Soil Amendments, Manures, Minerals and More

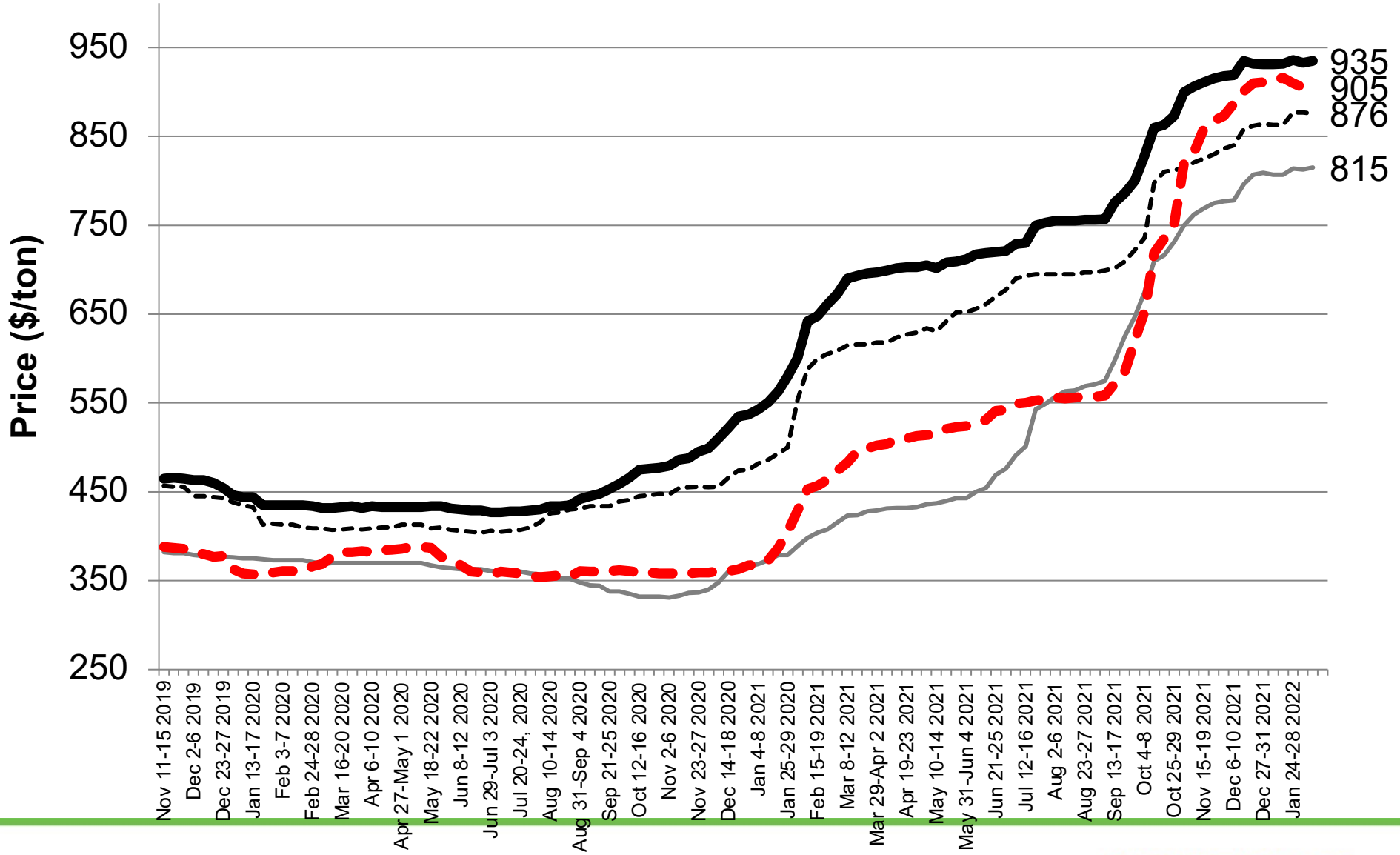
Pick TN Conference, Franklin

February 17th 2022

Forbes Walker

Biosystems Engineering and Soil Science

Dry Fertilizer Price, 2019-2022



Real. Life. Solutions.

