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Physiological and Yield Responses of Cotton to Urea with NBPT and DCD under Different Stress Conditions



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The Problem



- ❖ The cotton crop needs large amounts of nitrogen, about 125 kg N/ha.
 - 2 - 5% of plant dry matter (*Marschner, 1995*)
 - Involved in many metabolic processes, protein and nucleic acids etc
- ❖ N deficiencies result in poor growth and lower yields.
 - Decreased leaf area, growth rate, protein, photosynthetic rate, and hydraulic conductivity , and increased fruit shed, root:shoot ratio, and premature cutout (*Radin and Parker, 1979; Radin and Mauney, 1986; Wullschleger and Oosterhuis, 1990*)
- ❖ Cotton has low N use efficiency, only about 20-30 % of N applied is recovered by the plant (*Karlen et al., 1996; Constable and Rochester, 1988*)
- ❖ Nitrogen fertilizer is expensive and constitutes > 10% of total production cost.

Recovery Efficiency



$$\text{❖ } \uparrow \text{N Uptake} = \uparrow \text{N Availability} / \downarrow \text{N losses}$$

✓ Increase availability by N(urea) Fertilization

✓ Decreases losses using additives to inhibit loss of N

Urease Inhibitor : *N-(n-butyl) thiophosphoric triamide* (NBPT)

Inhibit urea hydrolysis - \downarrow **NH₃ volatilization**

Nitrification inhibitor - *Dicyandiamide* (DCD)

Inhibit nitrate formation in the soil - \downarrow **leaching and denitrification**

NBPT

- *N-butyl thiophosphoric triamide* - Urease Inhibitor



Benefit of NBPT to soil applied urea is well understood.

But addition of Urease Inhibitor to Foliar Urea ?

- (-) *Phenylphosphorodiamidate (PPD)* in Soybean increased leaf burn (Krogmeier et al., 1989)
- (±) *NBPT* in wheat no effect on leaf burn or yield (Rawluk et al., 1999)

Cotton



❖ Only limited research:

✓ NBPT

- Increased ^{15}N recovery (*Earnest and Varco, 2006*)

✓ DCD

- Results in yield - adequate rainfall conditions (*Frye et al., 1989; Gordon et al., 1990*)
- Toxic effect - concentrations $>15\%$ (*Reeves et al., 1988; Reeves and Touchton 1986, 1989*)

❖ Little is known about:

- ✓ Effect of these inhibitors on the physiology and growth of cotton.
- ✓ Cotton response to soil and foliar applications of NBPT and DCD
- ✓ Response of these inhibitors under stress conditions

Overall Objective

- To study the effects of urea with NBPT and DCD on cotton physiology and yield under heat and salinity stress.

Overall Hypothesis

- Application of urea with NBPT and DCD will increase N fertilizer use efficiency of cotton - (Ammonia and Nitrate Losses)
 - Sub-rates of nitrogen fertilization will maintain cotton growth and yield equal to the levels of the full recommended urea application.
 - High temperature and/or high salinity will negatively affect the performance of NBPT and DCD .

Study Overview

1. Physiological and yield responses of field-grown cotton to soil application of Urea with NBPT and DCD.
2. Physiology and yield responses of cotton to application of foliar Urea with NBPT.
3. Influence of High Temperature and Urea fertilization with NBPT and DCD.

Physiological and Yield Responses of Field-Grown Cotton to Soil Application of Urea with NBPT and DCD



Material and Methods

- **Location:** Marianna, Arkansas
- **Cultivar:** ST 4554 B2RF – standard management (except N)
- **Design :** RCBD with 5 treatments and 5 replications

Treatments	N Rate (kg/ha)	N Source	Split Applied
Treatment 1	0	-	
Treatment 2	125 (100%)	Urea	At 10 days After Germination
Treatment 3	94 (75%)	Urea	
Treatment 4	94 (75%)	Urea + NBPT (Agrotain)	At PHS Stage
Treatment 5	94 (75%)	Urea+NBPT+DCD (Super U)	

