Soil Testing and Nutrient Recommendations

T.L. Provin
Department of Soil and Crop Sciences
Soil Forming Factors

- **Parent Material**
  - CEC
    - Clay
    - Sands

- **Vegetation**
  - Organic Matter
  - Clay movement

- **Slope**
  - Water infiltration
  - Erosion

- **Time**
  - More time more weathering

- **Climate**
  - Warmer—more weathering
Sampling Protocols

- Depth
  - History
    - Previous methods of fertilization: manure, chemical fertilizer, broadcast, incorporated, banded
Sampling Protocols

• Depth
  – History
    • Previous methods of fertilization: manure, chemical fertilizer, broadcast, incorporated, banded
  – Cultivation
    • Conventional-thorough mixing
    • Reduced Tillage-limited mixing
    • No-till-zero to no mixing
Pasture

No-till

Reduced tillage

Conventional tillage
Sampling Protocols

- **Depth**
  - **History**
    - Previous methods of fertilization: manure, chemical fertilizer, broadcast, incorporated, banded
  - **Cultivation**
    - Conventional—thorough mixing
    - Reduced Tillage—limited mixing
    - No-till—zero to no mixing
  - **Irrigation/Rainfall**
    - Leaching of nutrients
    - Rooting density near soil surface
Sampling tools

• Soil conditions
  – Hardness and clay content of soil
    • Some push probes will not handle tough sampling conditions

• Depth of desired sampling
  – Deep profile sample often limited to powered tools
  – Concern over compacting sample in tube

• Cost of tools
  – Spade is often cheapest
  – Powered sampling equipment can exceed $20K
Soil Sampling Equipment

Push Tube-type soil samplers

Available from: Forestry Suppliers, JBK Mfg, JMC, on the web
Soil Sampling Equipment

The full selection
Profile Sampling

- New form for matched sets of profile samples.

- Subsoil sample is going to be either 6-12”, 6-18”*, or 6-24” depths. Report will provide a credit to be subtracted from 0-6” sample recommendations.

*Most favored sampling depth to promote.
6-12” to 6-18”

JMC and several other companies make 15-18” push probe tubes
When going deep (>18”)
Soil Sample Collection
The First Step

• Collecting a good representative soil sample can not be stressed enough.
  
  – Appropriate acreage per composite sample
  – Adequate subsamples
  – Proper depth
  – No foreign materials “just soil”
  – Avoided anomalies “cow pies and etc.”
Soil Sample Collection
The First Step

• Just remember, the soil test results are no better than the sample submitted.
Appropriate acreage per composite sample

• General recommendations
  – Samples represent 10-40 acres
    • Use 10 acres per sample for high producing soils (hay fields, grain and etc.)
    • Approach 40 acres for pastures and other field where low to modest nutrients are applied and removed.
  – Sample smallest area which could be fertilized separately
  – Sample historically similar soils (if the field has been abused, ie. received inadequate fertilization over the past, use a lower acreage per sample).
Appropriate acreage per composite sample

• General recommendations
  – Samples represent 10-40 acres
  – Sample smallest area which could be fertilized separately
  – Sample historically similar soils

• Deviations from norm
  – Site of former fertilizer storage
  – Site of present or former livestock facility
  – Troubleshooting
  – Low returning soils (historically limiting moisture)
The Map

• Make a map of your fields
  – You will use this for years to come.

• Consider:
  – Soil types
  – Slope
  – Historic cropping
  – Historic yields
  – Size and ability to fertilize each area
Collecting the soil sample

- **10-15 subsample per sample**
  - Any fewer and accuracy will drop dramatically

- **0-6 inch sample depth (based on research for the recommendations)**
  - If you go shallow, some results will be high, others low (just the opposite for too deep).

- **Clean plastic bucket**
  - Don’t contaminate your soil, it could effect your results.
Shovel Soil Sampling

• Dig a hole at least 6” deep with a “V” shape.

• Take the spade (sharpshooter) and cut a 1” slice.

• The using a knife (rigid 6” putty knife is best) cut the slice into a 1” strip.

• Place in clean plastic bucket and mix well with other 9-14 strips.
Soil Sampling: The Most Important Step
Troubleshooting using Soil Sampling

• Salinity
  – Depth: lower horizons-saltwater encroachment
  – Clay layers-impermeable layers

• Fertility
  – Excess Phosphorus-available iron and zinc

• Nitrates
  – Deep sampling-4 feet for annual rowcrops
Troubleshooting using Soil Sampling

- **Salinity**
  - Depth: lower horizons-saltwater encroachment
  - Clay layers-impermeable layers

- **Fertility**
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- **Nitrates**
  - Deep sampling-up to 4 feet for annual rowcrops
Troubleshooting-sampling Con’t

- Sample “problem” areas separate from normal areas
- If irrigated, sample water in addition to soil
- If herbicide injury is expected, contact laboratory which will perform analysis, regarding sampling protocol.
- Consider plant pathogens and nematodes
Sampling Intensity