UTEXTENSION
INSTITUTE OF AGRICULTURE
THE UNIVERSITY OF TENNESSEE

Overview

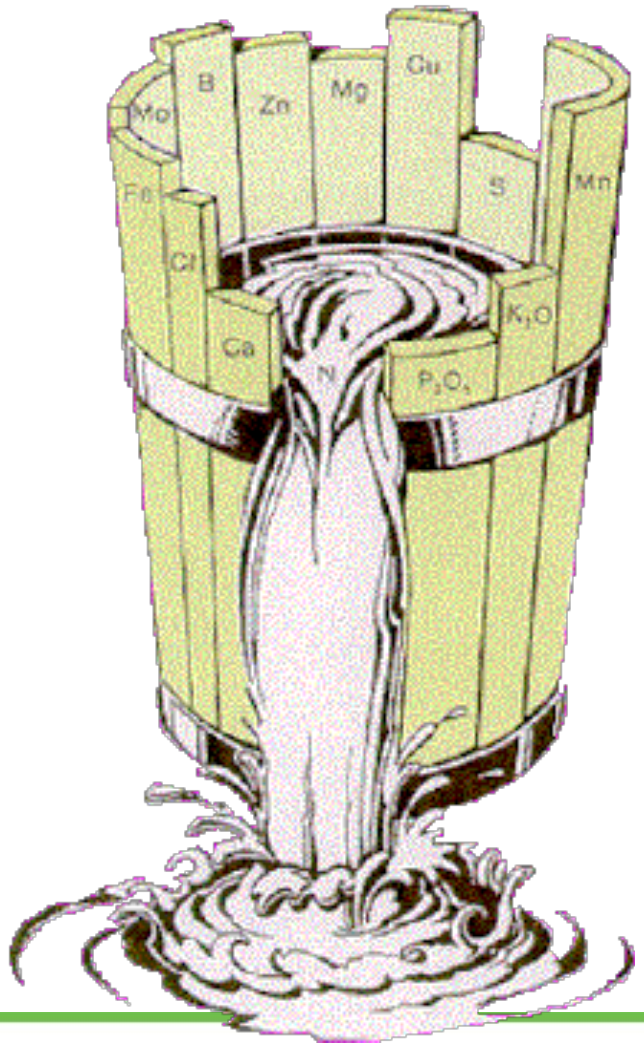
- What nutrients do plants need?
- How much do they need?
- Soil Amendments: lime, fertilizer
- Manures
- Biosolids
- Minerals
- Others: compost, biochar

Plant Nutrients

- Essential Nutrients
  - C, H, O
  - Primary: N, P, K
  - Secondary: Ca, Mg, S
  - Micro-nutrients: Cu, B, Zn, Fe, Cl, Mo, Mn, Co, Ni
- Soil pH

Liebig's Law of Minimum

- Justus von Liebig (1803-1873)
- German chemist
- Nutrient that is deficient or lacking will limit plant growth
- Also moisture, temperature, insect control, light, plant population and genetic capacities of plant varieties

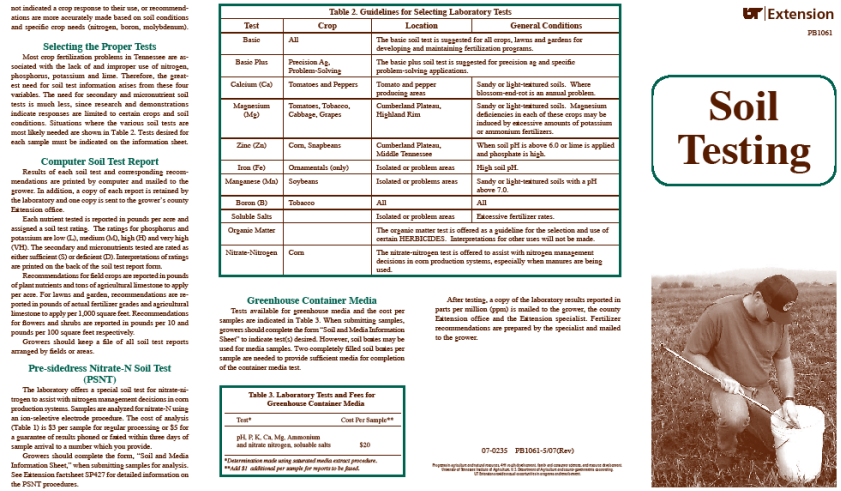


Soil pH

- Concentration of hydrogen ions
- Measured on logarithmic pH scale (1 to 14)
- Most crops need pH 5.7 to 6.5
- Micro-nutrient availability less at high pH
- Nutrient uptake; nitrification; acid rain
- Low pH (<5.5) = Al toxicity
  - Correct with calcitic or dolomitic lime
  - Determine with soil test

Soil Testing

- "Don't guess, soil test!"
- Sampling
  - 0 – 6"; Random
- UT Lab analyses
  - **Basic Plus**: Zn, Mn, Fe, Cu, Na, and B ($15)
  - **Container Media** -Saturated Paste Extract: pH, P, K, Ca, Mg, NH_4, NO_3, Sol. Salts ($20)
  - http://soilplantandpest.utk.edu/
- Interpretation of results
- Sufficiency vs. Maintenance



not indicated a crop response to their use, or recommendations are more accurately made based on soil conditions and specific crop needs (nitrogen, boron, molybdenum).

