UNIVERSITY OF ARKANSAS

Improving the Efficiency of Foliar Fertilization with Urea using Urease Inhibitors

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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 learaea, 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.

Challenge

- Improve cotton NUE
  - ✓ Agronomic Aspect
    - ➢ Increase yield
  - ✓ Economic Aspect
    - ➢ Maintain acceptable yields / lower N rates
  - ✓ Environmental Aspect
    - ➢ Decrease eergy input in the system
    - ➢ (NO_3^-) water table contamination
    - ➢ (N_2O and N_2) greenhouse gas

Recovery Efficiency

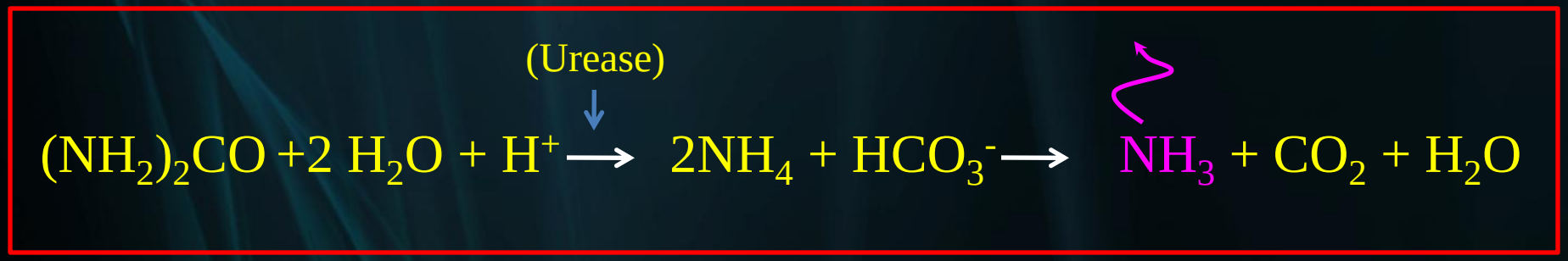
- ↑N Uptake = ↑N Availability / ↓N losses
  - ✓Urea Fertilization
    - ➢Split application (*Constable and Rochester, 1988)*
    - ➢Incorporation at planting *(Elberhar and Turpper, 1988)*
    - ➢Slow-release source *(Oosterhuis and Howard, 2008)*
    - ➢Crop rotations (Hons et al., 2004*)*

Use of Additives to Inhibit Loss of N

- Urease Inhibitor - *N-(n-butyl) thiophosphoric triamide* (NBPT)
  - ✓ Inhibit urea hydrolysis - ↓NH_3 volatilization
- Nitrification inhibitor - *Dicyandiamide* (DCD)
  - ✓ Inhibit nitrate formation in the soil - ↓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)

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

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)	

