# Nitrogen Management in Cotton

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Nitrogen (N) is the most heavily applied and one of the most expensive nutrients used for cotton production in Texas, and is also the most difficult to properly manage because of its reactivity and mobility in the soil environment. Inadequate N reduces the number of fruiting sites and potential yield, whereas excessive N can create rank growth, actually lower yields and quality, delay maturity, increase problems with disease, insects, and defoliation, and pollute ground and surface water resources. Recommended N rates are based on the N required to produce a crop at a realistic yield goal, and should be reduced by credits for residual nitrate nitrogen ($NO_3$-N) in the soil, as well as by any $NO_3$-N applied in irrigation water. Crediting soil and water $NO_3$-N requires collection and submission of samples to a laboratory for proper analysis.

The amount of N cotton requires depends on the yield potential of a given field. Texas AgriLife Extension Service recommends 50 pounds of N per acre (from all sources) be available for each bale produced (Table 1).

**Table 1. Nitrogen Recommendations for Various Yields of Cotton in Texas.**

| Yield (bales/acre) | Nitrogen Recommendation[1] (lbs/acre) |
|---|---|
| 0.5 | 25 |
| 1.0 | 50 |
| 1.5 | 75 |
| 2.0 | 100 |
| 2.5 | 125 |
| 3.0 | 150 |
| 3.5 | 175 |

**[1] Recommended amount should be reduced by the amount of residual $NO_3$-N in the soil and credits for $NO_3$-N from irrigation water.**

Accurately predicting the amount of supplemental fertilizer N needed by a crop is difficult because N can undergo chemical changes that influence its mobility and retention in the soil, as well as its availability to plants. Nitrogen leaching, denitrification, ammonia volatilization, and mineralization/immobilization (tie-up and later release of N by soil microbes involved in decomposition of organic residues) are processes that can quickly alter the amount of N available to plants.

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Crops obtain N from applied fertilizer, residual fertilizer in the soil (primarily $NO_3$), and N released (mineralized) from decaying organic residues. But of these sources, only the amount of N applied as fertilizer is generally accurately known. Residual N in the soil is highly dynamic, and the amount of N released from organic residues varies depending on soil and climatic factors. **Thus, soil should be tested each year for $NO_3$-N as near planting time as possible because a soil test gives only a point-in-time estimate of the amount of N available.**

The price of N fertilizers has risen dramatically over the past few years. For example, urea ammonium nitrate (32-0-0) was $180/ton in 2003 and in 2008 the price was $560/ton, representing a 211% increase. Due to very high fertilizer input costs, producers can no longer afford unnecessary applications. The return per pound of N will only be as good as the overall efficiency of the production system. Following established best management practices for proper variety selection, plant density, weed, insect, and disease management, irrigation management, etc. are all components of an effective N management strategy. Additionally, establishing a realistic yield goal and then applying the amount of N needed to meet that goal are imperative. Setting too high a yield goal can lead to over-application of N, excessive input costs, crop management problems, and increase pollution potential.

## Soil Sampling

**The foundation for a sound fertility program is soil testing.** The only way to properly estimate how much of a nutrient is needed is through the soil testing process. As mentioned previously, N is very dynamic in the soil system so sampling for N determination should be performed as close to planting as possible.

## Sampling Procedure

Sampling is generally done by hand with a soil probe. These can be purchased online from a number of sources. Hand probes cost from $25 to $150, depending on the type of probe, but good quality probes generally can be purchased for less than $100. For deeper sampling, hand probes may not suffice and it may be necessary to acquire a mechanical soil probe. A small shovel can also be used. With a shovel dig a V-shaped hole to the desired depth (usually 6 inches), take a 1-inch slice from the smooth side of the hole, and then take a 1 x 1 x 6 inch core from the middle of the slice and place it in a clean plastic bucket.

The soil analysis will only be as good as the soil sample collected. It is important that the soil sample be as representative of the field as possible. This means that the more subsamples collected within a given field, the better the overall composite sample will be. It is particularly important that separate soil samples be collected from those areas of the field with known soil differences or a history of production and/or management differences. In each area that is identified, collect 12 to 15 subsamples, place these in a clean plastic bucket to form a composite sample, thoroughly mix this sample, and then use the amount needed to fill the soil sampling bag. Bags can be obtained from most soil testing laboratories.

## Depth of Sampling

Historically, soil samples for fertilizer recommendations have been collected from a depth of 6 inches (commonly termed an "acre-furrow slice"). This "surface" sample is not only important for measuring N, but also to test for other essential plant nutrients such as phosphorus, potassium and micronutrients. However, because it is so mobile in the soil, plant available N (as $NO_3$) can many times be found deeper in the soil profile.

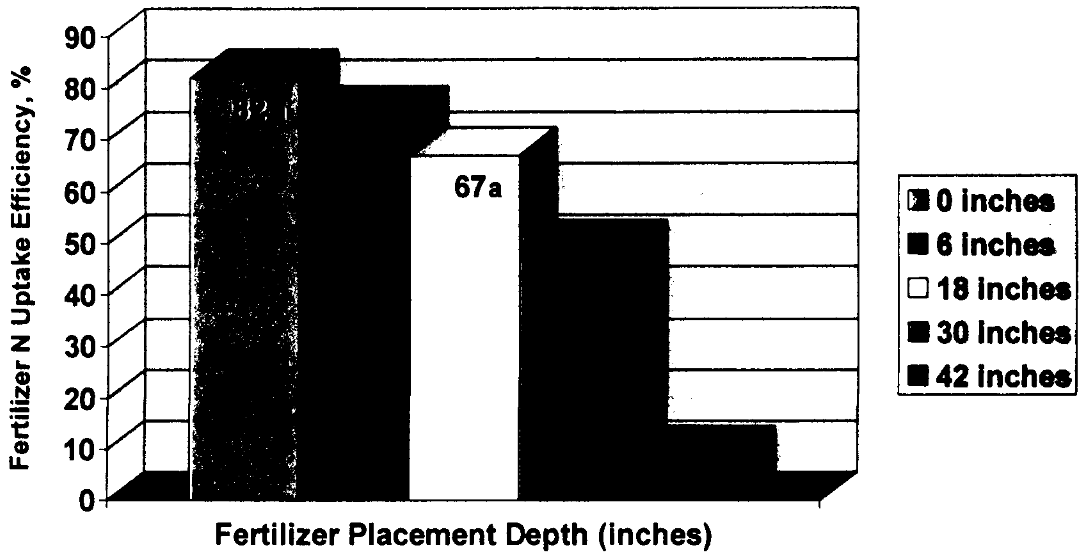
Research conducted over a seven-year period across Texas' major cotton production regions indicated that most fields contain some level of residual N in the soil profile (Table 2). Residual soil $NO_3$-N, measured to a depth of four feet, exceeded 100 lbs/acre at 33 sites (61%) and supplied the N necessary for optimum yields at those locations. The long-term study showed that residual $NO_3$-N was present in about two-thirds of fields tested (note that the majority of these field sites were commercial fields and not Texas AgriLife Extension Service or Texas AgriLife Research properties). In addition, recent research has shown that the cotton plant is very efficient at utilizing N down to a depth of 24 inches (Figure 1). **Consequently, any $NO_3$-N measured by soil testing to a depth of 24 inches can be subtracted directly from the amount of N fertilizer needed, based on the yield goal.**

