Appropriate Analyses for New Mexico Soils and Interpreting Soil Test Results

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Food comes from the earth. The land with its waters gives us nourishment. The earth rewards richly the knowing and diligent, but punishes inexorably the ignorant and slothful. This partnership of land and grower is the rock foundation of our complex social structure.- W. C. Lowdermilk

Soil testing helps us understand the environment in which our plants must survive. A complete understanding of the soil would include its physical, chemical, and biological properties. Physical characteristics relevant to plant production include soil texture, permeability, compaction, and water-holding capacity. Chemical properties include soil pH, salinity, plant nutrients, reactivity, and ion exchange. Soil biology determines how efficiently nutrients are released from organic matter, how well organic matter is decomposed, and how well the soil "breathes" or respires carbon dioxide.

Obtaining a Sample

A soil test is only as good as the sample from which it came. One core from a fairway does not represent the fairway or the whole golf course. Samples should be taken from areas that can be treated as distinct units. The rough differs from the fairway, and some areas cross boundaries that are vastly different in the soil's physical and chemical properties. It usually takes 12 to 15 subsamples combined into one sample in order to be confident in the soil test results from the lab. This many subsamples assures that you have retrieved soil that is representative of a management zone.

The soil depth for sampling should be between 6 and 8 inches. The tool of choice is a probe that allows easy soil retrieval without leaving behind a greatly disturbed area. Some soils are too hard to easily push in a probe and a hammer is necessary.

What To Test For

New Mexico State University's Soil, Water, and Plant Testing Lab routinely tests soil for the following properties: pH, electrical conductivity, calcium, magnesium, sodium, organic matter, inorganic nitrogen, phosphorus, potassium, and texture. These tests are unique to New Mexico, because there are specific ways the soil must be handled in the lab to get accurate results. Soil pH, electrical conductivity, calcium, magnesium, and sodium are determined from a saturated paste. Organic matter is determined from a procedure known as the Walkley-Black method. Inorganic nitrogen is determined with a procedure that extracts the two forms of inorganic nitrogen, ammonium and nitrate. Phosphorus is determined from extracting the soil with a solution of bicarbonate. This extractant is used commonly on soils with a pH above 7.2, and correlates very well with what a plant actually can remove from the soil environment. Potassium is determined from a water extract. Micronutrients are required by plants in small quantities and can be evaluated through soil testing using an extract known as DTPA (diethylenetriaminepentaacetic acid).

Saturated Paste

Tests performed on a saturated paste made from the soil sample correlate well to plant response. Making the paste usually takes 24 hours to complete. The paste is put under high suction, and the liquid is withdrawn from the paste. The pH, electrical conductivity, calcium, magnesium, and sodium are then determined from this water sample. The sample is known as the saturated paste extract and most closely resembles what a plant "experiences" under irrigated conditions.

Table 1. Pounds of elemental sulfur to lower soil pH with no free lime present.

pH Change	Sand	Loam	Clay
	pounds of sulfur per 1,000 square feet		
8.5 to 6.5	46	57	69
8.0 to 6.5	28	34	46
7.5 to 6.5	11	18	23
7.0 to 6.5	3	4	7

Table 2. Classification of soil organic matter into low, medium, or high as affected by soil texture.

Sandy Texture	Clay Texture	Classification
% soil organic matter range		
Less than 0.5	Less than 1.0	Very Low
0.5 - 1.0	1.0 - 2.0	Low
1.0 - 1.5	2.0 - 3.0	Moderate
More than 1.5	More than 3.0	High

Soil pH

Soil pH is a measure of the soil's acidity or basicity (alkalinity). A liquid is acidic if the pH is below 7.0, and alkaline if the pH is above 7.0. A neutral soil has a pH of 7.0. Technically, soil pH is the negative logarithm of the hydrogen ion activity (-log10 H^+) in the soil. Common household items that are acidic include vinegar, coke, and coffee, while detergents, bleach, and antacids are alkaline. Rain is naturally acidic with a pH of 5.6.

Ideally, soil pH should be near 6.5 in order to keep phosphorus in its most available form. Many micronutrients, such as iron and zinc, also are more available to the plant at a 6.5 soil pH. Other nutrients for plant growth are strongly affected by soil pH. Only nitrogen, potassium, and sulfur are unaffected by soil pH.

Soil pH in New Mexico is normally between 6.5 and 8.4. Mountain soils, where more rain occurs, generally have a soil pH below 7.0. Many garden soils that have received too much organic matter also have a low soil pH. For much of the state, soil pH is controlled by the presence of calcium carbonate (lime). Lime acts as buffer against changes in soil pH. Try a quick test to see if there is free lime in the soil. Simply pour a little vinegar on the soil. If the soil fizzes, then free lime is present. A soil with 5 percent lime in the top 6 inches has approximately 2,296 pounds of lime per 1,000 square feet. All of this lime must be neutralized before the soil pH can be lowered. Elemental sulfur is a common amendment used to lower soil pH. However, adding amendments does cost money. It is often more economical to establish plants that are tolerant of alkaline soils and are not sensitive to soil lime. This way, additional amendments are not needed to keep the plant green and alive.