• Cropping yields currently observed
  – Higher value crops should be sampled on a tighter schedule, as well as, fewer acres per sample

• History of cropping
  – Fallow cropping seasons
  – Forage/residue returned
  – High nutrient requiring crops

• Heterogeneity of field
  – The more diverse soil series, the greater need for additional sampling
Here the field is split into four distinct areas based on?
Here the field is split into four distinct areas based on:
- soil type
- slopes
- yields (due to water)
- possibly size (acreage not given)
Sampling Intensity, con’t

- General recommendations
  - Samples represent 10-40 acres
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Sampling Intensity, con’t

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Sub-sampling

• Single point sampling
  – Attempts to address changes in fertility (etc.) at a given location
  – Most likely to provide questionable/non-repeatable data

• X or Z pattern
  – Typically performed in grid sampling
  – Often dictates intensive sampling (lower samples per acre)
Grid sampling methods
Sub-sampling

- Single point sampling
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  - Most likely to provide questionable/non-repeatable data

- X or Z pattern
  - Typically performed in grid sampling
  - Often dictates intensive sampling (lower samples per acre)

- Random approach
  - Better to capture landscape features
  - More likely to follow soil series
More Sub-sampling

- Number of cores per sample
  - Ideally 10-15 cores for 10-40 acre composited samples
  - Samples with fewer cores should represent smaller acreages

- Mix all cores prior to filling sample bag
  - Thorough mixing will minimize locally “hot” or low spots
The Subsample

• Consider the amount of soil in a single soil core.

• What does a single core represent from a % of an acre?
Just what does a single core represent?

The Math

1” x 6” Soil Core, Assume Bulk Density = 1.3 g/cm$^3$

32 grams

2,000,000 lbs soil/6” depth x 454 g/lb

=0.00000352% of an acre
Sampling in a banded field

- What nutrients are being banded?
- What depth are nutrients being banded?
- What quantities of fertilizer have been applied?
- How long has the banding method been used?
- Are the bands in the same place each year?
When Bands Don’t Move

• Improper sampling can dramatically influence results
  – Divide row width by estimated width of banded zone or 6” which ever is more
  – Thus if 36 inch rows and 6” band, this equals 6
  – Divide number in half
  – Take one sample in estimated band area and other two samples 6 and 12 inches way (toward center of row)
Additional thoughts on sampling

- Use only a clean plastic bucket
- Use soil sample bags provided by laboratory or freezer bags.
- Provide laboratory with desired cropping data
- Send sample to laboratory as soon as possible
Sample Handling

• Thorough mixing of cores
  – Break up all cores
  – Use plastic bucket

• Sub-sample mixed cores
  – Submit at least a pint of sample, more if requiring soil texture, boron and etc.
  – Label all samples, fill out paperwork

• Air-dry soil samples
  – Reduces chance of change in nitrate and sulfate levels
  – Do not oven dry
Precision Ag

- Increased number of samples
  - Often observe 2, 3, 5 acres per sample
- Variable rate fertilizer technology
  - Expensive and may not be available
- The Cost
  - Questionable return in many areas
Soil pH and Limestone Requirements
Soil pH

• What is soil pH?
  – Negative log of the $H^+$ activity
  – Relationship between $H^+$ and $OH^-$

• Factors influencing soil pH
  – Base saturation of soil
  – Calcium, Potassium, Sodium, and Magnesium
  – Sodium saturation
  – Activity of soluble aluminum and Manganese
Soil pH, con’t

• The value obtained
  – Dependant on Test used
  – Timing of test

• Influences availability
  – Essential nutrients
  – Solubility of Al and Mn
  – Soil tilth
    • Calcium acts as a bonding agent holding clay plates together
Measuring Soil pH

- **1:1 soil to water**
  - Common protocol in sandy and loam soils

- **1:2 soil to water**
  - Used in areas with higher clay contents
  - Insures all soils entering laboratory can be run by same method

- **Paste/Slurry**
  - Attempts to mimic soil conditions
  - Very time consuming
  - Relies on art of laboratory technician
  - Each soil receives different amount of water
Interpreting Soil pH

- **pH 5.2**
  - Al and Mn activity increase significantly below this pH
- **Target pH**
  - Crop dependant
  - Plant Fe requirements
  - Al and Mn toxicity tolerance
  - Normally, desire 5.8-6.5 for most crops
- **Seasonal changes**
  - Changes during year-with soil salinity changes
Soil pH

• Important for multiple reasons
  – Reduce toxicity of select elements in soil
    • At low soil pH, both soluble aluminum and manganese can kill root tips and limit water and nutrient uptake
  – Enhance availability of plant nutrients
    • Different nutrients are more available at select soil pH levels
  – Maintain soil tilth
    • Low pH levels are associated with low soil calcium levels which can cause increase compaction and other negative soil physical properties.
Effect of Nitrogen Fertilizer on Soil pH
(Lufkin soil, Overton, Tx.)

