

Soil Fertility

Dale Rankin

Colorado County Extension Agent

Texas Agrilife Extension Service

Credits: And Special Thanks

- Dr. Mark McFarland Texas Agrilife Extension Service, Professor and Extension Soil Fertility Specialist
- Dr. Sam Feagley Texas AgriliFe Extension Service, Professor, and State Soil Environmental Specialist

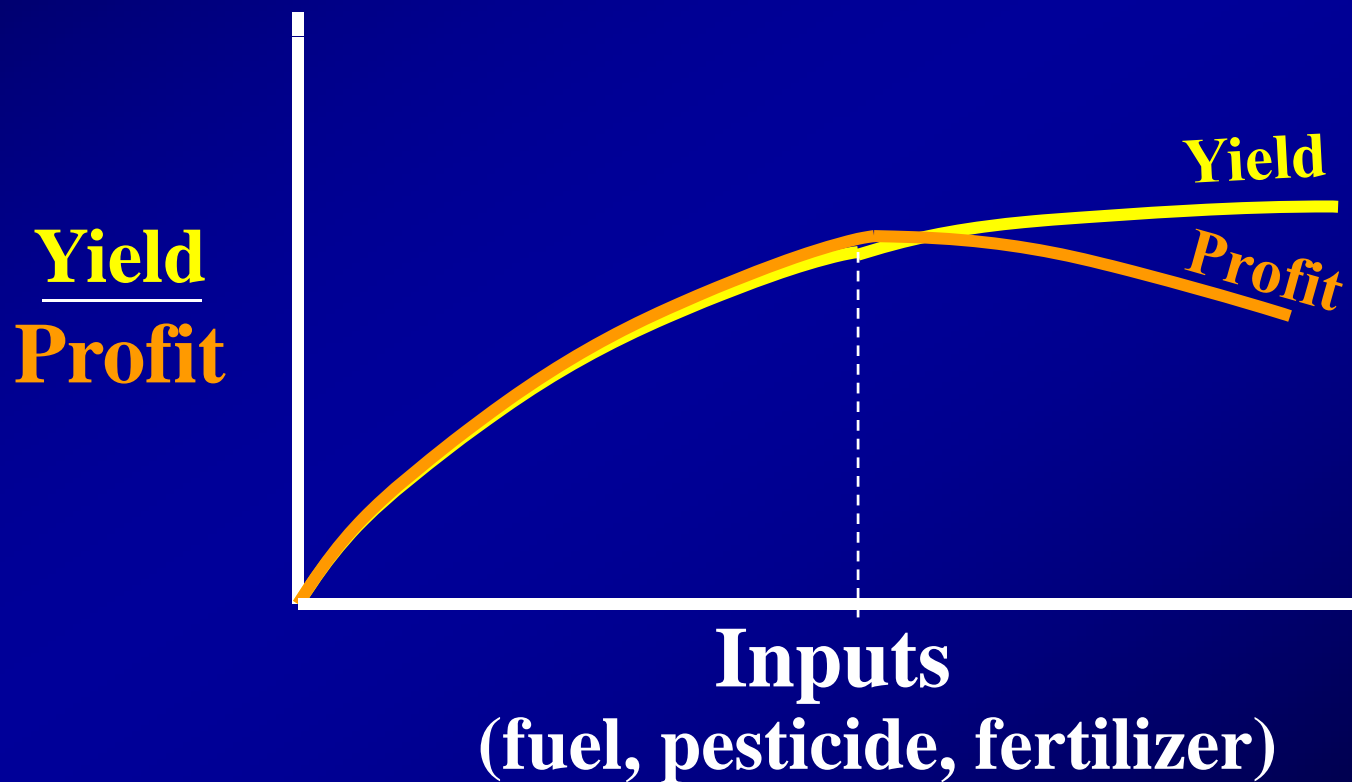
Fertilizer Management

Economic Returns

- High Yields
- High Quality



Manage Inputs



Soil Testing

The Key to Nutrient Management

A soil test is a chemical extraction that estimates the nutrient supplying power of a soil.

Identifies whether a nutrient is deficient, sufficient, or in excess.

