add 1 mL of *Acid Extracting Solution (6361).
5. Dilute to line with deionized water. Cap and shake for 5 minutes.
6. Use filter paper (0465) and a funnel (0459) to filter sample (see How to Use a Funnel and Filter Paper, page 10). Collect filtrate in a second vial. Use tissue extract in test procedures instead of soil extract.

PLANT TISSUE PROCEDURE

Follow the test procedures for nitrate nitrogen, phosphorus and potassium, using tissue extract instead of soil extract. Results should be used in a comparative manner, which can be used with the lists below to determine relative concentrations. The most meaningful test results will be obtained by comparing healthy plants to problem plants.

Guidelines for Interpreting Plant Tissue Tests

Test Factor	Test Reaction	Relative Amount Of Nutrient In Plant Tissue
Nitrate Nitrogen	Dark Pink Color	Abundant
	Light Pink Color	Adequate
	Colorless	No Reserve/Probably Deficient
Phosphorus	Deep Blue Color	Adequate
	Light Blue Color	Adequate
	Yellow to Colorless	Low to Deficient
Potassium	Heavy Precipitate	Adequate to Abundant
	Medium Precipitate	Low to Deficient
	Trace Precipitate	Deficient
	No Precipitate	Very Deficient

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