Environmental Factors
Nutrients

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Environmental and Cultural Factors Limiting Potential Yields

- Atmospheric Carbon Dioxide
- Temperature (Extremes)
- Solar Radiation
- Water
- Wind
- Nutrients (N and K)
- Others, ozone etc.,
- Growth Regulators (PIX)

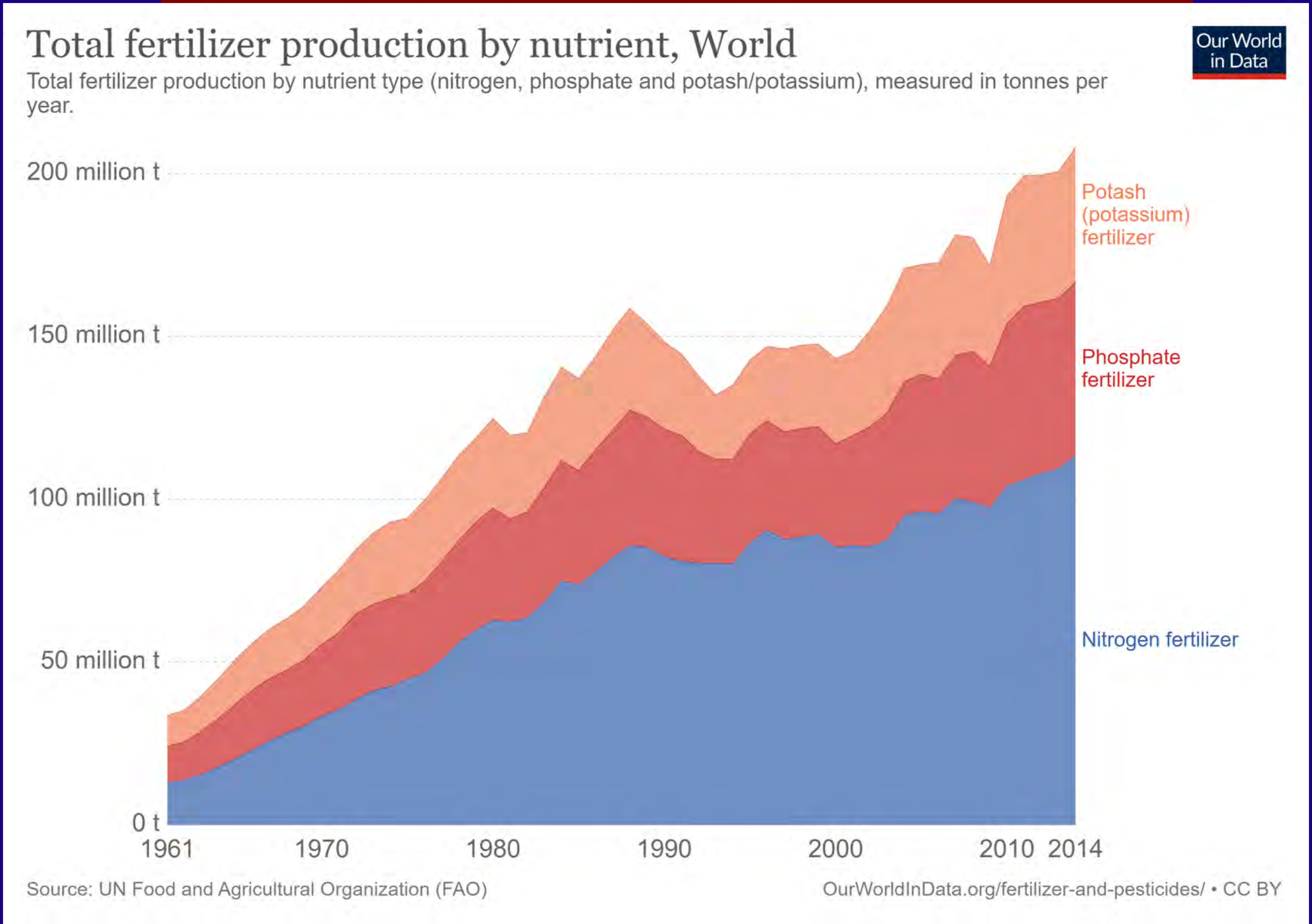
Nutrients - Objectives

The objectives of this lecture are to:

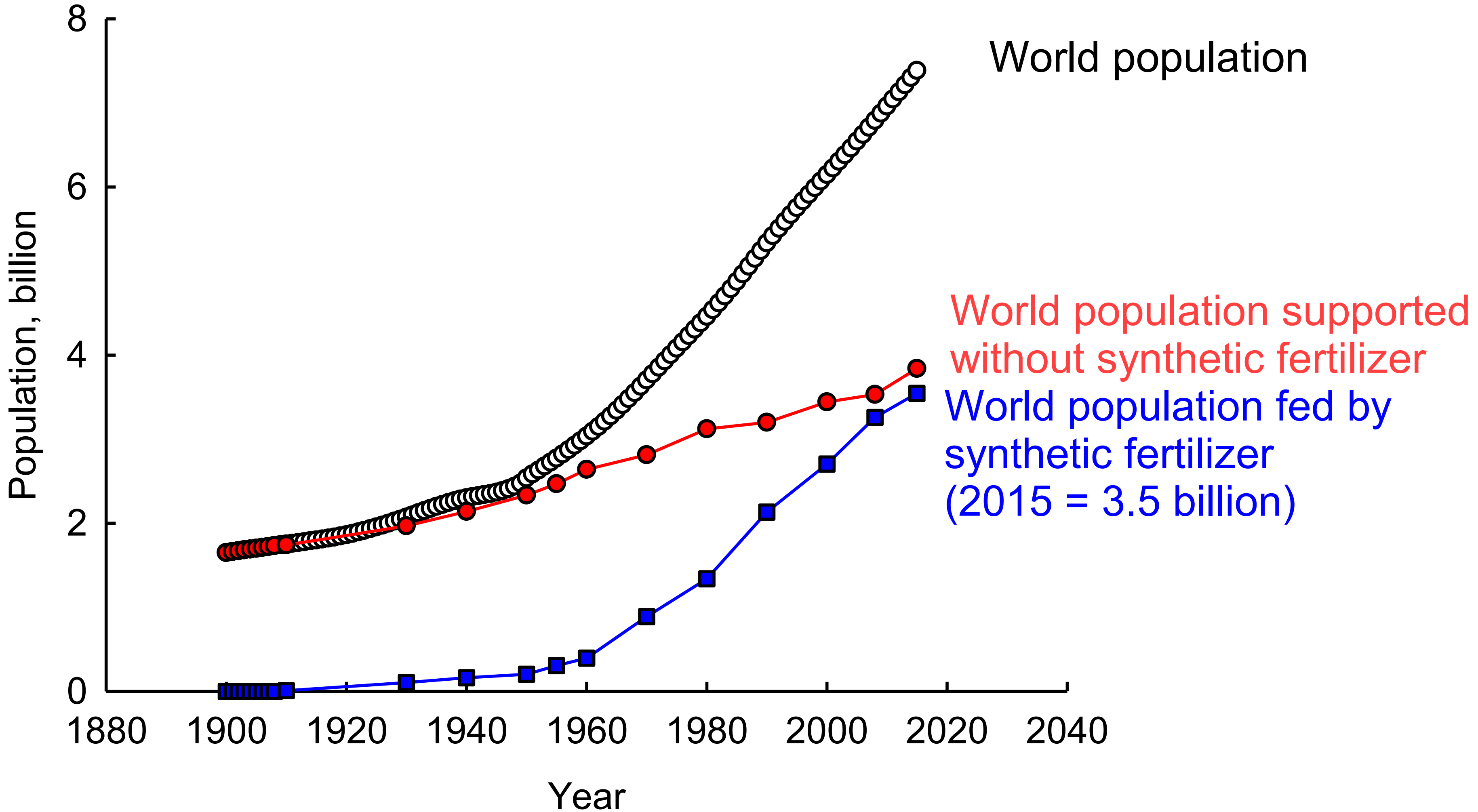
- Learn temporal trends in fertilizer usage (Major nutrients).
- Influence of major nutrients on plant growth and development.

Major Nutrients
Trends and some Statistics

Trends in World Commercial Fertilizer Use



How Many People does Nitrogen Fertilize Feed?



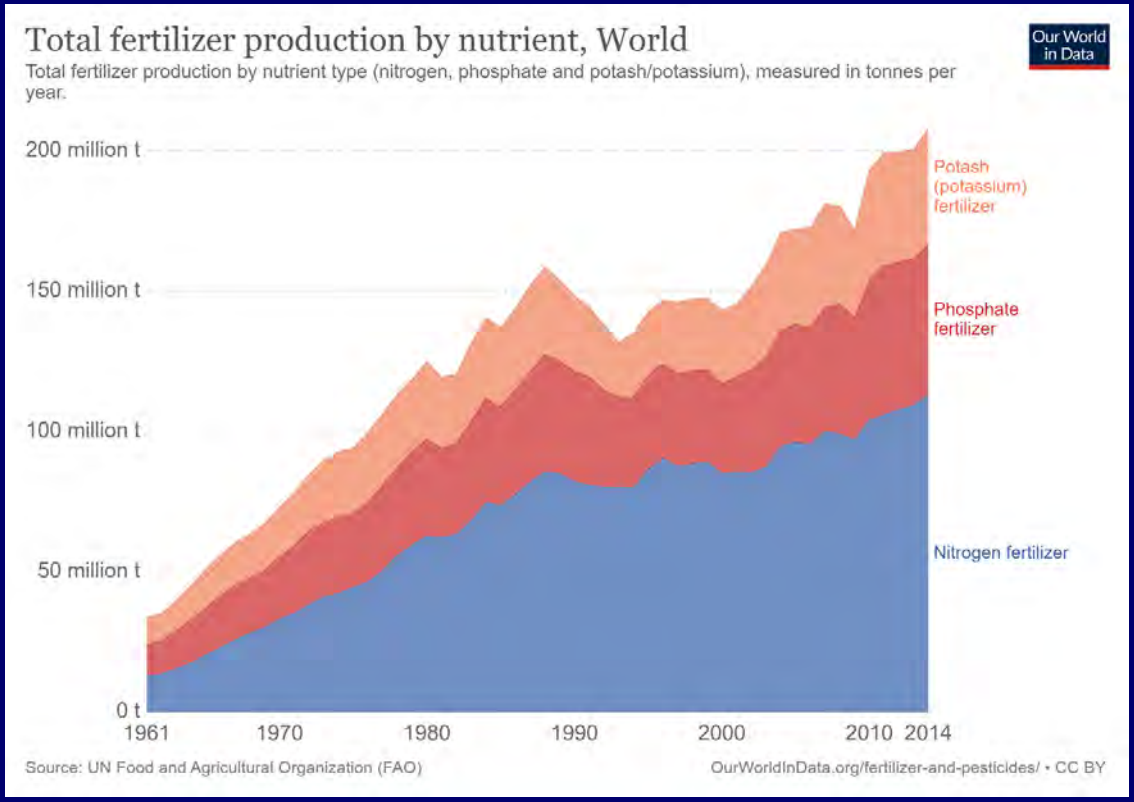
Erisman, J. W., Sutton, M. A., Galloway, J., Klimont, Z., & Winiwarter, W. (2008). How a century of ammonia synthesis changed the world. Nature Geoscience, 1, 636-639.