Measurements

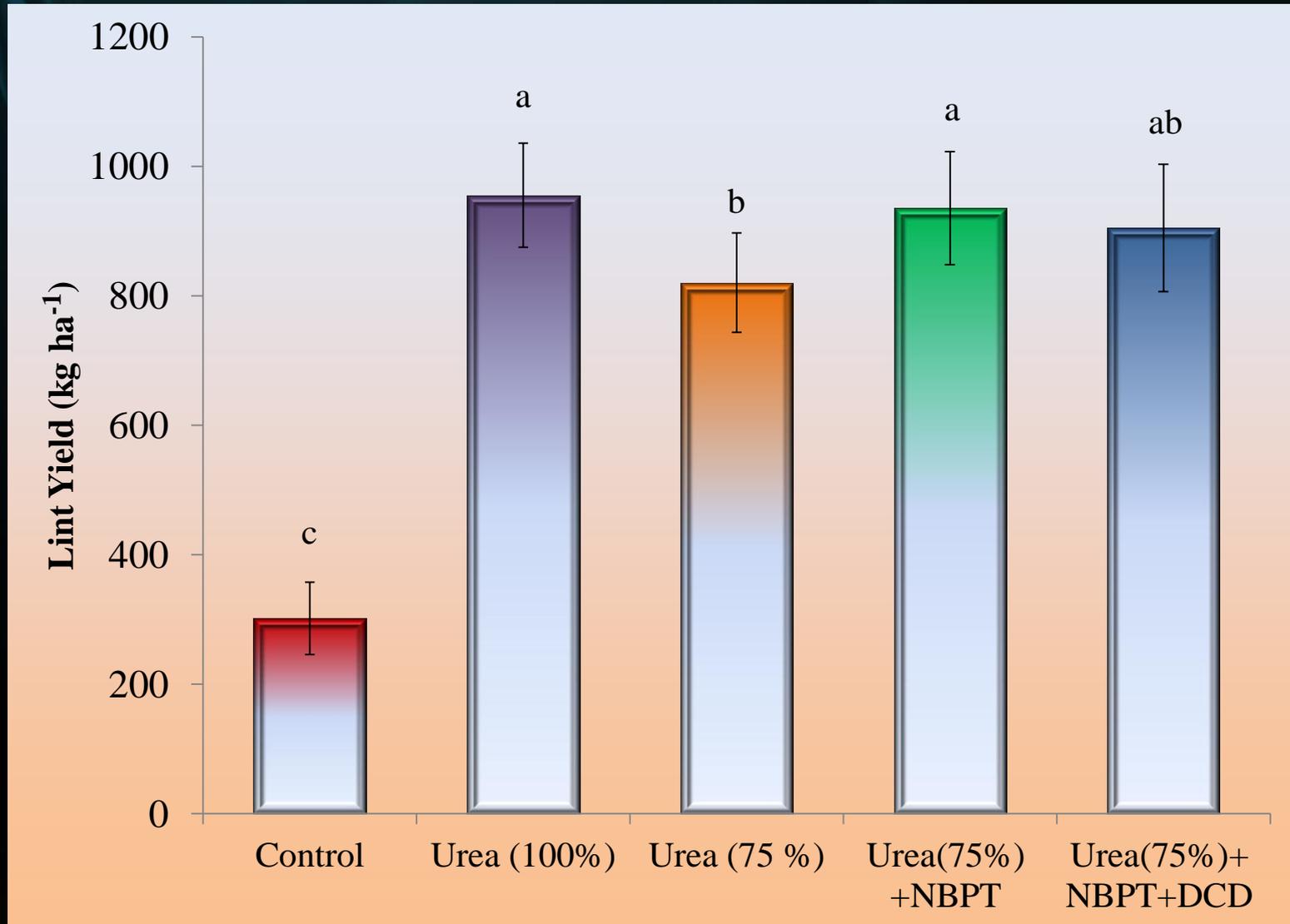


- ❖ Leaf Chlorophyll
- ❖ N Uptake (DM and N concentration)
- ❖ N use Efficiency (Estimation - difference method)