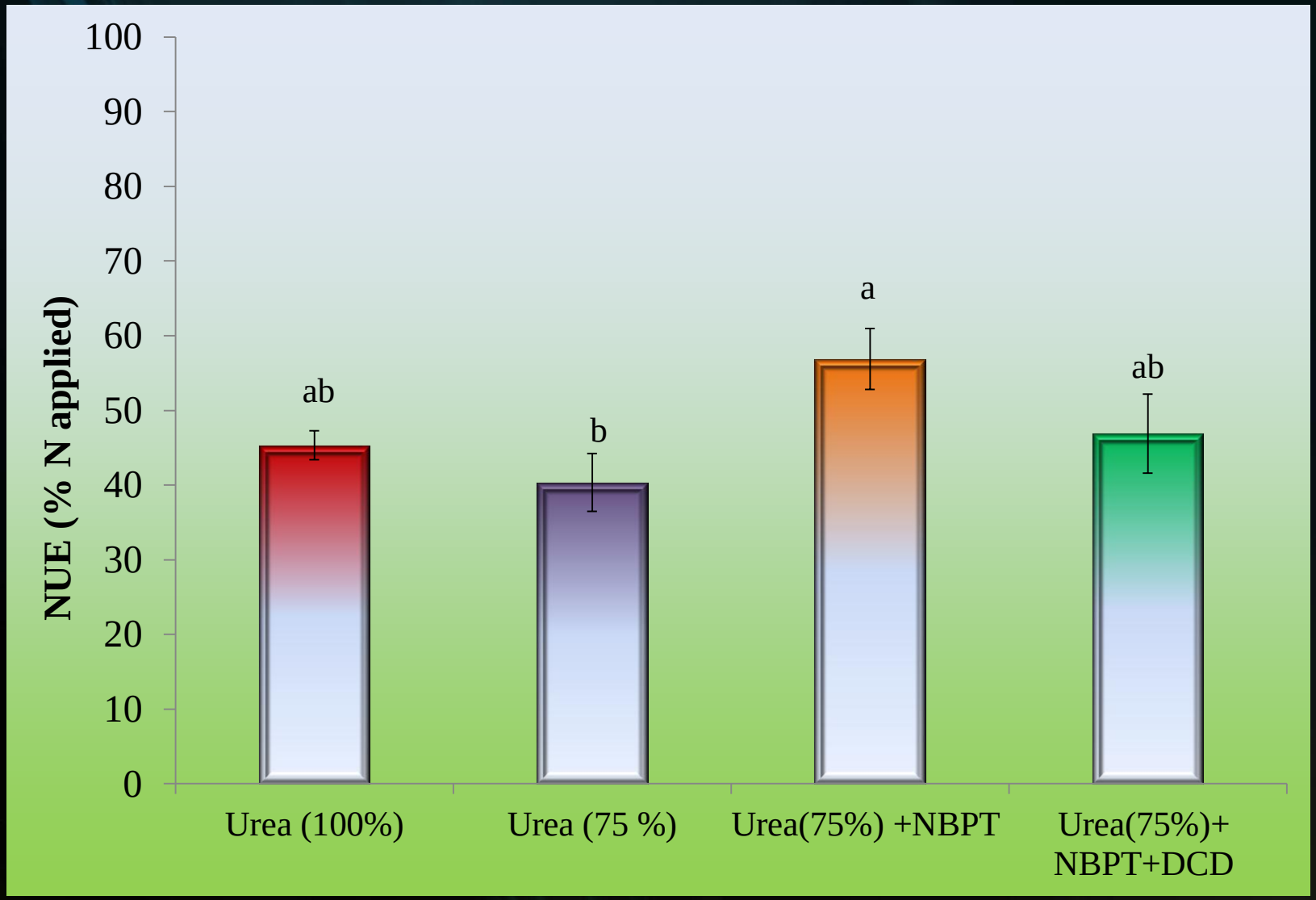
Measurements

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

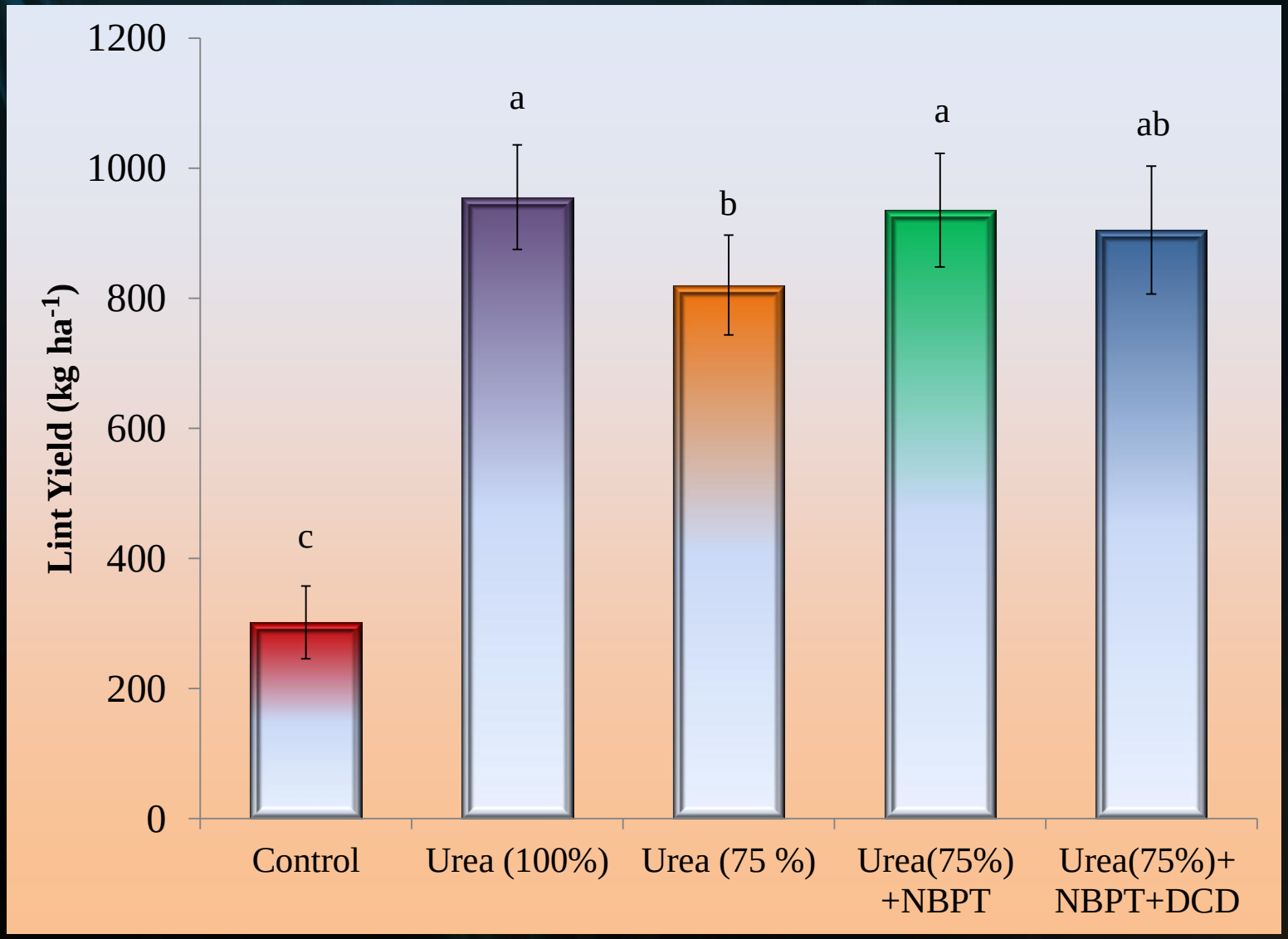
$$\text{N UE} = \frac{(\text{N Content Treatment X}) - (\text{N Content Unfertilized Control})}{\text{N Applied}} \times 100$$