Average After 3 Years

- None: 6.2
- Ammonium nitrate: 5.9
- Ammonium sulfate: 4.7
# pH Influence

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<th>Phosphate</th>
<th>Potash</th>
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<td>30</td>
</tr>
<tr>
<td>4.5</td>
<td>21</td>
<td>8</td>
<td>21</td>
</tr>
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**Nutrient Recovery**
pH 5.8-6.5 generally considered ideal for most crops.
Increasing Soil pH

- Good quality limestone is applied to soil.
- Till limestone in if possible.
- The calcium carbonate reacts with acidity in soil (the finer the particles, the faster the potential reaction) and forms carbon dioxide, water and soluble calcium.
- Limestone quality is measured through laboratory tests involving chemical purity and fineness.
Limestone Requirements

• Based on?
  – Liming material quality and type
  – Amount of ECCE material required
    • Soil texture and water pH ($pH_w$)
      – Estimating base saturation
    • Soil pH and extractable bases
      – Estimate base saturation and cation exchange capacity
    • Buffer pH
      – Measurements of reserve and active acidity
Limestone Requirements

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Limestone Quality

- **Neutralizing Value (chemical purity)**
  - Calcium carbonate equivalence (CCE)

- **Particle size (efficiency rating, ER)**
  - Smaller particles react faster and more completely.
  - Fine materials last just as long or longer than a mixture.

- \[ \% \text{ ECCE} = \text{CCE} \times \text{ER} \]
  (Effective Calcium Carbonate Equivalence)
Limestone Quality

Soil Test Recommendation = 100% ECCE

- **Product 1**: 50% ECCE
  - 1 ton/acre = 2.0 tons/acre limestone
  - 0.50 ECCE
  - $35/ton
  - $70/acre

- **Product 2**: 100% ECCE
  - 1 ton/acre = 1.0 tons/acre limestone
  - 1.0 ECCE
  - $50/ton
  - $50/acre

Purchase limestone based on price per ton and ECCE
Limestone, con’t

- Buffer soil pH
  - Measurements which rely on use of a “buffered” reagent to measure amount of active and reserve acidity on a given soil.
    - The more acidity on a given soil, the greater the drop in buffer solution pH
    - Are only used to determine liming material requirements
    - Include a number of tests:
      - SMP
      - Adams-Evans
      - Mehlich
      - Etc.
  - Data of little value without calibrated response table.
Near-term Acidity

- Consideration must be given for acidity produced by nitrogen fertilizers applied in the upcoming 1.5-2 years.
  - This acidity will be from 1.8-3.6 lbs of 100 ECCE per lb of N applied.
Liming Materials

• Most soil pH raising materials are referred to as liming materials
  – Agricultural limestone
  – Dolomite
  – Lime

• CCE
  – Calcium Carbonate Equivalent
    • Measure of purity of material

• ECCE
  – Effective Calcium Carbonate Equivalent
    • Measure of purity and grind
Liming Materials

• Properties of Quality
  – High ECCE
    • Recommendations based on 100 ECCE
  – Spreadability
    • Percent water
    • Particle size (powder material can be problematic)
  – Human/plant tolerance to contact
    • Lime and some industrial by-products can be caustic
Soil Conductivity

• A measure of the soluble salt content of the soil.

• Normally, only a problem in droughty areas of the state, poor quality irrigation water, or caused by salt spills and tidal waters.

• The lower the better (<800 umhos/cm)
Nitrogen Testing in Soils

- Soil sampling for nitrates
  - Depth (4 feet)
    - Nitrates are fairly soluble and will move with soil water
    - Lower nitrate-N is generally available if:
      - No root limiting layers
      - Root development occurring in that zone

- Sample holding issues
  - Nitrate-N analysis is a point in time estimate
  - Air drying is suggested to prevent changes in microbial biomass and subsequent nitrate-N levels
Nitrate-N

- Form of nitrogen taken up by most plants.
- The soluble residual form of nitrogen in soils.
- Considered 100% plant available in the upper 1 foot of soil.
- Laboratory give credit to this nutrient.
Laboratory Methods

• Extraction methods
  – Salt extractable
    • 1 or 2 molar KCl
  – Water extractable
    • Lower recovery, more noise due to soil dispersion issues

• Analysis methods
  – Ion selective electrode
    • Salt issues
    • Precision/accuracy
  – Nitrite conversion and analysis
    • Cd reduction (considered modern standard)
Interpretation of Nitrate Data

• Timing of sampling vs. planting date
  – Point in time estimate
    • Highly subject to rapid and dramatic change
    • Re-testing recommended if significant time lapse or rainfall has occurred
    • What about N tie-up/mineralization?
Nitrate Interpretations

• N-credits
  – Normally consider 1 ppm Nitrate-N to be equivalent to 2 lbs of available nitrogen
    • Assumes other factors are in “check”
      – Salinity
      – Available moisture
      – Tillage/compaction
  – Seldom evaluate deeper soil nitrate-N levels
    • Sufficient deeper profile N may be present for cropping needs?
Ammonium Issues

• Presence
  – Present in all soils
  – Associated with soil CEC sites
  – Outside or recent fertilization or legume production, is generally low
  – Questions about availability exist (estimates of 50-75 percent available—?)