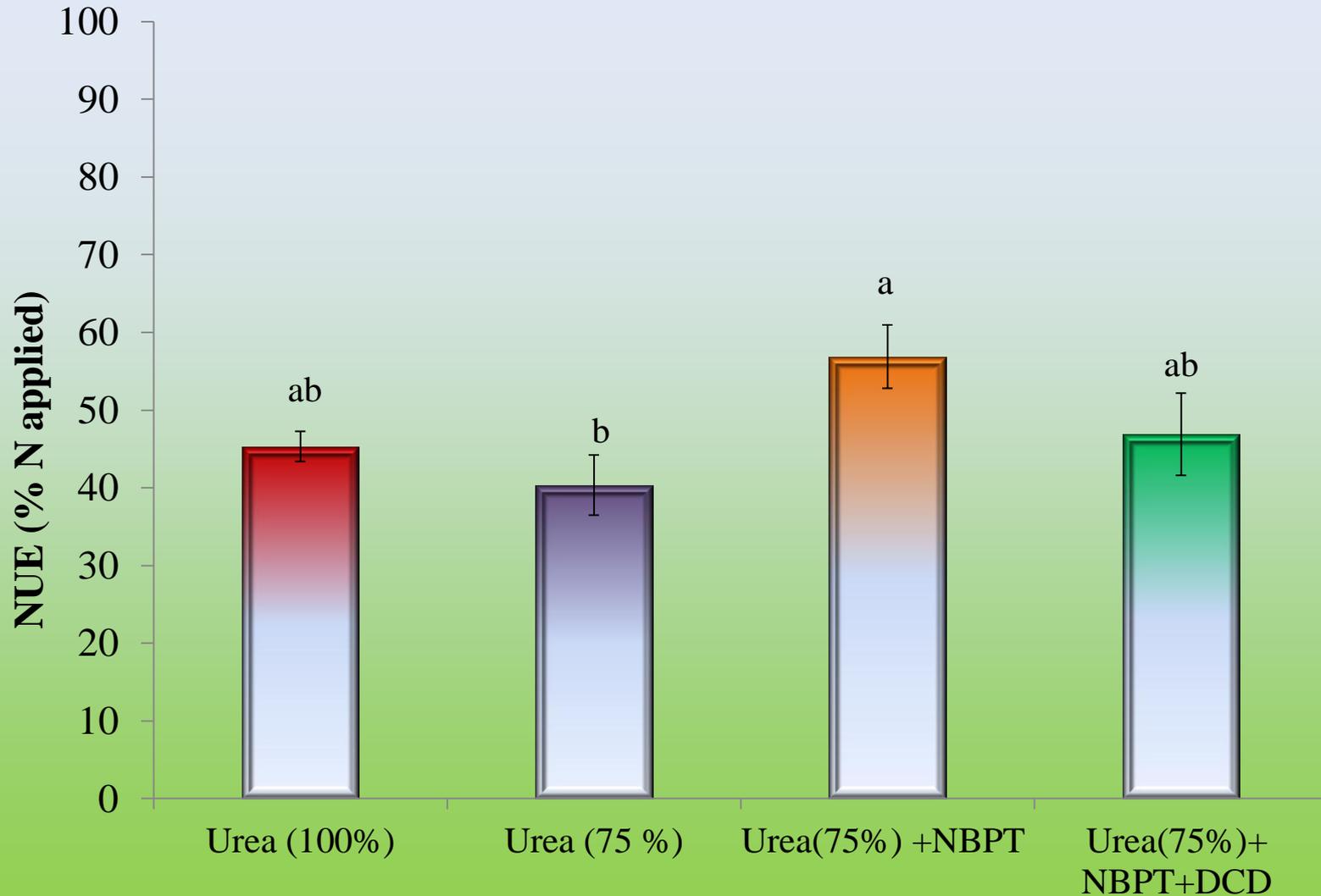
$$N\ UE = \frac{(N\ Content\ Treatment\ X) - (N\ Content\ Unfertilized\ Control)}{N\ Applied} \times 100$$

- ❖ N Partitioning (Stem, leaves, capsule wall, seeds)
- ❖ Fiber Quality
- ❖ Lint yield (Seedcotton and gin turnout)

Effect of NBPT and DCD with Urea on Yield



Effect of NBPT and DCD with Urea on Nitrogen Use Efficiency



Summary

(Field Experiment : Soil Applications)

- ❖ Application of urea with NBPT increased N fertilizer use efficiency of cotton.
- ❖ Sub-rates of nitrogen with NBPT maintained cotton growth and yield equal to the levels of the full recommended urea application.
- ❖ Addition of DCD to urea had no beneficial effect on yield or nitrogen use efficiency

To Study the Effects of Foliar Urea Application with NBPT on Cotton Plants



FOLIAR UREA



- Foliar Nutrient Application

- Main Purpose:

- Supplement Soil Nutrients - root problems
 - (+) low cost, rapid response
 - (-) foliar burn, chemical incompatibility, limited amount

- Urea – main N source for foliar N application

- Rapid absorption, low salt index and low phytotoxicity

- ✓ Results of foliar urea in cotton yields

- Highly variable: Maples and Barker (1993); MacConnell et al., 1998; Oosterhuis and Bondada (2001); Roberts et al., 2006; Wilborn et al., 2006.
 - **FACTORS:** soil conditions, N availability, fruit load and stress.

