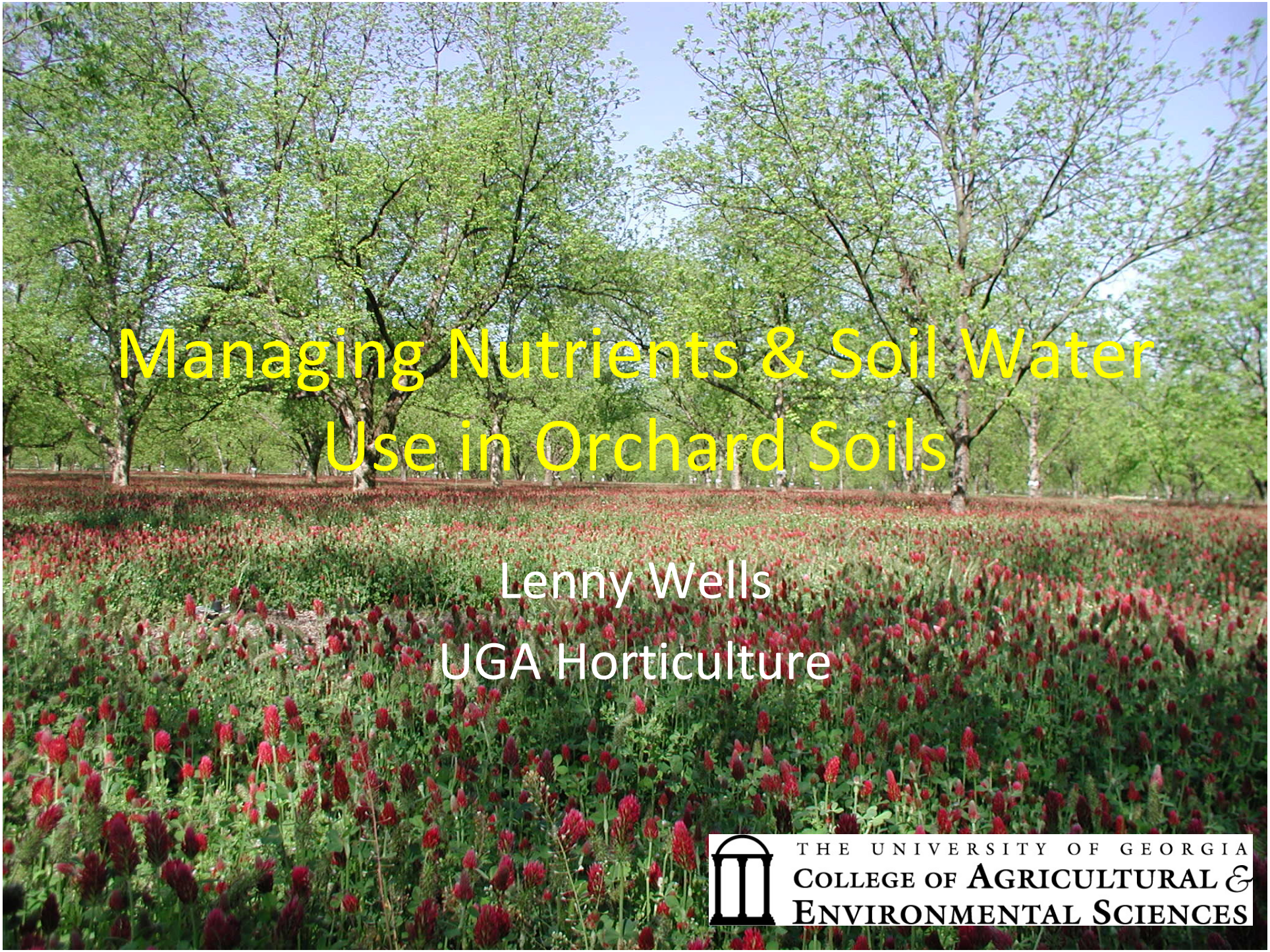


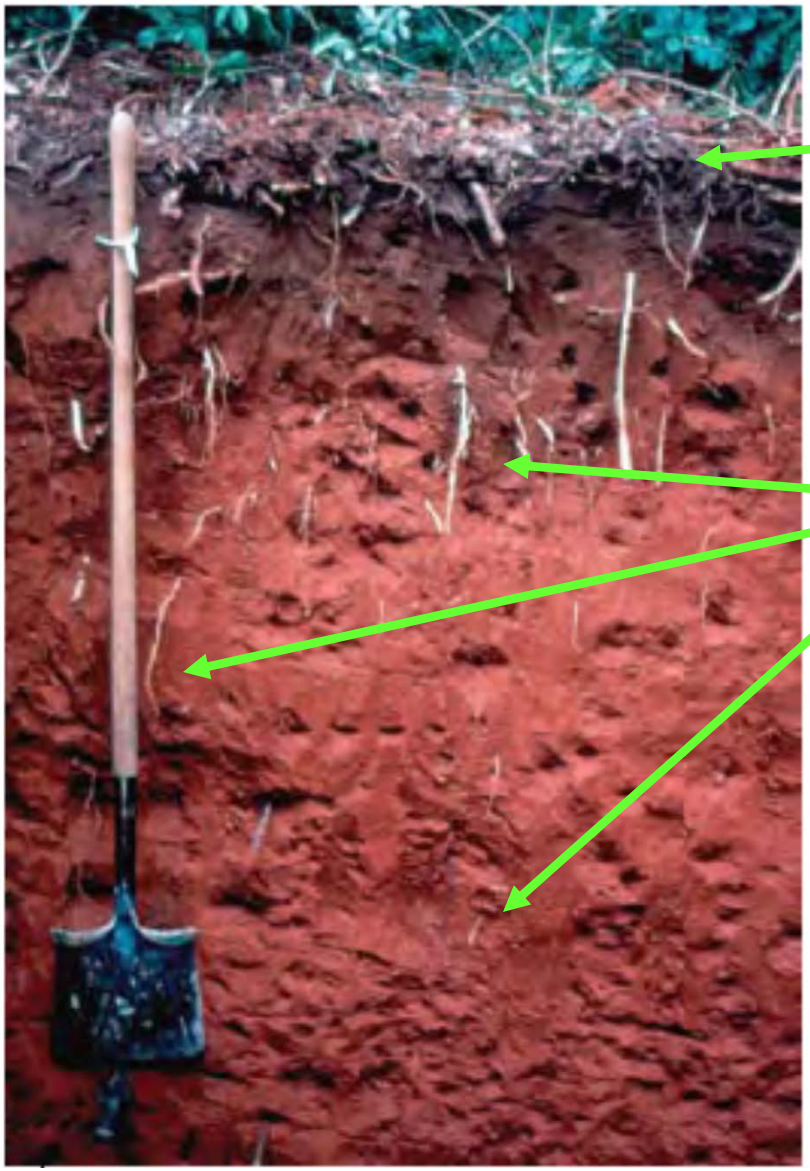
Managing Nutrients & Soil Water Use in Orchard Soils

Lenny Wells

UGA Horticulture

THE UNIVERSITY OF GEORGIA
COLLEGE OF AGRICULTURAL & ENVIRONMENTAL SCIENCES

What Does a Healthy Soil Look Like?

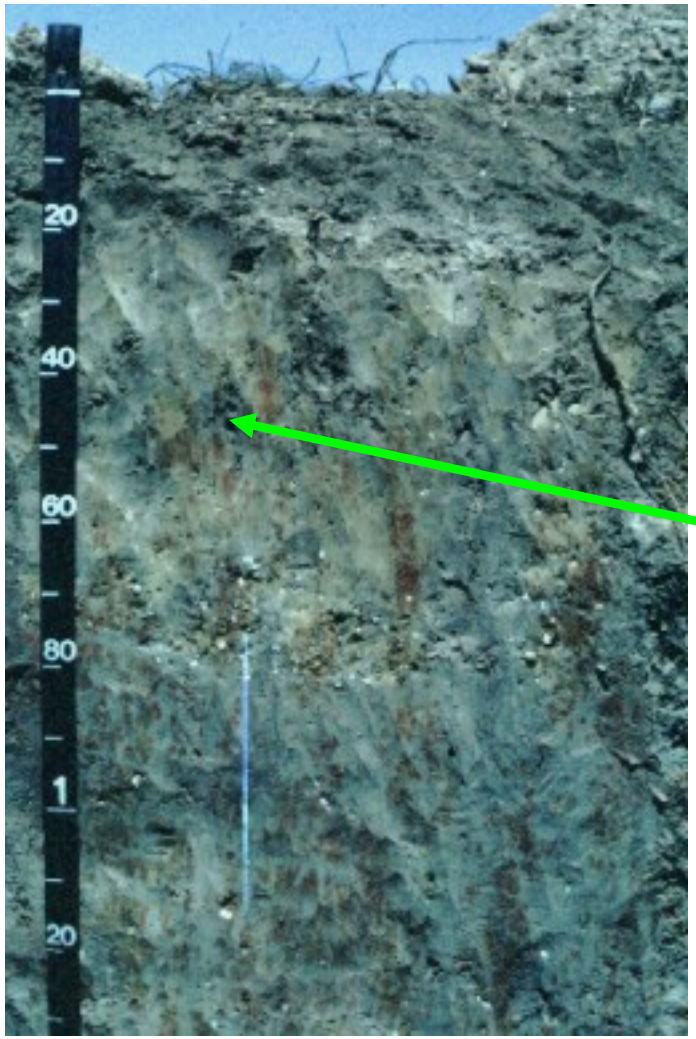


Dark brown to black surface layer
High in organic matter
Well aggregated

Feeder Roots grow to considerable depths

Orangeburg Soil Profile

What does poor soil look like?