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

N Use Efficiency



Lint Yield


1200
1000
800
600
400
200
0
Lint Yield (kg ha-1)
a
b
a
ab
c
Control
Urea (100%)
Urea (75 %)
Urea(75%) +NBPT
Urea(75%)+ NBPT+DCD

Summary

(Field Experiment)

- Urea-75% with NBPT
  - ✓ Compared Urea-100%
    - Chlorophyll =
    - N Uptake =
    - N Fertilizer Use Efficiency =
    - Lint Yield =

than Urea-75%

- 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

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 with Foliar Fertilization

Field Study

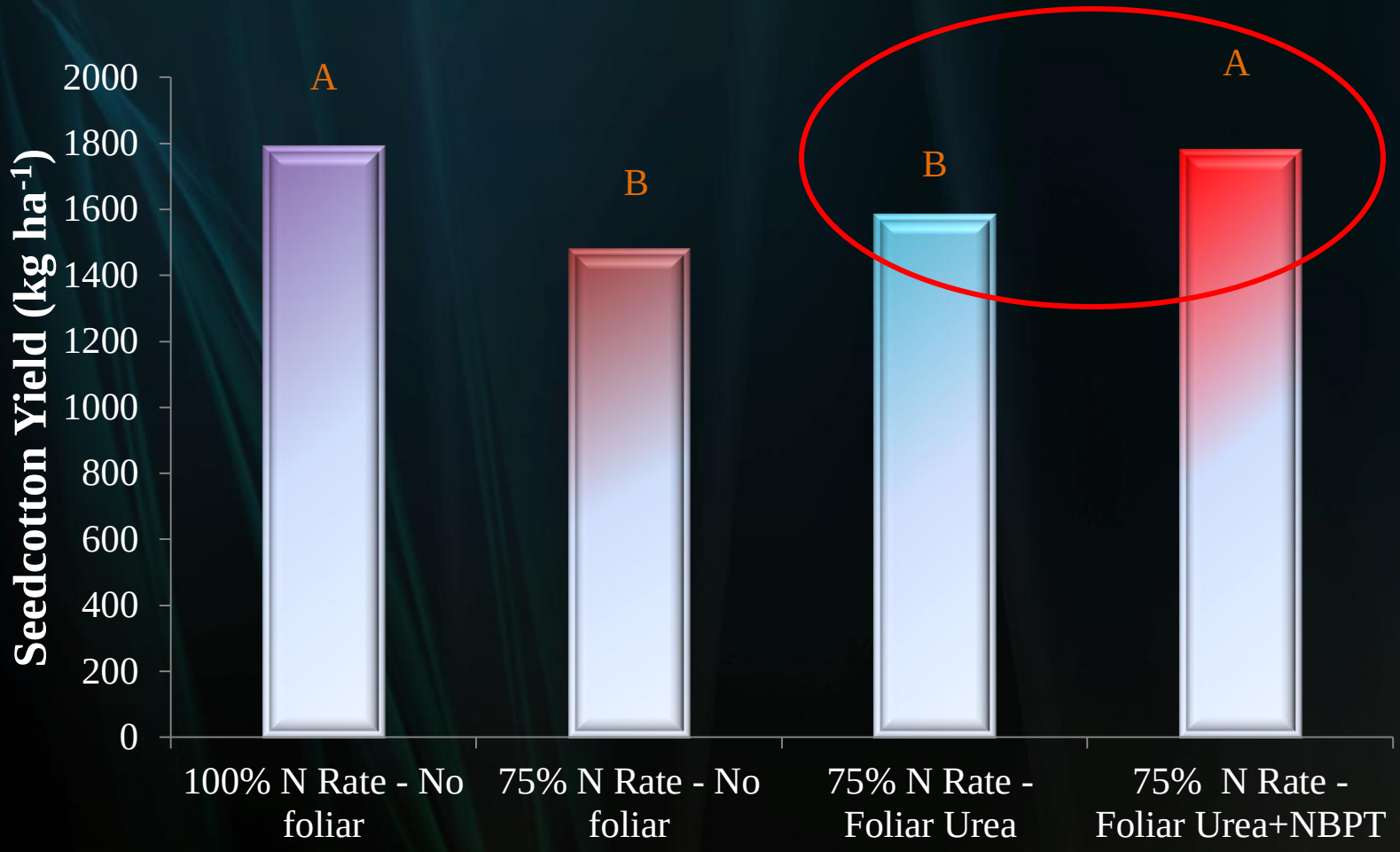
- Location: Lon Mann Cotton Research Station, Marianna, AR
- Cultivar: ST 4554 B2RF – Standard Management (Except N)
- Design : RCBD with 4 treatments and 5 replications