If your soil does not have any free lime, use table 1 to estimate the amount of elemental sulfur needed to lower the soil pH. Notice that you also need to know the soil texture in order to apply the correct amount.

Soil Electrical Conductivity (EC)

Total soil salts are determined on a sample to classify the soil as saline or nonsaline. Special management practices are necessary when soils test as saline. More detail on this test are provided in the "Introduction to Salinity" section.

Soil Organic Matter

A standard test for organic matter should be run on most soils to give an idea of the soil's nutrient reserve, improved water-holding capacity, and problems that might develop from excessive organic matter.

Soil organic matter (SOM):

- Helps strengthen soil aggregates, improving soil tilth and structure.
- Improves aeration and water infiltration.
- Increases water-holding capacity (0.08 to 0.19 inches per 1 percent SOM).
- Provides a significant number of nutrient exchange sites.
- Buffers against rapid changes in soil reaction.
- Forms stable organic compounds that can increase micronutrient availability.

- Provides a source of plant nutrients (0.7 pounds N per 1,000 square feet per year per 1 percent SOM per foot of soil).
- Provides a food source for soil microorganisms.

Organic matter also tends to lessen the effects of salinity on plant growth. Scientists at NMSU are studying crop responses to salinity under high organic matter conditions.

Nutrient Analysis

Three primary nutrients are tested on a routine basis at NMSU's Soil, Water, and Plant Testing Laboratory in Las Cruces. These nutrients include inorganic nitrogen, phosphorus, and potassium. Four micronutrients also can be requested and include iron, zinc, copper, and manganese. The nutrients are ranked according to the likelihood that plants would respond to additions of fertilizer. A soil that is ranked low means there is not enough of that nutrient for the plant to grow correctly and would benefit from an application of that nutrient. If the nutrient is ranked high there is little chance the plant would respond to additions of that nutrient.

Nitrogen

Inorganic nitrogen is reported as nitrate. Table 3 categorizes the inorganic nitrogen levels in soil into five broad categories.

The amount of fertilizer nitrogen needed is based on the amount of nitrogen in the soil and the amount of nitrogen required to adequately promote growth and performance of a given crop. Fast-growing plants generally require more nitrogen than slow-growing plants. Table 4 provides some guidelines for some grass species that would be appropriate for selected areas in New Mexico. Nitrogen fertilizer applications may be eliminated (at first), if the soil test is rated high for inorganic nitrogen. Fertilizer should be applied when temperature and moisture conditions favor active growth; they should not be applied during times of stress.

Phosphorus

The routine soil test at NMSU extracts plant available phosphorus using a sodium bicarbonate solution. This extractant has been shown to correlate very well with what a plant can remove from the soil. Table 5 interprets the extractable phosphorus into relative concentrations from very low to very high and attempts to ascertain whether or not there will be a response to added fertilizer.

Table 3. Interpreting soil inorganic nitrogen levels.

Classification	ppm	Response to Added N	Classification	ppm	Response to Added N
Very Low	< 3	High	High	31 - 50	Not likely
Low	3 - 10	High	Very High	>50	Not likely
Medium	11 - 30	Moderate			

Table 4. Fertilizer nitrogen rates for selected grasses when soil test values show moderate or low amounts of available inorganic (NO_3-N) nitrogen.

	Rate lb N/1,000 ft^2 per growing month			Rate lb N/1,000 ft^2 per growing month	
Species	Moderate Soil Test	Low Soil Test	Species	Moderate Soil Test	Low Soil Test
Bahiagrass	0.1	0.4	Centipedegrass	0.1	0.3
Bentgrass, Colonial	0.5	1.0	Fescue, Fine	0.1	0.4
Bentgrass, Creeping	0.5	1.3	Fescue, Tall	0.4	1.0
Bermudagrass, Common	0.5	1.0	Grama, Blue	0.1	0.3
Bermudagrass, Improved	0.7	1.4	Ryegrass, Annual	0.4	1.0
Bluegrass, Annual	0.5	1.0	Ryegrass, Perennial	0.4	1.0
Bluegrass, Kentucky	0.4	1.0	St. Augustinegrass	0.5	1.0
Bluegrass, Rough	0.4	1.0	Wheatgrass, Crested	0.2	0.5
Buffalograss	0.1	0.4	Zoysiagrass	0.5	0.8

Table 5. Interpreting soil inorganic phosphorus levels.