**Table 2. Nitrogen Management Study - Seven Year Summary.**

| | Locations | | |
|---|---|---|---|
| **Year** | **Total** | **Profile $NO_3$-N > 100 lbs. N/acre[1]** | **Response to Applied Fertilizer N** |
| 1998 | 6 | 1 | 3 |
| 1999 | 7 | 5 | 1 |
| 2000 | 7 | 5 | 0 |
| 2001 | 10 | 6 | 2 |
| 2002 | 9 | 5 | 2 |
| 2003 | 7 | 5 | 3 |
| 2004 | 8 | 6 | 2 |
| **Total** | **54** | **33** | **13** |
| | | **61% of Locations** | **24% of Locations** |

**[1] Samples collected to a depth of 36 or 48 inches.**

**Figure 1. Uptake efficiency of cotton for $^{15}N$-labeled fertilizer placed at various depths (sampled at early bloom).**




These studies clearly demonstrate the need to account for residual $NO_3$-N when determining fertilizer requirements, and support the recommendation for soil sampling to greater depths. Samples can be collected from several depths (0-6 inches, 6-12 inches, and 12-18 or 12-24 inches) to better define the residual N that may be present.

A good approach is to collect a 0-6 inch sample plus an additional sample to a greater depth. The 0-6 inch sample can be used to determine the amount of residual $NO_3$-N in that depth, the amounts of other essential plant nutrients, and provide a general fertilizer recommendation. An additional sampling depth below 6 inches can be used to determine residual $NO_3$-N only. This depth of sampling could be from 6 inches down to 12 inches or deeper, depending upon the soil and the sampling equipment used. The condition of the soil will largely determine the ease with which deeper soil samples can be collected using a hand probe. The 0-6 inch depth is generally obtained fairly easily using a hand probe, but 6-12 inch or deeper samples can be difficult in hard, dry soils or in fine-textured soils. When sampling under these conditions, it is acceptable to apply penetrating oil (such as WD-40) to the probe. When possible, a 6-18 inch or even a 6-24 inch sample is desirable, but this will likely require some additional sampling equipment.

**Regardless of how deep the soil sample is collected, be sure to note the sampling depth for your records** so you can calculate the amount of residual N in that field based on the soil test results. **Many laboratories will assume that each sample submitted is from a 0-6 inch depth. If this occurs for a 6-18 or 6-24 inch sample, the amount of residual $NO_3$-N will be significantly underestimated. For proper correction factors see the <u>Interpreting Soil Analysis section and Table 3</u> in this publication.**

## Sample Handling Prior to Analysis

If soil samples are wet and cannot be delivered to the soil testing laboratory within two days, they should be refrigerated or air dried. Do not allow soil samples to be exposed to temperatures above 75°F for any significant period of time. Be sure that all samples are properly labeled and soil forms are clearly filled out expressing the desired soil analysis.

## Interpreting the Soil Analysis

A soil sample analysis will report nutrient concentration, including N, in parts per million (ppm). The ppm value is then converted to pounds of nutrient per acre using established mathematical relationships. Nitrogen is usually reported as $NO_3$ because this is the most plant available form. The conversion formula from ppm $NO_3$-N to pounds of N per acre is dependent upon the bulk density of the soil. An acre-furrow-slice of soil is considered 6 inches deep and is assumed to weigh 2 million pounds. Therefore, if the soil is sampled to a 6-inch depth and the $NO_3$-N test indicates 15 ppm, then the appropriate factor to multiply by to obtain pounds of $NO_3$-N per acre is 2. Some soil testing laboratories will assume a different bulk density which in turn results in a slightly different weight for the soil. This is why the same ppm value reported by two laboratories may give slightly different pounds of N per acre.

Using the assumption that an acre-furrow-slice of soil weighs 2 million pounds and is consistent with depth, Table 3 provides conversion factors for different possible soil sampling depths. By multiplying laboratory $NO_3$-N values given in ppm times the appropriate conversion factor based on the depth of the sample, the estimated pounds/acre of plant available nitrogen in the sample can be determined.

**Table 3. Calculating $NO_3$-N per acre based on the depth of soil sample submitted (using 15 ppm $NO_3$-N as an example).**

| Sampling Depth (inches) | $NO_3$-N ppm | Multiply ppm by | $NO_3$-N lb/acre |
|---|---|---|---|
| 6 | 15 | 2.00 | 30 |
| 8 | 15 | 2.66 | 40 |
| 10 | 15 | 3.33 | 50 |
| 12 | 15 | 4.00 | 60 |
| 14 | 15 | 4.66 | 70 |
| 16 | 15 | 5.33 | 80 |
| 18 | 15 | 6.00 | 90 |
| 20 | 15 | 6.66 | 100 |
| 22 | 15 | 7.33 | 110 |
| 24 | 15 | 8.00 | 120 |

***Example calculations:***

1. A sample was taken with a hand probe to a depth of 12 inches. This sample was submitted to a laboratory which does not allow you to specify the depth of sampling on the form. This laboratory will assume it is a 0-6 inch sample. The amount of residual $NO_3$-N was determined to be 15 ppm. The actual sampling depth is 12 inches, therefore, the conversion factor is 4. The total amount of residual $NO_3$-N in this sample would be 60 lbs N/acre. .

2. A sample was taken with a hydraulic probe to a depth of 18 inches. The sampler did not partition this sample into 0-6 and 6-18 inch increments. Therefore, this sample represents the entire 18 inch depth. The amount of residual $NO_3$-N was determined to be 15 ppm. The actual sampling depth is 18 inches, therefore, the conversion factor is 6. The total amount of residual $NO_3$-N in this sample would be 90 lbs N/acre. Also, results and fertilizer recommendations for other plant nutrients typically would not be considered accurate due to the depth of sampling.

3. A sample was taken with a hydraulic probe to a depth of 18 inches. The sampler did partition this sample into 0-6 and 6-18 inch increments. Therefore, these samples represent 2 distinct sampling depths. The results for the 0-6 inch increment indicated 15 ppm residual $NO_3$-N. The factor for this increment is 2, therefore, a total of 30 lbs $NO_3$-N/acre were found. The results for the 6-18 inch increment indicated 15 ppm residual $NO_3$-N. The factor for this increment is 4 (18 inches - 6 inches = 12 inches), therefore the amount of residual $NO_3$-N is 60 lbs N/acre. If we total the amount in the entire sampling depth, we have 90 lbs N/acre. Also, in this case results and fertilizer recommendations for other nutrients based on the 0-6 inch sample could be used.

## Credits for $NO_3$-N from Irrigation Water

In some areas of Texas (for example in the High Plains and Rolling Plains), irrigation water contains enough $NO_3$-N that it should be credited toward the cotton N requirement. In order to determine if irrigation water contains significant NO3-N, a water sample must be collected and submitted to a testing laboratory (such as the Texas AgriLife Extension Service Soil, Water and Forage Testing Laboratory). For every one ppm of $NO_3$-N in irrigation water, 0.23 lbs/acre of N will be added to the soil with each inch of water applied. Thus, one acre-foot (12 inches) of 10 ppm $NO_3$-N irrigation water would supply about 27 pounds of N per acre. This can be calculated using the following:

ppm of $NO_3$-N in water x 0.23 x inches of water applied = lbs of N/acre added.