Field Study: Foliar Application

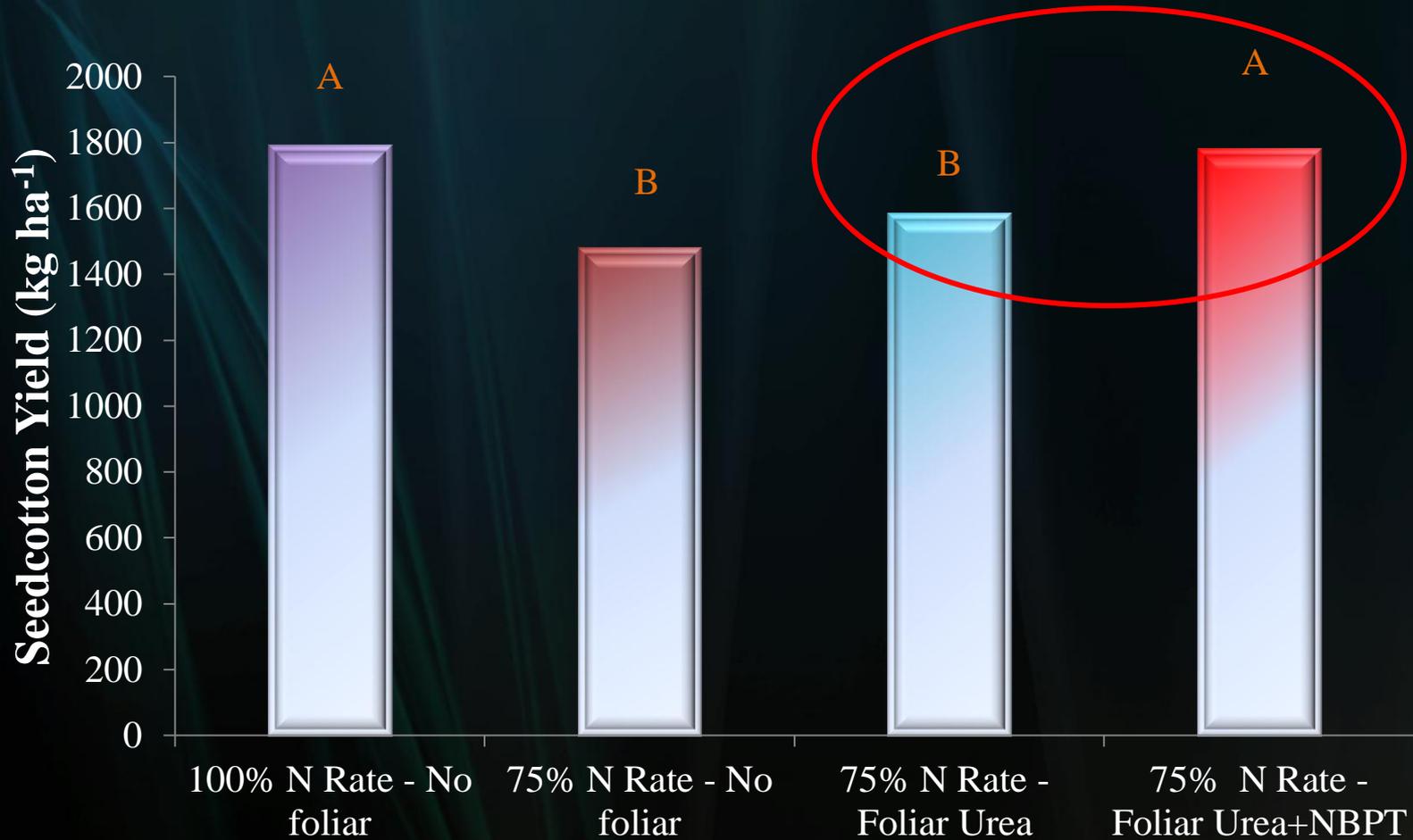
- **Location:** Lon Mann Cotton Research Station, Marianna, AR
- **Cultivar:** ST 4554 B2RF – Standard Management (Except N)
- **Design :** RCBD with 4 treatments and 5 replications

Treatment	Nitrogen	
	Soil N Application (kg/ha)	Foliar Nitrogen Application (12 kg N/ha)
1. 100% Soil N Rate – No Foliar	112 (100%)	No
2. 75% Soil N Rate – No Foliar	84 (75%)	No
3. 75% Soil N Rate - Foliar Urea	84 (75%)	Urea <i>at FF and FF+2weeks</i>
4. 75% Soil N Rate - Foliar Urea + NBPT	84 (75%)	Urea + NBPT (0.84%) <i>at FF and FF+2weeks</i>