Essential Elements Found to Limit Plant Growth in the Field

Primary Nutrients: Nitrogen, Phosphorus, Potassium

Secondary Nutrients: Calcium, Magnesium, Sulfur

**Micronutrients: Boron, Chlorine, Copper,
Iron, Manganese, Zinc**

Nutrient Uptake by Coastal Bermudagrass (2 T/A)

	Nutrient	Pounds/Acre	Pounds/Ton
Primary	Nitrogen	100	50
	Phosphorus	28	14
	Potassium	84	42
Secondary	Calcium	15	
	Magnesium	6	
	Sulfur	8	
Micro's	Copper	0.05	
	Manganese	0.05	
	Zinc	0.10	

Balanced Nutrition



Improved Bermudagrass Soil Test vs. Fertilizer Recommendation

Yield Goal	Soil Test (ppm)			Annual Rate (lb/A)		
	N	P	K	N *	P ₂ O ₅	K ₂ O *
Grazing	1	1	1	60	50	90
1 Cutting + Grazing	1	1	1	160	50	150
3 Cuttings hay	1	1	1	300	100	300
4-6 Cuttings hay	1	1	1	400	130	400

* Split applications of N and K.

Grazing vs. Hay

Most of the nutrients are recycled through the animals and back to the soil.



Coastal Bermudagrass Soil Test vs. Fertilizer Recommendation

Yield Goal	Soil Test (ppm)			Annual Rate (lbs/A)		
	N	P	K	N *	P ₂ O ₅	K ₂ O *
3 Cuttings	1	1	1	300	100	300
	5	22	75	290	50	150
	10	44	105	280	25	70

*Split applications of N and K.

Fertilizer Selection

Fertilizer		Spring rate (lbs/A)			Cost
Source	rate (lb/a)	N	P ₂ O ₅	K ₂ O	\$/acre
18 - 18 - 18	555	100	100	100	\$68
24 - 8 - 16	417	100	33	67	\$51

Fertilizer Selection

Fertilizer		Spring rate (lbs/A)			Cost
Source	rate (lb/a)	N	P ₂ O ₅	K ₂ O	\$/acre
18 - 18 - 18	555	100	100	100	\$68
24 - 8 - 16	417	100	33	67	\$51

Effect of Soil pH on Nutrient Recovery

pH	Nitrogen	Phosphorus	Potash
7.0	70	30	60
6.0	63	15	60
5.5	52	15	45
5.0	38	10	30
4.5	21	8	21

Below 5.5 can begin to have problems with aluminum and manganese toxicity

Liming to Correct Soil Acidity



Limestone Quality

➤ Neutralizing Value

- 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.

➤ $CCE \times ER = ECCE$

(Effective Calcium Carbonate Equivalence)



Deficient

Sufficient

Nitrogen Deficiency Symptoms

- Slow growth/stunted plants
- Yellow-green color (chlorosis)

Effect of Nitrogen Rate on Yield and Crude Protein

Annual N Rate (lbs/A)	Yield (tons/A)	Crude Protein (%)
0	2.7	8.0
100	4.4	9.1
200	5.9	10.5
400	8.6	11.7

Nitrogen Fertilizers*

	Formula	Grade
Anhydrous Ammonia	NH_3	82-0-0
Ammonium Nitrate	NH_4NO_3	34-0-0
Ammonium Sulfate	$(\text{NH}_4)_2\text{SO}_4$	20-0-0
Urea	$(\text{NH}_2)_2\text{CO}$	46-0-0
Urea Ammonium Nitrate		32-0-0

* Equally effective if properly applied.