As an example, suppose 15 inches of irrigation water are applied and the water test indicates 10 ppm for $NO_3$-N. Based on the above formula, an additional 34.5 lbs of N per acre will be applied during the growing season (10 ppm x 0.23 x 15 inches = 34.5 lbs N/acre). Table 4 provides a quick reference for other irrigation amounts and irrigation water $NO_3$-N concentrations. The pounds of N added in irrigation water should be subtracted from the overall amount needed by the crop for a specific yield goal.

**Table 4. Plant Available N in Irrigation Water**

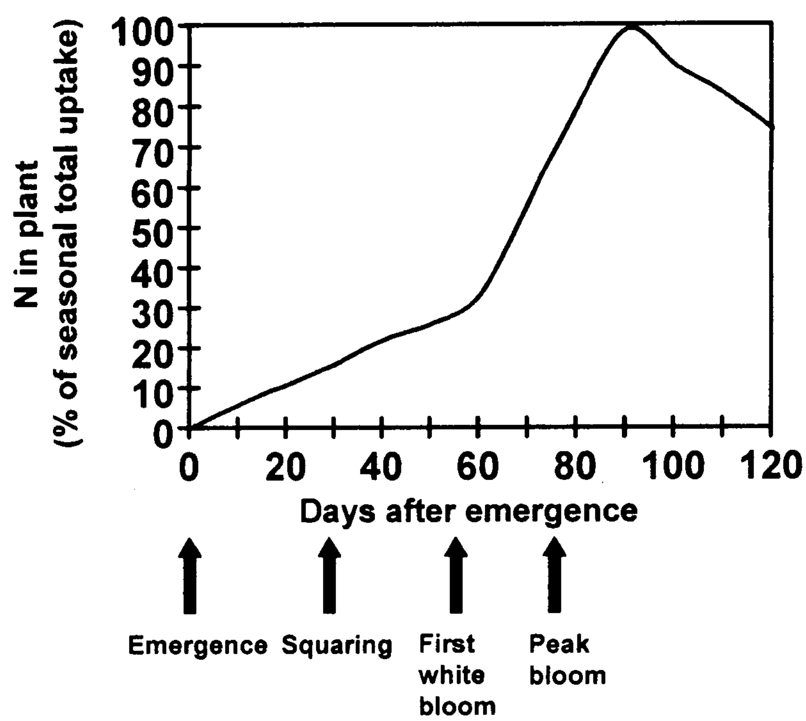
| **Water Applied (inches)** | **$NO_3$-N in Irrigation Water (ppm)** | | | |
|---|---|---|---|---|
| | **10** | **20** | **30** | **40** |
| | **lbs N added/acre** | | | |
| 9 | 20 | 41 | 61 | 82 |
| 12 | 27 | 55 | 83 | 110 |
| 15 | 34 | 68 | 102 | 136 |

## Nitrogen Application

Once residual soil N and possible irrigation water N contributions have been determined, an effective fertilization strategy can be developed. Cotton requires minimal amounts of N during the early growth stages (Figure 2). All of the N needed for a specific yield goal can be applied in a single preplant application, or in split applications. Splitting N applications generally results in greater N use efficiency. Split N applications should be made with one-third to one-half applied preplant and the remainder sidedressed during squaring. Knifing or injecting fertilizer into the soil will result in less N fertilizer loss compared to broadcast application, especially if considerable crop residue is present.

Fertigation (N fertilizer such as urea-ammonium nitrate - UAN, 32-0-0 applied through center pivot irrigation systems) is a practice that is gaining in popularity in many areas due to reduced application costs. The preferred fertigation method is to apply 20% of the total N required in a preplant application. Apply an additional 50% through the squaring stage, with the remaining 30% by early bloom.

**Figure 2. Relationship between N in cotton plants (expressed as a percentage of total seasonal uptake) and days after emergence.**




When N fertilizer is applied, the following can reduce its effectiveness:

1. Denitrification (volatilization) – $NO_3$-N is converted to a gaseous form of N. This occurs when oxygen levels in the soil are low, such as when water ponds or stands in a field after a rainfall event.
2. Immobilization (tie-up) – This can occur when a large amount of crop residue is present, and can require the use of higher N rates to feed microbial populations that decompose the crop residue. When planting into terminated small grains cover, or perhaps with large amounts of residue from a previous sorghum crop, additional N will be required.
3. Leaching $NO_3$-N out of the root zone – This is generally a problem only in sandy soils or when a significant amount of rainfall or irrigation occurs after N has been applied.
4. Ammonia Volatilization - This can occur when urea-based fertilizers such as urea, and urea ammonium nitrate (UAN) are broadcast surface applied. Factors favoring ammonia volatilization include:

1. High soil pH
2. Low cation exchange capacity (such as in low organic matter, sandy soils)
3. Large amounts of plant residues (urease enzyme present)
4. High temperatures
5. Moist conditions followed by rapid drying

In order to reduce ammonia loss from urea-based materials (this would also apply to broadcast or "dribbled" fluid UAN), the following strategies are suggested:

1. Incorporate into the soil by cultivation or at least by rotary hoeing after application – depths of 2 inches or more are adequate.
2. Time applications immediately before a center pivot irrigation event. Use spray mode immediately following a broadcast application if other soil incorporation is not used.

## Summary

Research in Texas has shown that deep soil sampling for N management in cotton production systems is effective. Crediting residual soil N to a depths as great as 24 inches can substantially reduce fertilizer N requirements, and may reduce other related input costs (growth regulators, defoliants). Together, soil and irrigation water testing for nitrogen are important management practices that can enhance both production economics and environmental stewardship.

Texas Agricultural Extension Service
The Texas A&M University System

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# TESTING YOUR SOIL

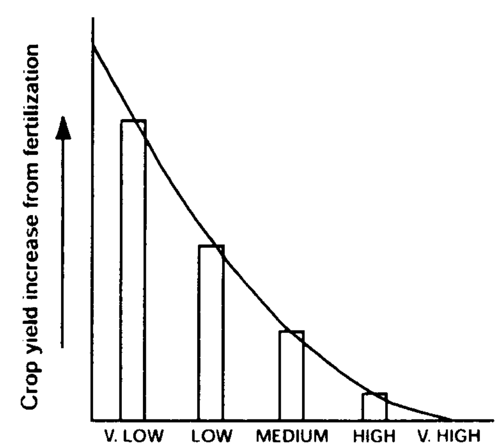
## How to Collect and Send Samples

T. L. Provin and J. L. Pitt*

Soil tests can be used to estimate the kinds and amounts of soil nutrients available to plants. They also can be used as aids in determining fertilizer needs. Properly conducted soil sampling and testing can be cost-effective indicators of the types and amounts of fertilizer and lime needed to improve crop yield.

The effects of adding a fertilizer often depend on the level of nutrients already present in the soil (Fig. 1). If a soil is very low in a particular nutrient, yield will probably be increased if that nutrient is added. By comparison, if the soil has high initial nutrient levels, fertilization will result in little, if any, increase in yield.