- **Measurement:**
 - Urea uptake, urease, membrane leakage and seedcotton yield

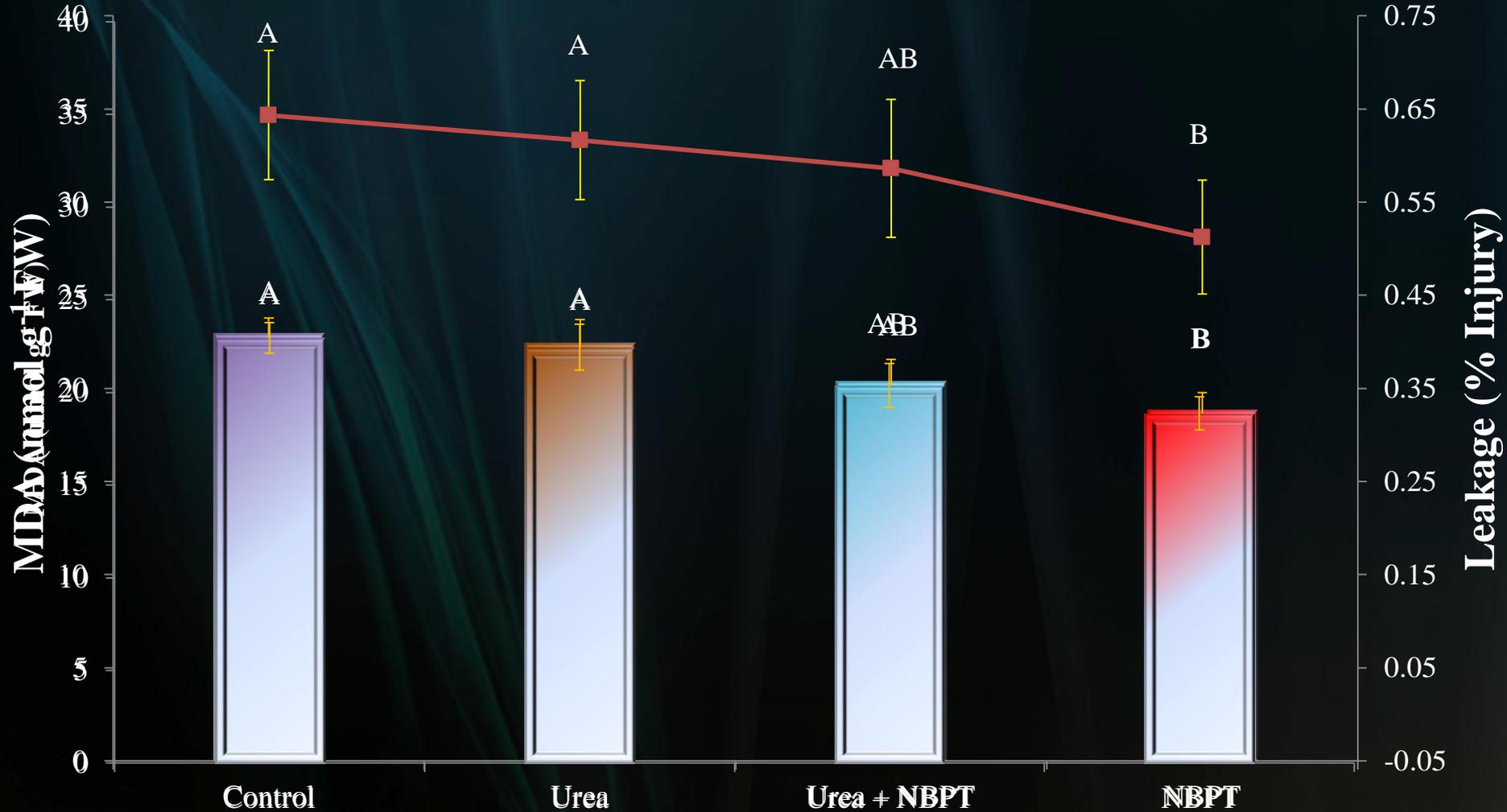
Results : Field Study Foliar Applications

Seedcotton Yield



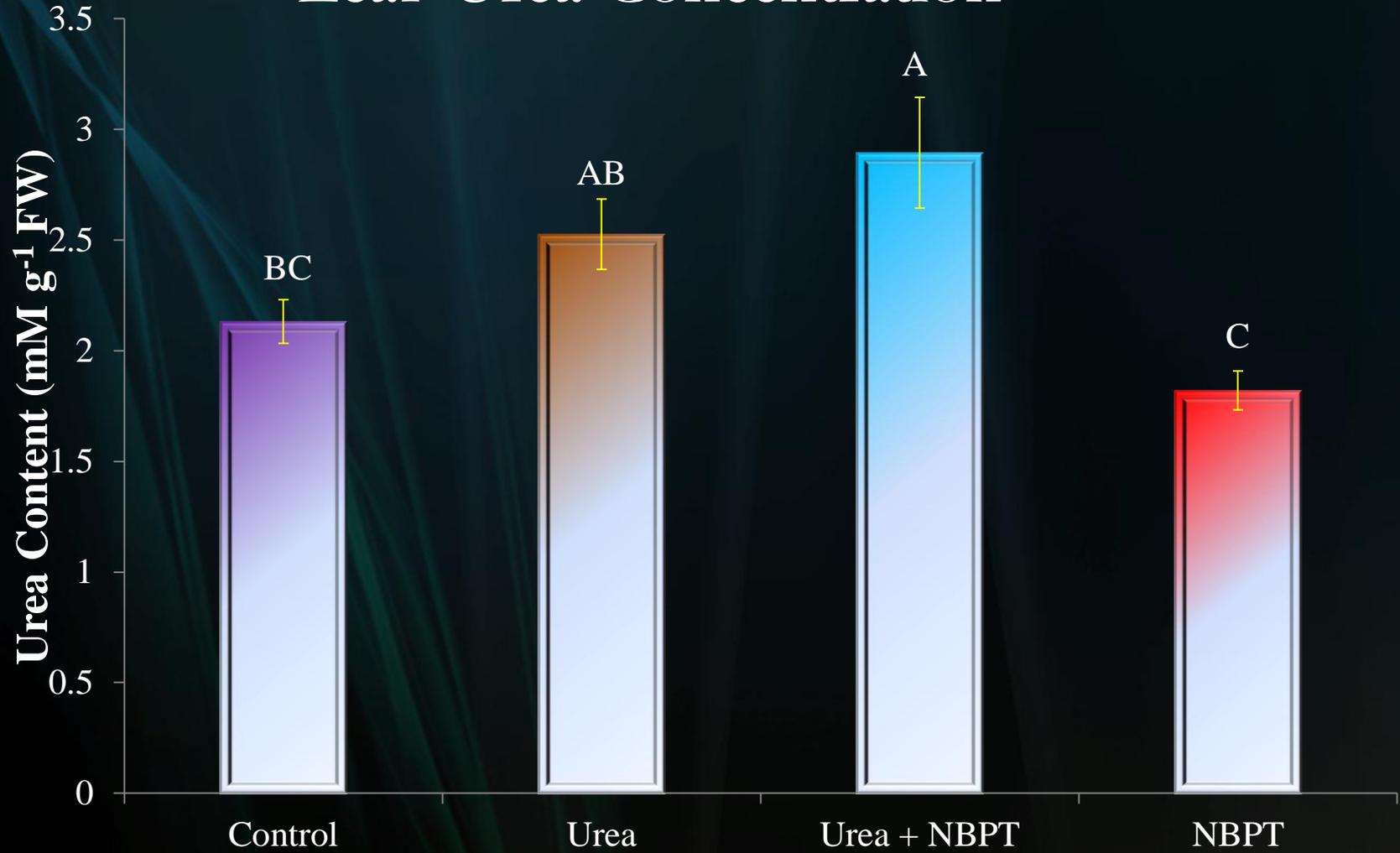
Results : Field Study Foliar Applications