Selecting the Proper Tests

Most crop fertilization problems in Tennessee are associated with the lack of and improper use of nitrogen, phosphorus, potassium and lime. Therefore, the greatest need for soil test information arises from these four variables. The need for secondary and micronutrient soil tests is much less, since research and demonstrations indicate responses are limited to certain crops and soil conditions. Situations where the various soil tests are most likely needed are shown in Table 2. Tests desired for each sample must be indicated on the information sheet.

Computer Soil Test Report

Results of each soil test and corresponding recommendations are printed by computer and mailed to the grower. In addition, a copy of each report is retained by the laboratory and one copy is sent to the grower's county Extension office.

Each nutrient tested is reported in pounds per acre and assigned a soil test rating. The ratings for phosphorus and potassium are low (L), medium (M), high (H) and very high (VH). The secondary and micronutrients tested are rated as either sufficient (S) or deficient (D). Interpretations of ratings are printed on the back of the soil test report form.

Recommendations for field crops are reported in pounds of plant nutrients and tons of agricultural limestone to apply per acre. For lawns and garden, recommendations are reported in pounds of actual fertilizer grades and agricultural limestone to apply per 1,000 square feet. Recommendations for flowers and shrubs are reported in pounds per 10 and pounds per 100 square feet respectively.

Growers should keep a file of all soil test reports arranged by fields or areas.

Pre-sidedress Nitrate-N Soil Test (PSNT)

The laboratory offers a special soil test for nitrate-nitrogen to assist with nitrogen management decisions in corn production systems. Samples are analyzed for nitrate-N using an ion-selective electrode procedure. The cost of analysis (Table 1) is $3 per sample for regular processing or $5 for a guarantee of results phoned or faxed within three days of sample arrival to a number which you provide.

Growers should complete the form, "Soil and Media Information Sheet," when submitting samples for analysis. See Extension factsheet SP427 for detailed information on the PSNT procedures.

Table 2. Guidelines for Selecting Laboratory Tests

Test	Crop	Location	General Conditions
Basic	All		The basic soil test is suggested for all crops, lawns and gardens for developing and maintaining fertilization programs.
Basic Plus	Precision Ag, Problem-Solving		The basic plus soil test is suggested for precision ag and specific problem-solving applications.
Calcium (Ca)	Tomatoes and Peppers	Tomato and pepper producing areas	Sandy or light-textured soils. Where blossom-end-rot is an annual problem.
Magnesium (Mg)	Tomatoes, Tobacco, Cabbage, Grapes	Cumberland Plateau, Highland Rim	Sandy or light-textured soils. Magnesium deficiencies in each of these crops may be induced by excessive amounts of potassium or ammonium fertilizers.
Zinc (Zn)	Corn, Snapbeans	Cumberland Plateau, Middle Tennessee	When soil pH is above 6.0 or lime is applied and phosphate is high.
Iron (Fe)	Ornamentals (only)	Isolated or problem areas	High soil pH.
Manganese (Mn)	Soybeans	Isolated or problems areas	Sandy or light-textured soils with a pH above 7.0.
Boron (B)	Tobacco	All	All
Soluble Salts		Isolated or problem areas	Excessive fertilizer rates.
Organic Matter			The organic matter test is offered as a guideline for the selection and use of certain HERBICIDES. Interpretations for other uses will not be made.
Nitrate-Nitrogen	Corn		The nitrate-nitrogen test is offered to assist with nitrogen management decisions in corn production systems, especially when manures are being used.

Greenhouse Container Media

Tests available for greenhouse media and the cost per samples are indicated in Table 3. When submitting samples, growers should complete the form "Soil and Media Information Sheet" to indicate test(s) desired. However, soil borates may be used for media samples. Two completely filled soil borates per sample are needed to provide sufficient media for completion of the container media test.

Table 3. Laboratory Tests and Fees for Greenhouse Container Media

Test*	Cost Per Sample**
pH, P, K, Ca, Mg, Ammonium and nitrate nitrogen, soluble salts	$20

*Determination made using saturated media extract procedure.
**Add $1 additional per sample for reports to be faxed.

After testing, a copy of the laboratory results reported in parts per million (ppm) is mailed to the grower, the county Extension office and the Extension specialist. Fertilizer recommendations are prepared by the specialist and mailed to the grower.

07-0235 PB1061-5/07(Rev)

Extension
PB1061

Soil Testing

How much do I need?