Retail Fertilizer Material Prices

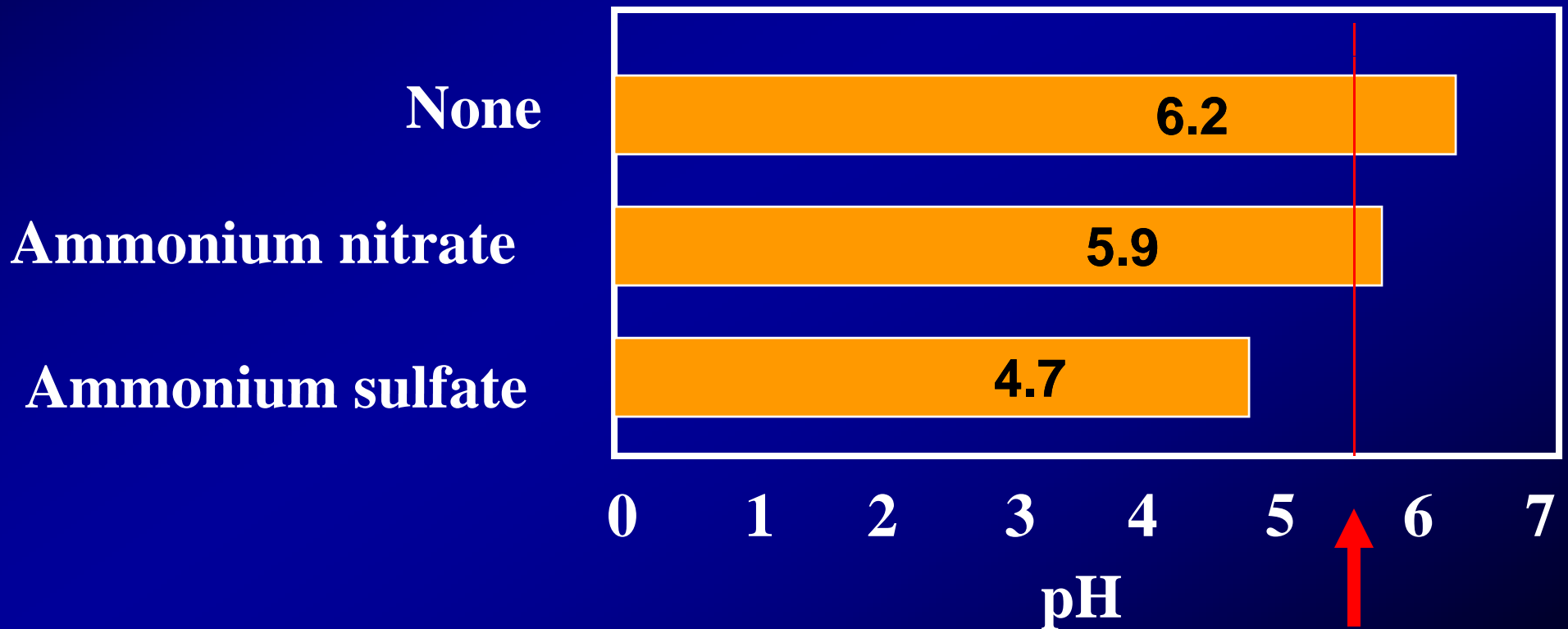
(January 2003 vs. 2009)

Source	\$/Ton			\$/Pound		
	03'	08'	09'	03'	08'	09'
82-0-0 (ammonia)	240	630	375	0.15	0.38	0.23
46-0-0 (urea)	250	531	345	0.27	0.58	0.38
32-0-0 (UAN)	180	410	390	0.28	0.64	0.61
18-46-0 (DAP)	295	995	480	0.23	0.78	0.38
0-0-60 (potash)	170	550	814	0.14	0.46	0.68

Effect of Nitrogen Fertilizer on Soil pH

(Lufkin soil, Overton, Tx.)