• Testing
  – Normally not routine
  – Often considered a luxury test
Phosphorus Soil Testing

• Overview
  – Soil phosphorus is sparingly soluble under agronomic levels
  – Often requires an acid or alkaline extraction
  – Extraction methods are developed to address regional soil/soil P issues
  – Are not a measure of total soil P, but potentially plant available P
STP Methods

• Methods use in Texas and region
  – Bray $P_1$
  – Bray $P_2$
  – Olsen
  – Mehlich 3
  – TAMU method (no longer supported by TCE)
  – Others
STP Chemistry

• Bray $P_1$ and $P_2$ tests
  – Developed by Bray and Kurtz in 1940’s to address available P and potentially available P ($Bray P_2$) in Illinois soils
  – Comprised on $NH_4F$ and HCl
  – Designed to extract Fe and Al phosphates
  – Fluoride added to prevent re-adsorption of extracted P
  – Considered a good overall extractant for acid soils.
  – In calcareous soils, fluoride precipitates with soil calcium
  – Bray $P_2$ designed to estimate potential P availability of rock phosphates previously applied
• Olsen
  – Developed to address availability of calcium phosphates in calcareous soils
  – Uses sodium bi-carbonates to raise soil bi-carbonate levels-allows for dissolution of one layer of calcium carbonates from soil carbonates
  – Considered standard soil P extractant in calcareous soils
  – TAMU research suggests under-estimates available soil P
  – Highly questionable value in acid soils
    • No mechanism for P removal
STP Chem, III

• Mehlich 3
  – Developed from Mehlich 1 and 2 to address available P in acid Piedmont soils (NC)
  – Uses Fluoride, acidity, and organic chelates
  – Multi-nutrient extractant
  – In acid soils, generally considered to extract ~5-10 percent more than Bray P₁
  – Has preformed very well in calcareous soils, likely because of the limited shaking time and modest dilution value.
STP Chem, IV

- Texas A&M method
  - Developed from Morgan STP
  - Uses EDTA, HCl and ammonium acetate at pH 4.2
  - Multi-nutrient extract
  - Most research soil P extract in Texas
  - Recent research suggests apatite (rock phosphate) may be extracted, if present.
  - Extracts exchangeable, weakly held P in acid soils, and calcium bond P in calcareous soils
STP Chem, V

- Other soil P tests
  - Resin exchangeable
    - No Texas research to support use
  - Chelates
    - Highly questionable
  - Water
    - Will not extract enough P to analysis with any level of precision and accuracy
    - If detectable levels (ppm) are observed, then no response to P would be expected anyway
  - ???
Comparison of P Data

• Acid soils
  – After discarding Olsen
    • Order of P extraction (lowest first)
      – Bray P$_1$ method (lower initial pH does effectively remove significant quantities of Al and Fe P)
    – Mehlich 3/Bray P$_2$ (normally consider Bray P$_2$ a stronger extract, but research data has shown Mehlich 3 to extract significant higher quantities of P from manured acid soils)
Comparison of Data, 2

• Calcareous soils
  – Order of P extractability (lowest first)
    • Bray P$_1$ (too weakly buffered to continue to extract P, fluoride is precipitated with soil calcium, thus resorption of extracted P occurs)
    • Olsen method (dissolution extraction, only so much can dissolve before solution is saturated with calcium)
    • Bray P$_2$ (limited research, but depending on soil, has similar fate as Bray P$_1$)
    • Mehlich 3
Soil P Chemistry

- **Al and Fe amorphous sites**
  - First soil P holding sites to be filled upon addition of fertilizer or manure
  - Can be extremely high energy (non-recoverable) sites
  - P saturation must occur prior to other P holding sites become satisfied
  - Occurs in both acid and calcareous soils

- **Anion Exchange**
  - Occurs but is not primary form of soil P or plant available P

- **Carbonates**
  - Phosphates react with soil carbonates (primarily CaCO$_3$) to form CaHPO$_4$ and Ca$_x$(H$_2$PO$_4$)$_x$ which then under goes slow transformation to less soluble minerals
STP and Data Interpretation