Trends in U.S. Total Commercial Fertilizer Use

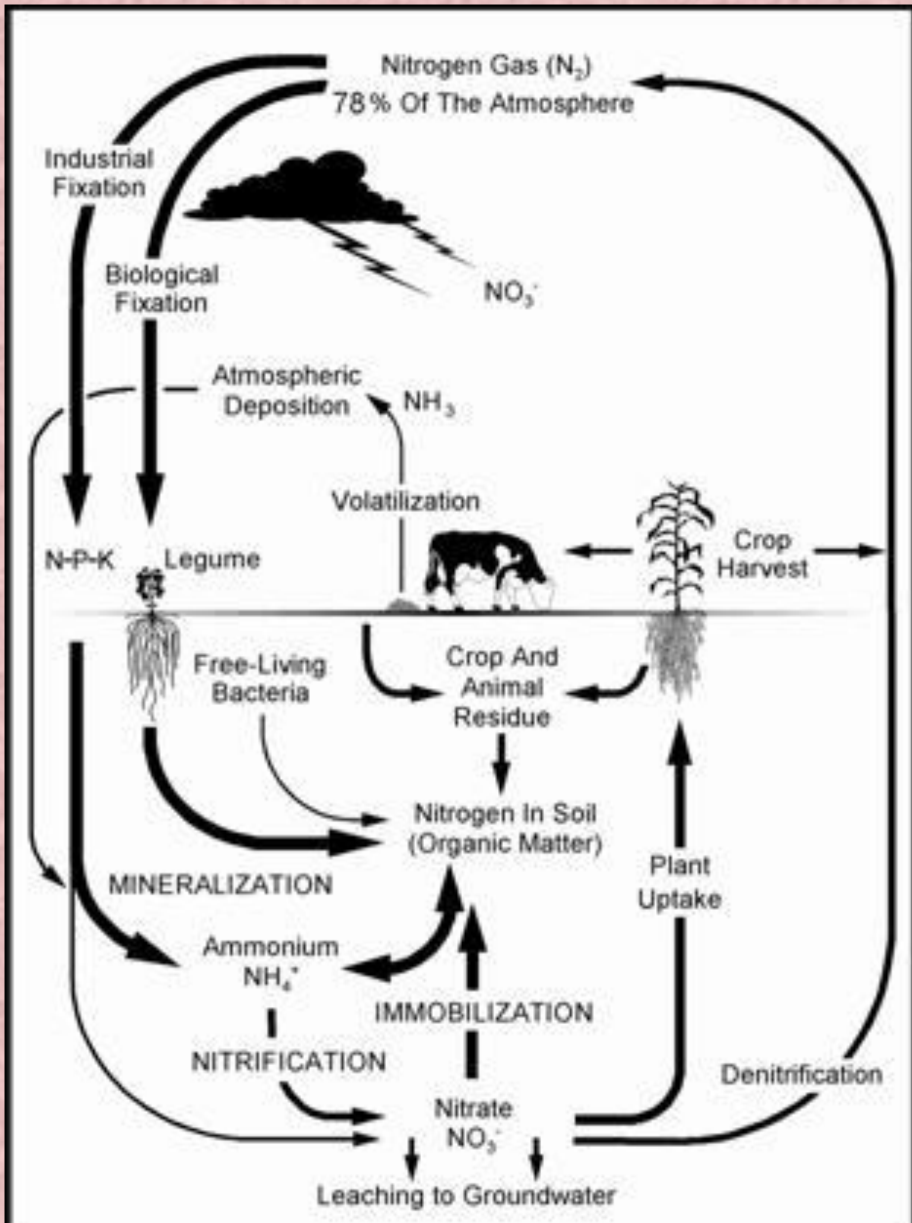
(Primary, Secondary and Micronutrients)

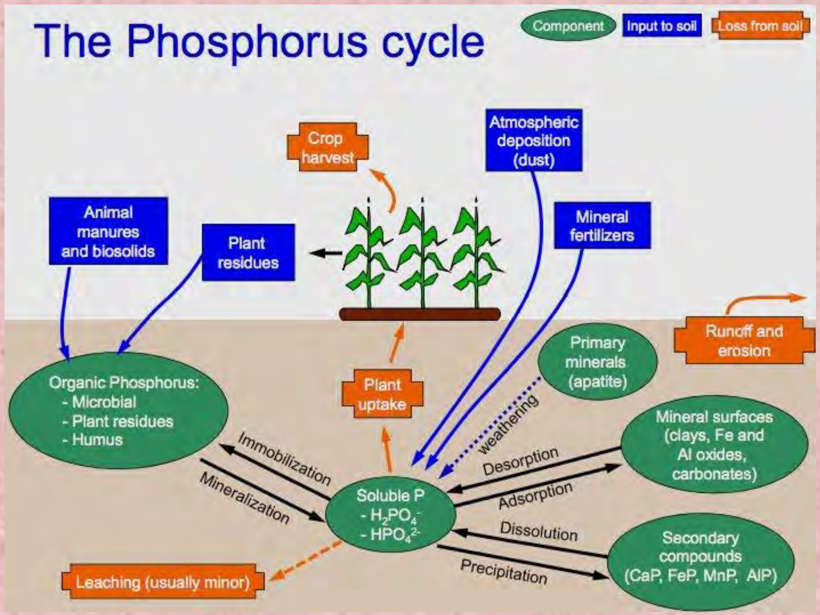
Commercial fertilizer use depends on variety of factors:

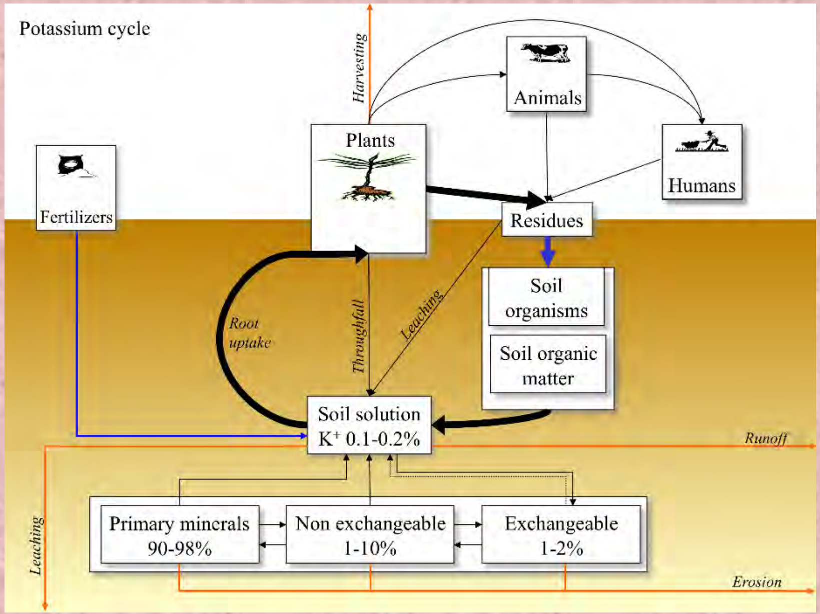
- Soil
- Climate and weather
- Feasible technology
- Crop mix
- Crop rotations
- Technological change
- Govt. programs
- Commodity and fertilizer prices
- Affordability



Major Nutrient Cycles







Major Nutrients and Their Influences

Nutrient Supply and Plant Growth

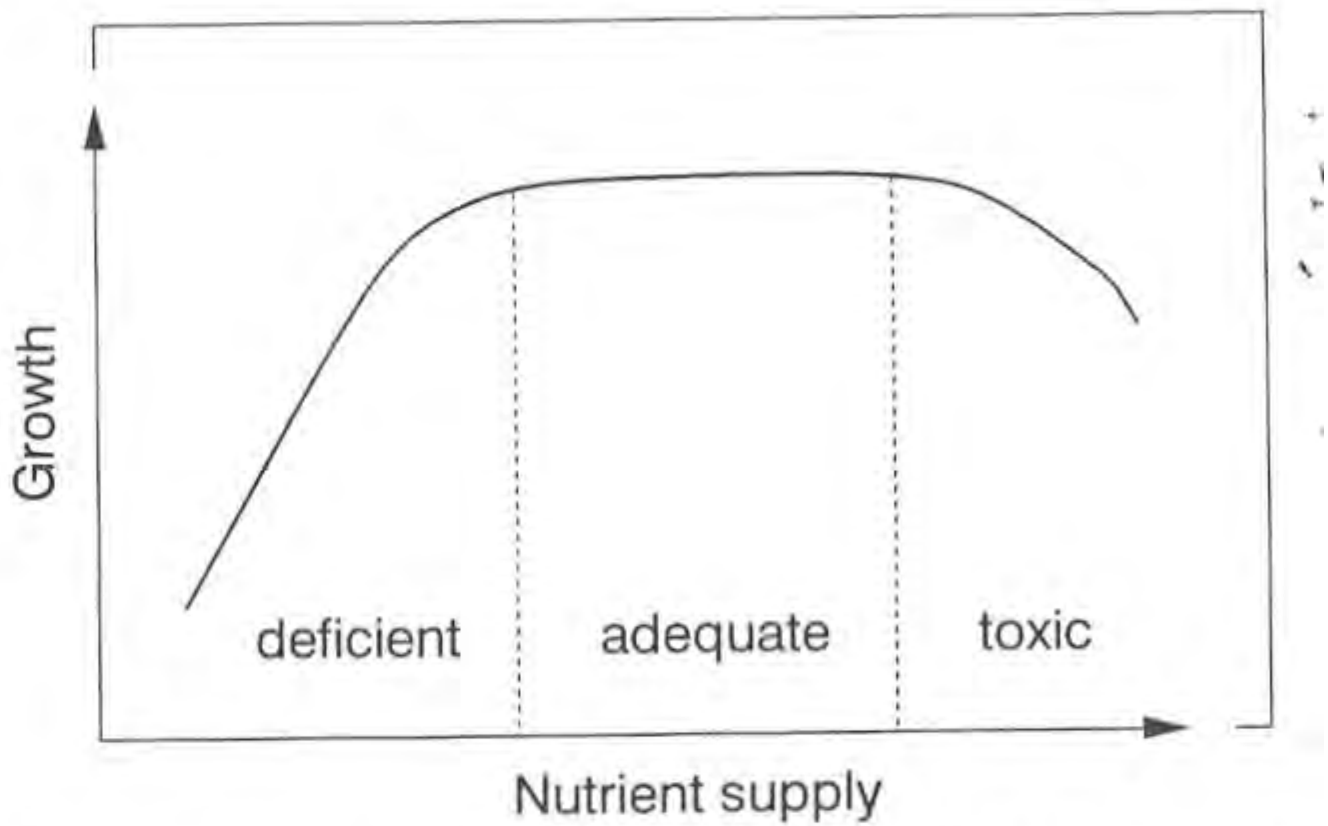


Fig. 12.1 Relationship between nutrient supply and growth.