Average After 3 Years



Phosphorus

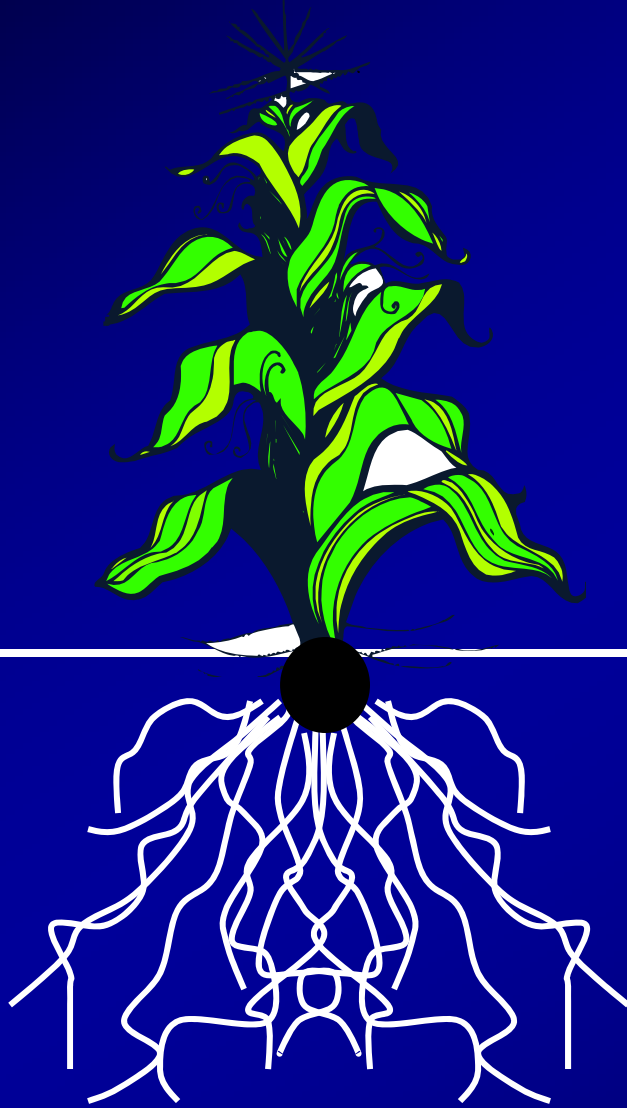
Characteristics and Functions

- Functions in Plant:** Simulates early growth and root formation.
Promotes optimum forage growth and quality.
- Movement in Soil:** Very immobile, will not leach or volatilize.
Subject to stratification (build-up in surface 2 to 3 inches of soil) when surface applied.

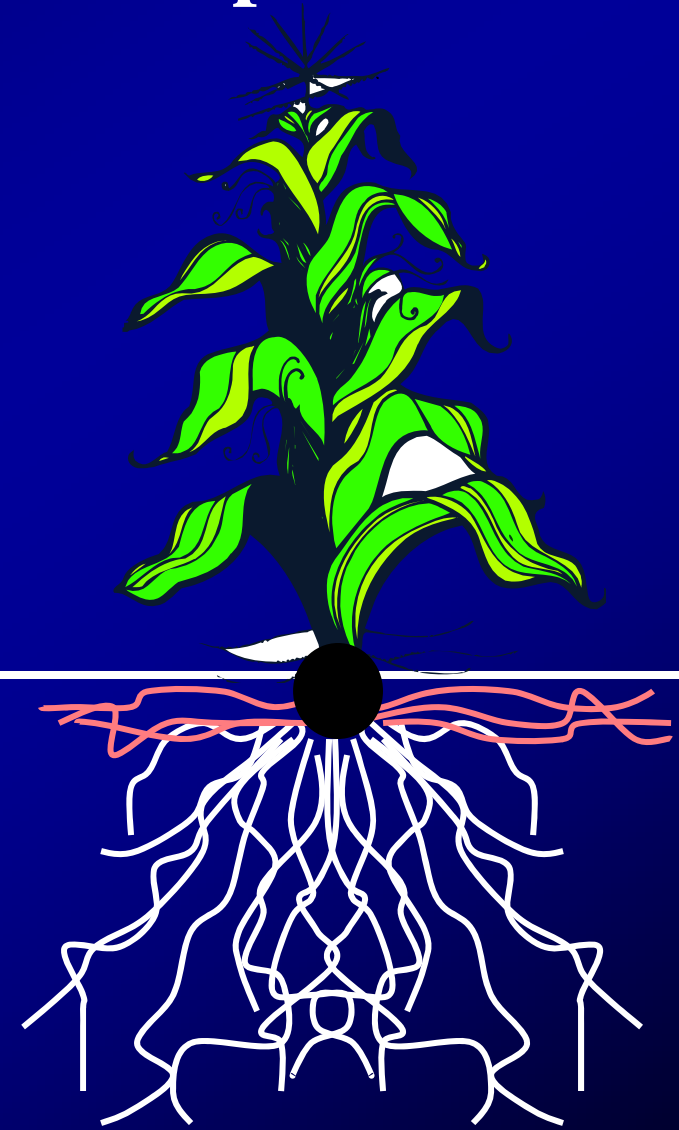
Dry Surface Response to Deep P

Wet Surface No Response to Deep P

Depth
(inches)



(ppm P)