• Crop Requirements
  – Vegetative mass
  – Normally consider .25-.30 percent plant P
• Application method/stratification
  – Tillage dependant
  – Irrigation/water dependant
Dry Surface

moist surface
Stratification

\[
\begin{array}{c}
150 \\
25 \\
5 \\
5 \\
3 \\
2 \\
\end{array}
\]
\[
= 60 \quad 8.8
\]

\[
\begin{array}{c}
45 \\
45 \\
40 \\
10 \\
5 \\
2 \\
\end{array}
\]
\[
= 43 \quad 5.7
\]
STP and Data Interpretation

- **Crop Requirements**
  - Vegetative mass
  - Normally consider .25-.30 percent plant P

- **Application method/stratification**
  - Tillage dependant
  - Irrigation/water dependant

- **Source of P**
  - Manure, inorganic fertilizer

- **P immobilization**
  - Lower testing soils generally have high immobilization factors (up to 100%)
Phosphorus

- Most long-term limiting nutrient in most Texas soils.

- Responsible for energy migration with plants and plant cells. (root and shoot growing points)

- At normal levels, sparking soluble and does not move much in soil.

- Critical level for most agronomic crops is 50 ppm Mehlich III P.
Phosphorus Issues

• Forage production acreage is often very low or low in available soil phosphorus, because long-term hay production removed about 10-30 lbs of $\text{P}_2\text{O}_5$ per ton.

• Low soil phosphorus results in reduced root development, **stand losses** and low nitrogen, potassium and other plant nutrient uptake.
Influence of Phosphorus Fertility in Low Testing Soils

<table>
<thead>
<tr>
<th>Rate of P $\text{P}_2\text{O}_5$</th>
<th>Yield</th>
<th>Response over Control</th>
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<tr>
<td>0 lbs $\text{P}_2\text{O}_5$</td>
<td>6950 lbs DM</td>
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<tr>
<td>30 lbs $\text{P}_2\text{O}_5$</td>
<td>7990 lbs DM</td>
<td>1040 lbs DM</td>
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<tr>
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<td>4150 lbs DM</td>
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<td>5950 lbs DM</td>
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<td>240 lbs $\text{P}_2\text{O}_5$</td>
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</tr>
<tr>
<td>500 lbs $\text{P}_2\text{O}_5$</td>
<td>17900 lbs DM</td>
<td>10950 lbs DM</td>
</tr>
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DeLeon, TX, 2000  Coastal Bemudagrass Hay 4 cuttings, STP=5-8 ppm
Potassium Testing

• Methods used in Texas
  – Neutral ammonium acetate
    • Considered standard
    • Some laboratories maybe underestimating K supplying power by shortening extraction time
  – Mehlich 3
    • Our research suggests this test may extract 10-15% more K can then ammonium acetate
    • Likely due to dissolution of primary soil K minerals
  – TAMU method
    • Similar to ammonium acetate
    • Observed difference of up to 5% in calcareous clays
    • Differences over ammonium acetate likely due to dissolution of soil K minerals in acid extract
Soil K Chemistry

- From soil standpoint
  - Clays
    - Primarily on CEC sites, limited K entrapment in interlayers (illite)
  - CEC
    - Soil organic matter CEC sites – limited in TX
  - K bearing minerals
    - Micas
    - Feldspars

- From plant standpoint
  - Water soluble
    - Mass flow of water and K
    - Location of K relative to plant roots
K Data Interpretation

• Crop Requirements
  – Grain/fruit
    • Each crop partitions different quantities of K into seed/fruit
      generally limited amount of K is removed by seeds/grain
  – Forage
    • High removal of K form field
      – For example: 10 tons of bermudagrass @ 1.5% K= 361 lbs $K_2O$
  – Yield
    • Naturally, the more crop removed, the more nutrient removed
K Data Interpretation, 2

• Sources of K
  – Limited difference in fertilizers, more based on application methods
    • Is K reaching plant roots

• K losses
  – Significant factor in sandy soils
  – CEC/base saturation

• Other Factors
  – Sodium
    • Expect up to 70% substitution of Na for K
• In general, 85% of potassium needs are strictly related to water uptake and water movement in the plant.

• Low potassium results in reduced water and nutrient uptake and poor winter survival.

• Hay harvests remove 30-50 lbs K$_2$O per ton per acre.
Micronutrient

• Primarily interested in:
  – Fe
  – Zn
  – Cu
  – Mn
  – B
  – Cl (limited interest in dryland wheat)
More on Micros

- Principle methods (Fe, Zn, Cu, and Mn)
  - DTPA
    - Considered standard for micronutrient analysis
    - Generally not subject to over-estimating non-plant available pools
  - HCl
    - Old method which has lost favor, subject to over-estimating iron and zinc in neutral to and alkaline soils
- Others
  - Mehlich 3
    - Our research shows limited value of this data in calcareous soils
    - Questionable in neutral soils
Boron Testing

• Hot water extraction
  – Considered standard
  – Best performed on irrigated soils with questionable water quality
  – Poultry litter applied soils
    • Compost and other manures also subject to B issues
  – Soils receiving limited rainfall
  – troubleshooting