Classification	ppm	Response to Added P_2O_5	Classification	ppm	Response to Added P_2O_5
Very Low	< 7	High	High	23 - 30	Not Likely
Low	8 - 14	High	Very High	>31	Not Likely
Medium	15 - 22	Moderate			

Table 6. Interpreting soil inorganic potassium levels.

Classification	ppm	Response to Added K_2O	Classification	ppm	Response to Added K_2O
Very Low	< 10	High	High	61 - 80	Not Likely
Low	11 - 30	High	Very High	>80	Not Likely
Medium	31 - 60	Moderate			

Table 7. Estimated nitrogen, phosphorus, and potassium rates for warm-season grasses, such as bermudagrass, zoysia and St. Augustine lawns, when soil test ntrigen (NO_3-N) is low.

Phosphorus	Potassium Rating				
Rating	Very High	High	Medium	Low	Very Low
	Pounds N-P_2O_5-K_2O per 1,000 square feet				
Very High	2.1-0-0	2.1-0-0	2.1-0-0.9	2.1-0-2.1	2.1-0-2.8
High	2.1-0-0	2.1-0-0	2.1-0.9-0.9	2.1-0.9-2.1	2.1-0.9-2.8
Medium	2.1-1.9-0	2.1-1.9-0	2.1-0.9-0.9	2.1-0.9-2.1	2.1-0.9-2.8
Low	2.1-2.3-0	2.1-2.3-0	2.1-2.3-1.4	2.1-2.3-2.1	2.1-2.3-2.8
Very Low	2.1-2.3-0	2.1-2.8-0	2.1-2.8-1.4	2.1-2.8-2.1	2.1-2.8-2.8

New Mexico soils that are low in organic matter usually are low in plant available phosphorus. Phosphorus usually is unavailable to plants in the alkaline pH of Western soils, and should be supplemented for a growing plant. As many as two applications per year may be required to achieve a healthy and vigorous root system. Phosphorus fertilizers can be applied at 1/5th the nitrogen rate when making routine applications. However, for the first fertilizer application in the spring, the phosphorus rate should be the same as the nitrogen rates if the soil test indicates low levels of available nitrogen.

Potassium

NMSU is unique in its approach to testing soil potassium (potash = K_2O). A water extract is made of the soil and the amount of potassium in solution is determined. Most other labs commonly used by farmers and homeowners rely on ammonium acetate as the extractant. Potassium levels should never be compared from lab to lab unless the methods are the same. Table 6 interprets the extractable potassium into relative concentrations from very low to very high and indicates the likelihood that there will be a response to added potash fertilizer.

Table 8. Classification of DTPA extractable iron.

Parts per Million (ppm) (DTPA Extractable Fe)	Classification
< 2.5	Low
2.5 - 4.5	Medium
> 4.5	High

Table 9. Classification of DTPA extractable zinc.

Parts per Million (ppm) (DTPA Extractable Zn)	Classification
< 0.5	Low
0.5 - 1.0	Medium
> 1.0	High

Table 10. Classification of DTPA extractable copper.

Parts per Million (ppm) (DTPA Extractable Cu)	Classification
< 0.3	Low
0.3 - 1.0	Medium
> 1.0	High

Table 11. Classification of DTPA extractable manganese (Mn).

Parts per Million (ppm) (DTPA Extractable Mn)	Classification
< 1.0	Low
1.0 - 2.5	Medium
> 2.5	High

A Sample Reference Chart

Table 7 depicts a cross-reference chart used to estimate the N, P_2O_5, and K_2O needed for some warm-season grasses based on soil testing for phosphorus and potassium. The nitrogen rate is based on low levels of available nitrogen.

Micronutrients

Iron (Fe): Iron is extracted with DTPA (a chelate) by most labs in the West. Iron deficiencies can occur with sensitive plants grown in alkaline or calcareous soil. Soil iron can be classified as low, medium, or high based on this DTPA extract (table 8). If the soil pH is above 7.5, less iron is available to the plant because the chemistry of soil favors rock formation. Even though a soil may test high in available iron, iron-sensitive crops may still exhibit deficiency symptoms. Chelates often are used to keep iron in a more available form but care should be taken to pick EDDHA or DTPA as the chelate of choice in New Mexico over EDTA. These two chelates are stable in New Mexico soil's, and plants generally will respond to their use.

Zinc (Zn): Zinc, like iron, is extracted with DTPA by most labs in the West. Zinc can be an economic problem for many crops like corn, sorghum, and pecans. Zinc is most unavailable in soils with a pH greater than 7.5. Extremely high levels of phosphorus can cause zinc deficiencies by competing for adsorption sites on the soil. Soil test results are classified as low, medium, or high (table 9).

Copper (Cu): Copper deficiencies have not been verified in New Mexico soils. Factors that contribute to copper deficiency are high organic matter, sandy textural class, and very high pH. General classification of copper is given in table 10.