Nitrogen Supply and Plant Growth

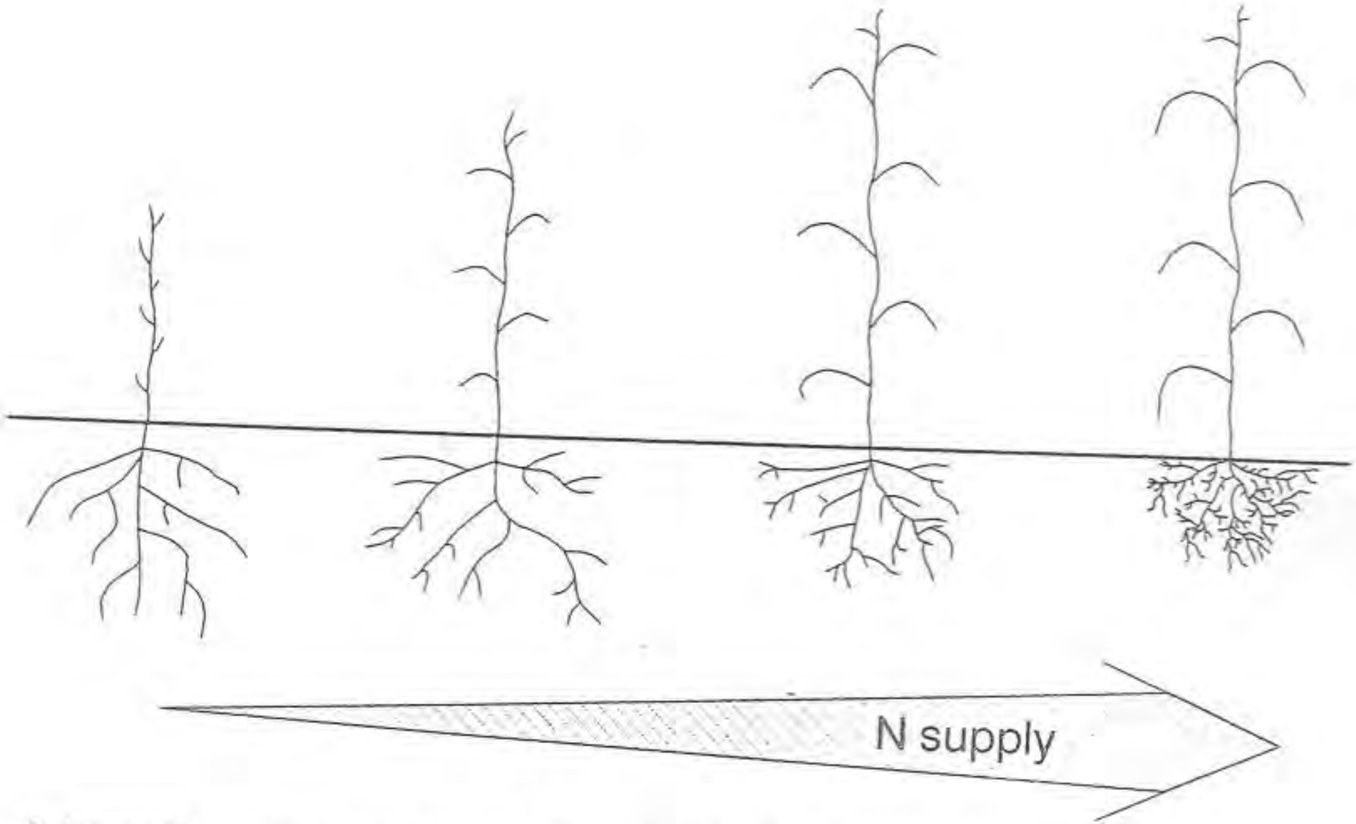


Fig. 8.16 Schematic representation of the effect of increasing levels of nitrogen supply roots during early growth stages on the root and shoot growth of cereal plants.

Nitrogen and Crop Yield

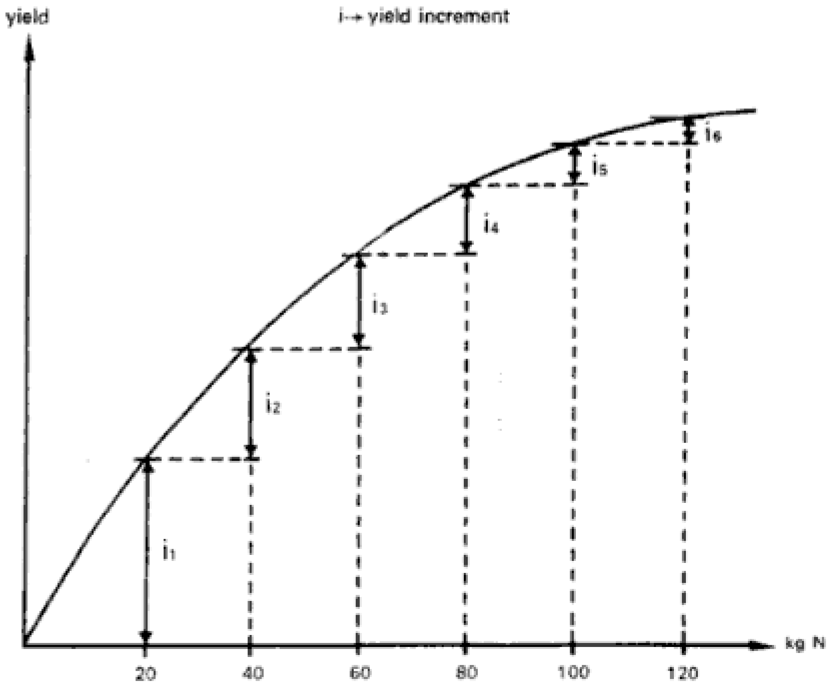
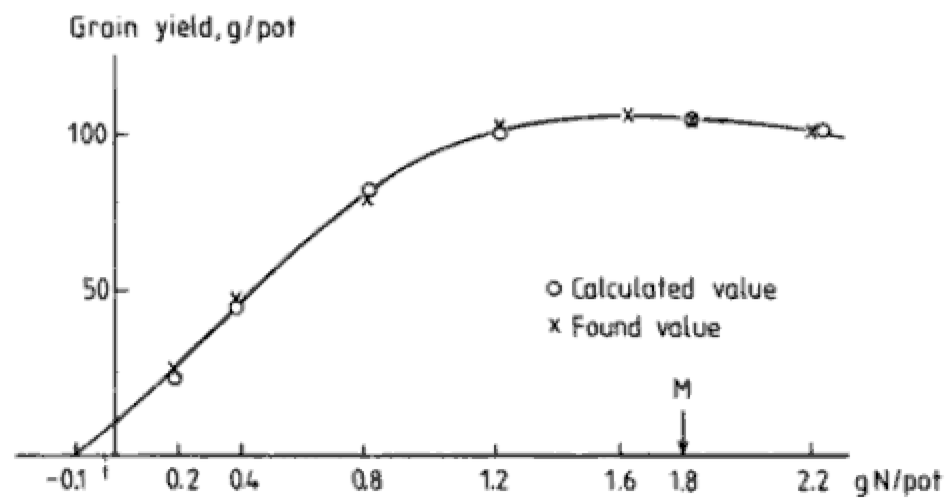


Figure 5.25 Response curve showing diminshing increments.

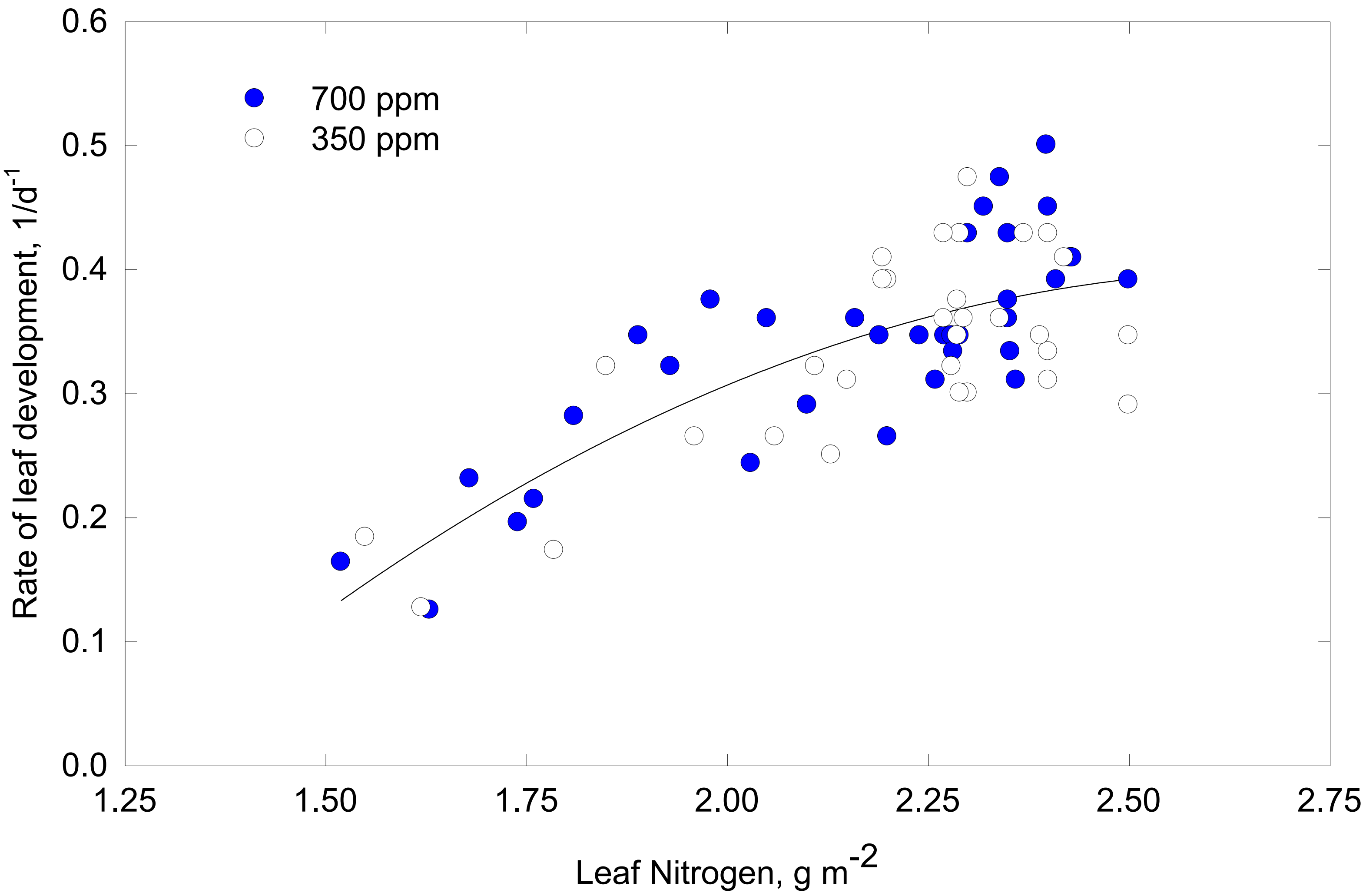


Question:

- Do processes within a crop vary in their response to nutrients?

