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Sampling and Submitting Soil Samples for Analysis

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Proper soil sampling prior to submission to a laboratory for fertility analysis is one of the most important steps that a grower takes to evaluate fertilizer needs. Subsamples of soil should be taken from uniform cropping areas and combined to make one sample. Uniform areas would include those with similar slope or soil type and texture. Good areas should be sampled separately from bad areas. The number of subsamples will depend on time constraints and labor availability; but generally, 15 to 20 subsamples per 40 irrigated acres (100 dryland acres) and six to eight subsurface cores reduces the variability found in soils so that lab analyses are consistent from year to year. Samples should be taken from the tillage depth for surface soils and tillage depth to 2 feet for subsoils. Sampling depth, however, may be different depending on which lab the sample is sent to, since fertilizer recommendations may be calibrated to certain depths. Sampling depth may also change with the type of information needed or cropping system used. For example; salt problems may be best addressed by sampling the top four inches or tillage depth to two feet if subsoil salinity problems are suspected. Subsoil sampling is necessary for corn (12"-24") and sugar beets (12"-24", 24"-36") to fully evaluate nitrogen levels and to take full advantage of the fertilizer recommendations suggested by Colorado State University.

No-till fields have to be sampled in a way to prevent the over- representation of residual fertilizer bands. Where fertilizer bands are known, methods have been developed to obtain a soil test value from six inch deep samples by using the following formula to determine the number of soil cores to be collected between-the-bands for every one in-the-band: S = 8 X band spacing (inches) / 12. Where S = number of soil cores to be taken between the bands for every soil core taken in-the-band. For example, if the P fertilizer bands were 24 inches apart, 16 soil cores should be collected outside of the band for every one collected in the band. If the band location is unknown it is recommended to use

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Sampling

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random sampling or paired sampling. Paired sampling can be done where the first core is taken randomly and the second core is taken 50 percent of the band spacing from the first, perpendicular to the band direction, (Westfall et al., 1991). An information sheet should be filled out to include past crops, manuring, crop to be grown, yield goal, and whether the crop is to be irrigated or not. Once samples are collected they can be air dried and placed in plastic lined soil sample bags or in plastic zip lock bags. Samples can then be sent or delivered to a laboratory for analysis. If it has been a long period of time since the sites were sampled or evaluated for fertility it may be necessary to request a full series of tests that include pH, salts, organic matter, N, P, K and micronutrients. If the field is sampled and evaluated every year, then it may require only an organic matter, N, P, K test. Check with the laboratory that will be doing the testing to get their package pricing.

Westfall, D.G., N.R. Kitchen, and J.C. Havlin. 1991 Soil Sampling: Guidelines for band-applied phosphorus. Better Crops With Plant Food 75 (No.2): 24-30

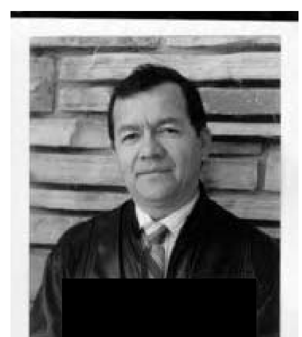
Jim Self

authors

Juan B. Rodriguez is a research associate at Colorado State University's Soil, Water, and Plant Testing Laboratory. His research program involves looking for ways to improve soil testing methods for macro- and micro- nutrients, bioavailability of nutrients in sludge amended soils, and the effect of salinity on plant growth. He also team teaches a graduate level course entitled "Soil and Plant Chemical Analysis."

Dr. Rodriguez holds a Ph.D. in Agronomy from Colorado State University, an M.S. from the University of Missouri. Prior to his appointment at CSU, Dr. Rodriguez taught courses in general, analytical and agricultural chemistry and was Director of Laboratory at Universidad Nacional Agraria-La Molina in Lima, Peru.

Dr. Rodriguez is an excellent resource if you have questions on lab methods and soil testing.



Dr. Juan B. Rodriguez

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Contributing authors are:
Troy Bauder, Water Quality
Mark Brick, Bean Production
Jessica Davis, Soils
Kirk Iverson, Soils & Agronomy
Duane Johnson, New Crops
Jerry Johnson, Crop Production
Sandra McDonald, Pesticides
James Self, Soil, Water & Plant Testing
John Shanahan, Crop Production
Reagan Waskom, Water Quality

Direct questions and comments to:
Gloria Blumanhourst
Phone: 970-491-6201
Fax: 970-491-2758
E-Mail:
gbluman@lamar.colostate.edu
Web Site:
http//www.colostate.edu/Depts/SoilCrop/extens.html.