Leaf Membrane Degradation and Leakage



Results : Field Study Foliar Applications

Leaf Urea Concentration



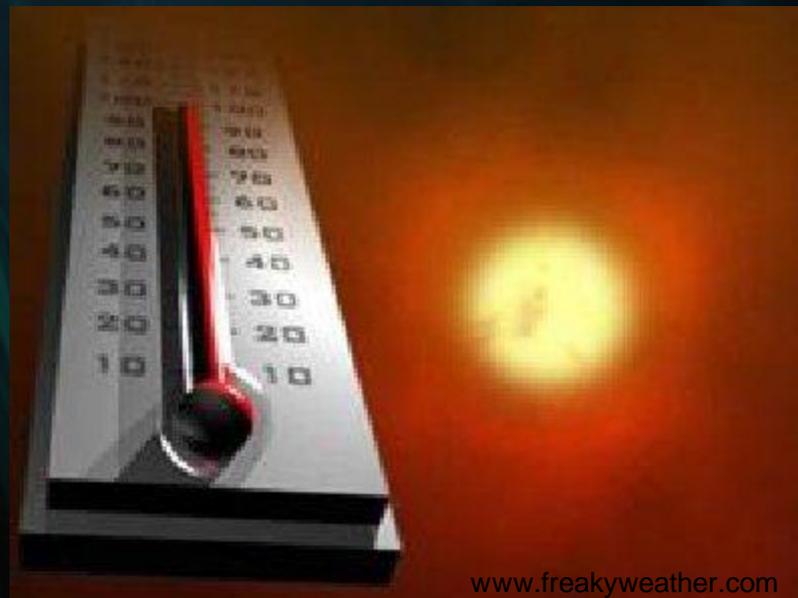
Summary

(Field Experiment : Foliar Applications)

- ❖ Addition of NBPT to foliar applied urea inhibits leaf urease activity and has the potential of increasing cotton yield.
- ❖ This study will be repeated to confirm findings.

Temperature Experiment

Influence of High Temperature and Urea Fertilization with
NBPT and DCD on Cotton Growth and Physiology



www.freakyweather.com

Temperature Problem

- ❖ Cotton originates from warm climates but does not grow and yield best under high temperatures.

However, temperatures during the season in the US Cotton Belt are normally above 95F (a threshold for decreases in growth).

- ❖ High temperatures effect all aspects of growth including germination, emergence, root growth, vegetative growth and yield development.

Explicit among these detrimental effects on growth is the absorption, translocation and assimilation of nutrients such as nitrogen.

Objectives

- ❖ To evaluate the effect NBPT and DCD on the physiology and growth of cotton under normal and high temperature conditions.

Hypothesis

- ❖ High temperature will negatively affect the performance of NBPT and DCD in all measurements proposed.

Material and Methods

- **Location:** Altheimer Laboratory, Fayetteville, AR
- **Cultivar:** (*Gossypium hirsutum*) ST 4554 B2RF
- **Soil:** Memphis Silt Loam, 2 liter pots
- **Treatments:**
 - **Nitrogen:** 5 treatments applied pre-plant and at pinhead square stage.
 - **Temperature:** Day temperature: Normal 30°C and Heat stress 38°C.