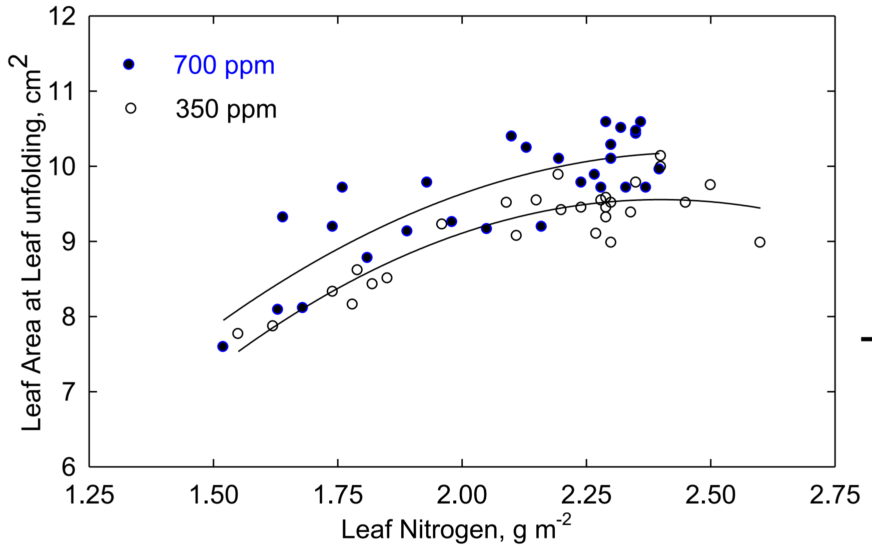
Nitrogen and Cotton Growth and Development

Leaf developmental response to N and elevated CO_2

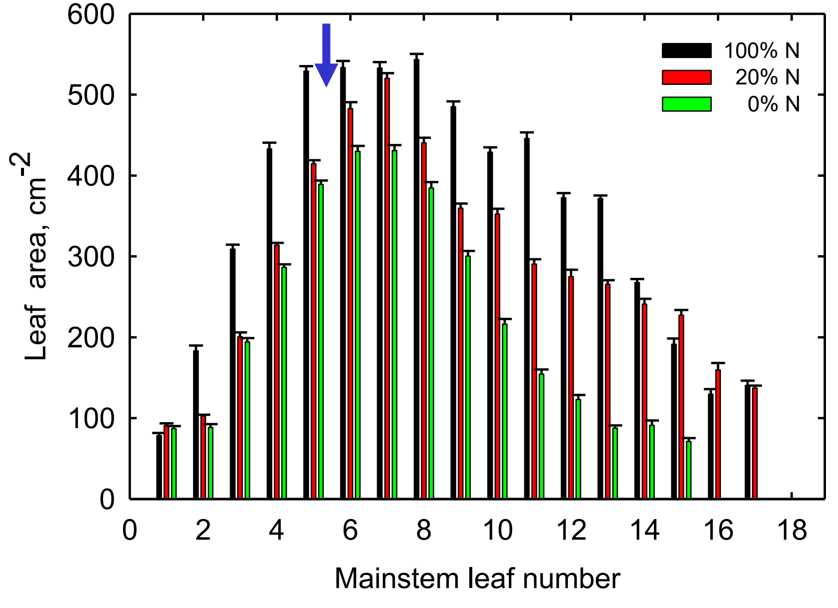


Nitrogen and Crop Growth and Development

Leaf growth response to N and elevated CO_2

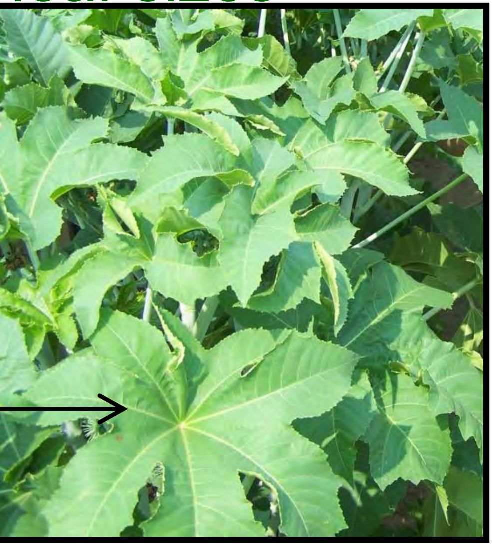


Cotton leaf area at leaf unfolding



Caster mature leaf sizes

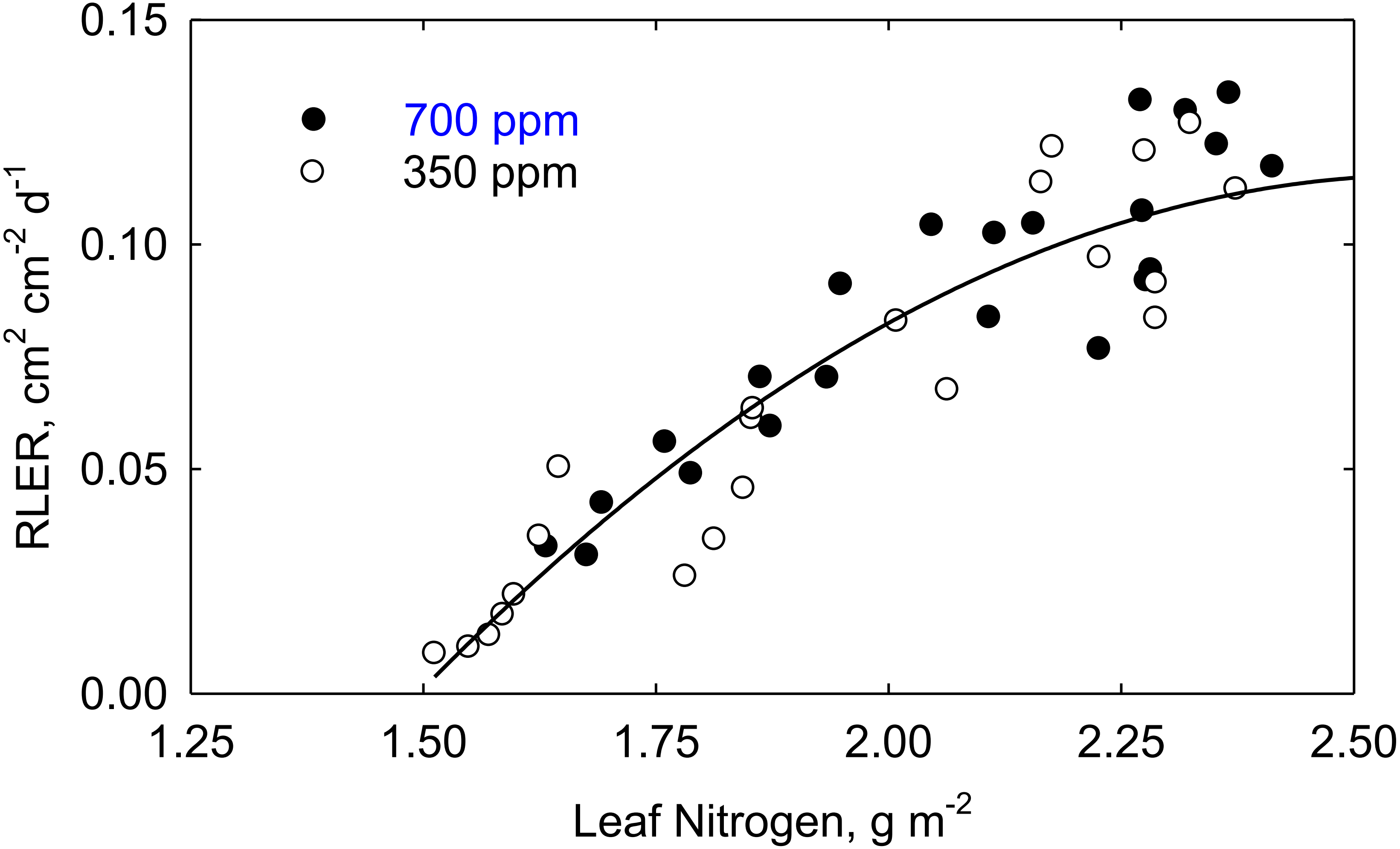
✓N treatments were imposed when leaf 5 was just unfolding