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 *at FF and FF+2weeks*
4. 75% Soil N Rate - Foliar Urea + NBPT	84 (75%)	Urea + NBPT (0.84%) *at FF and FF+2weeks*

- Measurement:
  - Seedcotton Yield (machine picked)

Results

Seedcotton Yield



Growth Room Study

Growth Room Study

- Location: AR Agricultural Research Station, Fayetteville, AR
- Environment: 30/20°C day/night temperature, 14 h photoperiod
- Cultivar: ST 4554 B2RF
- Design : CRD with 4 treatments and 5 replications

Treatment	Foliar Nitrogen Application (12 kg N/ha)
1 – Control	No
2 – Foliar Urea	Foliar Urea
3 – Foliar Urea + NBPT	Urea + NBPT (0.84%)
4 - Foliar NBPT Check	0.84 % of NBPT

No soil N – foliar urea treatments applied at pinhead-square

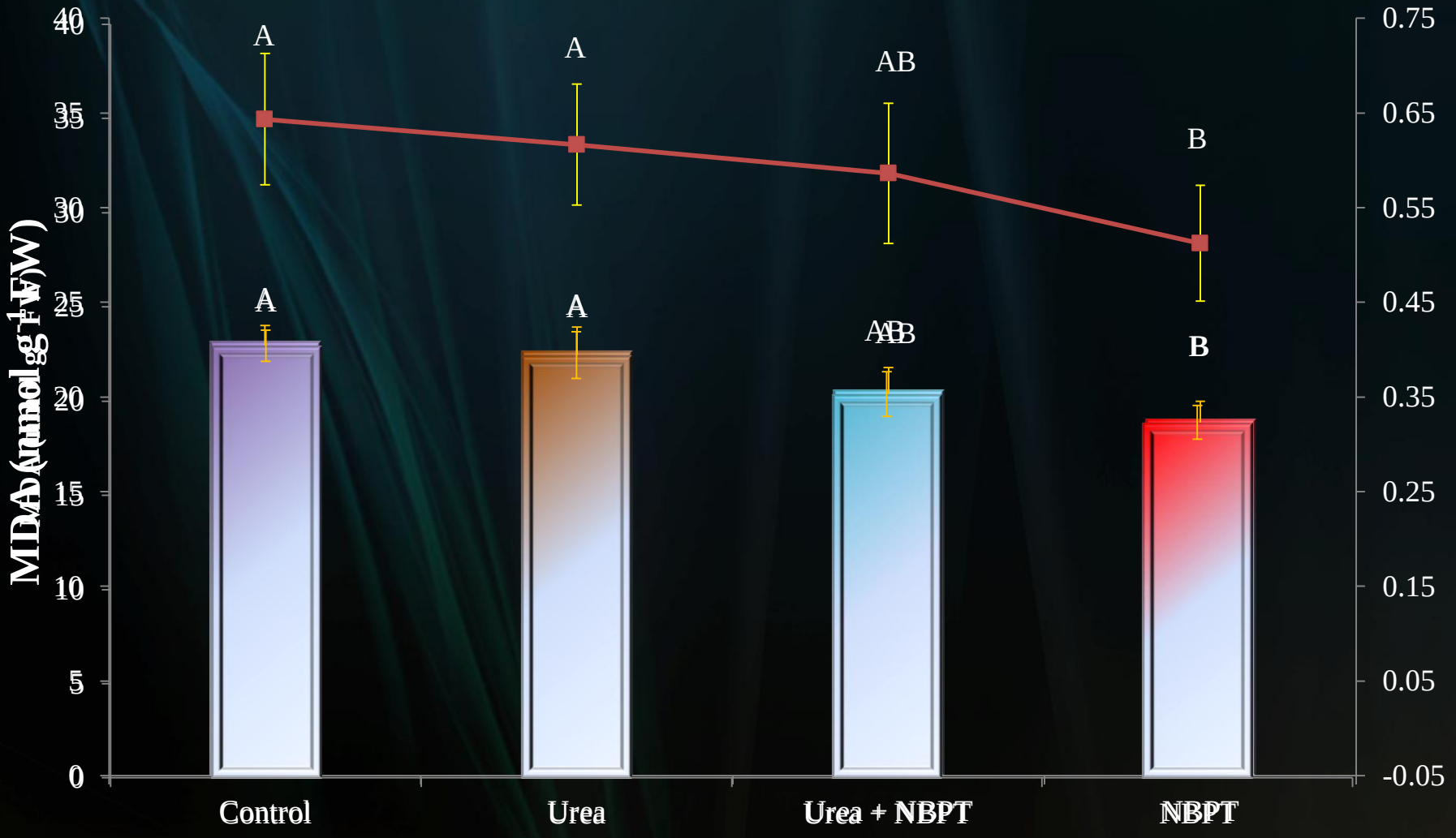
Measurements

- Membrane Decomposition:
  - Malondialdehide (MDA)
- Cell Integrity :
  - Membrane Leakage (% Injury)
- Photosynthesis:
  - Portable photosynthesis system Licor 6200
- Urea Assimilation:
  - Urea, Urease, Glutamine Synthetase and Protein