Light tan-gray soil indicates low organic matter

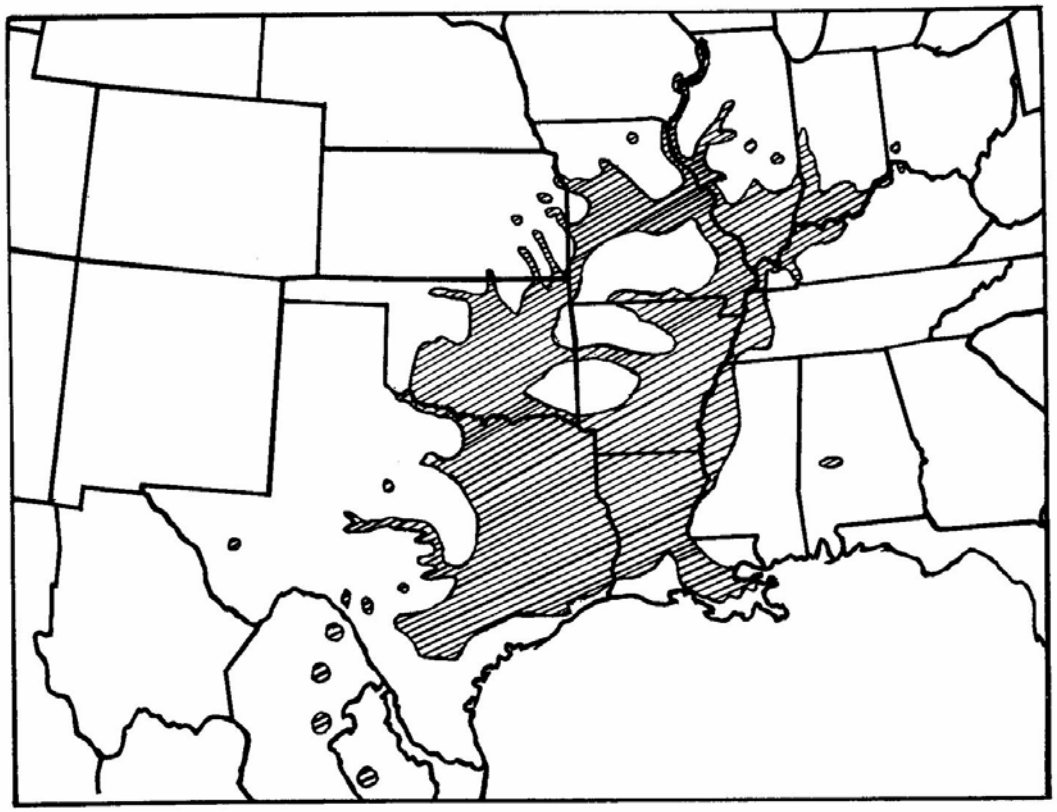
Blue/gray/greenish mottling indicates
Poor aeration and water-logging

Why should you focus on improving orchard soil health?

- Soil health is the key to maximizing nutrient efficiency, potentially reducing input costs
- Healthy Soils:
  - Efficient use of nutrients
  - Minimize water loss
  - Optimize yield and quality

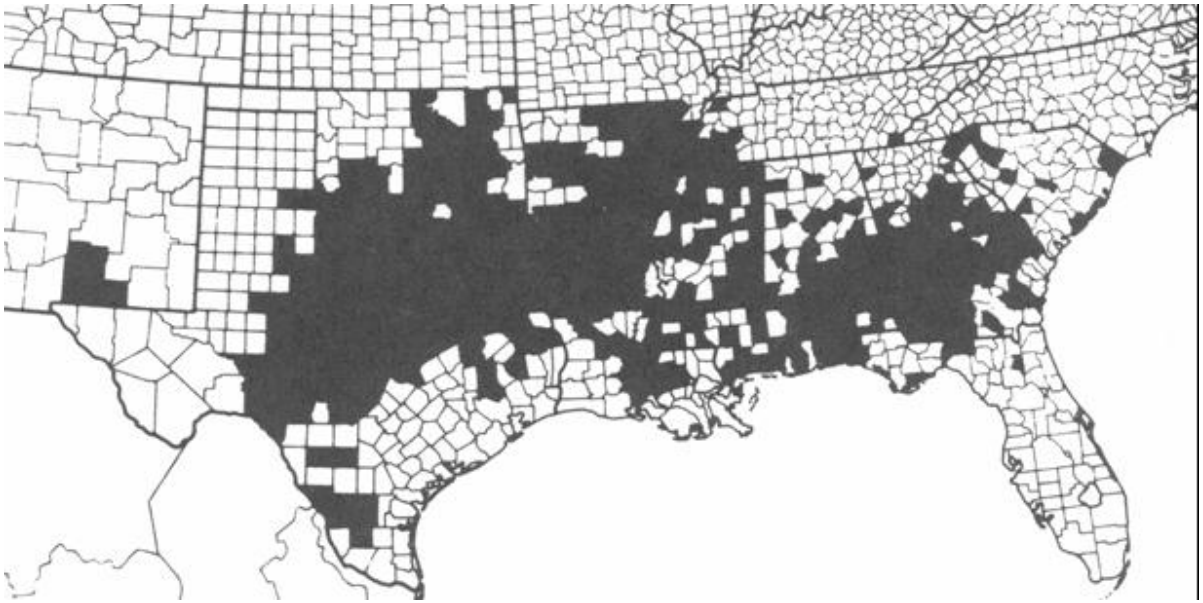
Native Pecan Soils

- Drain rapidly after flooding
- Receive additional deposits of sediment and debris (organic matter) after flooding
  - Very fertile
  - Available plant food found at considerable depth



Non-Native Soils
(SE Coastal Plain Soils)

- Upland Soils
  - Acidic
  - Generally deficient in N, P, K, S, Ca, Mg, Zn
  - Respond well to addition of fertilizer and organic matter
  - Sandy loam topsoil; permeable clay subsoil
    - Ruston, Norfolk, Tifton, Orangeburg, Greenville, Red Bay, Cecil (Skinner et al., 1938)



Organic Matter

- Pecan orchards are relatively high in organic matter
- Most organic matter will be at a shallow depth in the soil
- Fertilizers are most effective when soil organic matter is maintained at a high level
  - Availability of nutrients
  - C:N ratio
  - Water-Holding Capacity