• Others
  – Salt extracts
  – Sugar extracts
Chloride and others

• Chloride analysis
  – Primary interest in TX with dryland wheat
  – Simple water or dilute acetic acid extract
  – Recommendations still limited, plant tissue analysis better method

• Others
  – Mo, V, and Ni
  – No good soil testing methods currently available
Philosophy of Recommendations

• Spoon fed the plant
  – Address target level
    • Critical point
  – Assumes annual fertilization as determined by soil tests
  – Common philosophy of Southern Universities
    • Less potential loss of fertilizer dollar due to immobilization issues, leaching, and etc.
    • More prone to limited fertilization due to market fluctuations
Philosophy of Recommendations

• Spoon fed the plant
  – Address target level
    • Critical point
  – Assumes annual fertilization as determined by soil tests
  – May be altered to address need for “extra” nutrient to move overall status out of very low or low categories. Future TAMU P recommendations.
Philosophy of Recommendations, 2

• Buildup and Maintenance
  – Common philosophy in Midwest
  – Establishes a target level and attempts to hold fertility level at this target
  – Many require annual fertilization
  – Often requires considerable excess fertilization in early years
  – More prone to losses through leaching and immobilization
  – Sandy soils and K
Philosophy 3

• Feed the Plant
  – Assumes little or no nutrient availability/supply from soil
  – Soil test are preformed for soil pH and salinity
  – Philosophy most likely predetermined to fail
Philosophy, 4

- Base saturation vs. critical points
  - Base saturation theory assumes a certain percentage 3-5% of CEC must be filled with potassium
    - Theory works well for sandy weakly buffered soils
    - In high CEC soils, required K levels can become economically impractical
    - Limited research supporting this theory
  - Critical point theory assumes that a certain mass of nutrient is required irregardless of soil CEC
    - Works well of sandy loam and finer soils, but very coarse soils may not have sufficient CEC to hold potassium
    - Theory of most research universities
Fertilizer Timing

• Established warm season perennial grasses
  – If phosphorus and potassium are low or very low, consider application of these nutrients in fall prior to dormancy.
    • Phosphorus fertilizers are fairly low in solubility
    • Potassium (and likely phosphorus) will be taken up in fall and strengthen root system.
  – If levels are in moderate category, apply in spring with nitrogen.
  – Apply all phosphorus fertilizer in one application.
Fertilizer Timing

• Apply nitrogen fertilizers as close to time of need as possible.
  – Too early = weeds, nitrogen losses, nitrogen leaching
  – Too late = loss of production, loss of useable water, low protein forages

• Split apply potassium if suggested application rates are greater than 75 lbs $K_2O$ per acre.
More on Fertilization

• Timing
  – Prior to green-up (N and P), following each harvest (N) and late season (K)

• Sources/type of fertilizer
  – A pound is a pound of N, P, or K

• Placement
  – At establishment it is important to incorporate fertilizer and develop good seed bed.
  – After establishment, surface applications of fertilizer are generally sufficient.
Soil Test Report
# Soil Analysis Report

**Soil, Water and Forage Testing Laboratory**  
Department of Soil and Crop Sciences  
346 Hepck Center, 2474 TAMU  
College Station, TX 77843-2474  
979-845-4816 (Phone)  
979-845-5998 (Fax)  
Visit our website: [http://soiltesting.tamu.edu](http://soiltesting.tamu.edu)

Sample received on: 10/30/2009  
Printed on: 11/13/2009  
Area Represented: not provided

---

**Crop Grown:** IMPROVED AND HYBRID BERMUDA GRASS (NON-IRRIGATED, 3 HAY CUTTINGS)

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<thead>
<tr>
<th>Analysis</th>
<th>Results</th>
<th>CL*</th>
<th>Units</th>
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<th>Low</th>
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*CL = Critical level is the point which no additional nutrient (excluding nitrate-N, sodium and conductivity) is recommended.

**Limestone:** Limestone recommendations are based on 100 ECCE timing products. Limestone applications ≥3 tons/acre should be made ≥4 months prior to crop establishment to lessen micro-nutrient availability issues.

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## Soil Analysis Report

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979-845-4816 (phone)  
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Visit our website:  [http://soiltesting.tamu.edu](http://soiltesting.tamu.edu)

Sample received on:  10/30/2009  
Printed on:  11/13/2009  
Area Represented:  not provided

Report generated for:  
Joe  
Blow  
123 Somewhere Lane  
Nowhere, TX 7000

Tejas County  
Laboratory Number: 1  
Customer Sample ID: #1  
Crop Grown: IMPROVED AND HYBRID BERMUDA GRASS (NON-IRRIGATED, 3 HAY CUTTINGS)

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<td>3.40 tons 100ECCE/acre</td>
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Fertilizer Recommended:
- 50 lbs N/acre
- 100 lbs P2O5/acre
- 90 lbs K2O/acre
- 0 lbs Ca/acre
- 0 lbs Mg/acre
- 10 lbs S/acre
Crop Grown: IMPROVED AND HYBRID BERMUDA GRASS (NON-IRRIGATED, 3 HAY CUTTINGS)

<table>
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<td>90 lbs K2O/acre</td>
<td>0 lbs Ca/acre</td>
<td>0 lbs Mg/acre</td>
<td>10 lbs S/acre</td>
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</table>

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Sulfur: Available sulfur may be found deeper in soil profile, thus limiting any response to added sulfur.