Manganese (Mn): Manganese deficiencies have begun to show up in pecans and some other crops in New Mexico. Deficiency symptoms can occur under the same conditions that promote iron and zinc deficiencies. Manganese can be classified as low, medium, or high depending on the amount extracted with DTPA (table 11).

Table 12. Size limits of soil separates and their classification.

USDA Classification

International Classification

Name of Separate	Diameter (range) mm	Size Fraction Designation	Diameter (range) mm
Very coarse sand	2.0 - 1.0		
Coarse sand	1.0 - 0.5	I	2.0 - 0.2
Medium sand	0.5 - 0.25		
Fine sand	0.25 - 0.1	II	0.20 - 0.02
Very fine sand	0.1 - 0.05		
Silt	0.05 - 0.002	III	0.02 - 0.002
Clay	below 0.002	IV	below 0.002

Table 13. Approximate amounts of available water held by soils of different textures.

Soil Texture	Inches of Water per Foot of Soil Inches	Maximum Rate of Irrigation Inches per Hour (bare soil)
Sand	0.5 - 0.7	0.75
Fine sand	0.7 - 0.9	0.6
Loamy sand	0.7 - 1.1	0.5
Loamy fine sand	0.8 - 1.2	0.45
Sandy loam	0.8 - 1.4	0.4
Loam	1.0 - 1.8	0.35
Silt loam	1.2 - 1.8	0.3
Clay loam	1.3 - 2.1	0.25
Silty clay	1.4 - 2.5	0.20
Clay	1.4 - 2.4	0.15

Soil Texture

The last item reported on an NMSU soil test is soil texture. Soils are composed of mineral particles with an infinite number of sizes and shapes. Individual mineral particles are divided into three major categories on the basis of their size: sand, silt, or clay (table 12). Many of soil's important physical and chemical properties are associated with the surface of these particles. Soil texture is estimated by "feel" but sieves or hydrometer readings can be requested.

Soil texture gives an indication about the soil's water-holding capacity and the maximum irrigation rate (table 13).

Conclusions

Soils are complex biological, chemical, and physical systems. Diligence in interpreting soil test results can save hundreds of dollars every year. The only way to know what a soil is like is to start with a soil sample. Contact NMSU's Soil, Water, and Plant Testing Lab at Box 30003, Dept 3Q, Las Cruces, NM 88003, or phone (505) 646-4422. Call for prices. Other labs also can be used (table 14). Be sure to follow the interpretation given by those labs. Also, individual labs vary in services offered, prices, and the time they require for analysis. The list of laboratories in table 14 is not all-inclusive, and the list of services may change over time. To select a lab, consider convenience, services offered, and quality.

Table 14. Soil testing laboratories used by New Mexico homeowners.

Agricultural Testing and Research Lab
PO Drawer 1318
Farmington, NM 87499
(505) 326-2730

MDS Harris
621 Rose St.
P.O. Box 80837
Lincoln, NE 68501
(402) 476-2811
www.mdsharris.com

NMSU Soil, Water and Plant Testing Lab
MSC 3Q Box 30003
Dept of Agronomy and Horticulture
Las Cruces, NM 88003
505-646-4422

Servi-Tech Labs
POB 1397
1816 E. Wyatt Earp
Dodge City, KS 67801
316-227-7123

Soil and Water West, Inc.
1700 Southern Blvd.
Rio Rancho, NM 87124
505-891-9472

Ward Laboratories
4007 Cherry Ave
Kearney, NB 68848-0788
308-234-2418
800-887-7645

There is a North American Laboratory Proficiency Program administered by Utah State University (1-801-797-2217). This program provides a manual with detailed descriptions of recommended analytical methods and also runs a Quality Assurance/ Quality Control (QA/QC) program. Participating labs are sent samples to analyze throughout the year and their results are compared to other laboratories. These comparisons are sent back to the labs to help them improve techniques and methods. Most laboratories have a QA/QC program. By running duplicate samples and comparing results, or by periodically analyzing standards during sample runs, a lab can determine
if its results are reproducible and accurate.

Fertilizer recommendations are based on soil test results. However, there are different nutrient management philosophies that will impact recommendations.

Questions to ask a lab include:

- What analyses does your laboratory offer for the homeowner?
- What do they cost?
- How long will it take to get results?
- Do you participate in the North American Laboratory Proficiency Program?
- Are your analytical methods EPA-approved or described in the North American Laboratory Proficiency Program?
- Is the lab associated with a co-op or fertilizer company?
- What is your philosophy in making fertilizer recommendations? Do they match your philosophy?

Finally, keep a record of your lab results. If you need help interpreting the results please consult with your New Mexico State University Cooperative Extension Service county office.

Notes