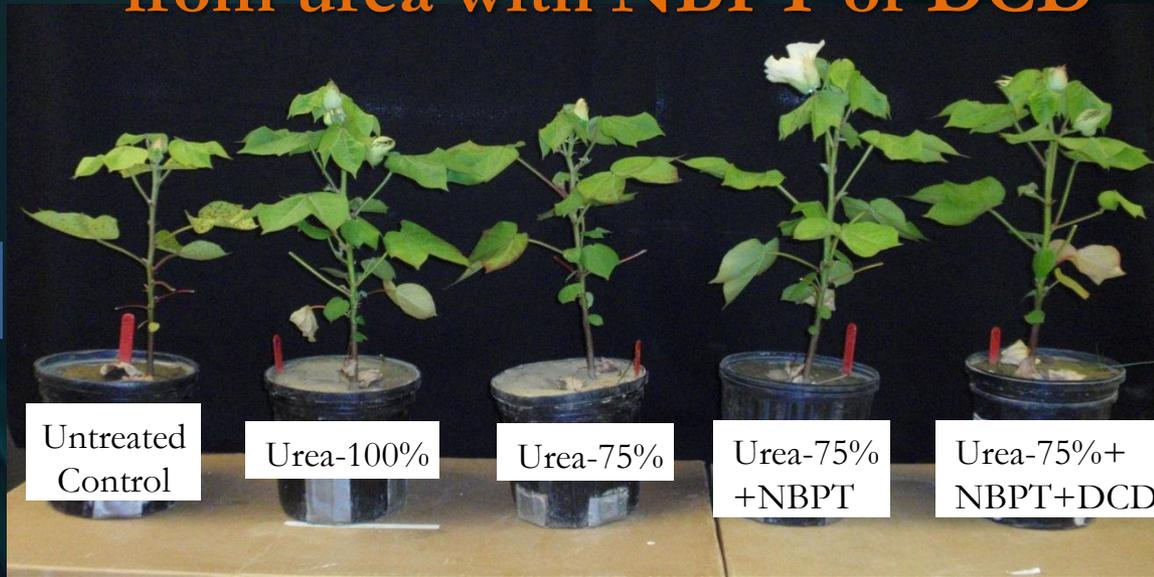


Controlled Environment Chamber

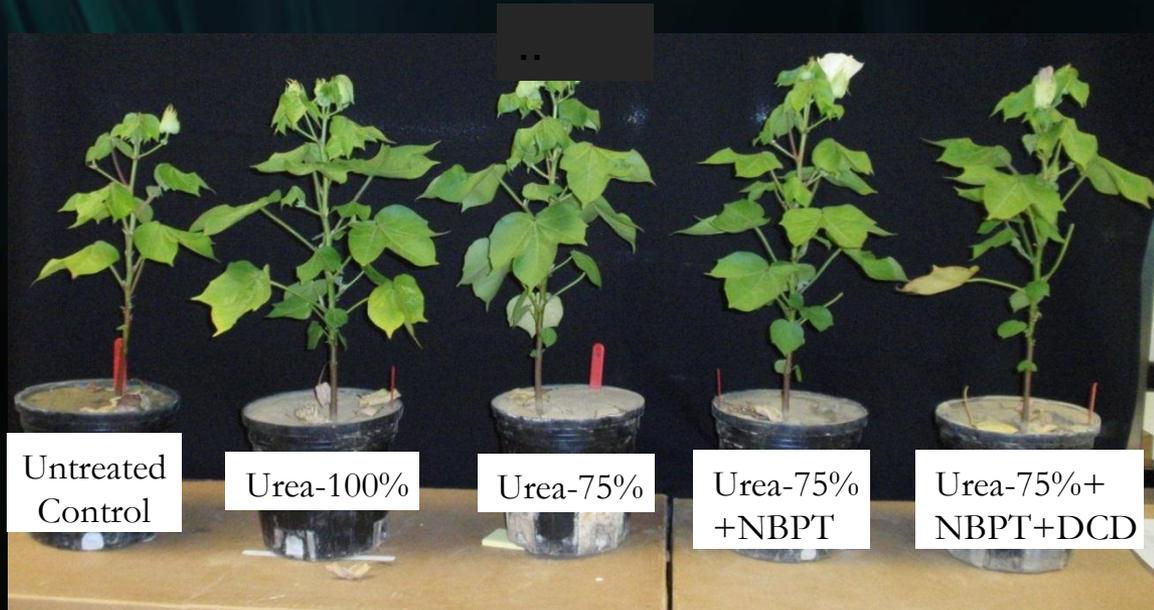
Treatments	N Rate (kg/ha)	N Source	Day Temperatures
Treatment 1	0	-	
Treatment 2	125 (100%)	Urea	
Treatment 3	94 (75%)	Urea	30°C and 38°C
Treatment 4	94 (75%)	Urea+NBPT (Agrotain)	
Treatment 5	94 (75%)	Urea+NBPT+DCD (Super U)	