Understanding and Using Soil Tests for Phosphorus

What is a Soil Test? A soil test is defined as a chemical method for estimating the availability of a specific nutrient in the soil. The soil test must be calibrated against nutrient rate experiments in the field, in order to predict nutrient needs of crops.

Field studies are very costly, and require a minimum number of twelve experiments done over two or three years to establish the critical level necessary to develop fertilizer recommendations. The critical level is the calibrated value of the nutrient. When the nutrient level is below the critical level, crops will probably respond to fertilizer application. When the nutrient level is above the critical level, crops will probably not respond to fertilizer applications.

Recently, new soil test methodologies have been developed without doing nutrient rate experiments in the field. When using these new methodologies, fertilizer recommendations are based on simple correlations in which the amount of nutrient extracted in the laboratory with the method under study is correlated with values obtained from a previously calibrated soil test method. If the correlation is strong, then the new method could be used to predict nutrient needs.

The correlation technique is based on the hypothesis that if two methods correlate well, then both methods are indexing the same pool of available soil P and if one method satisfactorily predicts crop response, the other should be just as effective.

There are many soil tests to estimate the availability of phosphorus for plant growth. In the western United States, the most commonly used tests are Bray (Bray and Kurtz P-1), Mehlich 3, Olsen et al. (sodium bicarb),and Soltanpour and Schwab. Other tests available include: Morgan, Mehlich P-1, Ahmed and Islam, Onken et al., and Rodriguez et al.

Acid soils in general need acid extractants while alkaline soils need basic extractants. The Bray and Kurtz P-1 and Mehlich-3 tests contain acid extractants that were developed to predict the availability of phosphorus for acid soils. The Olsen et al., and Soltanpour and Schwab tests contain basic extractants that were developed to estimate the availability of phosphorus in alkaline soils, including those soils containing free calcium carbonate. Soil P tests developed for acid soils are not recommended for analysis of P in alkaline soils, because the extraction efficiency is lowered by the alkalinity of the soil. Similarly, soil tests developed for alkaline soils do not work well in acid soils.

When soil from the same sample is tested by two different methods, the resulting quantity of available P may be different. The numerical results differ because different soil tests extract different quantities of P. But the farmer submitting the samples expects the P levels to be the same. While the available P numbers may vary, the fertilizer recommendations based on the tests should be very similar.

Let's use an example: A dryland millet farmer collects a soil sample and sends one-third of the sample to three different labs.

RESULTS		P_2O_5 Needed for Max. Yield
Lab # 1 =	3 ppm-P	30 lb/A
Lab # 2 =	12 ppm-P	30 lb/A
Lab # 3 =	20 ppm-P	30 lb/A

The available P results from each lab are different because each lab uses a different soil P test, but the amount of P_2O_5 needed for maximum yield should be the same or similar for all three labs.

Juan B. Rodriguez

Field Kits for Soil and Water Analysis

In situations where a rapid analysis is more important than a high degree of accuracy, the use of field test kits is sometimes warranted. A number of quick soil and water test kits have been commercially developed that allow "field testing." Field tests can alleviate the problem of slow turn-around time in commercial soil testing laboratories and offer a cheaper cost per sample, if enough samples are run. Field kits are best used for water analysis because no extraction steps are necessary for water samples. Soils can be extracted and analyzed with field test kits, but in most cases there is inadequate correlation data to make accurate fertilizer recommendations. For this reason, these field test methods are best used for qualitative assessments of soil properties such as pH, free lime, or conductivity. Semi-quantitative assessments of soil contaminants such as PCB, hydrocarbons, triazoles and other industrial chemicals can also be accomplished with commercially available field kits.

Commercial kits are available for N, P, K and micronutrient analysis in soil, but it is difficult to recommend any of these methods, except for NO_3-N analysis. Since NO_3 is water soluble, there are fewer problems with varying extractants. The main differences between laboratory and field analysis will be the soil drying, grinding, shaking and analytical techniques. Repeatable results depend upon a standardized field procedure. A useful technique is to have a well-mixed soil with a known NO_3-N content for use in the field as a standard to check the accuracy of your analysis. We have tested several commercially available NO_3-N field kits and found they correlated very well with lab results when careful technique is used.

Be aware that many commercially available test kits determine NO_3-N on soil volume basis. Commercial labs will report soil nutrients an a weight basis and results are reported as ppm NO_3-N. Make sure your results are expressed on a weight basis before you compare results of a test kit with those of the CSU Soil Testing Laboratory. For a soil sample with a bulk density of 1.0, the results would be the same for weight or volume basis. For most Colorado soils, the difference could be significant.

As with any analytic method, proper sampling technique is a critical step in field testing. Follow the typical sample collection steps and gather enough subsamples for a representative soil sample.