Figure 1. The probability of a crop yield increase resulting from fertilization depends on the initial amount of available nutrients in the soil.




*Assistant Professor and Soil Chemist/Laboratory Director, Extension Assistant-Laboratory Manager, Soil, Water, and Forage Testing Laboratory; The Texas A&M University System.

There are three steps involved in obtaining a soil test:

1) obtain sample bags and instructions,
2) collect composite samples,
3) select the proper test, and complete the information sheet and mail to the Soil, Water, and Forage Testing Laboratory at 345 Heep Center, College Station, TX 77843-2474. Contact the lab at (409) 845-4816, FAX (409) 845-5958, or at the Web site http://soil-testing.tamu.edu for additional information.

## Obtain sample bags and instructions

County Extension offices provide soil sample bags, sampling instructions and information sheets for mailing samples to the Soil, Water, and Forage Testing Laboratory of the Texas Agricultural Extension Service.

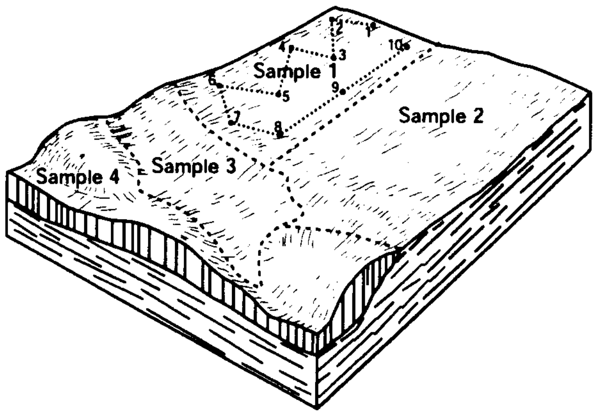
Sample bags provided by the Extension service hold a sufficient amount of soil for use in most soil tests. Fill the sample bag or other suitable container with approximately 1 pint of a composite soil sample. Any suitable container can be used for the sample, but it is important to complete the information sheet and follow the instructions for collecting and mailing samples.

## Collect composite samples

The objective in sampling is to obtain small composited samples of soil that represent the entire area to be fertilized or limed. This composited sample is comprised of 10 to 15 cores or slices of soil from the sampling area.

To sample a field or pasture, make a map that identifies each area in the field where subsamples were taken (Fig. 2). Fields or tracts of land with differences in past cropping, fertilization, liming, soil types or land use will require several composite samples. The field identification map should be used each time samples are collected from that field to compare results over time.

Figure 2. Fields should be subdivided into sampling units as needed and a composite sample should be collected from each unit.

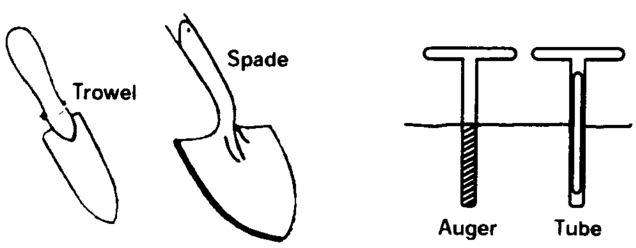



Factors that will affect results include sampling tools, number of subsamples, depth of sampling, and soil compaction and moisture.

## Sampling tools

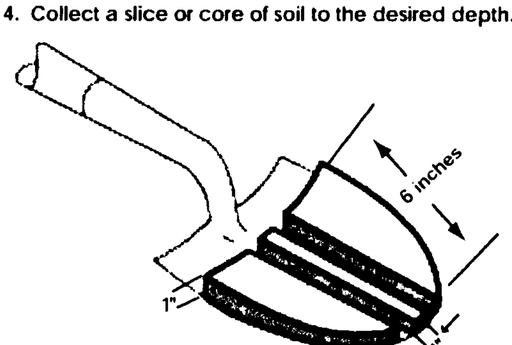
Several tools can be used to collect samples (Fig. 3). The choice depends on soil conditions and sampling depth.

Figure 3. These tools can be used to collect soil samples.




The selected tool must be able to cut a slice or core through the desired layer of soil as illustrated in Figure 4. The objective is to obtain a cross section of the plowlayer or layer being subsampled.

Figure 4. Collect a slice or core of soil to the desired depth.




## Number of samples

In fields up to 40 acres, collect at least 10 to 15 cores or slices of soil per composite sample. Composite samples should represent the smallest acreage that can be fertilized or limed independently of the remaining field or acreage. The development of precision agriculture has allowed some producers and fertilizer suppliers to manage soil fertility levels on 1- to 3-acre parcels. In small gardens and lawns, five to six cores may be adequate. Because soils are variable, it is important to obtain enough subsample to ensure a representative composite sample. A greater number of cores makes the sample more representative of the field.

Unusual problem areas should be omitted or sampled separately. To properly diagnose the causes of poor crop production, collect separate composite samples from the good and poor growth areas. Do not include soil from the row where a fertilizer band has been applied.

## Depth of sample

Traditionally, soil samples are collected to a depth of 6 inches. This depth is measured from the soil surface after non-decomposed plant materials are pushed aside. This sampling depth can be significantly altered based on tillage or fertilization practices.

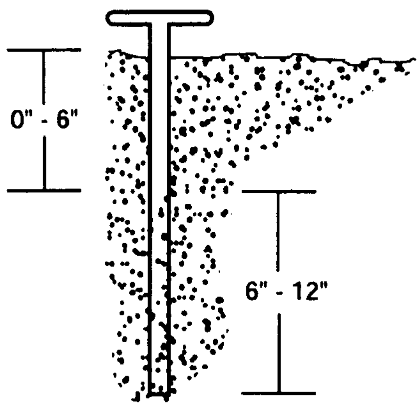
Stratification (accumulation at the surface) of phosphorus and lime from prior surface applications can dramatically alter soil test data. Stratification is of particular concern in reduced tillage and nonirrigated fields that receive limited rainfall. In these instances, subsurface sampling depths may vary from 2 to 8 inches or 3 to 9 inches below the surface. Also, deviations from the traditional 6-inch sampling depth may be required if fertilizer has been placed deeper in the soil.

Deep rooted perennial crops can require deeper subsurface sampling. The slow movement of most plant nutrients prevents any dramatic manipulation of subsurface nutrient levels, however sampling data can be useful to assess pH or salinity problems. Subsurface sampling is illustrated in Figure 5.

When sampling perennial sod crops, sample to a depth of 4 inches. Discard the surface 1/2 inch of soil before mixing the subsamples. Use this sampling method in all established lawns, golf greens and similar turf applications.

The Texas Natural Resource Conservation Commission (TNRCC) requires extensive soil sampling for some land uses. Individuals sampling soil for TNRCC compliance should follow TNRCC protocols and directions.

Figure 5. A sampling tube or auger is needed to collect subsurface samples.




## Select the proper test

Several different soil tests are available at the Extension Soil, Water, and Forage Testing Laboratory. These include tests for routine nutrients, micronutrients, boron, detailed salinity, lime requirement, texture and organic matter. After taking the soil sample, select the appropriate test to obtain the desired information.