Time: 2 h and 24 h after treatment application

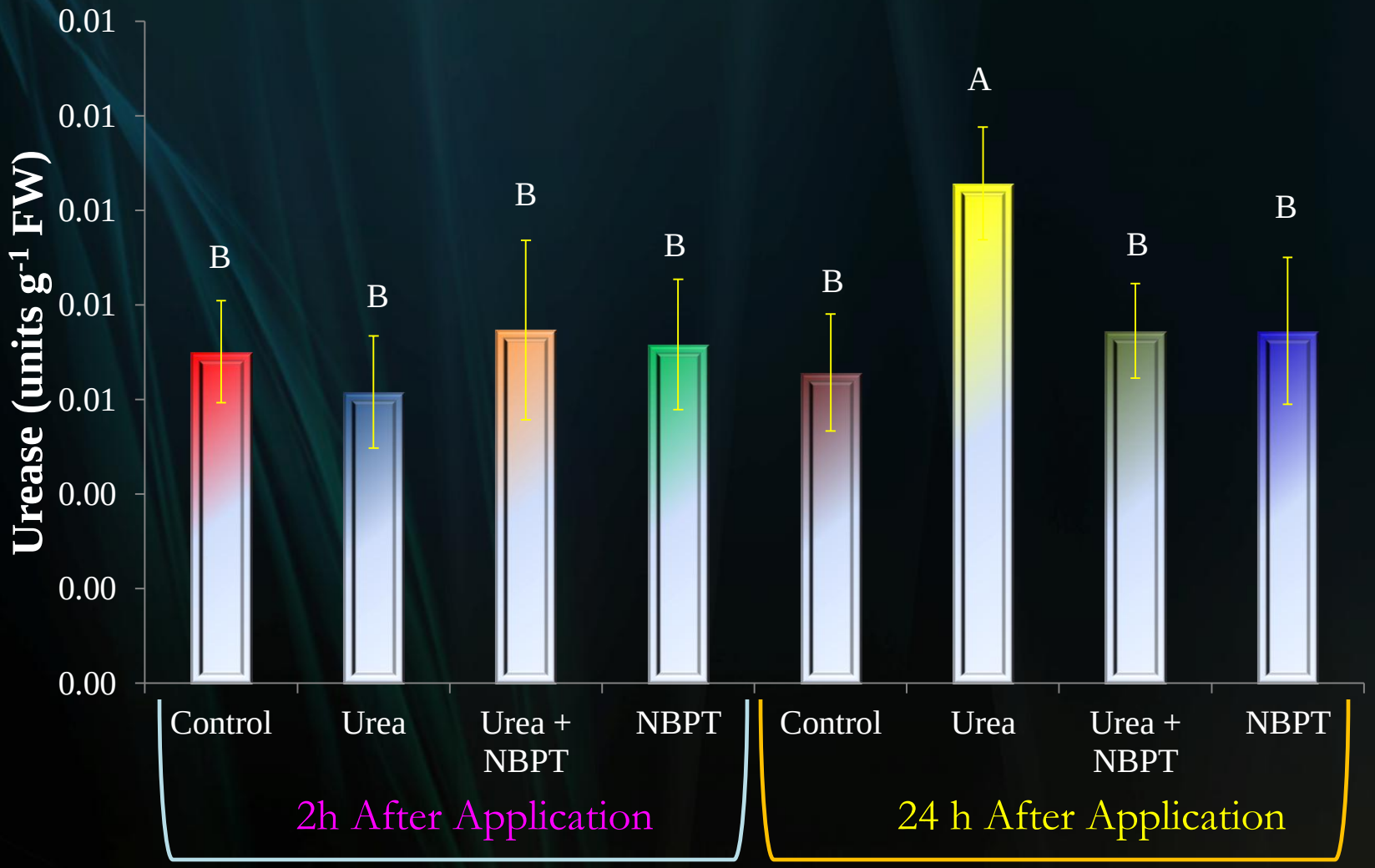
Results

Leaf Membrane Degradation and Leakage



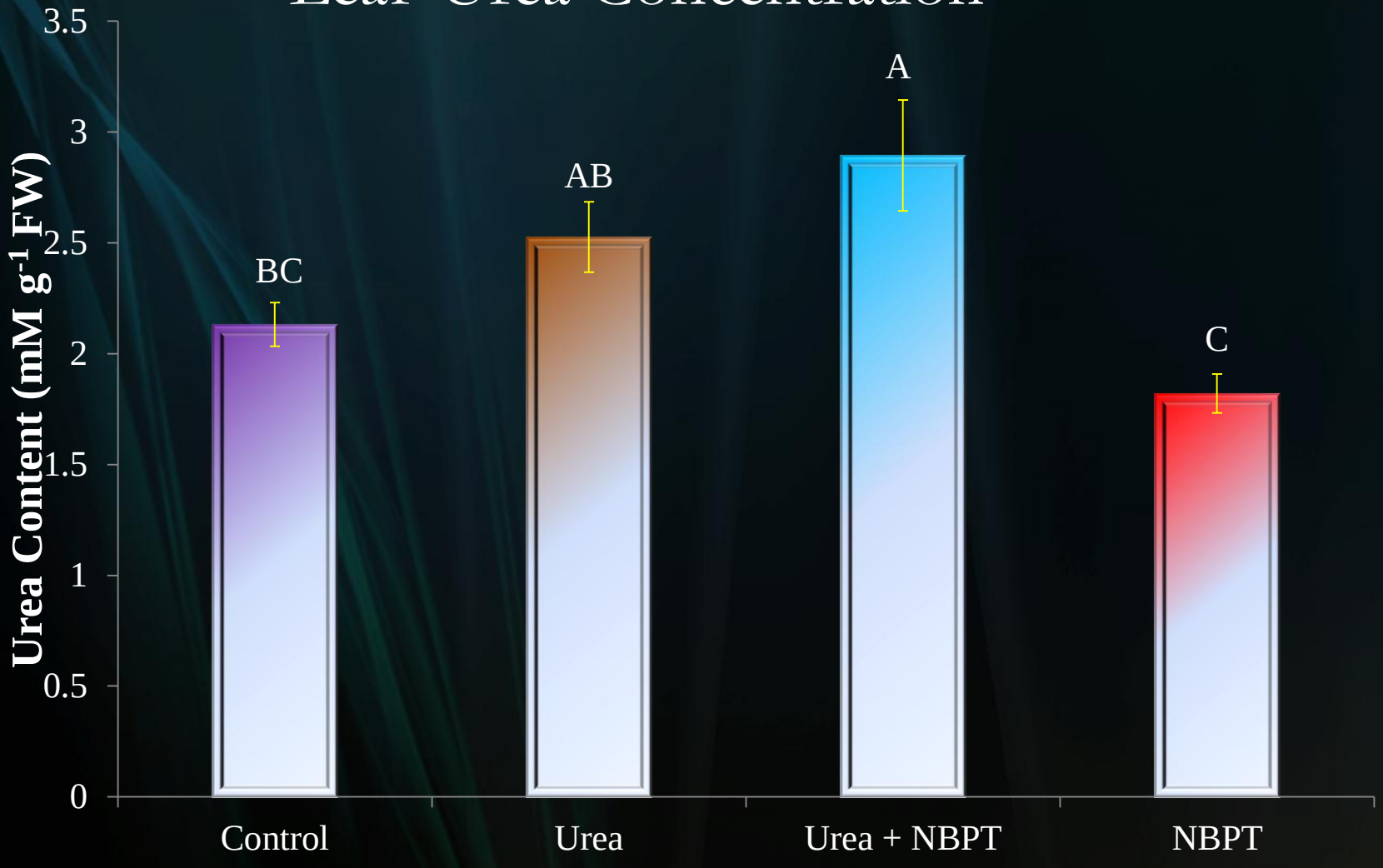
Results

Leaf Urease

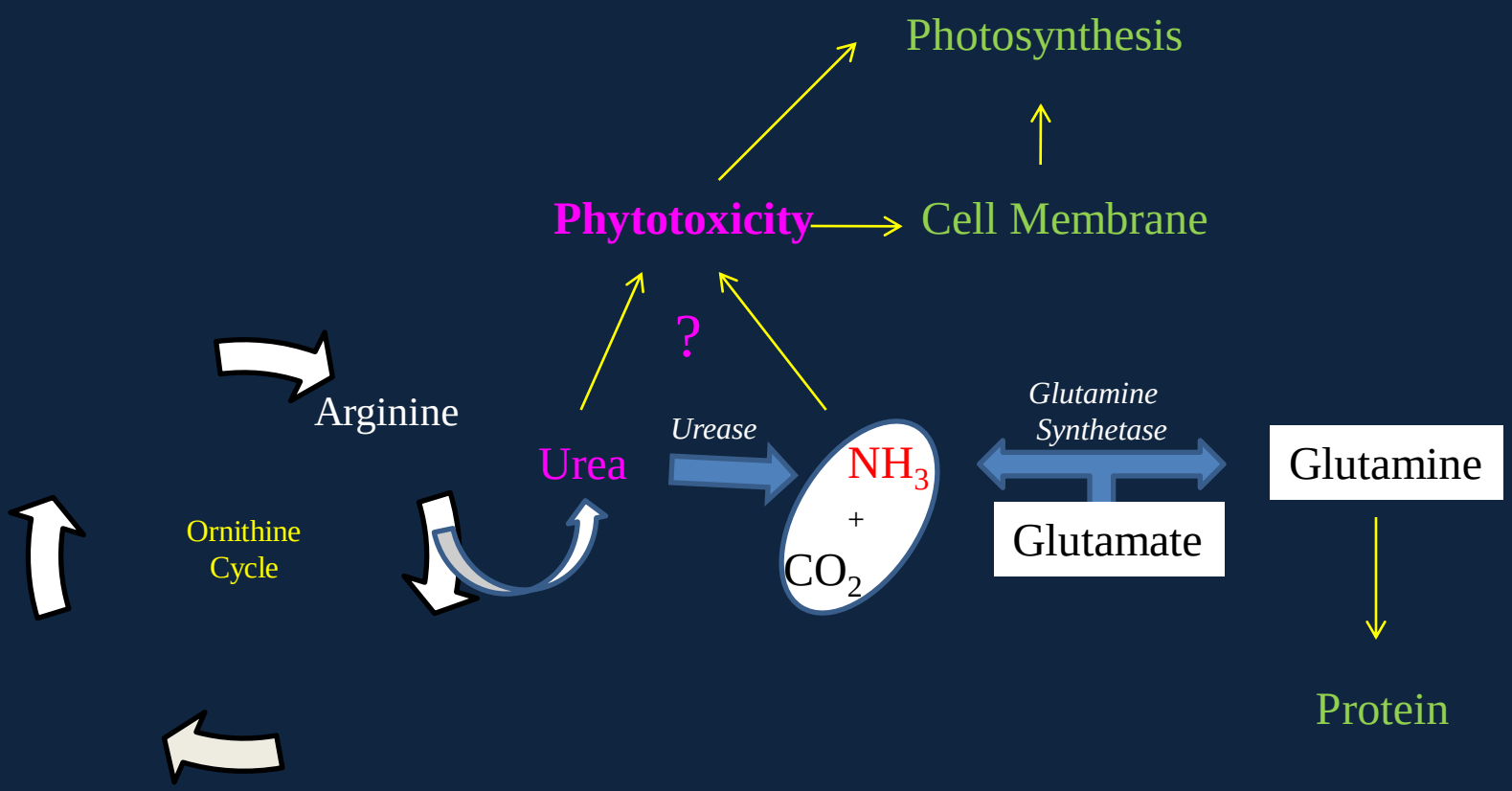


Results