Methods: pH and conductivity 2:1; nitrate-N/Cl:red.; P, K, Ca, Mg, Na, and Si/Mehlich 3 by ICP; Fe, Zn, Mn, and Cu/DTPA by ICP; and Bi/hiot water by ICP.
Soil Test Report

• **Critical Level:** The test level at which no additional fertilizer (nutrient) is recommended.

• **Units:**
  - umhos/cm  a unit measuring electrical conductivity
  - ppm  parts per million  If interested, you can multiple ppm X 2 to get pounds per acre.
Soil Test Report

• The graphic interpretation is placed across a range of ratings (ExLow-Excess). The ranking are based on probability of response to additional nutrients.

  Exceptionally low 95+% probability
  Very low 90% probability
  Low 75-90% probability
  Medium 15-75% probability
  High 1-15% probability
  Very high <1% probability
  Excessive Likely to result in detrimental response
Texas A&M Agrilife Extension Service
Soil, Water and Forage Testing Laboratory

Please note: Only submittal forms with a "13" in the right corner are valid and current. Old forms are no longer valid and should be recycled.

Laboratory business hours

Address for United States Postal Service:
Soil, Water and Forage Testing Laboratory
2478 TAMU
College Station, Texas 77843-2478

Address for all other couriers (FedEx, UPS and etc.):
Soil, Water and Forage Testing Laboratory
2610 F&B Road
College Station, Texas 77845

Contacts:
Voice 979.845.4816 Fax 979.845.5638 Email: soiltesting@ag.tamu.edu

The Soil, Water and Forage Testing Laboratory is housed in the Department of Soil and Crop Sciences and is part of the Texas A&M Agrilife Extension Service, an agency within The Texas A&M University System.

About the Lab | Our Submittal Forms | Sending Samples

Soil Fertility Recommendations | Listing of Current Methods | Fertilizer Calculators | Publications
# Nitrogen Soil Fertility Recommendations for Texas Grain and Row Crops

updated on 3-30-2012: soiltesting.tamu.edu

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</tbody>
</table>
Fertilizer Calculators

The fertilizer calculators provide the user the ability to enter a soil testing recommendation for nitrogen (N), phosphate (P2O5) and potash (K2O) and enter one or more fertilizer grades to determine:
1) Is the selected fertilizer appropriate for the soil test determined nutrient needs?
2) Do additional fertilizer or nutrient sources need to be added to meet soil test determined nutrient needs?
3) What application rates of N, P2O5 and K2O are being applied?
4) What application rate of fertilizer(s) is required to meet the soil test determined nutrient needs?

The fertilizer grade, commonly referred to as the fertilizer analysis, is represented by the three numbers with dashes between the numbers, commonly located on the front of a fertilizer bag. A more detailed description will be presented on the fertilizer label of bagged fertilizers. The first number represents the total nitrogen of the product (as a percentage), followed by the available phosphate (also as a percentage), and finally the third number represents available potash (also as a percentage). In some cases, additional numbers maybe included on the grade listing and represent other major plant nutrients. In all cases, the fertilizer label will describe these additional nutrients with greater specificity.

- **Urban Fertilizer Calculator - Basic edition, Single Fertilizer Entry**
  The urban calculator allows for quick evaluation of a retail bagged fertilizer and its fulfilling the soil test recommendations for your lawn, garden or other small area.

- **Urban Fertilizer Calculator - Commonly Available Fertilizer List and Single Fertilizer Entry**
  This calculator includes a user selectable list of commonly available fertilizers found in home and garden centers in addition to the functions of the calculator above.

- **Agricultural Fertilizer Calculator**
  The agricultural fertilizer calculator allows for the input of up to three different dry fertilizers and calculates the individual rates of application and total combined fertilizer rate.

- **Obtain new recommendations for other crops or yield goals**
  This interface will quickly calculate new N, P, and K requirements for other crops, yield goals or land uses based on your existing nitrate-N, phosphorus and potassium soil test data. This will be expanded in the future to provide other nutrients.

- **Nitrogen Cost Calculator**
  Calculate the cost per pound of nitrogen for up to 4 different nitrogen fertilizers at a time.

- **Nitrogen Cost in Blended Fertilizer Calculator**
  Calculate the cost per pound of nitrogen for up to 4 different nitrogen fertilizers for blended fertilizers containing phosphorus and potassium.