Nitrogen and Crop Growth and Development

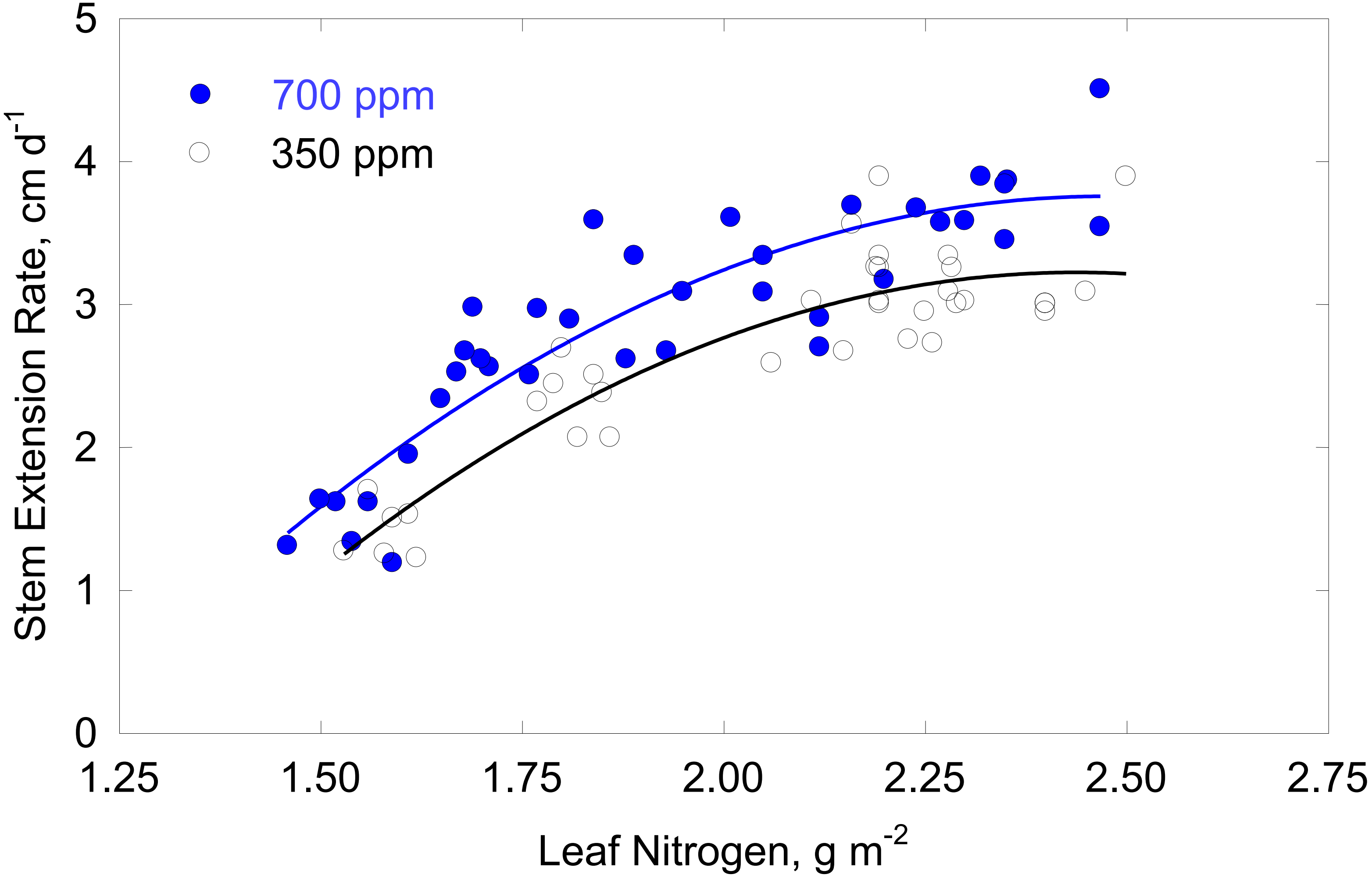
Cotton leaf growth response to N and elevated CO_2

RLER = Relative Leaf Expansion Rate



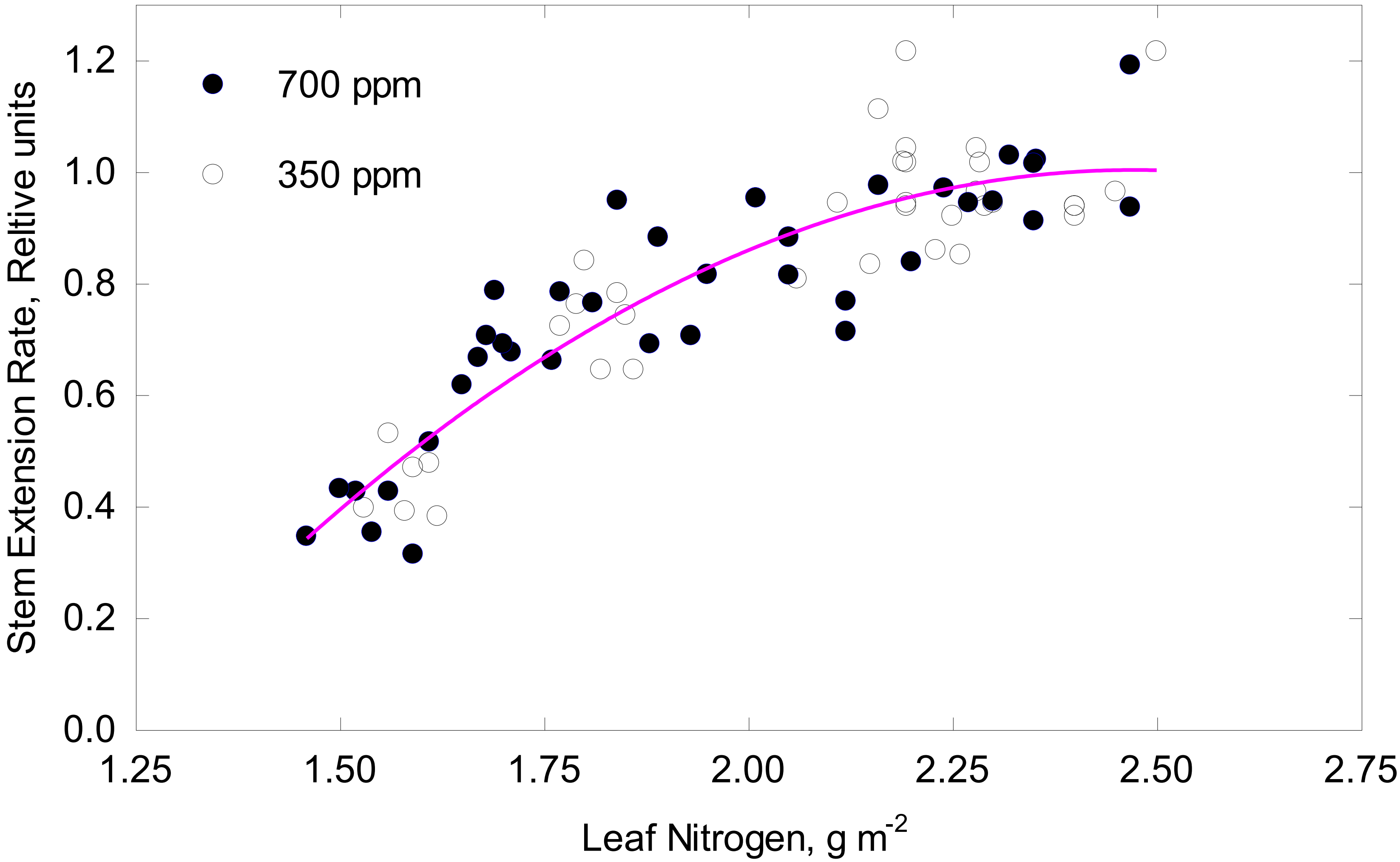
Nitrogen and Cotton Growth and Development

Stem elongation response to N and elevated CO_2



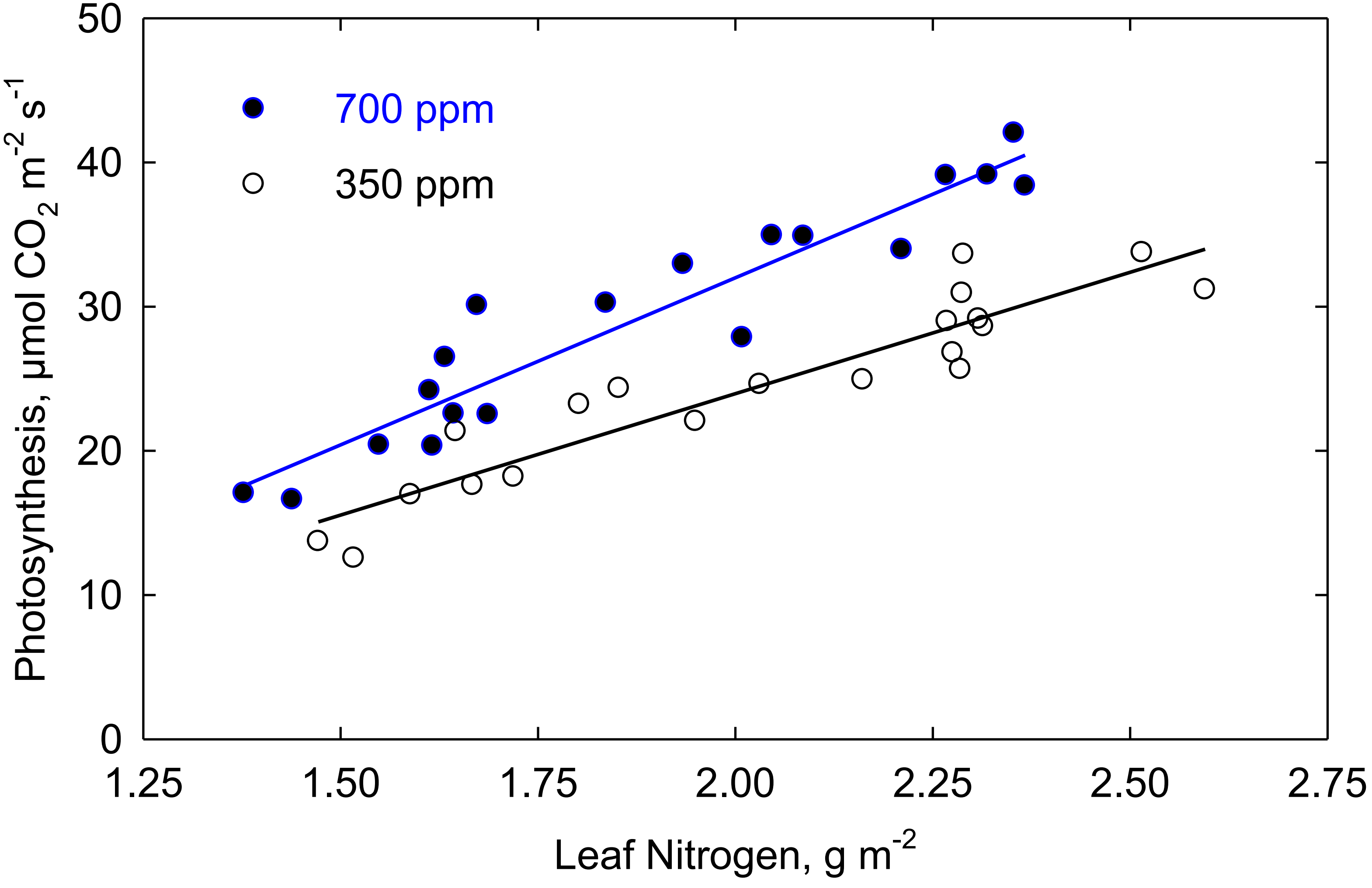
Nitrogen and Cotton Growth and Development