	Orchard Soil Organic Matter (1-6” depth)
Mean	3.63%
Sample Range	1.74-5.80%

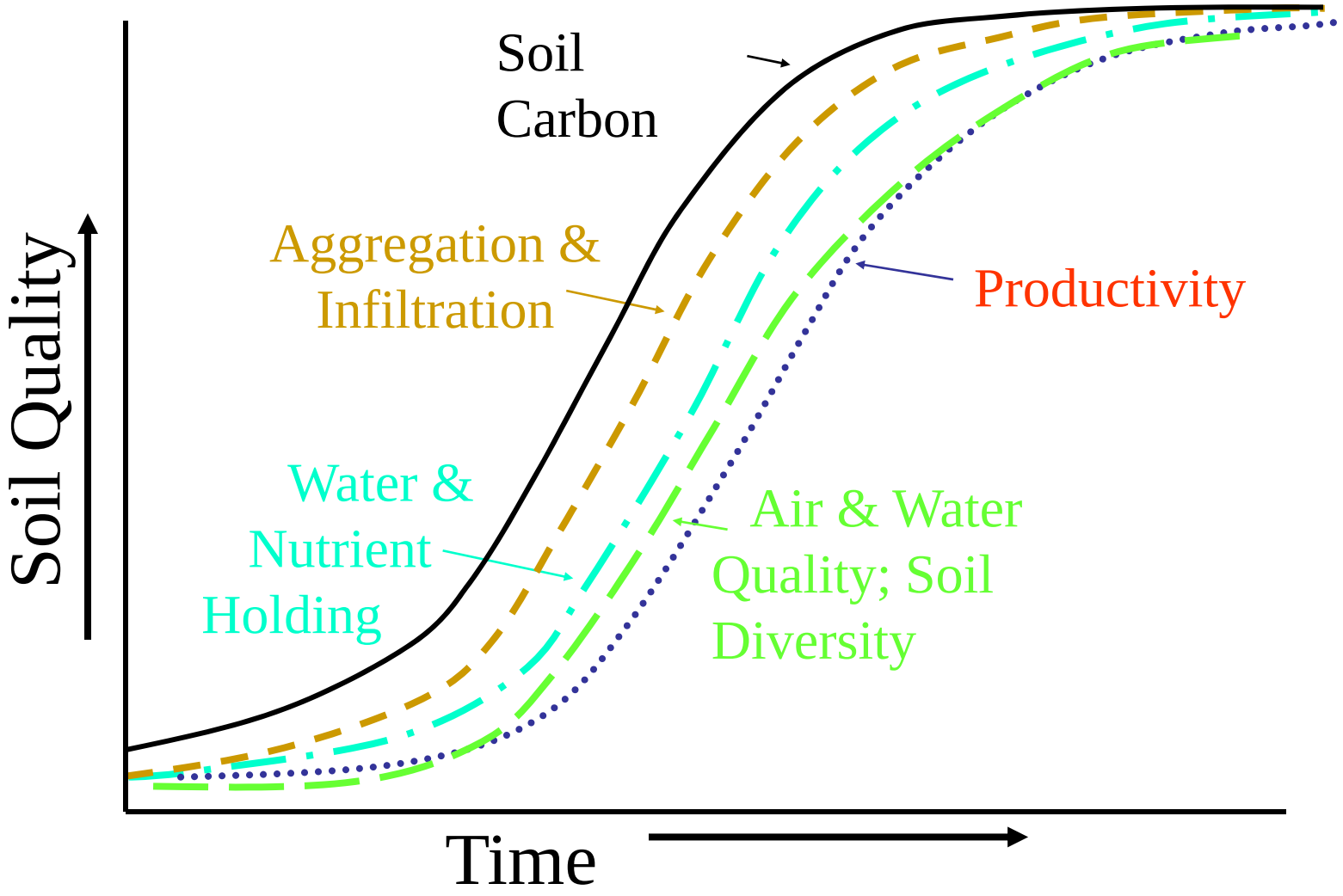
Average forest soil organic matter in Georgia Coastal Plain = 2.52% (Giddens, 1957)

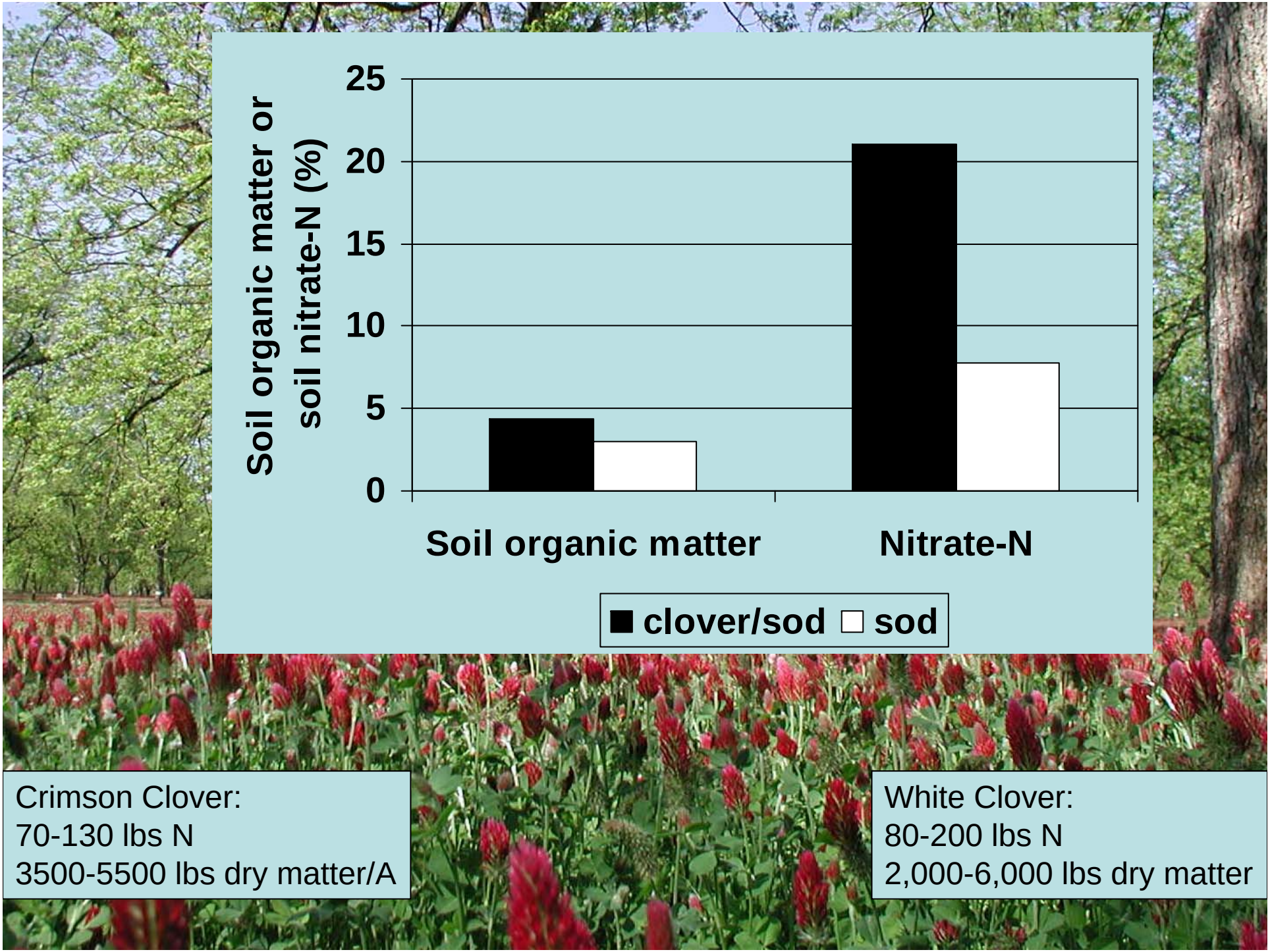
Soil Carbon

- C:N ratio
  - Determines the rate at which N is mobilized or immobilized in the soil
  - Optimal Range (15:1-20:1)
  - <12:1 –stimulates decomposition of OM
  - Clover: (15:1)
  - Poultry Litter (10:1-25:1)
  - Grass: (40:1-80:1)

	C:N ratio (1-6” depth)
Mean	13:1
Sample Range	12:1-16:1

Benefits of Soil Carbon





Crimson Clover:
70-130 lbs N
3500-5500 lbs dry matter/A

White Clover:
80-200 lbs N
2,000-6,000 lbs dry matter

How much N should I apply?

- 10 lbs/ 100 lbs expected crop
- Medium to Heavy soils:
  - On year 150 lbs/A
  - Off year 75 lbs/A

- Sandy Soils: Increase rates by 25% and use multiple applications
- Apply N credits for clover

How much N does my clover provide?

- At 100% ground cover and 6” height:
  - 2000 lbs/A of dry matter
  - Add 150 lbs/A for every inch over 6”

- So, for 18” clover: 2000 lbs + 1800 lbs = 3800 lbs dry matter

- If stand is less than 100% (x %)
  - 60% stand = 3800 X0.6 = 2280 lbs
  - Legumes typically have 3.5% N at flowering
  - After flowering = 2.0-3.0%

- Lbs/A * %N
  - 60% stand: 2280 lbs X 0.03 = 68.4 lbs N/Acre
  - 90% stand: 3420 X0.03 = 102.6 lbs N/Acre