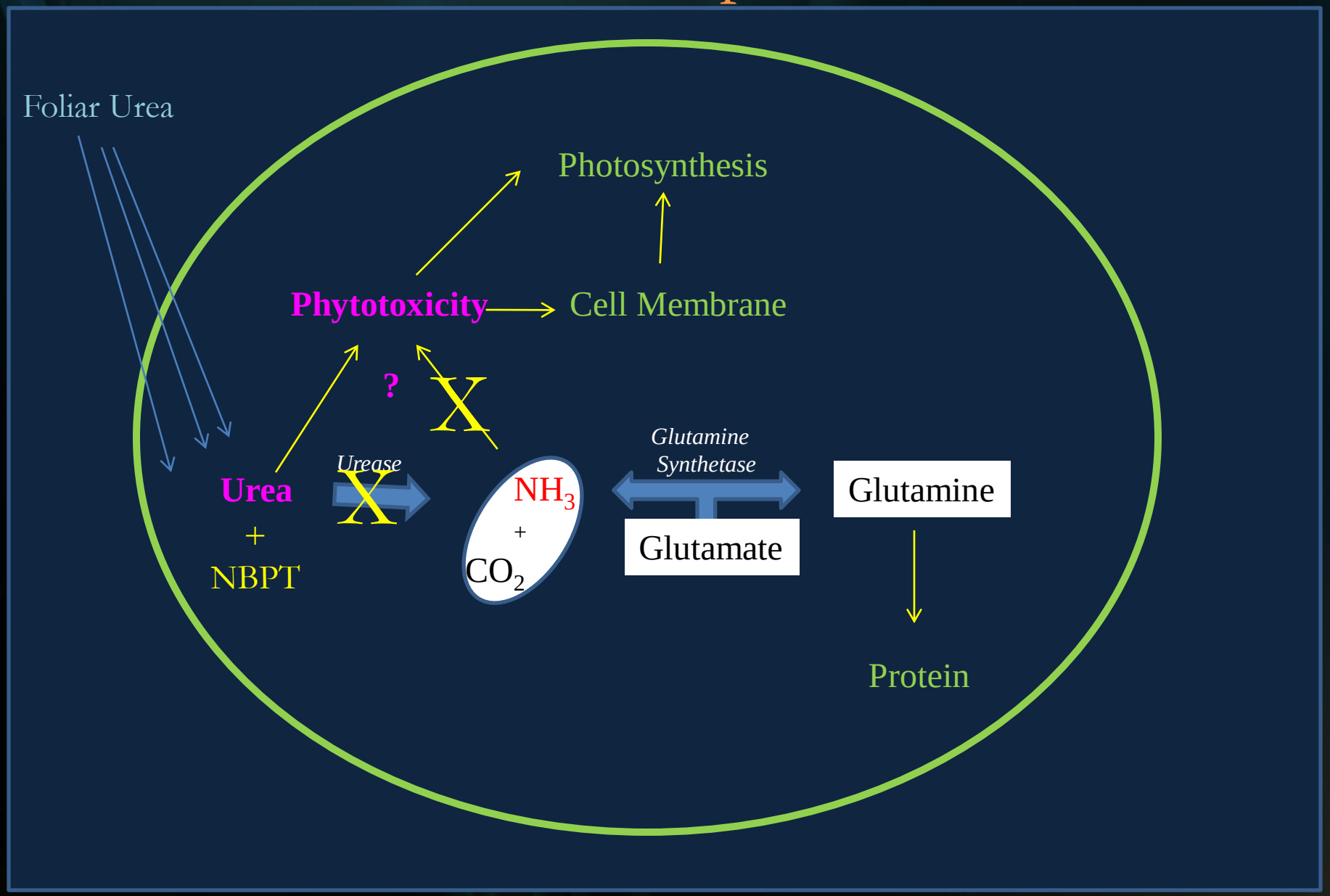
Leaf Urea Concentration



Leaf Urea Assimilation



Results Interpretation



Summary

Addition of NBPT to Urea Resulted in:

- Field Experiment with Urea and NBPT
  - Cotton yield ↑

- Growth Room Studies
  - Urease Activity ↓
  - Trends:
    - Urea ↓
    - MDA and Membrane Leakage ↓
- Field Experiment with Foliar Urea and NBPT
  - Increase in cotton yield

Conclusion

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.

Acknowledgements

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THANK YOU!