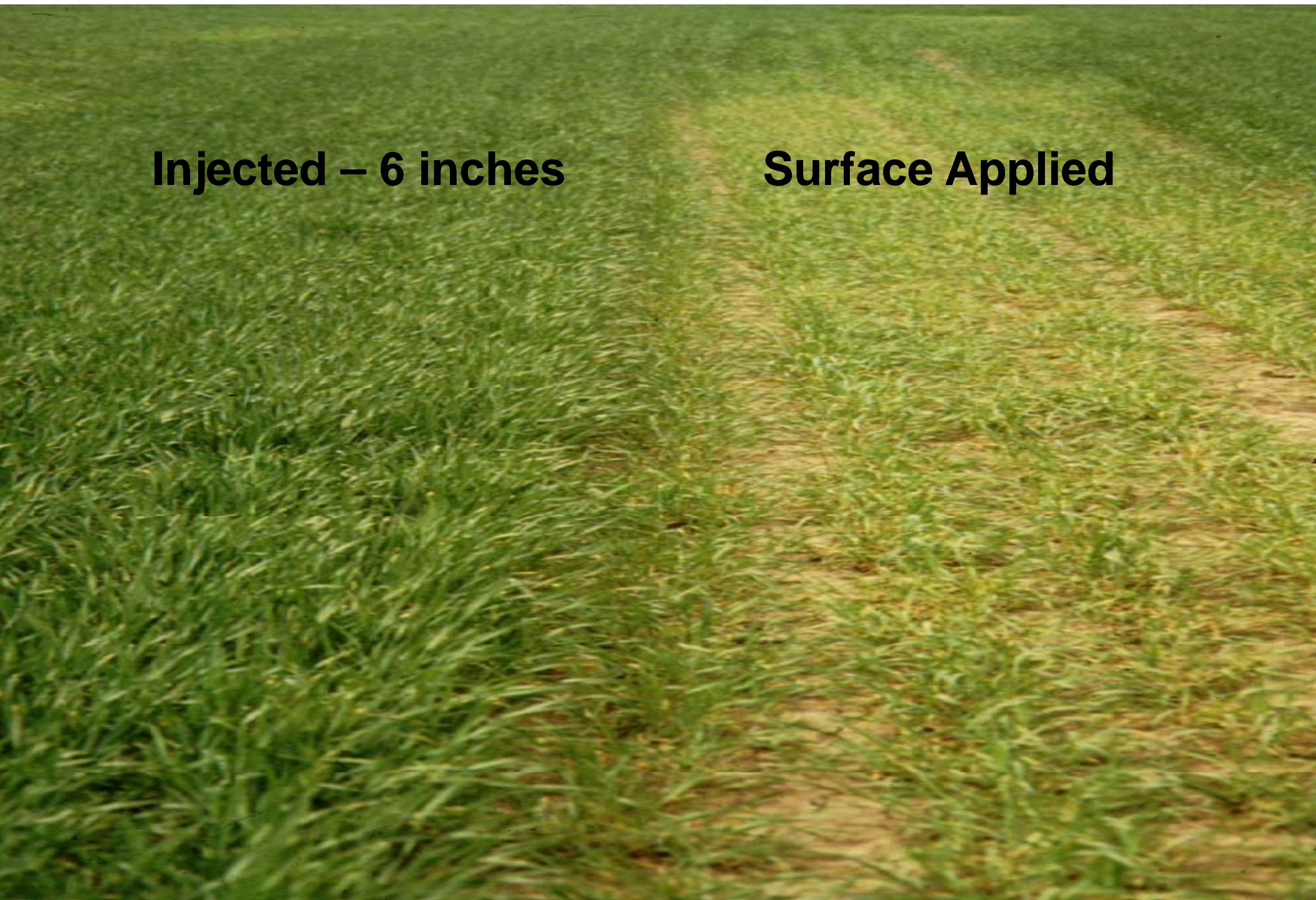


0-2
2-8
8-14
14-20
20-26

57
20
9
1
1

Injected – 6 inches

Surface Applied





Phosphorus Management

Establishment: Soil test !!

Apply and incorporate phosphorus fertilizer before planting.

Last chance to get it in the root zone.

Phosphorus Fertilizer

	Formula	Grade
Ordinary superphosphate	$\text{Ca}(\text{H}_2\text{PO}_4)_2$	0-18-0
Triple superphosphate	$\text{Ca}(\text{H}_2\text{PO}_4)_2$	0-46-0
Monoammonium phosphate (MAP)	$\text{NH}_4\text{H}_2\text{PO}_4$	11-48-0
Diammonium phosphate (DAP)	$(\text{NH}_4)_2\text{HPO}_4$	18-46-0
Ammonium polyphosphate (AAP)		10-34-0

***Liquid and dry forms equally effective**

Potassium

Characteristics and Functions

- Available Forms:** Potassium ion (K^+)
- Functions in Plant:** Controls stomates → water use efficiency
Increases disease resistance
Improves cold hardiness
- Movement in Soil:** Does not leach (medium/heavy soils)
Will not volatilize.
- Part of clay minerals – high levels in most clay soils.