- **Limestone Cost Calculator**
Cotton Nitrogen Fertilizer Calculator

Enter requested data in tan boxes
Analyzed for all data boxes can be performed by the Texas A&M University Soil, Water and Forage Testing Laboratory

Yield goal (bales/acre): 3

Adjusted N recommendation (lbs/acre): 0

Soil Test Nitrate-N (ppm):
- 0-6" sampling depth: 12

Profile Nitrate Data:
Enter data for only one depth below:
- 6-12" sampling depth: 1
- 6-18" sampling depth: 1
- 6-24" sampling depth: 1

Irrigation Nitrate-N credits:
Leave blank for dryland cotton systems
- ppm Nitrate-N: 12
- Planned inches/acre to be applied: 10

Manure N application:
Leave blank if no applications are planned
- % N in manure: 
- Application rate (dry tons): 
  Calculated at 40% annual availability

Effluent N application:
Leave blank if no applications are planned
- % N in effluent: 0.05
- Application rate (acre inches): 10
  Calculated at 50% annual availability

Additional information can be located at: soiltesting.tamu.edu, soilcrop.tamu.edu, cotton.tamu.edu, varieties testing.tamu.edu

Reset
Texas A&M Agrilife Extension
Soil, Water and Forage Testing Laboratory
Agricultural Fertilizer Management Calculator-version 1.2

Enter selections, recommendations and pricing in the red boxes.

Soil Test Recommended Nutrient rates lbs/acre

- **Nitrogen**: 100 lbs N/acre
- **Phosphorus**: 50 lbs P₂O₅/acre
- **Potassium**: 126 lbs K₂O/acre

(Does your soil test recommendations suggest split applications of potassium?)

Your First Fertilizer Selection

This is the grade of fertilizer you might have historically used or available at your local ag retailer. Please use the red drop-down boxes to select each number of the fertilizer grade.

- **Nitrogen** (N): 12
- **Phosphate** (P₂O₅): 12
- **Potash** (K₂O): 12
- **Price per ton**: 540.00

Apply this amount of selected fertilizer:

416.7 lbs fertilizer/acre

Nitrogen applied: 50 lbs N/acre
Phosphate applied: 50 lbs P₂O₅/acre
Potash applied: 50 lbs K₂O/acre

How this fertilizer supplies your soil test needs:

- **AN ADDITIONAL 50 LBS/N ACRE NEEDED.**
- **AN ADDITIONAL 75 LBS K₂O/ACRE REQUIRED.**

Your Second Fertilizer Selection-applied in addition to first fertilizer selection

- **Nitrogen** (N): 10
- **Phosphate** (P₂O₅): 0
- **Potash** (K₂O): 10
- **Price per ton**: 340.00

Apply this amount of selected fertilizer:

500 lbs fertilizer/acre

Nitrogen applied: 50 lbs N/acre
Phosphate applied: 0 lbs P₂O₅/acre
Potash applied: 50 lbs K₂O/acre

How this fertilizer supplies your soil test needs:

- **Nitrogen needs fulfilled**
- **Phosphate needs fulfilled**

- **AN ADDITIONAL 25 LBS K₂O/ACRE REQUIRED.**
Your Third Fertilizer Selection-applied in addition to first two selections

<table>
<thead>
<tr>
<th>Nitrogen (N)</th>
<th>Phosphate (P2O5)</th>
<th>Potash (K2O)</th>
<th>Price per ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>60</td>
<td>540.00</td>
</tr>
</tbody>
</table>

Apply this amount of selected fertilizer:

41.7 lbs fertilizer/acre

Nitrogen applied
0 lbs N/acre

Phosphate applied
0 lbs P2O5/acre

Potash applied
25 lbs K2O/acre

How this fertilizer supplies your soil test needs:

Nitrogen needs fulfilled
Phosphate needs fulfilled
Potash needs fulfilled

Summary of Calculations

<table>
<thead>
<tr>
<th>Fertilizers selected</th>
<th>Rate (lbs/acre)</th>
<th>Cost ($/acre)</th>
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<tbody>
<tr>
<td>12 - 12 - 12</td>
<td>416.7</td>
<td>$112.51</td>
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<tr>
<td>10 - 0 - 10</td>
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<td>$85.00</td>
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<td>0 - 0 - 60</td>
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<td>$11.26</td>
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<tr>
<td>Total weight and cost of fertilizer applied</td>
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<td>$208.77</td>
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</table>

Nitrogen requirements have been met.
Phosphate requirements have been met.
Potash requirements have been met.
Other References

• Web
  – http://soiltesting.tamu.edu

• Modification of Recommendations

• Hardcopies
  – Also available on Extension Soil and Crop Sciences web pages (soiltesting.tamu.edu)
More Information

- http://soiltesting.tamu.edu
- http://soilcrop.tamu.edu
- http://agrilifeextension.tamu.edu