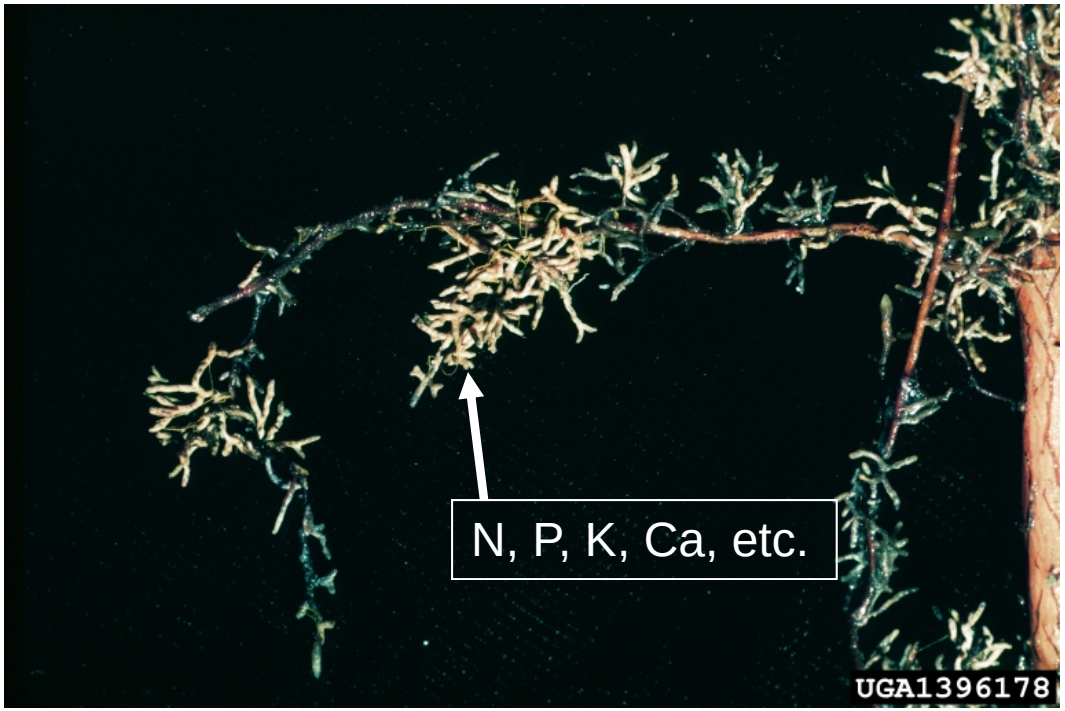
- Organic Matter effect
  - For every 1% increase in soil OM, approx. 10 lbs N released

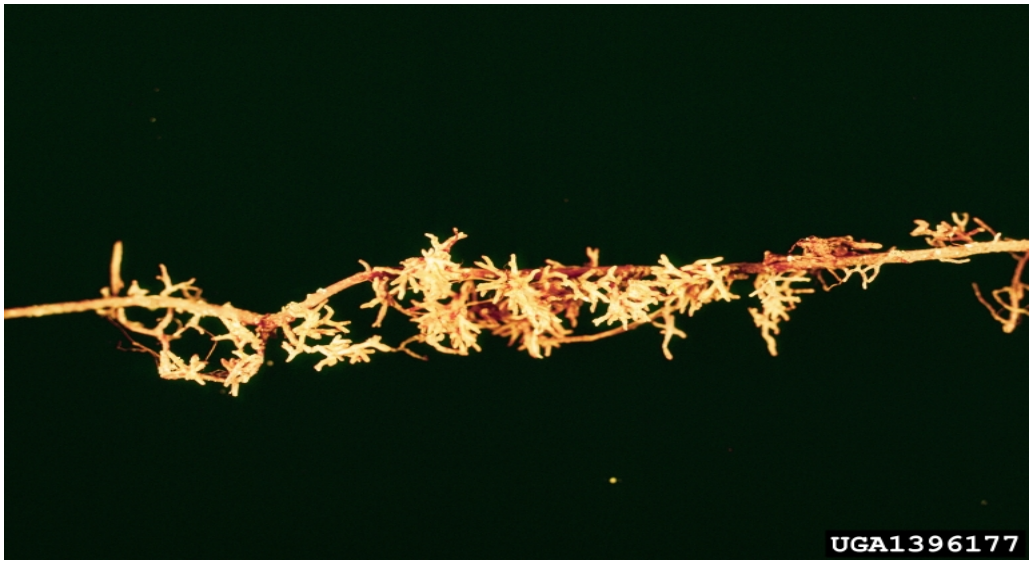
Life in the Soil

- Non-tilled soils promote fungal based food webs
- Mycorrhizae—”fungus roots”
  - Mutualistic association
  - At least 7 ectomycorrhizas are described as infecting pecan
  - Mycorrhizae prefer conditions where organic matter is found
  - Why are mycorrhizae important?
    - They extend the root system

Mycorrhizae

- The mineralization of nutrients is often slow in acid soils
- Mycorrhizal associations enable trees to compete for limited resources
- Pecan seedlings inoculated with mycorrhizae have >uptake of N,P, K, Ca, Mg, Cu, and Mn (Sharpe and Marx, 1986)
- Conditions favorable for mycorrhizal development:
  - High organic matter
  - High light intensity—related to carbohydrate production
  - Adequate soil moisture





Year	Treatment	MIP	MBC	Phosphotase
2008	Clover	46.7a	---	10.6a
	Clover/Litter	22b	---	9.8ab
	Litter	26.5ab	---	7.5b
	AN	25.9ab	---	7.4b
2009	Clover	13.3a	250a	3.5a
	Clover/Litter	6.7ab	220a	3.2ab
	Litter	3b	140a	2.8bc
	AN	4.3b	180b	2.9abc
	Control	4.4b	170b	2.3c
2010	Clover	4a	140a	9.6a
	Clover/Litter	0b	120b	8.6a
	Litter	0b	100b	10.4a
	AN	0b	120b	10.5a
	Control	0b	120b	13.3a

Year	Treatment	Soil N (%)	SOM
2008	Clover	0.10a	2.65a
	Clover/Litter	0.10a	2.75a
	Litter	0.10a	2.70a
	AN	0.10a	2.25b
2009	Clover	0.12a	2.44a
	Clover/Litter	0.14a	2.44a
	Litter	0.14a	2.15ab
	AN	0.13a	2.28a
	Control	0.13a	2.01b
2010	Clover	0.14a	1.93a
	Clover/Litter	0.11ab	1.78ab
	Litter	0.11ab	2.10a
	AN	0.10ab	1.74ab
	Control	0.09b	1.44b

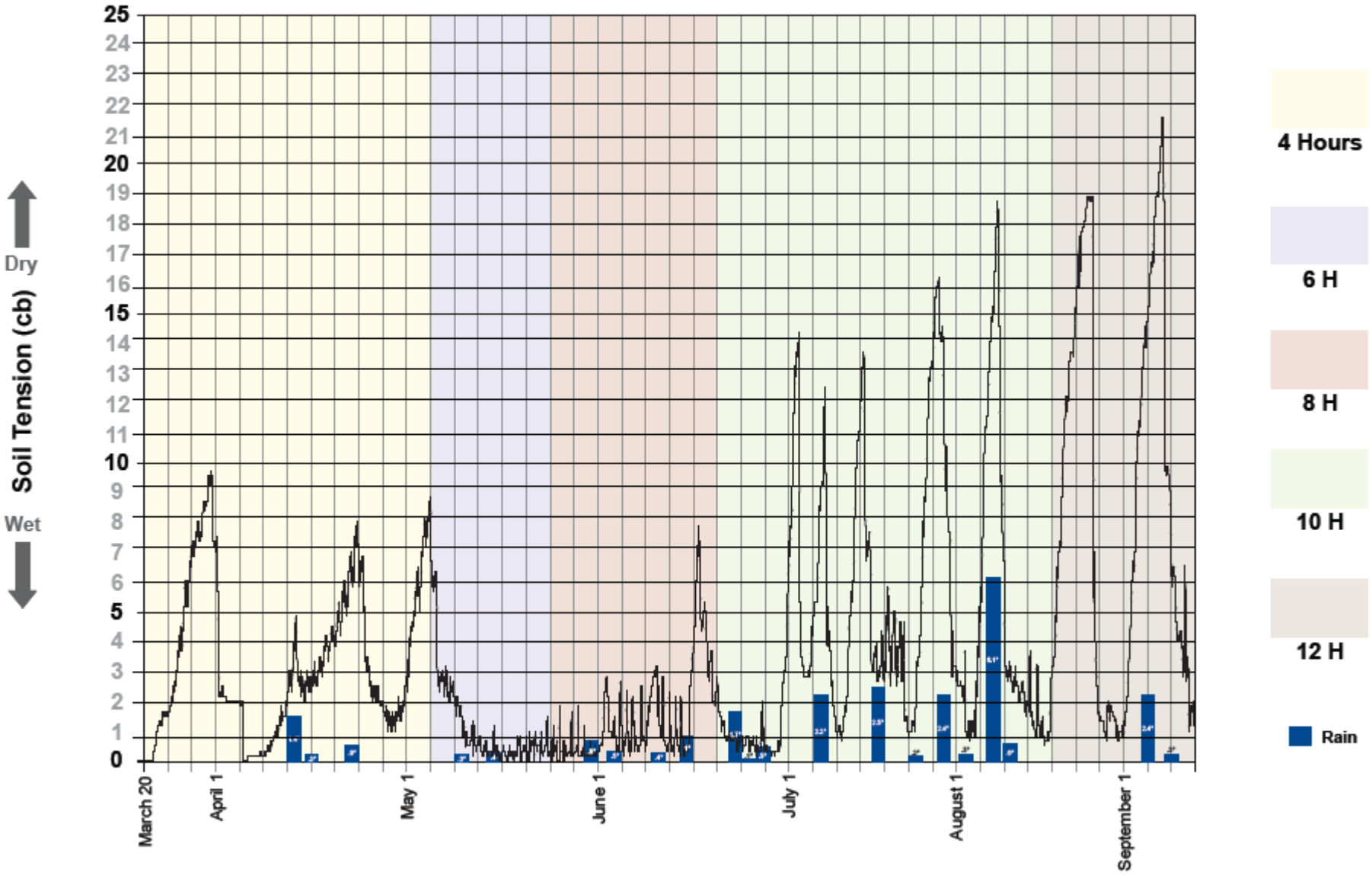
Effect of Clover on Orchard Soil---Year 1