Below are listed the names and addresses of a few suppliers of field test kits. This list is intended only as a starting point and does not imply endorsement of their products. Please contact us if you would like more information on field testing kits.

Hach Company, P.O. Box 389, Loveland, CO 80539, (800) 227-4224.

Hawk Creek Laboratory, Box 686, Glen Rock, PA 17327, (800) 637-2436.

Spectrum Technologies, Inc., 12010 S. Aero Drive, Plainfield, IL 60544, (800) 248-8873.

ConAgra Technologies, Goodfield, IL 61742, (800) 634-5471.

Reagan Waskom

Making Fertilizer Recommendations

After a soil sample has been analyzed, it is necessary to make some type of interpretation of the results so that the client can understand how the analytical data of the soil test relates to the amount of fertilizer that must be added to the soil to correct nutrient deficiencies. There are several assumptions that are made in interpreting soil tests. These include: 1) The soil is at least as deep as the plant normally roots. If the soil is only 20-30 inches deep, there is only a partial root zone available to supply the nutrients and water. 2) There are no conditions inhibiting root growth such as plow pans, or compacted soils. 3) Other growth factors such as moisture, temperature or salt levels are adequate. 4) Good seed selection, weed control and correct planting times are used to achieve optimum crop yields.

Several philosophies are used as the basis for fertilizer recommendations that can result in different suggestions based on the same soil test. One common scheme is termed the prescription method where only the nutrients needed for that year's optimum crop yield are recommended. Only the crop's need would be supplied. The amount of fertilizer suggested depends on the method of application or crop residues left on the soil. Another method for making recommendations is termed prescription plus buildup where nutrients are suggested for the crop plus additional nutrients are recommended to increase the value of that nutrient in the soil. This method may be used for phosphorus, potassium and micronutrients. It would not be common to use it for nitrogen. In the process of building up the soil, testing would be necessary to not only determine deficiencies but also the possibility of toxic levels of nutrients in the soil especially in the case of excessive micronutrients.

A third scheme for making recommendations would be to recommend the application of the total fertilizer needed during a full rotation. Enough fertilizer would be added to the first crop of the rotation to carry over to the second crop. The addition of more fertilizer at the beginning of a rotation could cause problems with potential fertilizer runoff or ground water contamination. The grower must also decide if the cost of two applications is cheaper than the lowered efficiency of fertilizer when it is applied so far ahead of the second crop in the rotation.

A fertilizer recommendation requires a soil test value to provide the proper suggestions for fertilizer application. Soil test values alone are meaningless except to group the soils into different categories having similar amounts of that available nutrient. Once the general amount of fertilizer needed is known, it is then necessary to consider other factors that can affect the amount of fertilizer to be applied. The other factors include: 1) subtracting a certain amount of recommended fertilizer for each ton of manure to be added, 2) subtracting a certain amount of recommended fertilizer for residual P or N left over from certain previous crops, 3) adding or subtracting from the recommended fertilizer base for yield goals that are larger or smaller than the reference value, 4) adding or subtracting fertilizer depending on the area's climate, 5) adding or subtracting recommended nitrogen or phosphorus because of unusually high or low humus or crop residue levels in the soil.

When evaluating soil tests, keep in mind that the probability of a profitable response is much greater on a soil that tests low in a given nutrient than on one that tests high. For example, there would be a 70-90% chance of getting a yield response where there is a low soil test. A profitable response may occur from fertilizer application at a high level of fertility when other production factors are optimum.

Soil tests are very useful as a diagnostic tool and should be used as part of any management scheme. When a good representative soil sample is taken and all factors involved in making accurate fertilizer recommendations are considered, it is amazing how often the recommendations work!

Jim Self

How do Soil Testing Labs Measure Up

We have been comparing the turn-around time, costs, lab results, and fertilizer recommendations of soil testing labs for the past two years. A farmer's field was chosen in each participating county and sampled to two feet deep, and then the soil sample was split into ten subsamples (after mixing vigorously) and sent to ten labs. The labs which were utilized include: Ward Laboratories, Stukenholtz Laboratory, Servi-Tech Laboratories, Olsen's Agricultural Laboratory, Midwest Laboratories, Harris Laboratories, Weld Laboratories, Triple S Lab (no longer in business), Grand Junction Laboratories, A & L Laboratories, Root and Norton Laboratories, Agricultural Testing and Consultants, Irrigated Research Foundation Farm, Colorado Analytical Laboratory, and the Colorado State University (CSU) Soil, Water and Plant Testing Laboratory.