Potassium Deficiency

- Stand decline
- Winter kill
- Disease susceptibility
- Poor water use efficiency

Fertilizer Management

- K is luxury consumed
- Split/balance applications for each cutting (fall?).

Sources of Nutrients

- Commercial Fertilizer
- Organics
 - Manures
 - Composted manures
 - Biosolids

Sources of Nutrients

- Selected Commercial Fertilizers
- N
 - Anhydrous ammonia, 82-0-0
 - Urea, 46-0-0
 - Ammonium nitrate, 33-0-0
 - Ammonium sulfate, 21-0-0
 - UNA, 32-0-0

Sources of Nutrients

- Selected Commercial Fertilizers
- P – diammonium phosphate, 18-46-0
monoammonium phosphate, 11-48-0
calcium phosphates, 0-20-0 to 0-45-0
- K – potassium chloride, KCl, 0-0-60

Elemental Concentrations in Various Manures

Animal	N	P ₂ O ₅	K ₂ O	Ca	Mg	Na
	-----%-----					
Dairy	1.35	1.24	1.64	3.69	0.60	0.24
Beef	1.36	1.21	1.85	1.43	0.49	0.67
Poultry	3.15	5.52	3.13	2.98	0.61	0.76
Swine	7.6	4.1	3.1	2.6	0.7	0.5
Biosolids	5.00	3.50	0.62	2.87	0.26	0.22

Elemental Concentrations in Various Manures

Animal	Zn	Fe	Cu	Mn	S
	-----mg/kg-----				
Dairy	129	4430	36	195	3778
Beef	92	2582	18	251	5026
Poultry	602	2668	465	579	7661
Swine	5000	800	400	2000	-
Biosolids	1340	2278	473	357	-

Typical Application Rates

- **Should always be determined by soil testing**
- Biosolids (Class A) – 1 to 2 T/A
- Poultry litter – 2 to 3 T/A
- Cattle/Dairy – 10 to 25 T/A

Delivery of Nutrients

- Commercial fertilizers - \$50 /A
- Biosolids - \$38-46/T
- Poultry litter - \$8-45/T
- Cattle - \$1-2/T up to 5 miles

Disadvantages of Manures

- Unwanted seeds
- Nutrient amounts not the same as plant uptake, so over apply some and under apply other nutrients
- Trash, etc. in manure
- Slow release of nutrients

Advantages of Manures

- Maintains or adds organic matter to the soil
- Adds all essential plant nutrients to the soil
- Slow release of nutrients, application timing
- If organic matter is increased
 - Nutrient cycling increased
 - Soil air and water relationships improved
 - Soil aggregation/stability improved
 - Soil cation exchange capacity increased
 - Soil drainage improved

Soil Amendment or SNAKE OIL?

Reference

- Compendium of Research Reports on Use of Non-Traditional Materials for Crop Production. 1984. NCR-103 Committee. Cooperative Extension Service, Iowa State University

Types of Soil Amendments

- Biological inoculants and activators
- Growth stimulants and regulators
- Mineral nutrient sources (low volume/low analysis)
- Soil conditioners
- Wetting agents
- Others

Examples of Each Type of Soil Amendment

Biological inoculants and activators

- Agra-Life
- Genesis II
- Medina
- Phosphobacterin

Growth Stimulants and Regulators

- AgroPlus
- Culbac
- Dinoseb
- Sea Born Plus and Sea Born Plus F

Mineral Nutrient Sources

- Bayfloan
- Hybortite
- Plen-T-4
- Shur-Gro

Soil Conditioners

- Fertilaid
- Leonardite
- Wonderlife
- Humate

Wetting Agents

- Basic H
- Saturall
- Sol-Ez
- Trazco

Other

- Extend
- Promesol
- SRC-101
- Enagizer

Research Comparing Soil Amendments to Commercial Fertilizer

Murdock, Rieck and Curtsinger, University of Kentucky, mid to late 1970

Corn Grown on a Tilsit Silt Loam, West KY

Material Applied	Rate	Average Yield (bu/A)
Agriserum	1 pt/bu	37.2
Medina Water	1 gal/A	31.1
Super Natent	1 gal/A	29.5
NaChurs	9 gal/A	29.8
Fertilizer in row	9-19-9/A	44.4
Fertilizer broadcast	120-130-104/A	119.1
No Fertilizer	0	36.2