- University of Tennessee Plant, Soil and Pest Center
  - https://soillab.tennessee.edu/soil-testing-and-fertilizer-recommendations/
- Basic plus: $15
    - Water pH, Mehlich 1 Phosphorus, Potassium, Calcium, Magnesium, Manganese, Iron, Copper, Sodium and Boron
- Other tests: $10 to $35
    - Organic matter, soluble salts, sulfate, nitrate, C:N ratio, container media, particle size
- Plant tissue analysis: $40
    - % N, P, K, Ca, Mg, S, Cu, Mn, Zn, Fe, B

Computer Codes
1. CAB

CABBAGE

Soil Test Recommendations for N, P_2O_5 and K_2O (Pounds Per Acre)

	Nitrogen	Phosphate (P_2O_5)				Potash (K_2O)				
		Soil Test Levels*								
Practice	(NT)	L	M	H	V	L	M	H	V	Notes
1. Establishment	90	90	60	30	0	180	90	30	0	1,2

*NT = Not Tested L = Low M = Medium H = High V = Very High

Notes: Lime recommendations from Lime Chart 2

1. Apply an additional 30 pounds of nitrogen per acre as a sidedressing when heads begin to form.

2. Apply two pounds of Boron per acre at planting.

Computer Codes
1. VC

(VINE CROPS) CUCURBITS, CANTALOUPES,
CUCUMBERS, SQUASH, PUMPKIN, WATERMELONS

Soil Test Recommendations for N, P_2O_5 and K_2O (Pounds Per Acre)

	Nitrogen	Phosphate (P_2O_5)				Potash (K_2O)				
		Soil Test Levels*								
Practice	(NT)	L	M	H	V	L	M	H	V	Notes
1. Establishment	30-40	90	45	0	0	60	30	0	0	1,2

*NT = Not Tested L = Low M = Medium H = High V = Very High

Notes: Lime recommendations from Lime Chart 2

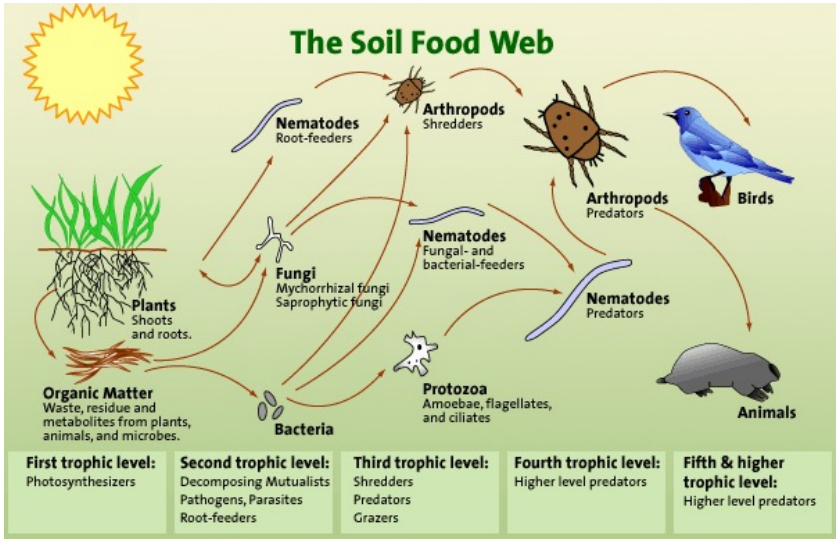
1. Apply an additional 15-30 pounds of nitrogen per acre when runners are 12 inches long or at early bloom.
2. If cantaloupes, cucumbers or squash are being grown on plastic with fertigation, apply all of the recommended phosphate and 1/2 of the recommended nitrogen and potash prior to laying the plastic. Distribute the remaining nitrogen and potash in weekly intervals over the remainder of the growing season (4 to 6 weeks).

UT Soil Test Lab: 2008 to 2016

	M1P Low	M1P Med	M1P High	M1P Vhigh	Total Samples
Total samples	42,810	20,769	43,475	31,457	138,511
% all soils tested	30.9	15.0	31.4	22.7	138,511
% row crop soils tested	32.4	19.6	37.4	10.6	41,011
% commercial fruit and nuts	36.8	13.4	28.1	21.8	1,955
% cool season forages	38.4	16.7	31.0	13.9	41,341
% home and garden	17.6	7.6	25.0	49.8	24,549
% residential lawn and ornamentals	26.7	11.7	27.4	34.3	16,040
% commercial vegetables	24.4	9.9	27.0	38.6	4,435
% warm season forages	39.6	15.9	31.3	13.2	3,827

Other Tests: Soil FoodWeb

- Based on the concept of that bio-diversity in the soil is good for a healthy soil or compost
- Soil, compost, and compost tea analysis
- Measure the "correct" density of bacteria and fungi and amount of bacterial / fungal activity. Also nematodes, protozoa etc.
- Labs in Europe, USA, Africa etc.
- What do the numbers mean?