Orangeburg Soil

Treatment	% Change NO_3	% Change P	% Change K	% Change SOM
Crimson Clover	-42%	-25%	-45%	+1.02
Ammonium Nitrate	+1.2%	-16%	-36%	+0.61

Soil samples at 1-6” depth

Mockingbird Farms (microjet irrigation 2008)

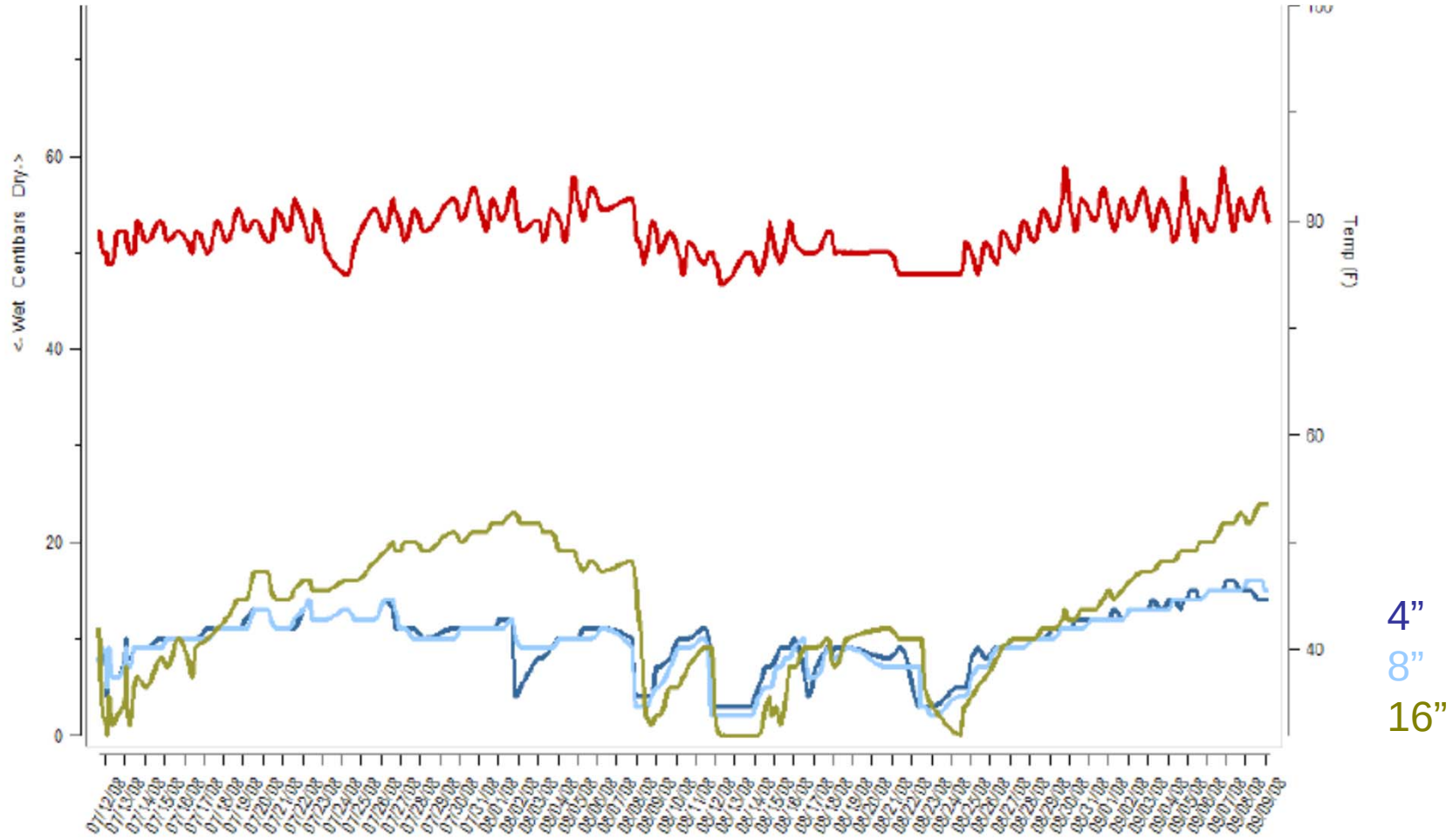


Stripling Irrigation

UGA Pecan Team
Dougherty County Extension Service

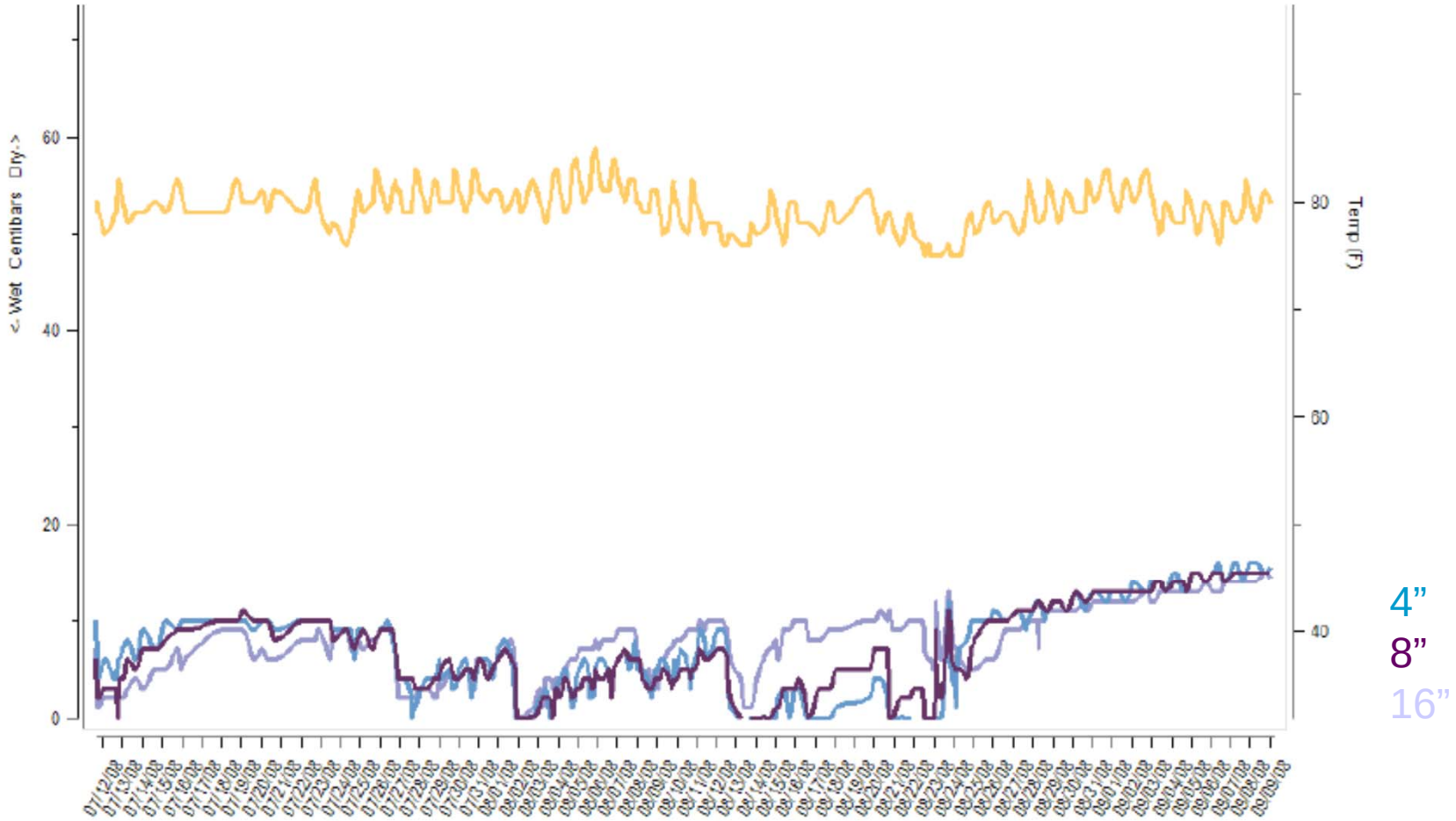
The University of Georgia
College of Agricultural and Environmental Sciences