Lilly, North Carolina, 1978

Corn Yield for the Soil Additives and Specialty Products Field Tests

Treatment	Corn Yield (bu/A)
Check, no N	43.2
Agra-Life	40.5
70 lb/A N (30 + 40)	85.3
110 lb/A N (30 + 80)	99.0
150 lb/A (30 + 120)	95.0
Agra-Life + 70 lb/A N (30 + 40)	89.5
Genesis II, No N	51.2
Agriblend + 150 lb/A N (30 + 120)	94.1
Extend + 110 lb/A N (30 + 80)	87.8
Extend + 150 lb/A N (30+120)	97.0

LSD .05

9.2

Effects of Humic Acid on Tifton 85 Bermudagrass Yield

Treatment	Yield (bu/A)		
	2003	2004	2005
Fertilizer only	4.16	4.50	4.78
+ 0.5 gal/a HA	4.18	4.26	4.95
+ 1.0 gal/a HA	3.98	4.18	4.73
+ 2.0 gal/a HA	4.21	4.39	4.95
+ 3.0 gal/a HA	4.13	4.22	4.89
P > F	0.347	0.837	0.629
LSD	NS	NS	NS

Effects of Humic Acid on Tifton 85 Bermudagrass Yield

Treatment	Yield (bu/A)		
	2003	2004	2005
Fertilizer only	4.16	4.50	4.78
+ 0.5 gal/a HA	Not Different	Not Different	Not Different
+ 1.0 gal/a HA	Not Different	Not Different	Not Different
+ 2.0 gal/a HA	Not Different	Not Different	Not Different
+ 3.0 gal/a HA	Not Different	Not Different	Not Different
P > F	0.347	0.837	0.629
LSD	NS	NS	NS

Fertilizer Products

Great for Hay Fields and
Cattle Pastures



Great for Yards



Great for Gardens and Crops



GRASSHOPPER
Becomes active the next day
Fertilizes grass
Soil quality less relevant
Fertilizer bypasses soil
Cost \$15-20 per acre
Can be mixed w/ herbicide

vs.

GRANULAR
Requires rain to become active
Fertilizes soil
Soil test necessary to repair imbalance
Fertilizer often caught/wasted in soil
Cost \$40-60 per acre
Herbicide requires a 2nd application

GRASSHOPPER 30-10-10



Liquid Fertilizer

Active the next day - without rain
Twice as effective - half the cost

GRASSHOPPER is an advanced liquid fertilizer that is absorbed thru the grass making nitrogen and nutrients available immediately without rain.

Hay N' Spray

For more information:
Sharp Ranch
1328 FM 71 W
Talco, TX 75487

Fertilizer Products

Grasshopper 30-10-10

- \$20/acre
- Rate: $3.5 \text{ bags}/7 \text{ acres} = 0.5 \text{ bags/acre}$
 - = 7.5 lbs N / acre
 - = 2.5 lbs P_2O_5
 - = 2.5 lbs K_2O
 - 12.5 lbs/acre ($\$20/12.5 = \1.60)

Advantages and Disadvantages of Soil Amendments

Advantages

- No advantages were found with any of the non-traditional soil amendments in this 13 state study in the 1970's at recommended rates of the soil amendments
- Many of these products are still available, some are available with different names

Disadvantages

- No yield increases with the non-traditional soil amendments
- Some decreased yields at recommended rates
- Texas has no soil amendment regulations as most states do

Traditional Soil Amendments

- Manures and biosolids
- Gypsum
 - Good source of calcium and sulfur
 - Does not change the pH of the soil
- Agricultural Limestone
 - Good source of calcium and sometimes magnesium
 - Increases the pH of the soil

Soil Testing: It's Worth the Effort



Routine Soil Testing:

- * 1-3 year interval
- * Micro's every other time

Sampling Methods:

- * Composite samples
- * 12-15 cores per field
- * Mix and ship immediately.