Stem Elongation Rate Response to N and elevated CO_2



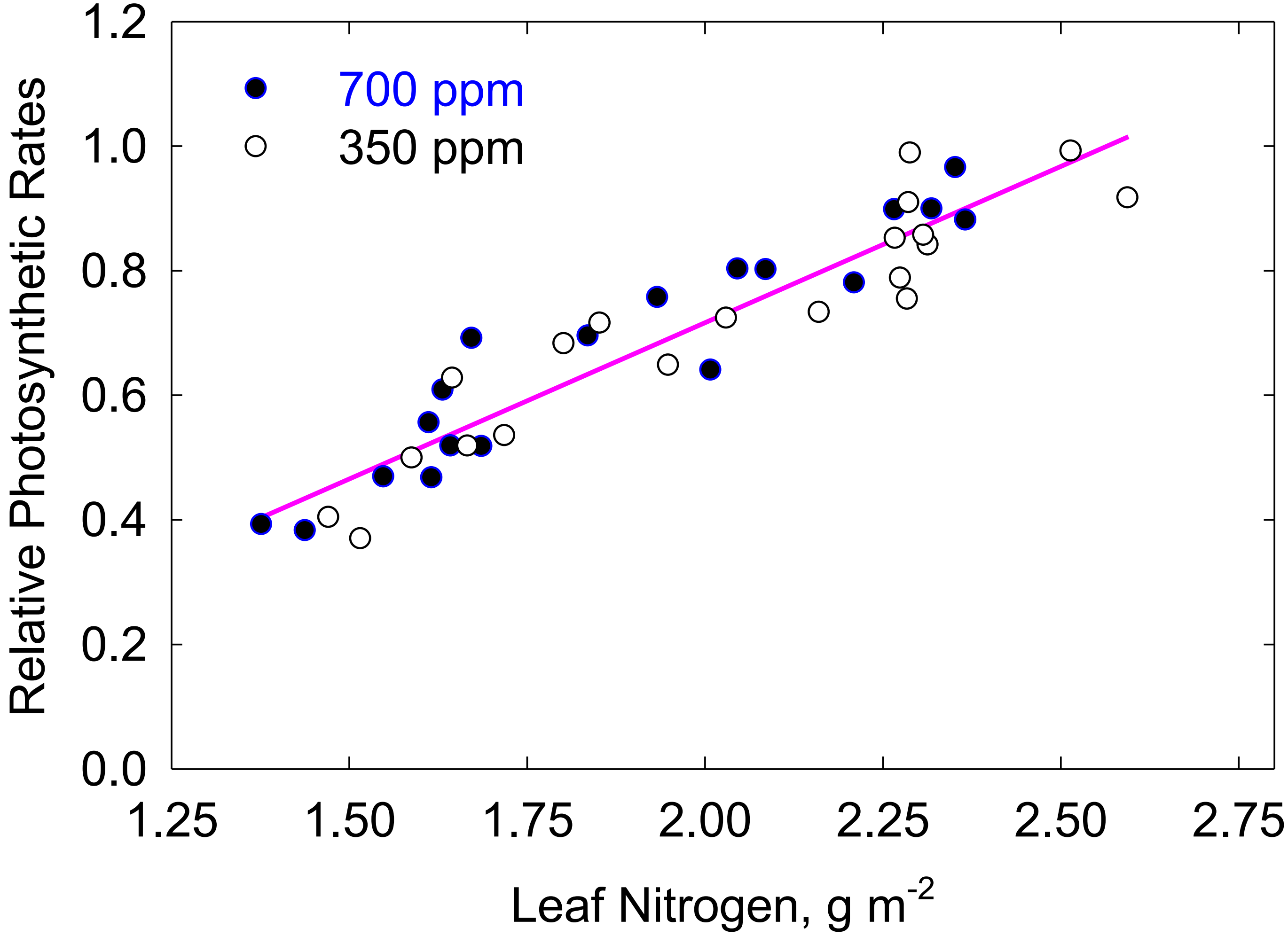
Nitrogen and Cotton Growth and Development

Leaf photosynthetic response to N and elevated CO_2



Nitrogen and Cotton Growth and Development

Relative Rates of Photosynthesis



Can we use one function for all processes in a given crop?

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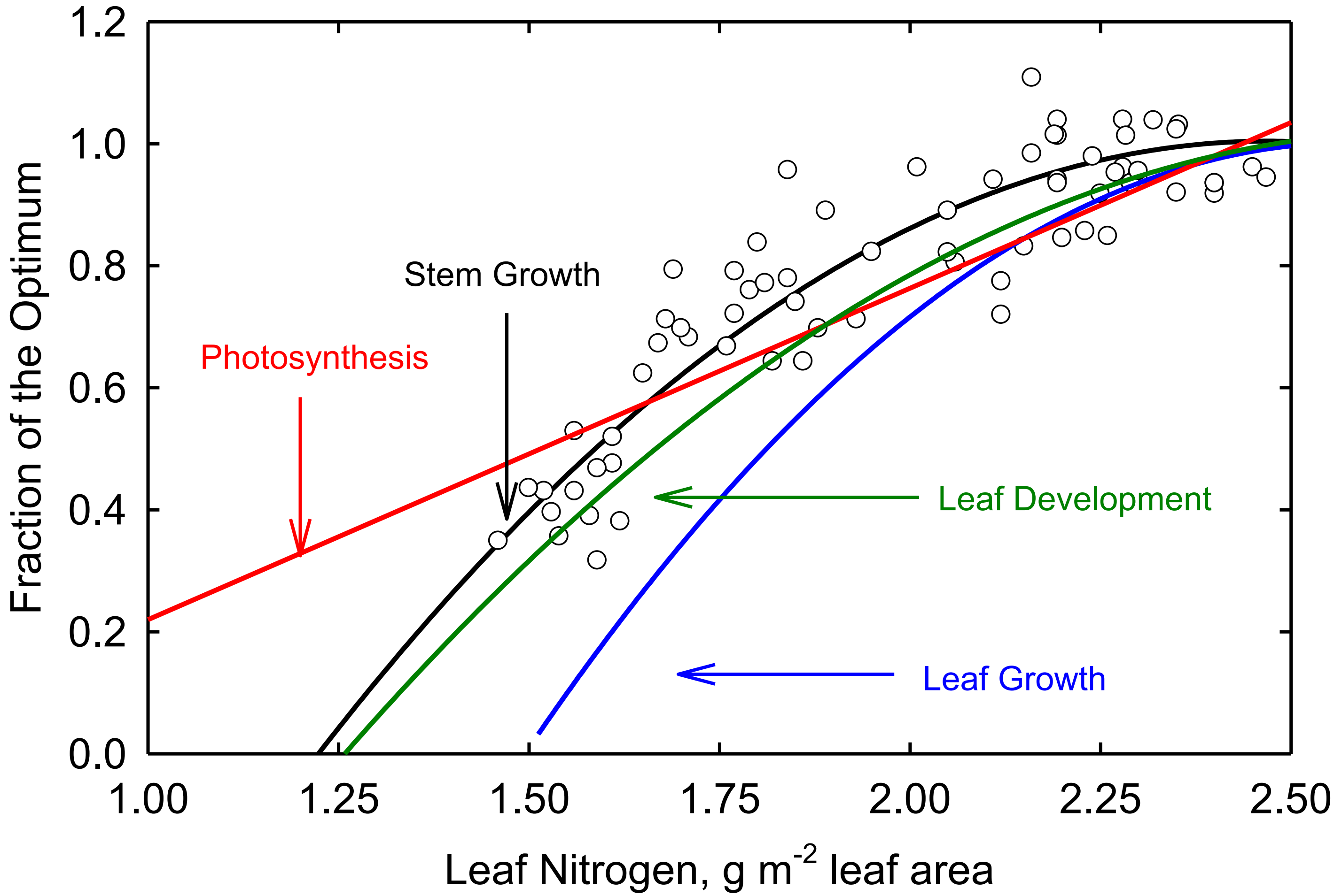


N-Deficient ⟷ N-Sufficient

Questions:

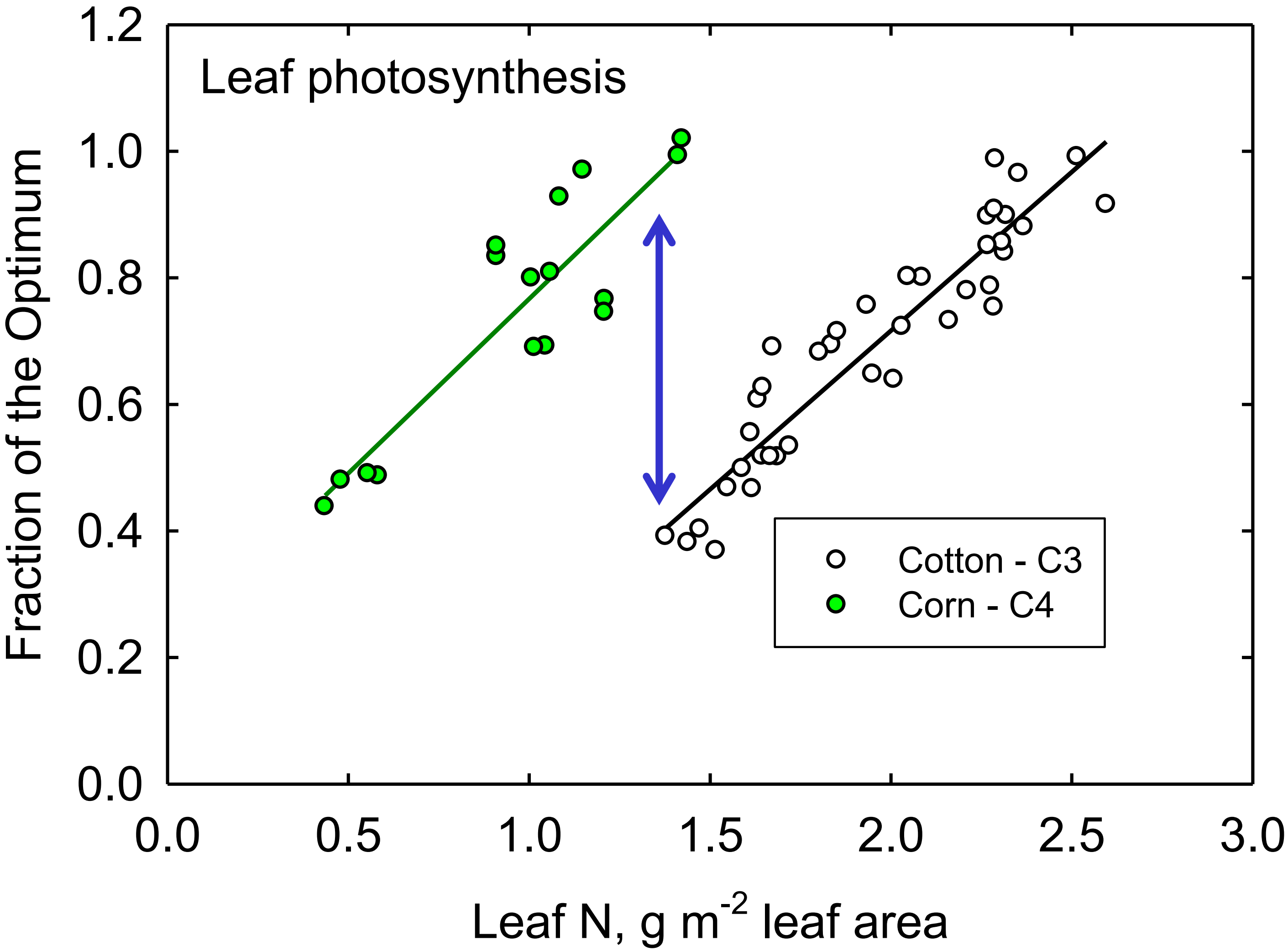
- Do species vary in their response to nutrients?