Orchard Soil Tension Under Sod July-September 2009



Orchard Floor Cover= Sod Only

Orchard Soil Tension Under Clover July-September 2009



Orchard Floor Cover = Sod+Clover

Effect of Poultry Litter and Clover on 'Desirable' Pecan

Treatment	Leaf N (2008)	Leaf N (2009)	Leaf N (2010)	Leaf N (2011)	Leaf N (4 yr avg)
Poultry Litter	2.52a	2.63a	2.48a	2.67a	2.58
Crimson Clover	2.41a	2.67a	2.44a	2.54a	2.51
Litter + Clover	2.44a	2.96a	2.43a	2.59a	2.60
Ammonium Nitrate (75 lbs N/acre)	2.57a	2.66a	2.46a	2.67a	2.59
Untreated		2.67a	2.44a	2.47a	2.52

Effect of Poultry Litter and Clover on 'Desirable' Pecan

Treatment	Yield/tree (2008)	Yield/ tree (2009)	Yield/tree (2010)	Yield/tree (2011)	Yield/tree (4 yr avg)
Poultry Litter	92.7a	122ab	42a	85ab	85.4
Crimson Clover	94.7a	86ab	36a	57.5b	68.6
Litter + Clover	87a	84b	43a	105a	79.8
Ammonium Nitrate (75 lbs N/acre)	62a	129a	32a	92.6ab	78.9
Untreated	---	130a	17b	51.8b	66.2

If you maintain clover in row middles, apply N to herbicide strips

Summary

- The use of clover as a cool season cover crop between tree rows provides multiple benefits for pecan orchard soil quality, including increased MIP and MBC, as well as better soil moisture retention at all depths.
- Soil phosphatase activity is enhanced by clover during two of the three years of study.
- Soil elemental properties, including total nitrogen (N), and soil organic matter (SOM), are also enhanced by clover, although there was an obvious time lag in the response of soil N.

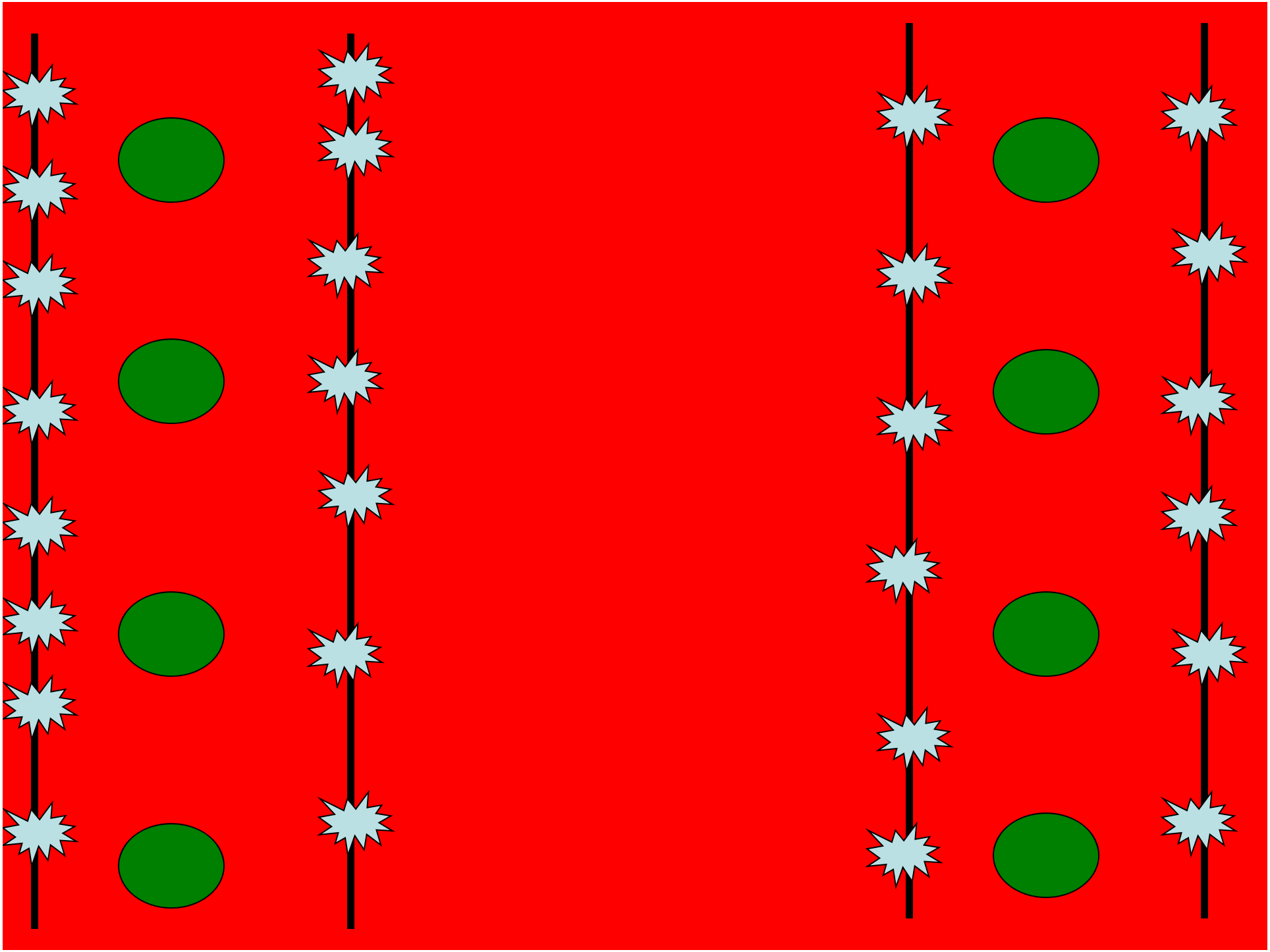
Summary

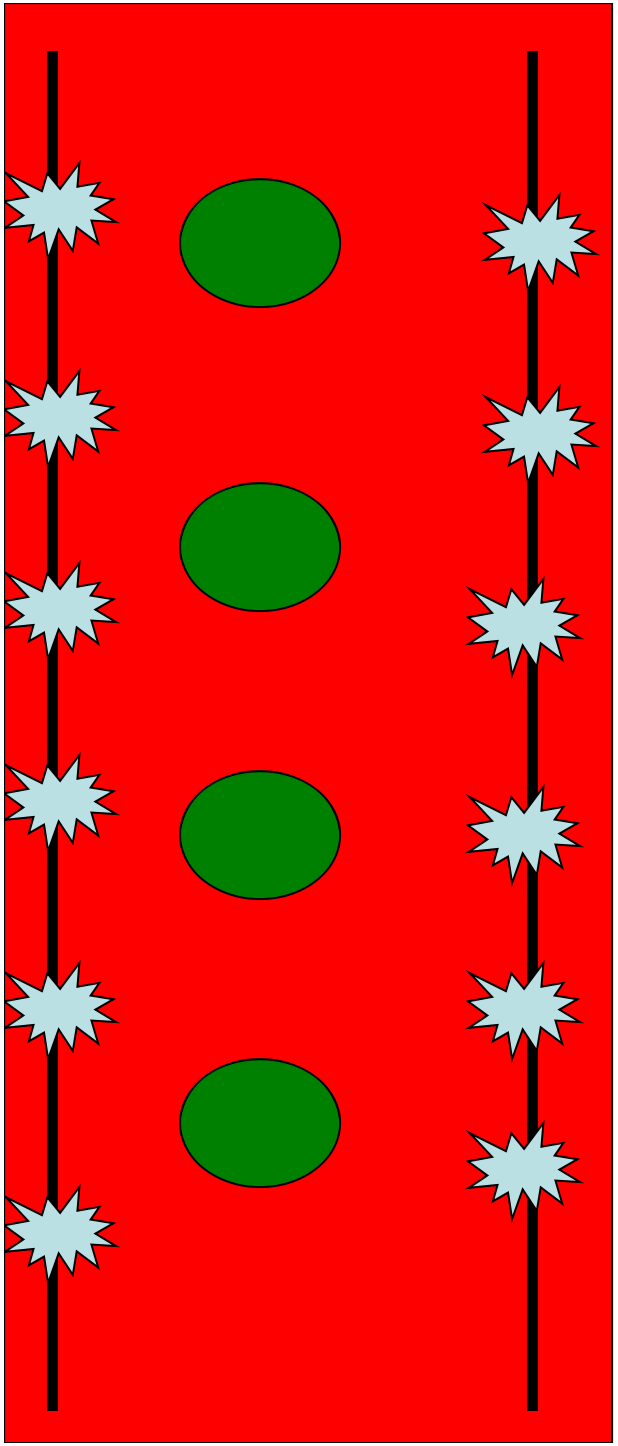
- Poultry Litter should be applied in March
- On very sandy soil, crimson clover contributes about 30 lbs additional N per acre early in the establishment phase
- Clover also enhances organic matter and biological activity of soil*
- Clover can provide adequate late season N, but fertilizer application is necessary in spring where clover is used
- Particularly in a wet year, additional late season fertilizer application may be necessary