Procedure for Taking Soil Samples

Field 1

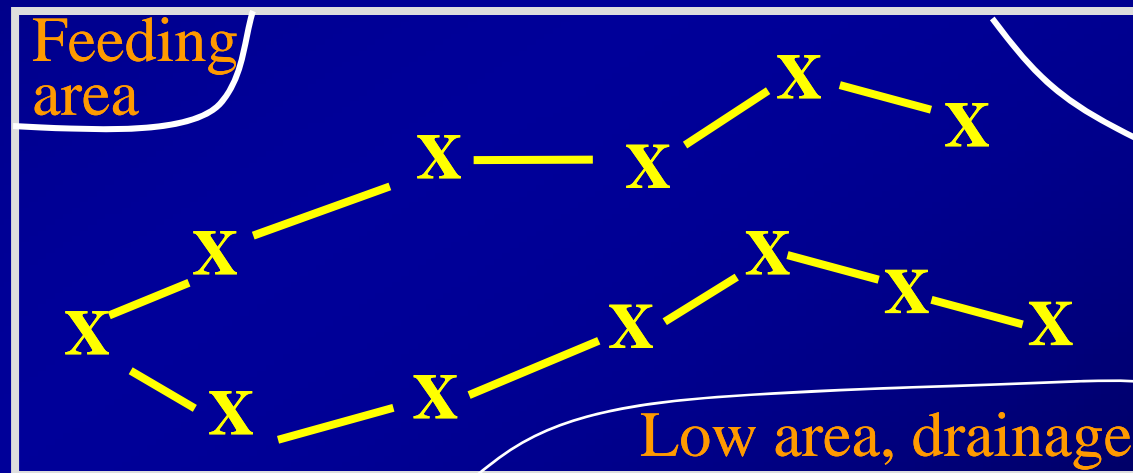


X

Procedure for Taking Soil Samples

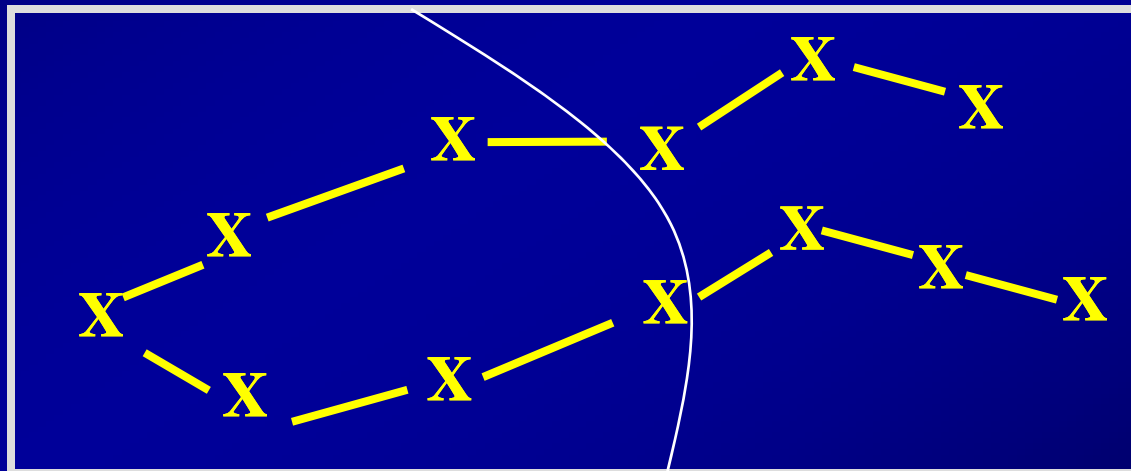
- Take 10-20 cores for each management area.

Field 1



Procedure for Taking Soil Samples

Clay Field 1 Sand



Recommendations

- 1. Soil test every 1 to 3 years on irrigated and 3 to 5 years on dryland
- 2. Apply nutrients as close to when the crop needs it as possible
- 3. Split apply N and K with all of P at first application
- 4. Choose source of nutrients that is most economical for you
- 5. Sources of organic nutrients should be applied 1 to 3 months prior to planting and should be incorporated to reduce potential for runoff and N volatilization
- 6. If P is stratified, use tillage to mix soil at least 6 inches

<http://soilcrop.tamu.edu>



Effects of N Rate on Yield of Tifton 85 Bermudagrass

N rate (lbs./A/cutting)	Tons/Acre		
	2001	2002	2003
50	4.71 d	3.15 c	3.07 c
75	6.14 c	5.18 b	4.03 b
100	6.78 b	6.32 a	4.15 ab
125	7.43 a	6.47 a	4.49 a
150	--	--	4.53 a

Effect of P Rate on Yield of Improved Bermudagrass

P rate (lbs. P ₂ O ₅ /A)	Yield (T/A)	
	Tif 85	Coastal
0	7.29 c	3.71
60	7.93 b	4.00
90	8.77 a	3.97
120	8.16 b	4.01
Rec.	90	80

* Rec = Mehlich 3 soil test recommendation