The **routine** test determines the soil pH, salinity, nitrates ($NO_3$-N), and levels of the primary nutrients (P - phosphorus, K - potassium, Ca - calcium, Mg - magnesium, Na - sodium, and S - sulfur) available to plants. The routine test will provide the basic N-P-K fertilizer recommendation for selected crops. This test meets most application needs.

The **micronutrient** test estimates the levels of zinc (Zn), iron (Fe), manganese (Mn) and copper (Cu) in the soil that are available to plants. Conduct this test for specialty crops, in soils with high pH on which corn or sorghum is being grown, or to provide general guidelines for troubleshooting deficiencies.

The **boron** test determines the level of water extractable boron (B) in the soil. Conduct the test where clover, alfalfa or other legumes are grown on sandy soils or when soils are being irrigated and water quality is of concern.

The **detailed salinity** test uses a saturated paste extract to measure the pH, electrical conductivity and water soluble levels of the major cations in the soil. From these levels, the Sodium Adsorption Ratio (SAR) is calculated. Conduct this test when water quality is of concern; in soils in the western part of the state where the rate of evaporation or transpiration exceeds the rainfall; when previous soil tests have shown an increase in sodium or salinity; or in areas where brine and salt water spills have occurred. Some TNRCC permits also may require a detailed salinity test.

The **lime** requirement determines the amount of lime needed to raise the soil pH to a desired level. This determination is needed on very acidic (pH $<5.2$) or acidic soils (pH $<6$) where alfalfa or other legumes are grown.

**Texture** and **organic matter** are specialty tests for specific applications. The texture determines the amount of sand, silt and clay in the soil. This test may be requested when installing a septic system. The organic matter may be requested for general information. Both tests often are requested for environmental or research purposes.

The information form, obtained from the county Extension office, requests information about soil conditions, acreage sampled, past cropping, fertilization and an estimate of the expected yield. All information is important in relating soil test results to suggested fertilization and liming. The expected yield is an indication of intended management, past production levels and local environmental factors that control yields. Uncontrolled production factors such as nematodes and disease should be considered in estimating a yield goal or expected yield. In areas where samples are collected from problem fields, the condition of plants should be described along with observations that would aid in relating soil test results to the problem.

Soil samples should not be stored for long periods of time prior to shipping to the laboratory. The levels of nitrate-nitrogen in the soil may change if the samples are stored wet. In addition, the nitrate-nitrogen data from properly dried samples may be of little value if environmental conditions and plant growth have altered levels in the soil. Air drying samples in the shade on clean brown paper is strongly recommended. Do not oven dry the samples because high drying temperatures can alter test results.

Instructions for mailing are provided with the sampling instructions. The fee for each sample should be noted and payment should accompany the samples. The information sheet and payment should be attached to the sample package. Between 5 and 7 days are required to obtain results for routine analyses from the laboratory. In-depth analyses of samples require additional testing and processing time. Therefore, it is important to conduct sampling early in the season. This will ensure that test results are available in time to make necessary fertilizer and lime applications.

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AgriLIFE RESEARCH AgriLIFE EXTENSION

# Nutrient Management for Texas High Plains Cotton Production

### Soil Sampling and Testing

Soil testing is the first step in fertilizer management, for all nutrients. We recommend the following depths and scheduling of soil sampling and testing for irrigated and dryland cotton fields in the High Plains:

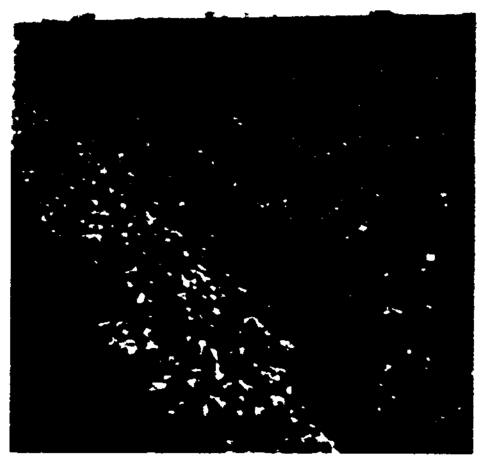

Table 1. Soil sampling schedule

| Soil test | Irrigated | Dryland |
|---|---|---|
| Nitrate-nitrogen (0-24 inches) | Every year | Every 2-3 years |
| Phosphorus, Potassium, and micronutrients (0- 6 inches) | Every 2-3 years | Every 2-3 years |

### Nitrogen

Nitrogen (N) is important in rapid growth and fruiting. It is contained in plant proteins and is a part of the chlorophyll molecule.

•Urea ammonium nitrate (32-0-0) is the most common liquid N fertilizer. It is convenient for fertigation in center-pivots or drip systems. If applied with a ground rig, it is best to knife-in 32-0-0. Dribbling 32-0-0 is also a sound practice, although there may be some ammonia loss. Do not spray-apply 32-0-0. Solid urea (46-0-0) is becoming more popular. Few producers have equipment to apply 46-0-0 in bands. It is best to broadcast urea just prior to re-listing beds to avoid ammonia loss, which can be substantial with 46-0-0. Alternatively, spray irrigation with a center pivot is effective in moving 46-0-0 into the soil.

•Nitrate ($NO_3^-$), a negatively charged "anion," is the main nitrogen form in soils. It is subject to leaching from heavy rain or over-irrigating.

•Soil testing for nitrate should be to a depth of 24 inches. This is because the clayey subsoils on the High Plains hold substantial amounts of nitrate.

•Indicate on the soil test form that the sample is for the 24-inch depth.

•Soil testing for other nutrients like phosphorus (P), potassium (K), and zinc (Zn), only requires the typical 6-inch sample.

Table 2 can be used to determine your N fertilizer requirements, simply: 1) choose a yield goal, 2) soil test to 24 inches for nitrate-nitrogen and multiply results in ppm by 8 to convert to lb N/ac, 3) subtract soil test value from number in column two.

Table 2. Cotton nitrogen requirements for various yield goals.

| Yield goal | Nitrogen requirement[1] |
|---|---|
| bales/acre | N/acre |
| 0.5 | 25 |
| 1.0 | 50 |
| 1.5 | 75 |
| 2.0 | 100 |
| 2.5 | 125 |
| 3.0 | 150 |
| 3.5 | 175 |
| 4.0 | 200 |

[1]Nitrogen fertilizer plus 0-24 inch soil nitrate (in lb N/acre)

*Example*: A 0-24 inch soil test nitrate-nitrogen result is 3.8 ppm. Multiply this by the unit conversion factor 8 = 30 lb nitrate-nitrogen/ac. If your yield goal is 2.0 bales/acre then Table 2 says your total nitrogen requirement is 100. Subtract the soil test value as:

100 lb N/ac – 30 lb N/ac = 70 lb N fertilizer/acre needed

or from start to finish:

100 lb N/ac – (3.8 ppm X 8) = 70 lb N fertilizer/acre needed

Timing of Nitrogen Fertilizer Application

•In dryland, if you have access to a ground rig applicator that can band apply, wait until two weeks after emergence, then knife-in entire dose several inches off the seed row using 32-0-0 (urea-ammonium nitrate) alone or with 10-34-0 (ammonium polyphosphate) if P is needed. If you have a broadcast applicator, apply urea (46-0-0) alone or with 11-52-0 (monoammonium phosphate) or 18-46-0 (diammonium phosphate) if P is needed before disking in herbicides and or re-listing operations.