- http://www.soilfoodweb.com/

Other Tests: Woods End Lab

- Compost tests – required by some states if you are marketing compost
- Compost analysis
  - Composition: density, solids, organic matter, pH
  - Nutrients: N (total, organic, NH_4 and NO_3) P, K, Ca, Mg etc.
  - Metals; Cu, Zn, Fe, Pb, Hg etc.
  - Bacteria: Coliform, E. coli
- Home test kits for soil, compost and manure: ammonia and carbon dioxide
- Recognized by Organic Materials Review Institute (OMRI for OMRI-Listing™, Mulch and Soil Council (MSC) and is a Manure Analysis Proficiency) (2005-2009) certified laboratory and CAP Compost Analysis Proficiency (2010-2011) lab
- http://www.woodsend.org/

Lime and Liming Products

- Calcitic: calcium carbonate
  - Quick lime: calcium oxide – caustic!
  - Hydrated lime: calcium hydroxide – caustic!
- Dolomitic: calcium carbonate and magnesium carbonate
- Particle size important
- Other products:
  - Lime stabilized biosolids
  - Poultry litter
  - Gypsum: calcium sulfate (no effect on pH, but ties up Al)

Fertilizer Analyses?

5 % N

20% P_2O_5 = 8.75% P

20% K_2O = 16.5% K

- P to P_2O_5 = 2.29; K to K_2O=1.2

Fertilizer Analyses?

- 3% N = 3% / 100 x 50 lb
  = 1.5 lb / 50 lb bag
  = 60 lb per ton
- 3% P_2O_5 = 1.5 lb / 50 lb bag
  - or 60 lb per ton
- 3% K_2O = 1.5 lb / 50 lb bag
  - or 60 lb per ton

Common Fertilizer Materials

- Urea: 46-0-0
- Ammonium nitrate: 34-0-0
- Ammonium sulfate: 21-0-0+24S
- Diammonium phosphate: 18-46-0
- Triple superphosphate: 0-46-0
- Single superphosphate: 0-20-0
- Potassium chloride: 0-0-60
- Potassium sulfate: 0-0-50+18S
- Potassium nitrate: 13-0-44

Manure Use in US*

- Used on 15.8 million acres (5% crops)
- Half of it on corn (mostly dairy and swine manure)
- Broiler litter in southeastern US
  - Corn, Peanuts, Cotton
  - Hay / pasture
- *Report to Congress. Manure Use for Fertilizer and for Energy. June 2009

Broiler Litter in Tennessee

- Excretion by broilers*
  - 12,000 tons nitrogen
  - 8,000 tons phosphorus (as P_2O_5)
  - 8,000 tons potassium (as K_2O)
- How many tons litter?
  - Estimated 150 to 200,000 tons
- "Typical" nutrient content
  - 60 lbs N : 50 lbs P_2O_5 : 50 lbs K_2O
  - Approximately a 3 : 2.5 : 2.5 fertilizer
- Worth $80 per ton as NPK (Feb 2022)
  - $0.98 per lb N, $0.52 per lb P_2O_5 and $0.67 per lb K_2O

*Based on ASAE Manure Production Characteristics; *ASAE D384.2 March 2005

Effect of Storage on Litter

Concentration (lbs per ton)	2004 "Fresh"	2005 1 year old	2006 2 years old	Percent Change
Nitrogen (N)	59	64	63	8
Plant available N	29	32	32	8
Phosphorus as P_2O_5	68	89	93	37
Potash as K_2O	59	77	80	36
Calcium	51	69	73	44
Sulfur	9	13	14	51
Zinc	0.7	1.0	1.0	41
Copper	0.7	0.9	1.0	39
Moisture (%)	31.5	22.0	18.3	-42

Litter Analysis by University of Arkansas, Agricultural Diagnostic Lab,

Biosolids Use*

- 16,583 wastewater treatment plants in US
  - About 55% land-applied / 45% to landfill
  - 7.2 million dry tons land applied (2004)
  - 74% used on farms
  - 23% Class A, 34% Class B, no data on rest
- Not much change in recycling since 1990s

*North East Biosolids & Residuals Association (2007)