Nitrogen

Young trees

- **Year 1:** **1 lb 10-10-10in June if growth is good**
  (2-4' terminal growth)
- **Year 2:** **1 lb in April and 1 in June**
- **Year 3-4:** **2 lbs in April and June**
- **Year 5-7:** **4 lbs in April and June**

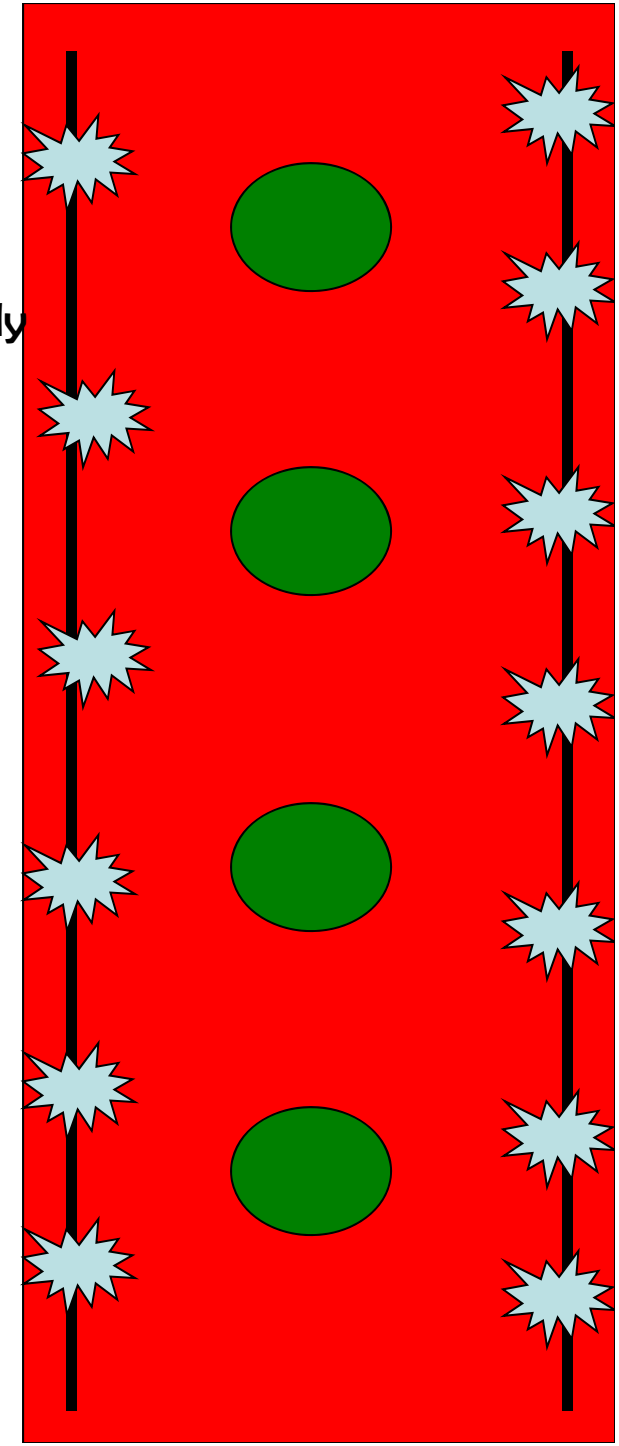




- 40 X 40
- 12 foot wide herbicide strip:
- 12/40 = 30%
- Can reduce area that you apply fertilizer to by 70% with band application

At a rate of 75 lbs per acre:
100 acres X 75 = 7500 lbs N
7500 X 30% = 2250 lbs N

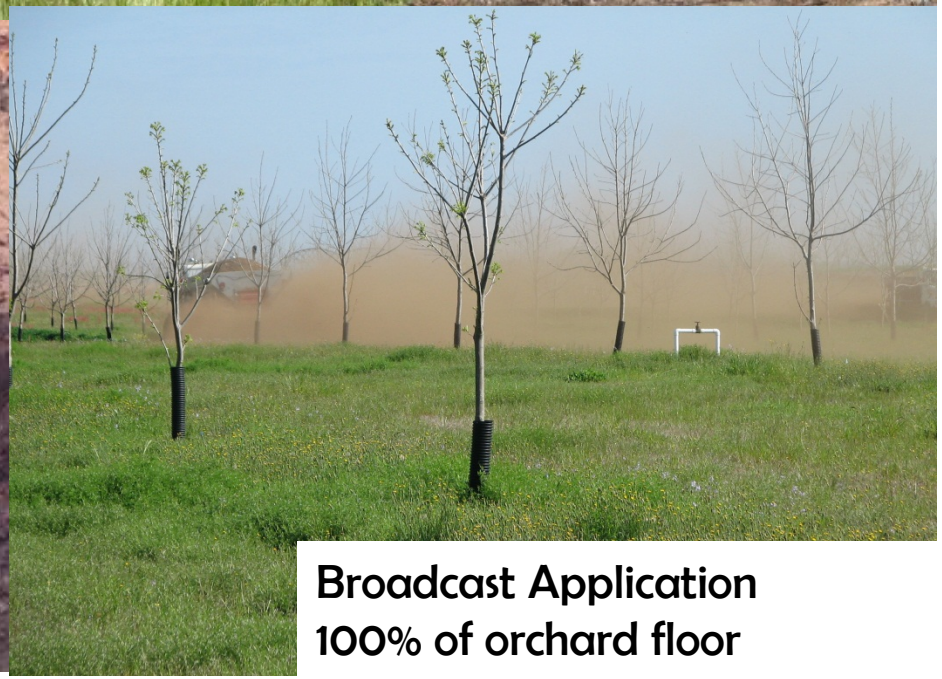
- At $1/lb = a savings of $52.50 per acre with band application



Broadcast Band Application
24% of orchard floor

Liquid 28-0-0-5 applied over herbicide strip
30% of orchard floor

Injection Through Drip System



Broadcast Application
100% of orchard floor

Fertilizer Application Method

Effect on Leaf N

Treatment	Leaf N 2008	Leaf N 2009	Leaf N 2010 (%)	Leaf N 2011	Leaf N Average
Simulated Injection 28-0-0-5	2.98a	2.94a	2.73a	2.55a	**2.80**
Broadcast Band Ammon. Nitrate	2.89ab	2.80a	2.52b	2.46ab	**2.66**
Broadcast Ammon. Nitrate	2.85b	2.89a	2.60b	2.46ab	**2.70**
Liquid N Herbicide Sprayer 28-0-0-5	2.80b	2.96a	2.42c	2.37b	**2.63**

N rate for all treatments = 70 lbs/treated acre

Funded by GACCP

Fertilizer Application Method
Effect on Yield

Treatment	Yield 2008 (lbs/tree)	Yield 2009 (lbs/tree)	Yield 2010 (lbs/tree)	Yield 2011 (lbs/tree)	Yield Average (lbs/tree)
Simulated Injection 28-0-0-5	129.6a	128a	134a	4.97b	**99.1**
Broadcast Band Ammon. Nitrate	107.8a	144a	98b	10.9ab	**90.1**
Broadcast Ammon. Nitrate	107.5a	176a	105ab	27.5a	**104**
Liquid N Herbicide Sprayer 28-0-0-5	152.9a	115a	124ab	2.38b	**98.6**

N rate for all treatments = 70 lbs/treated acre

Funded by GACCP

Summary

- Applying N to smaller percentage of the orchard floor reduces cost with no effect on production or leaf N through the 3rd year as compared to broadcast application of ammonium nitrate over 100% of the orchard floor
- Liquid 28-0-0-5 applied via drip may be the most efficient means of N fertilization

WHEN GROWING PECANS:
IF YOU HAVE TO CHOOSE BETWEEN
WATER AND FERTILIZER……

CHOOSE WATER!