- How about functional groups such as C_3 versus C_4?

- Is there a difference between the functional groups in their response to nutrients?

Can we apply cotton algorithms for other crops?

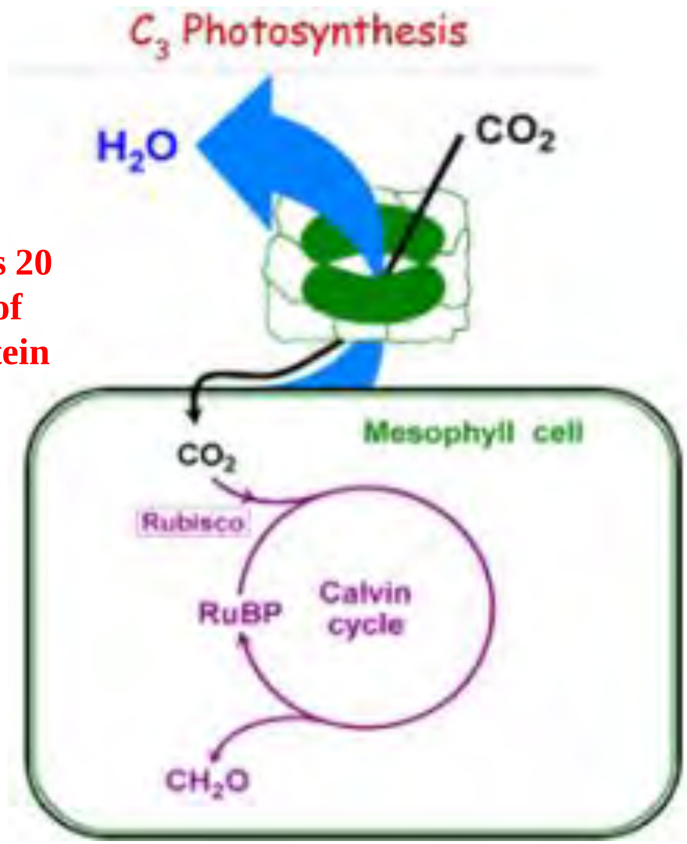
N and Photosynthesis – Functional Groups

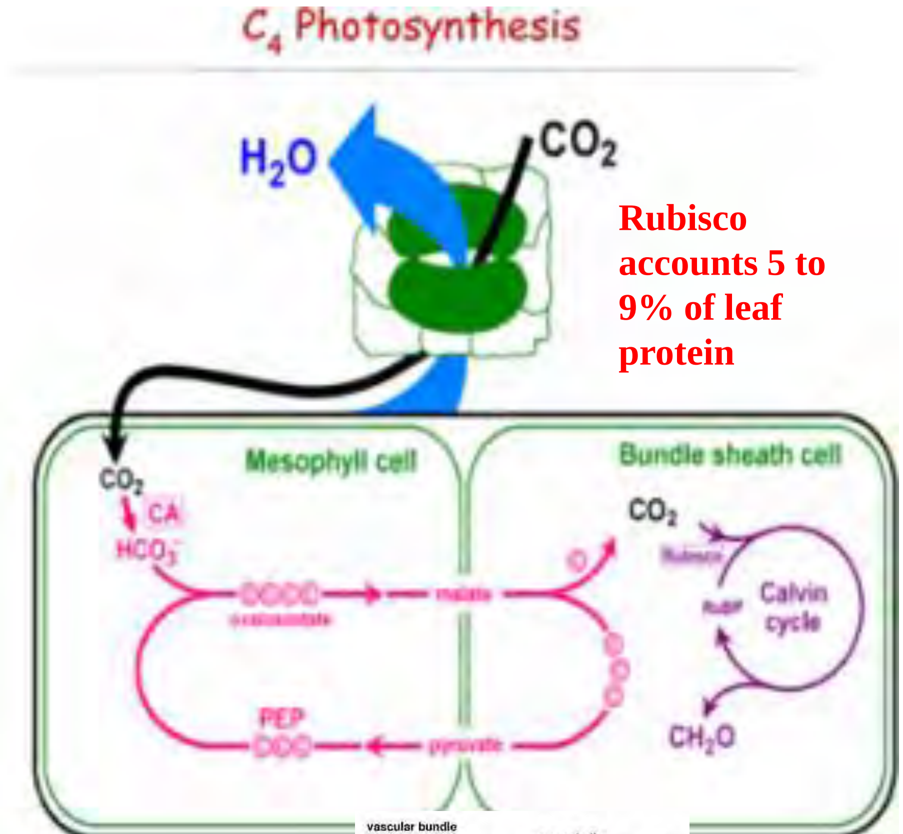


Can we apply cotton algorithms for other crops?

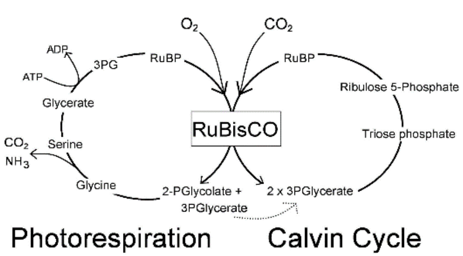
Why do they differ in their response to N

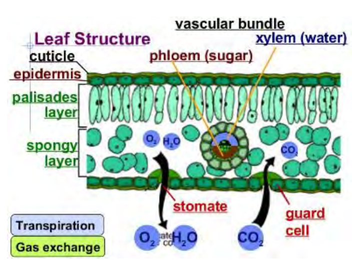
Rubisco accounts 20 to 30% of leaf protein