Effect of High Temperature on Cotton Growth from urea with NBPT or DCD

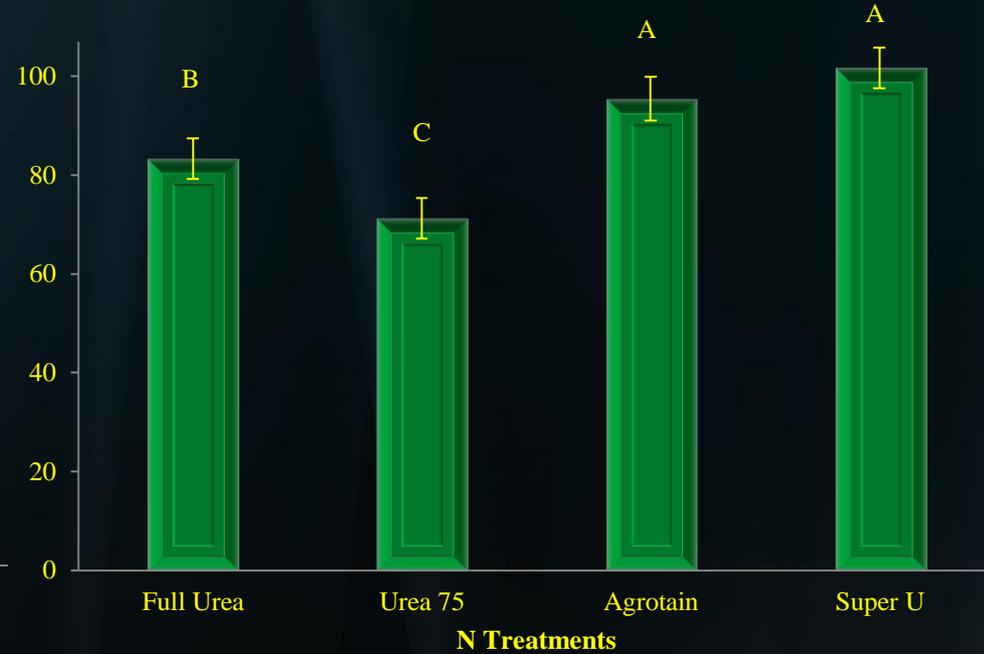
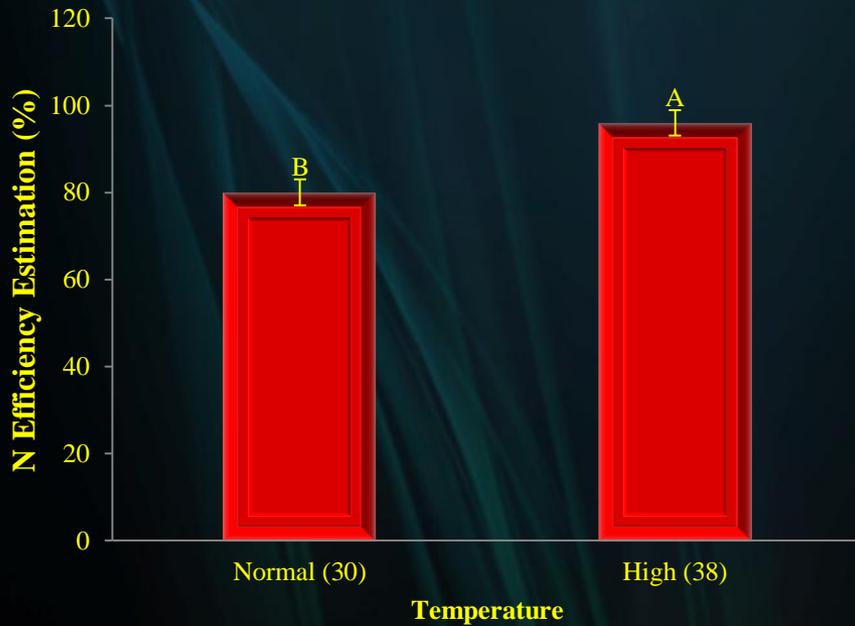
30°C



38°C



Fertilizer N Efficiency



Effect Tests

Source	Nparm	DF	Sum of Squares	F Ratio	Prob > F
Temp	1	1	1958.7905	14.5123	0.0009*
Treat	3	3	4150.3019	10.2496	0.0002*
Temp*Treat	3	3	1140.6601	2.8170	0.0616

Overall Conclusions



- ❖ Application of urea with NBPT and DCD will increase N fertilizer use efficiency of cotton
 - ✓ NBPT - YES
 - ✓ DCD - NO
- ❖ Sub-rates of nitrogen will maintain cotton growth and yield equal to the levels of the full recommended urea application
 - ✓ NBPT - YES
 - ✓ DCD - NO
- ❖ **Addition of NBPT to foliar applied urea inhibits leaf urease activity and has the *potential* of increasing cotton yield**
- ❖ High temperature did not affect the performance of NBPT and DCD in all measurements.

Acknowledgements



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**THANK
YOU!**