We followed the fertilizer recommendations from each lab, and replicated each of these treatments two to four times (depending on

Table 1: How Do Soil Testing Labs Measure Up? Results of a two-year comparison of Soil Testing Labs in Colorado.

	Tturn-around Time (days)	Analysis Fee ($)	Fertilizer Cost ($/acre)	Yield
Baca County				
CSU	53	$22.00	$31.01	176 bu/acre
Other Labs	9.7 (6-12)	$27.18 ($15.85-50.50)	$54.79 ($28.00-86.71)	181 bu/acre (173-186)
Delta County				
CSU	14	$16.57	$33.25	193 bu/acre
Other Labs	7.6 (4-12)	$31.22 ($17.60-51.42)	$67.13 ($34.15-119.52)	188 bu/acre (178-197)
Kit Carson County				
CSU	6	$23.50	$20.33	187 bu/acre
Other Labs	7.8 (6-10)	$21.04 ($11.75-44.00)	$47.45 ($27.21-86.56)	195 bu/acre (184-207)
Logan County				
CSU	30	$22.00	$0.00	15.9 tons/acre
Other Labs	10.4 (5-15)	$30.33 ($13.25-60.00)	$38.97 ($1.94-84.67)	16.5 tons/acre (15.8-17.3)
Morgan County				
CSU	22	$16.50	$31.56	143 bu/acre
Other Labs	14.3 (7-38)	$19.80 ($15.50-25.80)	$86.08 ($74.53-101.12)	140 bu/acre (134-147)

Labs

(Continued from page 6)

location and field size). Corn was grown, and yields were measured. In 1996, this experiment was done in Delta, Kit Carson, and Morgan counties, and in 1997, the test was carried out in Baca, Logan, and Pueblo counties. The Pueblo location was harvested very late due to weather conditions, and, therefore, that data is not quite ready to be released.

A summary of the results is shown in the table on page 6. In four out of five cases, the CSU lab had a longer turn-around time than the private labs. The analysis fee at CSU was usually lower than the average fee of the private labs, but there were several private labs with prices lower than CSU's.

The fertilizer recommendations varied considerably across labs. About 30% of the private labs recommended micronutrients (Zn, Mn, B, S, or Cu), and CSU did not recommend micronutrients in any of the test cases. The average N, P, and K recommendations also tended to be higher from the private labs than the CSU lab. Therefore, the fertilizer costs (per acre) were usually lowest using CSU's recommendations. Among private labs, the range in recommendations and fertilizer costs was large, with a difference of at least $25/acre up to over $80/acre depending on the lab being used. In spite of CSU's recommendations being low, fertilizer recommendations from other labs never resulted in a significantly higher yield than CSU.

In summary, the CSU lab is slower than private labs, the fertilizer recommendations are usually lower than private labs, but the recommendations are solid. Recommendations from other labs never led to significantly higher yield than the CSU lab. There are a number of private labs whose recommendations were close to CSU's but had quicker turn-around time than CSU.

Many heartfelt thanks to the cooperating farmers and Bruce Bosley, Randy Buhler, Wayne Cooley, Tim Macklin, Ron Meyer, and Frank Sobolik for making this on-farm research possible. The complete data set will be released this spring; if you'd like to receive a copy please let me know (jgdavis@lamar.colostate.edu).

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web sites

Looking for more information on soil testing? It's on the web! Visit:

National Society of Consulting Soil Scientists: http://www.nscss.org/
Provides links to numerous sources of information on soil science, consulting and vendors.

Yahoo's soil science sites: http://www.yahoo.com/Science/Agriculture/Agronomy/soil_Science/
Search engine for specific information on soil science, soil sampling, and any other topic you wish to search.

Agrisurf-Soils: http://www.agrisurf.com/agrisurfscripts/agrisurf.asp
Links to 63 sites on conservation, erosion, fertility, sampling and analysis, and others.

CSU Cooperative Extension Soils Programs: http://www.colostate.edu/Depts/SoilCrop/extension/Soils/
Provides information on current CSU extension soils programs and research in Colorado. Multiple links to soil related sites across the country. Links to CSU publications on soil sampling, testing, and interpretation.

Soil, Plant, and Water Testing: http://www.ag.state.co.us/DPI/publications/fact11.pdf
Direct link to a document containing more than 30 listings of regional public and commercial laboratories offering testing services.

Soil Sampling and Testing Equipment Suppliers:
Links to soil sampling and testing equipment suppliers and information on how to order catalogues.

- Gemplers-http://www.gemplers.com
- Ben Meadows-Http://www.benmeadows.com/bmeadow.html
- NASCO-http://www.nascofa.com/
- Forestry Suppliers-www.forestry-suppliers.com/
- Hach-www.hach.com