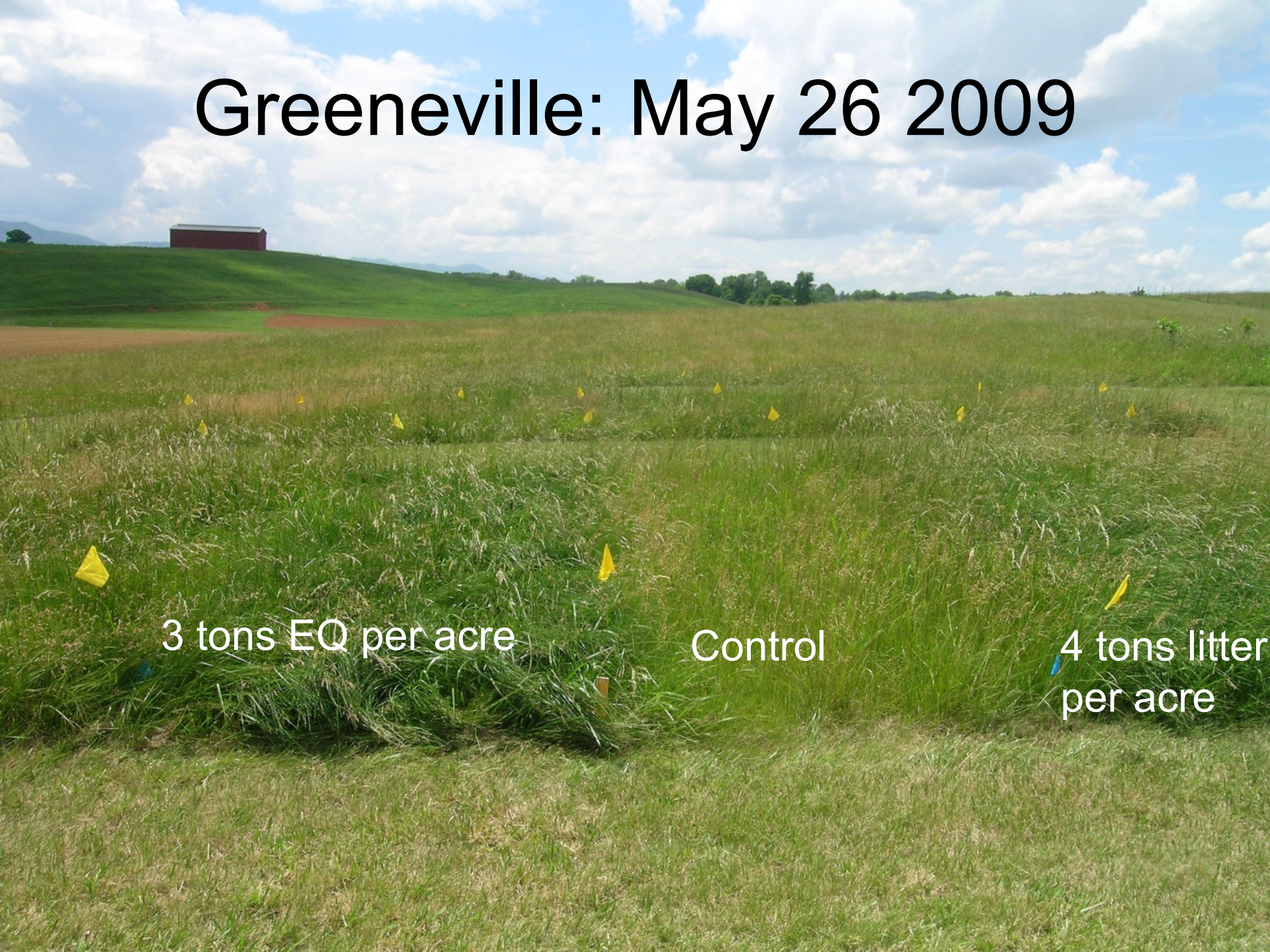
Biosolids

- Cannot be used in organic systems
- Class A or Class B – site restrictions
- Good source of P
- How has it been treated
  - Lime stabilized or not?
- P content varies
- Usually minimal or no cost