Pecans and Water

- Pecans have a very efficient water transport system
- Developed ability to avoid stomatal closure under high temps with adequate water
- Pecans are very inefficient users of water
- Require large amounts of water to support optimal growth and fruit production

Pecan Water Use

- Pecans extract most of their water from the upper 32 inches of the soil profile
- Need 60” of water per year
  - In the SE, rainfall can account for 50-67% of needs
- Pecan trees can use as much as 350 gal/day
- Greatest demand is during August/September
- Pecan Irrigation systems are designed to be supplemental to rainfall
- At 12 trees per acre, Drip/Microjet system capacity should be 3600-4200 gallons/acre/day

- Trees can translocate water from roots in moist soil to those in dry soil
- The pecan tree's water needs can be supplied by wetting only a portion of the root zone
- A single line can be as good as or better than a line on each side with the same number of emitters

	Yield	% Increase	$ Value of Increase (@$1.34/lb)	% Kernel	Nuts/lb
No Irrigation	803a	0	0	41.8a	65
1-sided Irrigation	2044b	64	$1662.94	48.7b	54.5
2-sided irrigation	2045b	64.5	$1663.94	50.3b	58

Worley, 1982

Value of Fertilizer

Fertilizer Rate (lbs/acre)	Yield/Acre (lbs)	% Increase	Value of Increase (@$1.34/lb)
0	1696	0	0
400 lbs biennially	1837	8.3	188.94
400 lbs annually	2211	30	690.10
800 lbs annualy	1577	-7.0	-159.46

'Stuart'

Worley, 1974

Value of Irrigation

Water Application (Gal/Day/Acre)	Yield/Acre (lbs)	% Increase	Value of Increase (@ $1.34/lb)
0	1034	0	0
1200	1374	32	455.60
3600	1761	70	974.18

'Stuart'

Daniel, J.W. 1982

Return on New Irrigation System Example: 25 acre orchard

- Cost of new irrigation system: $26,800
- Value of increase in production: $974.18/acre X 25=$24,354.50
- 26800-24354.50=$2445.50 left to recover in year 2

- At increase of only $455.60/acre, the cost of the system can be recovered in 3 years

Assumes $1.34/lb.

Return on New Irrigation System Example: 100 acre orchard

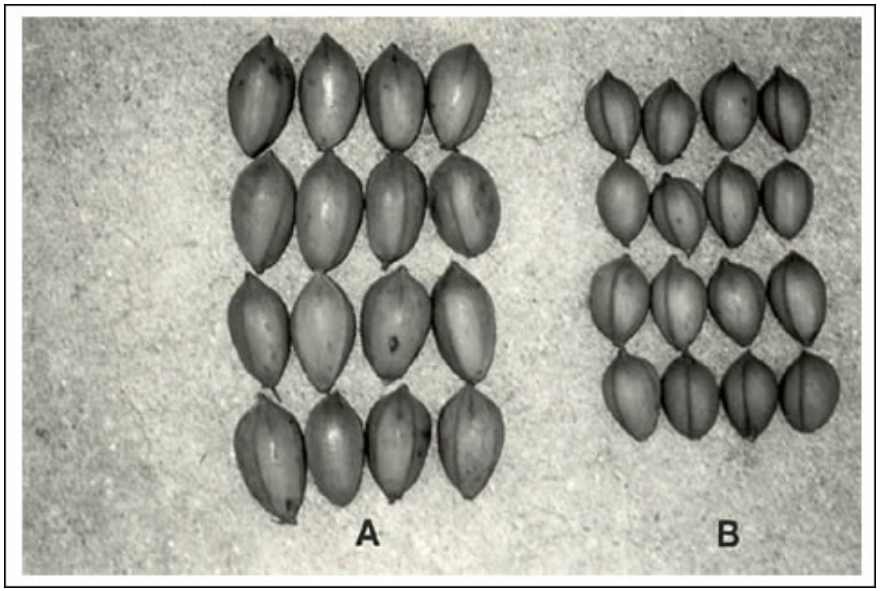
- Cost of new irrigation system: $54,000
- Value of increase in production: $974.18/acre X 100=$97,418.00
- 97,418-54,000= +$43,418
  - Difference in 1200 gal capacity vs 3600 gal capacity=$51,858

- At increase of only $455.60/acre, the cost of the system can be recovered in 2 years

Assumes $1.34/lb.

Other Advantages of Irrigation

- Increased Nut Size/Quality, Nut Retention
- Minimizes Shuck Decline/Sticktights
- Enhances shuck split
- Reduces Severity of alternate bearing
- Ability to inject fertilizer and systemic insecticides



Pecan Irrigation Schedule

Month		Drip (%cycle)	(hrs/day)		Sprinkler (inches/A/wk)
April		60	7.2		0.5
May		70	8.4		.75
June		80	9.6		1
July		90	10.8		1.25
August		100	12		1.5
September		100	12		1.5
October		90	10.8		1
November		60	7.2		0.5

Pecan Irrigation Schedule

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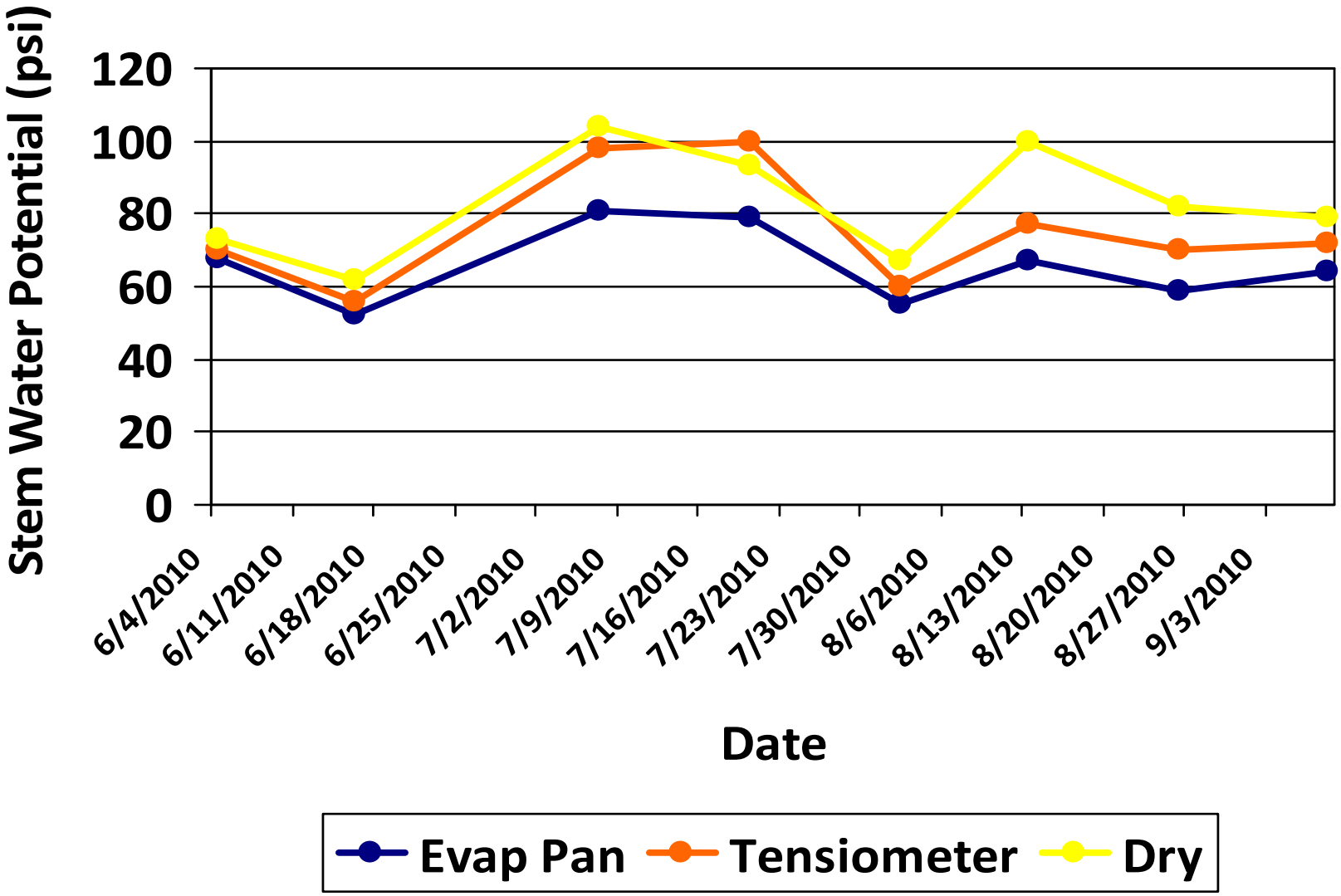
November		60	7.2		0.5

Tree Water Status 2010



2010 Results

	Nut Retention (%) (July 20)	Drought Induced Nut Drop (# nuts beneath canopy) (Aug. 13)	Yield (lbs/tree)
Evap Pan	61a	22.6a	59a
Tensiometer	65a	27.8a	48ab
Dry	60a	122.8b	30b

Summary

- If you have to choose between water and fertilizer, choose water
- Water is key to many important processes involved in the development of a pecan crop
- Well capacity for pecans should be approx. 4000 gal/acre/day
- Irrigation provides the most immediate results and the fastest return on investment of virtually any management practice you can use