•For row watering, use same strategy as above. For center pivots and subsurface drip, ground apply 30 lb N/ac pre-plant if soil test nitrate in 0-6 inches < 4 ppm, and/or heavy sorghum or other residue is present. Apply remainder of N requirement through center pivot in 30 lb N/ac doses starting at first square and no later than early bloom. For drip systems apply balance of N between first square and early bloom in daily drip irrigations.

**Phosphorus**

Phosphorus (P) is important in promoting early rooting. It is involved in plant energy storage and transfer.

•Soil test (0-6 in.) is step one

•P fertilizer (either dry 11-52-0, 18-46-0 or liquid 10-34-0) is best band-applied preplant.

•Banding P fertilizer is more efficient than broadcasting. This is because the calcium carbonates in our soils bind or "fix" most of the phosphorus (as calcium phosphate) when it is broadcasted (incorporation does not help).

•Liquid P fertilizer (either phosphoric acid or 10-34-0) can be injected into the drip system.

•10-34-0 salts out easily in "hard" (high calcium and magnesium salts) irrigation water unless acidified to pH 6.0 (it is best to acidify with urea/sulfuric acid mix like N-pHURIC). However, we do not routinely recommend this practice.

•Before deciding to acidify a drip or center-pivot irrigation system and fertilize at the same time with phosphoric acid, consider that phosphoric acid is twice the cost of 10-34-0 in $ per lb of $P_2O_5$.

•Table 3 shows P fertilizer rates for various soil test values and extracts. This approach does not depend on yield goal, or whether cotton is dryland or irrigated. The Bray P extract is not appropriate where soil pH > 7.6. Mehlich 3 or Olsen is the best soil test P extract for West Texas. Although we recommend soil sampling and testing for P every 2-3 years (because soil test P doesn't change rapidly like nitrate-nitrogen does), you should P fertilize every year according to the table below.

Table 3. Phosphorus fertilizer rates based on soil test values.

| Mehlich 3 | Olsen | P fertilizer rate |
|---|---|---|
| ------------- ppm | ----------- | lb $P_2O_5$/ac |
| 0 -5 | 0 – 2.5 | 100 |
| 5 – 10 | 2.5 – 5.0 | 90 |
| 10 – 20 | 5.0 – 10.0 | 70 |
| 20 – 30 | 10 – 15 | 50 |
| 30 – 40 | 15 – 20 | 30 |
| 40+ | 20+ | 0 |

For maintenance of adequate soil test P levels, 30 lb $P_2O_5$/ac can be applied for Mehlich 3 tests of 30-40 ppm (15-20 ppm Olsen P). This may not be an economical practice for dryland farms. It is not necessary to apply P if Mehlich 3 P is > 40 ppm (20 ppm Olsen P). Adjust your P program every 2-3 years based on soil sampling and testing.

**Potassium**

Potassium (K) is important in plant water relations, energy relations, and in enzyme activation.

•Generally one does not need to apply fertilizer K where the soil test K is > 150 ppm. Adequate soil test K (> 150 ppm) is common in West Texas (and western USA). One could consider maintenance fertilizer K applications of 30-40 lb $K_2O$/ac if soil test K is between 150 and 200 ppm K. High-yield producers (e.g. subsurface drip) can adopt the "replacement philosophy" of adding as much K as they remove in cottonseed (about 1.8 % $K_2O$) to avoid long-term "K mining" if soil test K is between 150 and 200 ppm. We do not recommend maintenance or replacement K fertilizer applications if soil test K > 200 ppm. Cotton burrs are high in K (about 2.5 % $K_2O$), and therefore "burr extractors" on stripper harvesters help maintain K soil fertility

•Potassium chloride (KCl) (0-0-63) is the most common K fertilizer. It mixes with water for fertigation or ground application.

•Potassium hydroxide (KOH), or caustic potash (0-0-37) a caustic liquid, or potassium thiosulfate ($K_2S_2O_3$) can be used for high chloride ($Cl^-$) irrigation water

**Zinc**

Zinc (Zn) is important in plant enzymes, which catalyze reactions.

•Soil testing from 0-6 inches is step one. Zinc is not needed when soil > 0.28 ppm Zn.

•Zn fertilizer comes in liquid chelates (eg. 10 % Zn as Zn-EDTA) or dry zinc sulfate ($ZnSO_4.H_2O$, 34 % Zn) .

•Chelated Zn stays more available to plants as the calcium carbonate in our soils "fixes" Zn from Zn sulfate. ("Chelate" is Greek for "claw" and describes a ring structure with the Zn ion bonded in the center).

•Zn-EDTA mixes easily with either 32-0-0 or 10-34-0 (same caution for 10-34-0 in hard irrigation water).

•Therefore Zn-EDTA can be banded pre-plant with 10-34-0 or injected in-season with 32-0-0.

•$ZnSO_4.H_2O$ is cheaper than Zn-EDTA (but is fixed by $CaCO_3$ in our soils). •The following table shows Zn fertilizer recommendations (not dependent on yield goal).

Table 4. Zinc fertilizer rates based on soil test zinc concentrations.

| DTPA Zn ppm | lb Zn/ac |
|---|---|
| 0 – 0.19 | 4 |
| 0.19 – 0.28 | 2 |
| 0.28 + | 0 |

**Sulfur**

Sulfur (S) is an important component of many plant amino acids.

•S plant requirements are 1/20 of N requirements.

•Atmospheric S deposition onto West Texas soils is decreasing as coal-fired power plants "clean up." Therefore S soil fertility may become more of an issue.

•The main form in soil is the sulfate anion ($SO_4^{=}$). It is common in West Texas soils as part of calcium and magnesium sulfate.

•Sulfate is generally low in sandy surface soils, but accumulates in our clayey subsoils, like nitrate does. To soil test for sulfate therefore, you should request this analysis on the 24-inch samples you take for nitrate-nitrogen.

•The only soils in West Texas that might need S fertilization are deep sands (eg. Tivoli soil) or the Brownfield loamy sand soils that have 20 inch sandy surface horizons.

•Solid S sources are ammonium sulfate (dry) (21-0-0-24S), gypsum (calcium sulfate, $CaSO_4$-$H_2O$ is 16 – 18 % S), sulfuric acid ($H_2SO_4$), urea-$H_2SO_4$ liquid (N-pHURIC).

•Potassium thiosulfate, $K_2S_2O_3$ (0-0-25-17S), and ammonium thiosulfate $(NH_4)_2S_2O_3$ (12-0-0-26S) are fluid S sources.

For more information contact:
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(Phone: 806-747-4013, email: k-bronson@tamu.edu)
Randy Boman, Professor Extension Agronomist-Cotton
(Phone: 806-746-4049, email: r-boman@tamu.edu).

Revised, February, 2009

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***Soil, Water and Forage Testing Laboratory***
***Department of Soil and Crop Sciences***
***Texas AgriLife Extension Service***

**SP 09**

# PROFILE SOIL SAMPLE INFORMATION FORM

Please submit this completed form and payment with samples. Mark each sample bag with your unique sample identification and ensure that it corresponds with the sample identification written on this form. *See sampling and mailing instructions on the back of this form.