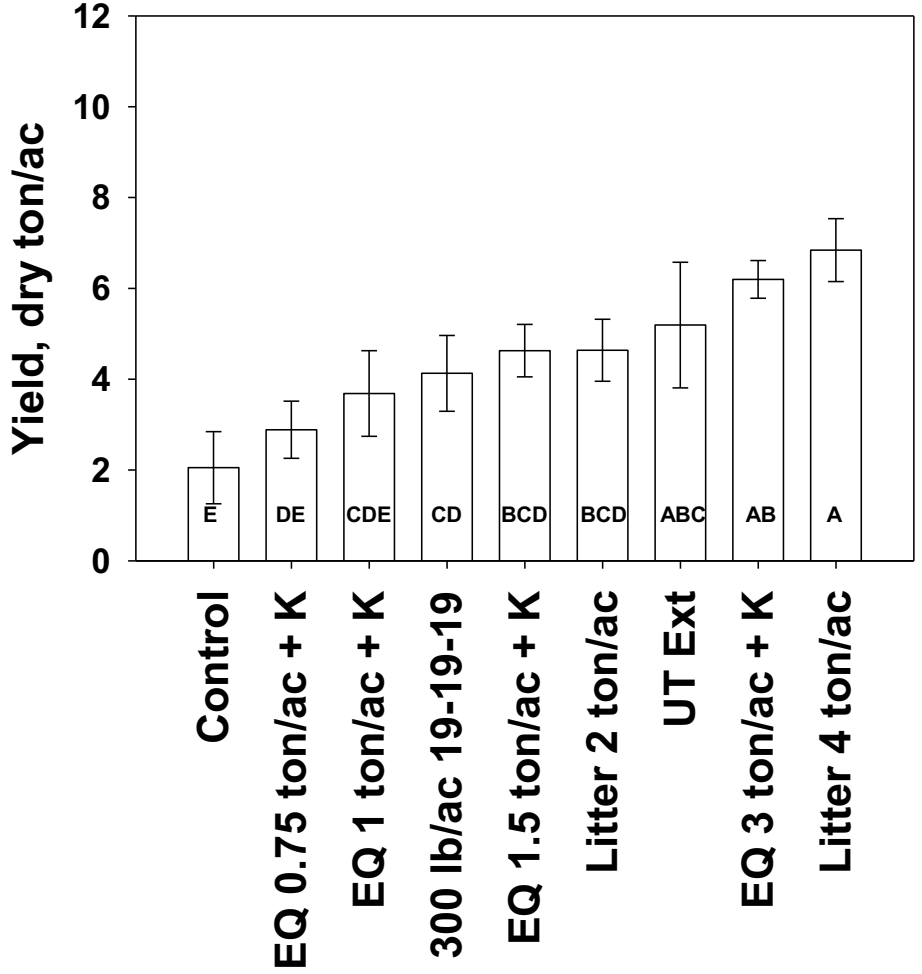
Biosolids Analysis: Lime

Parameter	**2001**	**2005**
Total nitrogen (lbs per dry ton)	40.4	72.0
Plant available nitrogen (lbs per dry ton)	20.2	36.0
Total phosphorus (lbs P_2O_5 per dry ton)	76.8	109.9
Total potassium (lbs K_2O per dry ton)	2.4	2.9
pH	12.4	8.0
Percent solids	34.1%	26.4%
Wet tons per dry ton	2.9	3.8

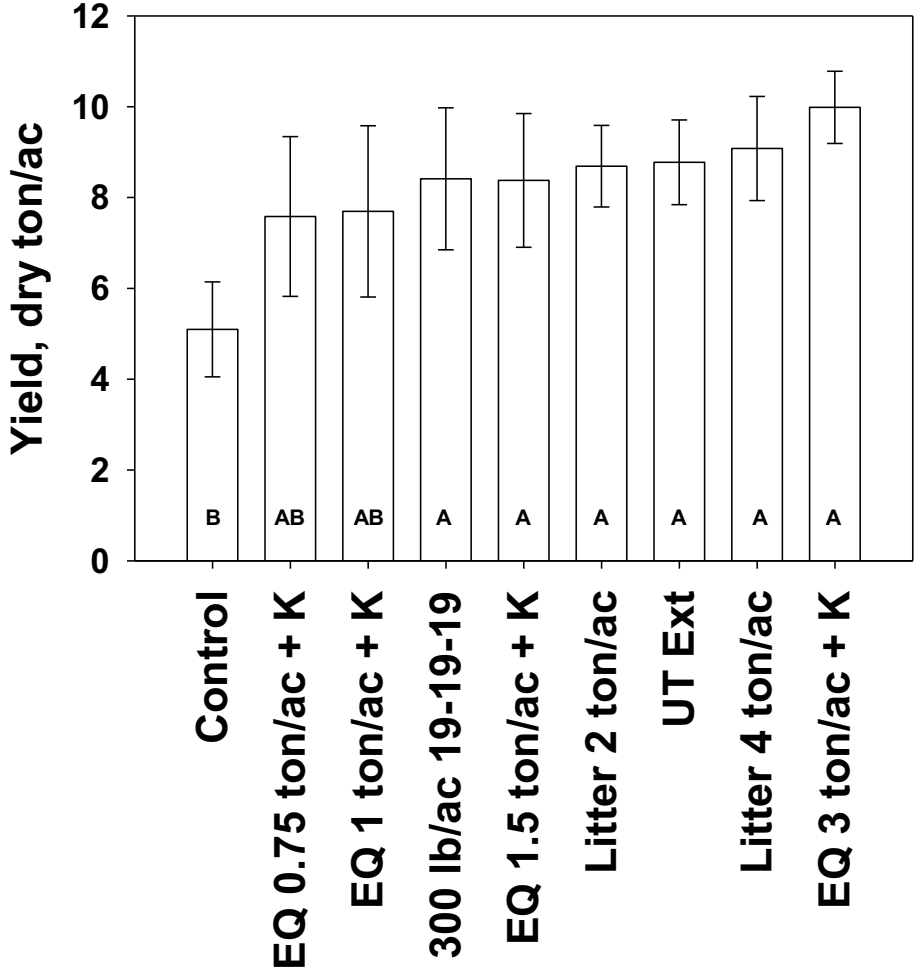
Greeneville: May 26 2009



Fescue Yield: First Cut



Greeneville REC; harvested 05/26/09



Plateau REC; harvested 06/02/09

Organic Soil Amendments Can Be Used?**

- Aquatic plant extracts
- Elemental sulfur
- Humic acids
- Magnesium sulfate – mined only
- Micronutrients - nitrates or chlorides are not allowed
- Soluble boron products
- Sulfates, carbonates, oxides, or silicates of zinc, copper, iron, manganese, molybdenum, selenium, and cobalt

** USDA National Organic Program

What Soil Amendments Can Be Used?**

- Liquid fish products — can be pH adjusted with sulfuric, citric or phosphoric acid
- Potassium chloride — derived from a mined source
- Sodium nitrate (Chilean Nitrate) — no more than 20% of the crop's total nitrogen requirement

** USDA National Organic Program

Sources of Nitrogen

- Manure
- Cover Crops
- Plant Products
- Animal Byproducts
- Seaweeds
- Mined nitrate (Chilean Nitrate)

Sources of Phosphorus

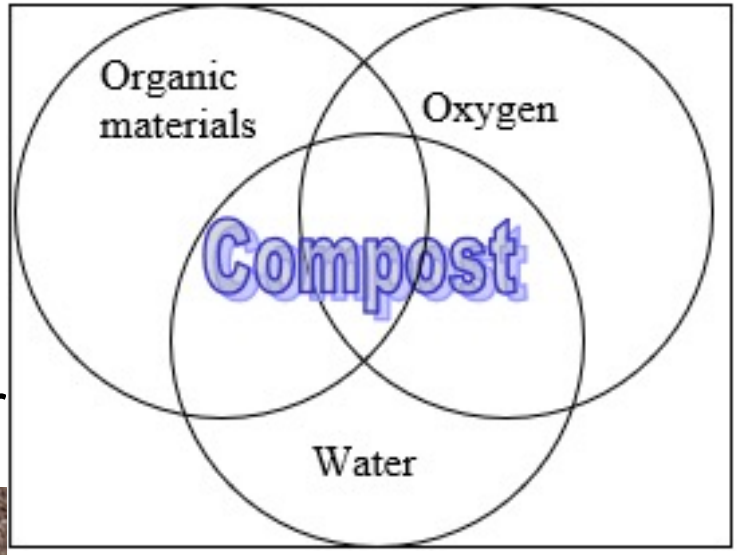
- Manures and compost
- Rock phosphate
- Phosphatic clays
- Bone meal
- Guano

Sources of Potassium

- Manures and compost
- Greensand
- Langbeinite (Potassium-magnesium sulfate)
- Potassium Sulfate
- Rock Powders
- Sylvinite (Potassium Chloride)
- Wood ash

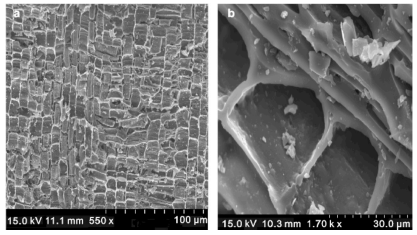
Other Amendments: Compost

- What is compost?
  - From managing the decomposition of heterogeneous organic materials
  - Final product is a stable homogenous organic material called compost
  - Aerobic microbes
- Aerobic microbes need:
  - Food (organic materials)
  - Water
  - Oxygen
- Source of nutrients, organic matter microorganisms



Other Amendments: Biochar

- Charcoal-like material
- Typically produced from woody biomass
- Decomposed at high temperatures in absence of oxygen
- Improves “poor” soils, water management
- Modify soil chemical and physical properties
  - Increased CEC = Plant nutrient holding capacity
  - Larger surface area = Water holding capacity
  - Modify pH?
  - Source of nutrients (P and K)
  - Increases carbon sequestration



Jarrah wood biochar (SEM). Joseph *et al.* (2015)

Summary

- Don’t guess soil test!
- Don’t guess have your organic amendments analyzed!
- Match soil amendments with UT soil test recommendations – if you are using private or out-of-state labs what do the numbers mean?
- Do not over-apply nutrients