**(PLEASE DO NOT SEND CASH)**

**SUBMITTAL AND INVOICE INFORMATION:** This information will be used for all official invoicing and communication.

Name ______________________________ County where sampled ____________________

Address ______________________________ Phone ____________________

City ____________________ State ______ Zip ______

Payment (DO NOT SEND CASH)
☐ Check
☐ Money Order
☐ Credit Card – requires additional form*

Amount Paid $____________________
Make Checks Payable to: **Soil Testing Laboratory**
*Credit card payment forms can be downloaded at http://soiltesting.tamu.edu

**CLIENT NAME:** Client name will only be included with information above on result reports.

Name ______________________________

This form is only for paired (surface and subsurface) profile sample submittal. All subsurface samples must have a corresponding surface soil. If submitting non-profile samples, use form D-494.

| SAMPLE I.D. | | SAMPLE INFORMATION (Required) | | | (See options listed | |
|---|---|---|---|---|---|---|
| **Laboratory # (For Lab Use)** | **Your Sample I.D.** | **Acreage Represented** | **Previous lime/ fertilizer** | **What are you growing?** | **Requested analyses** | **How is forage used?** |
| | | | | | ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 | ☐Grazing (G) ☐ G&H ☐Hay (H) ☐*Min. requirement |
| | **This subsurface sample must correspond to surface sample listed above.** | | **Sampling Depth: ☐6-12" ☐6-18" ☐6-24"** | | ☐10 | |
| | | | | | ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 | ☐Grazing (G) ☐ G&H ☐Hay (H) ☐*Min. requirement |
| | **This subsurface sample must correspond to surface sample listed above.** | | **Sampling Depth: ☐6-12" ☐6-18" ☐6-24"** | | ☐10 | |
| | | | | | ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 | ☐Grazing (G) ☐ G&H ☐Hay (H) ☐*Min. requirement |
| | **This subsurface sample must correspond to surface sample listed above.** | | **Sampling Depth: ☐6-12" ☐6-18" ☐6-24"** | | ☐10 | |

**Describe any problems you have observed to want to correct:**

| | |
|---|---|
| **1. Routine Analysis (R)** (pH, NO3-N, Conductivity and Mehlich III by ICP P, K, Ca, Mg, Na, and S) | **$10 per sample** |
| **2. R + Micronutrients (Micro)** (DTPA Zn, Fe, Cu, and Mn) | **$15 per sample** |
| **3. R + Micro + Hot Water Soluble Boron (B)** | **$20 per sample** |
| **4. R + Detailed Salinity (Sal)** (saturated paste extractable Ca, Mg, K, Na, conductivity and pH) | **$25 per sample** |
| **5. R + Micro + Sal** | **$30 per sample** |
| **6. R + Micro + Detailed Limestone Requirement (Lime)** | **$20 per sample** |
| **7. R + Micro + B + Lime + Organic Matter + Sal** | **$50 per sample** |
| **8. R + Textural Analysis** | **$20 per sample** |
| **9. R + Organic Matter** | **$20 per sample** |
| **10. Nitrate-N only** (nitrogen crediting recommendations only) | **$4 per sample** |

**Note: Organic Matter, Detailed Salinity and Texture may require longer processing time.**

Form S3-09

# Procedure for Taking Profile Soil Samples

**Taking the Soil Sample (Refer to Figure 1)**

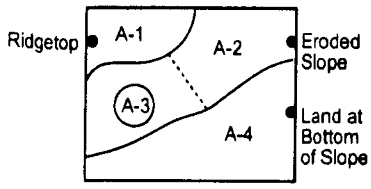
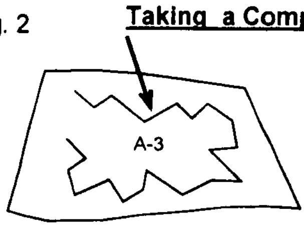



Fig. 1

- Take one composite sample for every 10 to 40 acres. A separate sample should be taken for:
  - ⇒ Areas with different soil types
  - ⇒ Areas with different land uses or fertilizer uses
  - ⇒ Areas with different terrain
- Approximately 1 pint of the composite soil sample is required for routine analyses.
- Additional sample is required for texture or detailed salinity (submit 2 sample bags marked identically).
- Avoid sampling areas such as small gullies, slight field depressions, terrace waterways, or unusual areas.
- When sampling fertilized fields, avoid sampling directly in fertilized band.

Fig. 2




**Taking a Composite Sample (Refer to Figures 2 and 3)**

- Take a sample from 15 different areas within the composite sampling area.
- Use soil sampling tube when collecting the lower profile samples. The use of augers and shovels risk contaminating these samples with surface soil thus skewing the results for nitrate-N levels. Ideally, both the surface (0-6") sample and subsurface (6-12", 6-18" or 6-24") sample will be collected in the same sampling core and split at the appropriate depths into clean plastic buckets.
- Clear litter from the surface (do not remove decomposed black material).
- Repeat in 10 to 15 different places. Thoroughly break up each sample core to facilitate proper sample mixing.

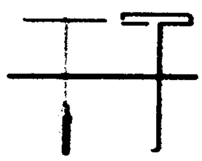


Fig. 3

- To improve the nitrate-nitrogen analysis, air-dry each sample prior to sending to the laboratory. **Do not use heat** to dry samples. Completely fill soil sample bag or other suitable pint container.
- Remix the sample after air drying, while also confirming that all cores are fully broken up.
- Do not use old vegetable cans, tobacco cans, match boxes, glass containers, etc. to submit samples. Insure each sample has a unique id.
- If sending in more than one sample bag of the same soil (when testing for salinity, texture and etc.) mark the bags with the same sample ID and also indicate bag1 of 2, bag 2 of 2, etc.

**Shipping the Sample and Payment (Refer to Figure 4)**

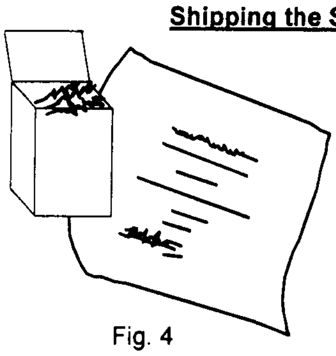


Fig. 4

- Complete the information form on the front page (information required for recommendations).
- Please include payment with the sample. Send check or money order made out to Soil Testing Laboratory. **DO NOT SEND CASH**. Please note that the ***price is per sample.***
- Be sure to keep a record for yourself of the area represented by each sample.
- Be sure that sample numbers on sample bags correspond with sample numbers on the front page.
- Send samples and payment to:

**Soil, Water and Forage Testing Laboratory**
**2474 TAMU**
**College Station, TX 77843-2474**

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**For further information please contact:**
**Your local County Extension Service Office**
**or**
**Soil, Water and Forage Testing Laboratory**
**2474 TAMU**
**345 Heep Center**
**College Station, TX 77843-2474**
**Phone: (979) 845-4816**
**soiltesting@tamu.edu**

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*Soil, Water and Forage Testing Laboratory*
*Department of Soil and Crop Sciences*
*Texas AgriLife Extension Service*

D-494

**S** 08

# SOIL SAMPLE INFORMATION FORM

Please submit this completed form and payment with samples. Mark each sample bag with your sample identification and ensure that It corresponds with the sample identification written on this form. *See sampling and mailing instructions on the back of this form.

**(PLEASE DO NOT SEND CASH)**

**SUBMITTAL AND INVOICE INFORMATION:** This information will be used for all official invoicing and communication.

Name ______________________________ County where sampled ______________

Address ______________________________ Phone ______________

City ______________________ State______ Zip ______ ______________

**CLIENT NAME:** Client name will only be included with information above on result reports.

Name ______________________________

Lab Use only

Payment (DO NOT SEND CASH)
- ☐ Check
- ☐ Money Order
- ☐ Credit Card – requires additional form*

Amount Paid $______________
Make Checks Payable to: **Soil Testing Laboratory**
*Credit card payment forms can be downloaded at http://soiltesting.tamu.edu

**Sample ID SAMPLE INFORMATION (Required)** (see options listed below)

| Laboratory # (For Lab Use) | Your Sample ID | Acreage Represented | Previous lime/ Fertilizer | What are you growing? | Requested Analyses | How is Forage Used? |
|---|---|---|---|---|---|---|
| | | | | | ☐1 ☐2 ☐3<br>☐4 ☐5 ☐6<br>☐7 ☐8 ☐9 | ☐Grazing (G) ☐G&H<br>☐ hay (H)<br>☐ *Min. requirement |
| | | | | | ☐1 ☐2 ☐3<br>☐4 ☐5 ☐6<br>☐7 ☐8 ☐9 | ☐Grazing (G) ☐G&H<br>☐ hay (H)<br>☐ *Min. requirement |
| | | | | | ☐1 ☐2 ☐3<br>☐4 ☐5 ☐6<br>☐7 ☐8 ☐9 | ☐Grazing (G) ☐G&H<br>☐ hay (H)<br>☐ *Min. requirement |
| | | | | | ☐1 ☐2 ☐3<br>☐4 ☐5 ☐6<br>☐7 ☐8 ☐9 | ☐Grazing (G) ☐G&H<br>☐ hay (H)<br>☐ *Min. requirement |
| | | | | | ☐1 ☐2 ☐3<br>☐4 ☐5 ☐6<br>☐7 ☐8 ☐9 | ☐Grazing (G) ☐G&H<br>☐ hay (H)<br>☐ *Min. requirement |
| | | | | | ☐1 ☐2 ☐3<br>☐4 ☐5 ☐6<br>☐7 ☐8 ☐9 | ☐Grazing (G) ☐G&H<br>☐ hay (H)<br>☐ *Min. requirement |

**Describe any problems you have observed to want to correct:**

| | |
|---|---|
| **1. Routine Analysis (R)**<br>(pH, NO3-, P, K, Ca, Mg, Na, S and Conductivity) | **$10 per sample** |
| **2. R + Micronutrients (Micro)**<br>(Zn, Fe, Cu, and Mn) | **$15 per sample** |
| **3. R + Micro + Boron (B** | **$20 per sample** |
| **4. R + Detailed Salinity (Sal)**<br>(TDN and energy calculated) | **$25 per sample** |
| **5. R + Micro + Sal** | **$30 per sample** |
| **6. R + Micro + Detailed Lime Requirement (Lime)** | **$20 per sample** |
| **7. R + Micro + B + Lime + Organic Matter + Sal** | **$50 per sample** |
| **8. R + Textural Analysis** | **$20 per sample** |
| **9. R + Organic Matter** | **$20 per sample** |

**Note: Organic Matter, Detailed Salinity and Texture may require longer processing time.**

Form S2-08

# Procedure for Taking Soil Samples

## Taking the Soil Sample (Refer to Figure 1)

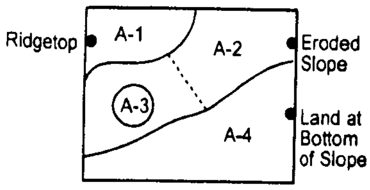


Fig. 1

- Take one composite sample for every 10 to 40 acres. A separate sample should be taken for:
  - ⇒ Areas with different soil types
  - ⇒ Areas with different land uses or fertilizer uses
  - ⇒ Areas with different terrain
  - Approximately 1 pint of the composite soil sample is required for routine analyses.
  - Additional sample is required for texture or detailed salinity (submit 2 sample bags marked identically).
- Avoid sampling areas such as small gullies, slight field depressions, terrace waterways, or unusual areas.
- When sampling fertilized fields, avoid sampling directly in fertilized band.

## Taking a Composite Sample (Refer to Figures 2 and 3)

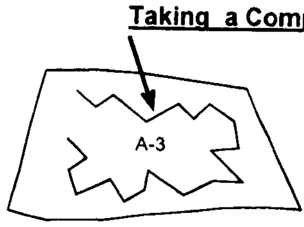


Fig. 2

- Take a sample from 10 to 15 different areas.
- Use a spade, soil auger or soil sampling tube.
- Clear litter from the surface (do not remove decomposed black material).
- When using a soil auger or sampling tool, make the core or boring 6 inches deep.
- When using a spade:
  - ⇒ Dig a V-shaped hole and take a 1-inch slice from the smooth side of the hole.
  - ⇒ Take a 1 x 1 inch core from the center of the shovel slice.
- Repeat in 10 to 15 different places. Put in a clean plastic bucket or other non-metallic container, thoroughly mix and remove a pint (or more if additional tests are desired) as a composite sample representing the whole field or area.

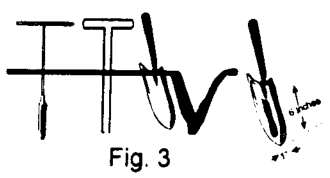

Fig. 3

- To improve the nitrate-nitrogen analysis, samples may be **air-dried** before sending to the laboratory. **Do not use heat** to dry samples. Completely fill soil sample bag or other suitable pint container. Do not use old vegetable cans, tobacco cans, match boxes, glass containers, etc. to submit samples. If more than one sample bag is used, label bags as 1 of 2, 2 of 2, etc.

## Shipping the Sample and Payment (Refer to Figure 4)

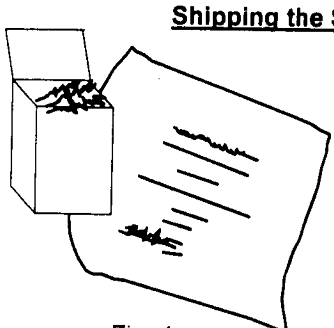

Fig. 4

- Complete the information form on the front page (information required for recommendations).
- Please include payment with the sample. Send check or money order made out to Soil Testing Laboratory. **DO NOT SEND CASH**. Please note that the ***price is per sample.***
- Be sure to keep a record for yourself of the area represented by each sample.
- Be sure that sample numbers on sample bags correspond with sample numbers on the front page.
- Send samples and payment to:

**Soil, Water and Forage Testing Laboratory**
**2474 TAMU**
**College Station, TX 77843-2474**

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**For further information please contact:**
**Your local County Extension Service Office**
**or**
**Soil, Water and Forage Testing Laboratory**
**2474 TAMU**
**345 Heep Center**
**College Station, TX 77843-2474**
**Phone: (979) 845-4816**
**soiltesting@tamu.edu**

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