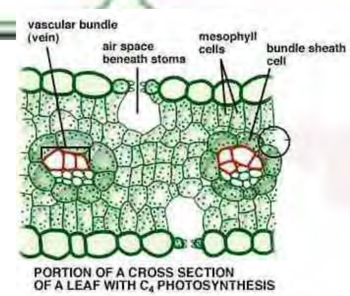




Rubisco accounts 5 to 9% of leaf protein

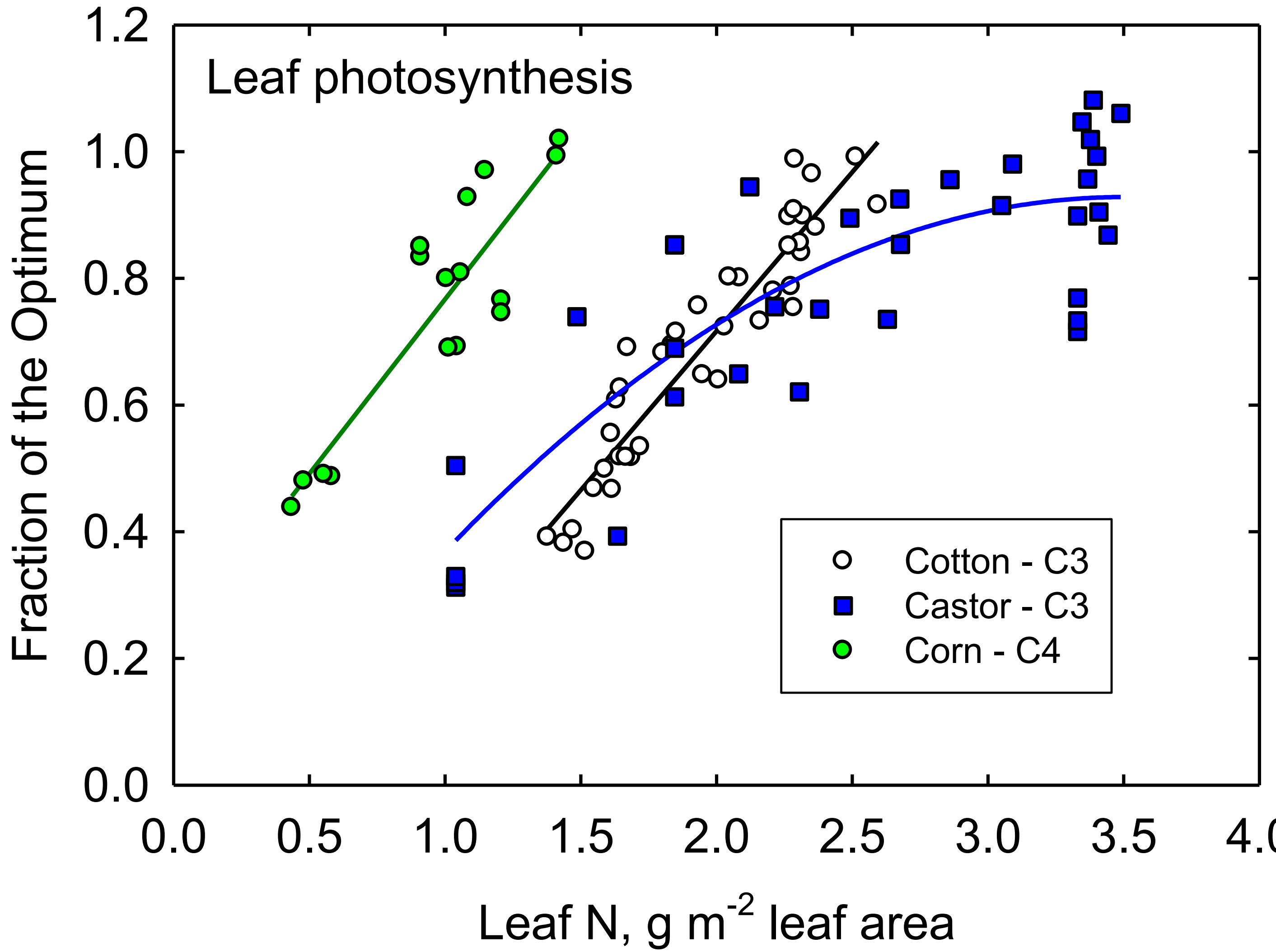






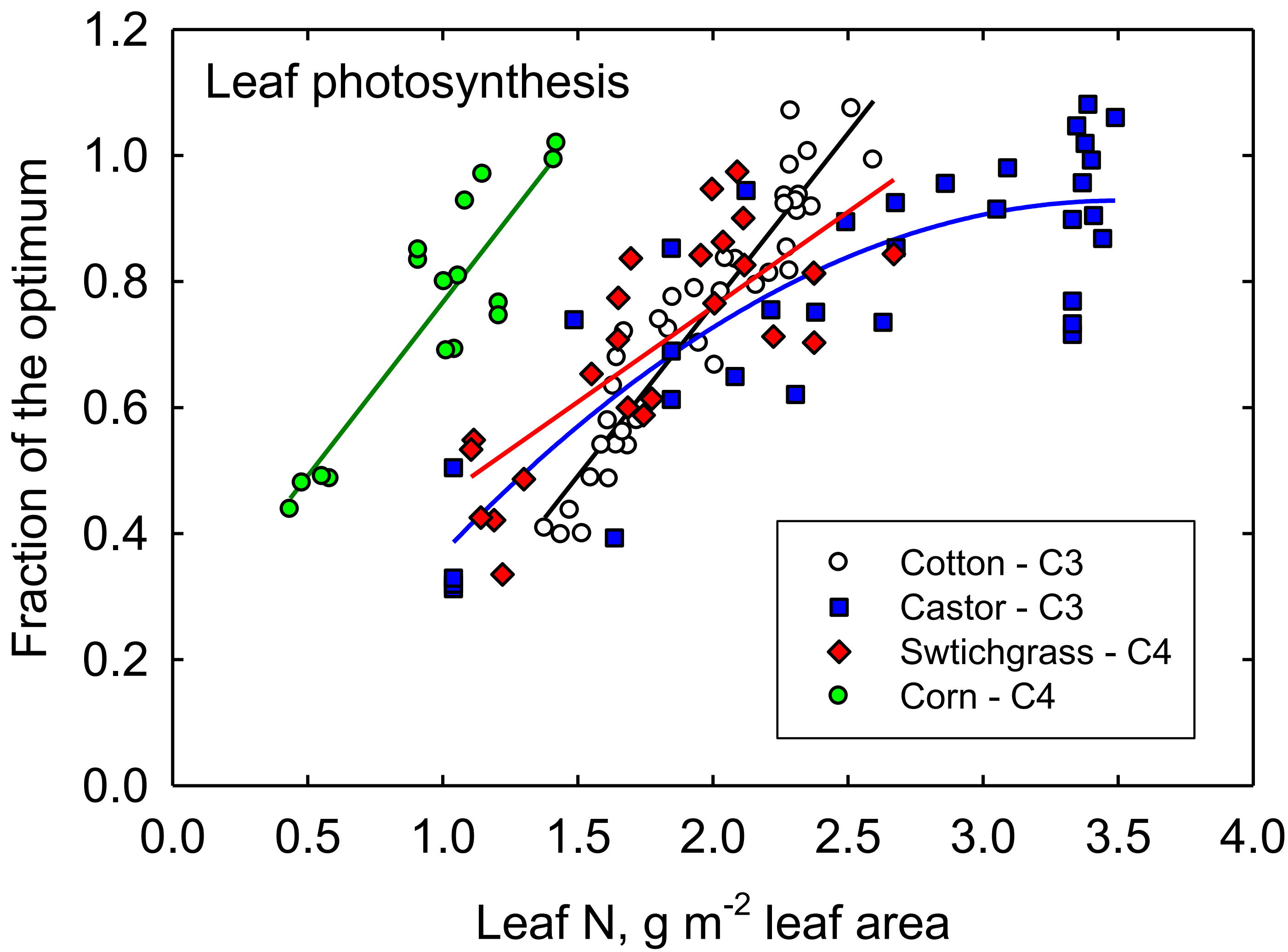
Can we apply cotton algorithms for other crops?

N and Photosynthesis – Several Crops



Can we apply cotton algorithms for other crops?

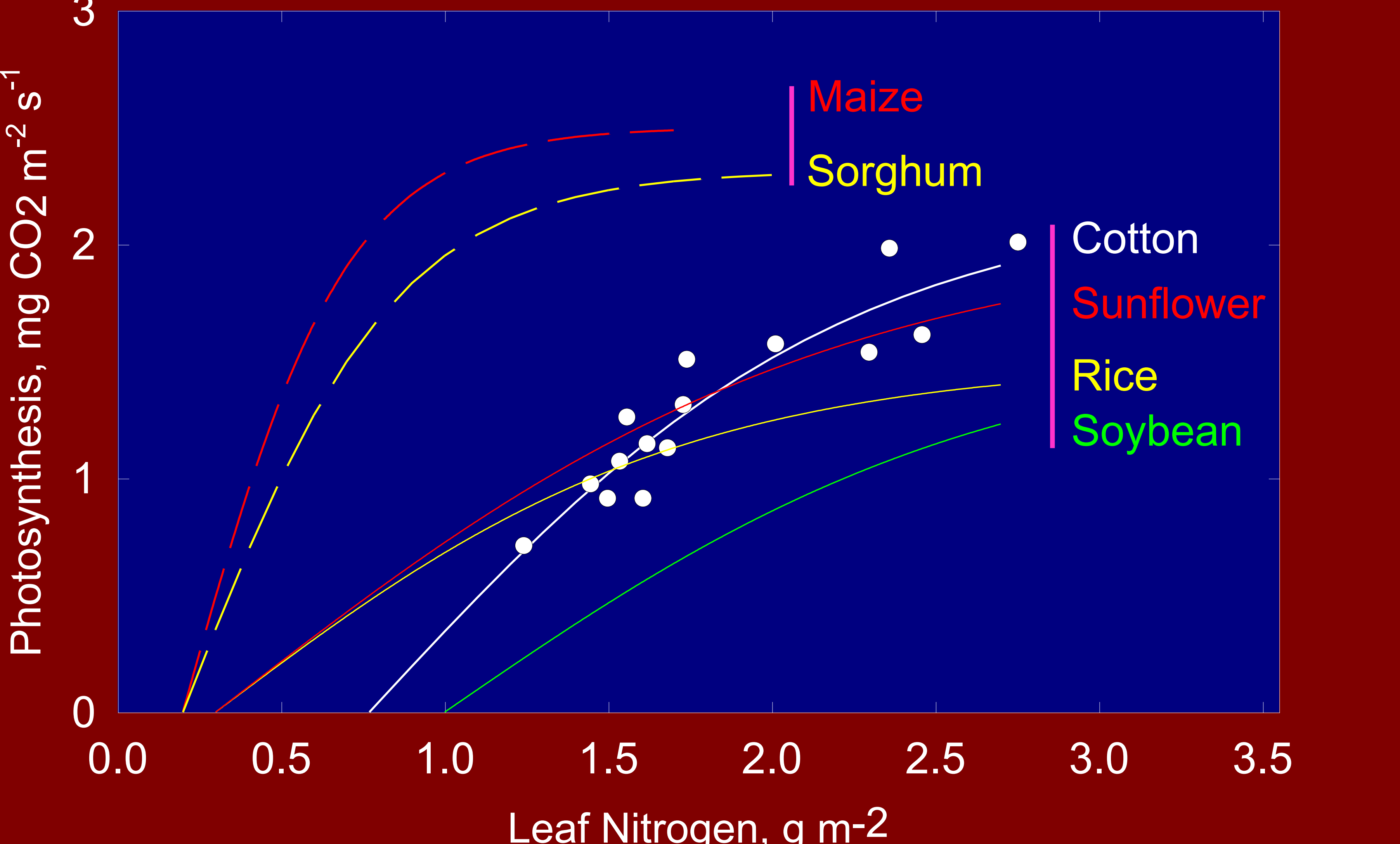
N and Photosynthesis – Several Crops



N-Deficient ⟷ N-Sufficient

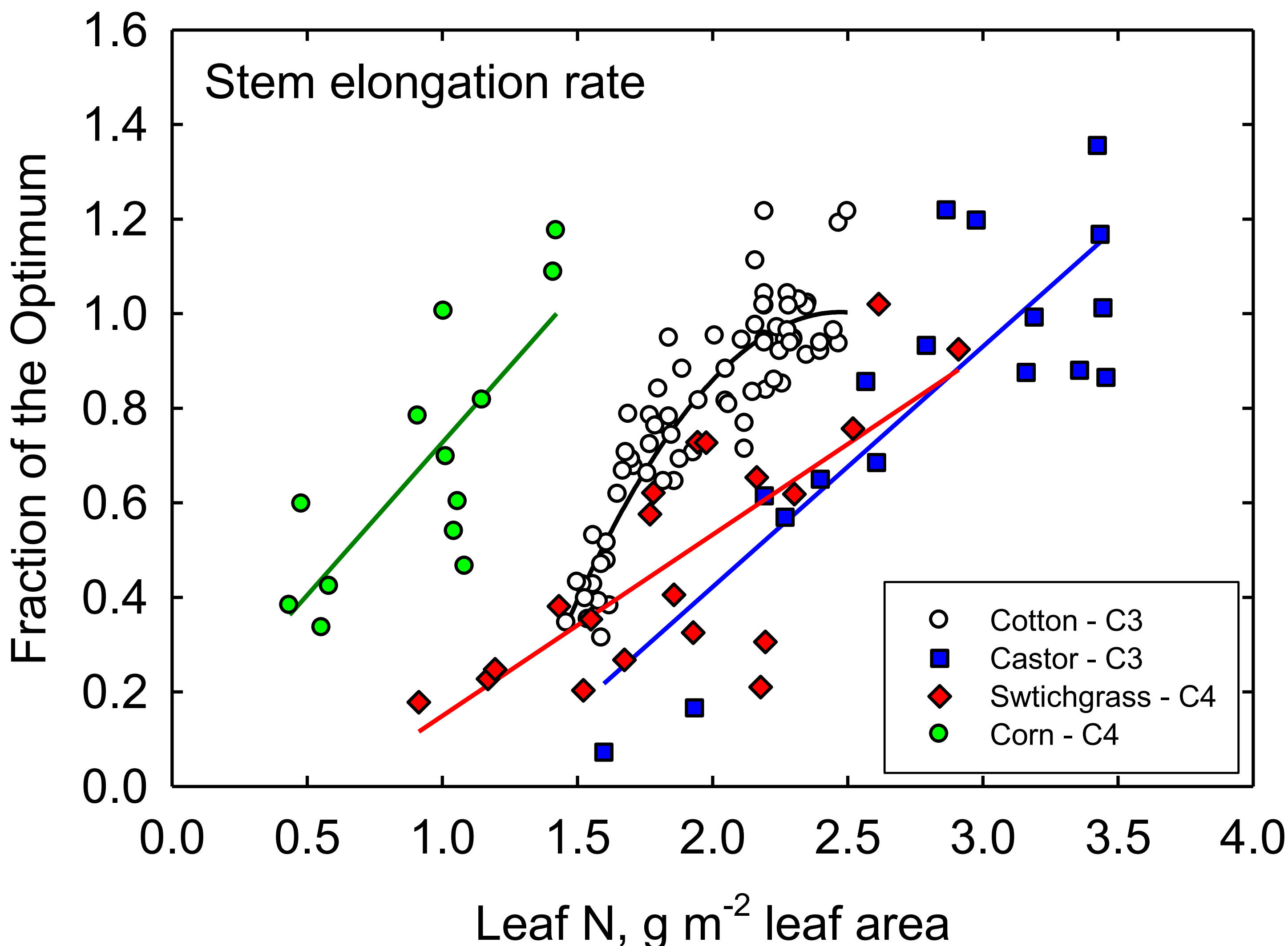
Photosynthesis - Variability Among Species

Response to Leaf Nitrogen



N-Deficient ⟷ N-Sufficient

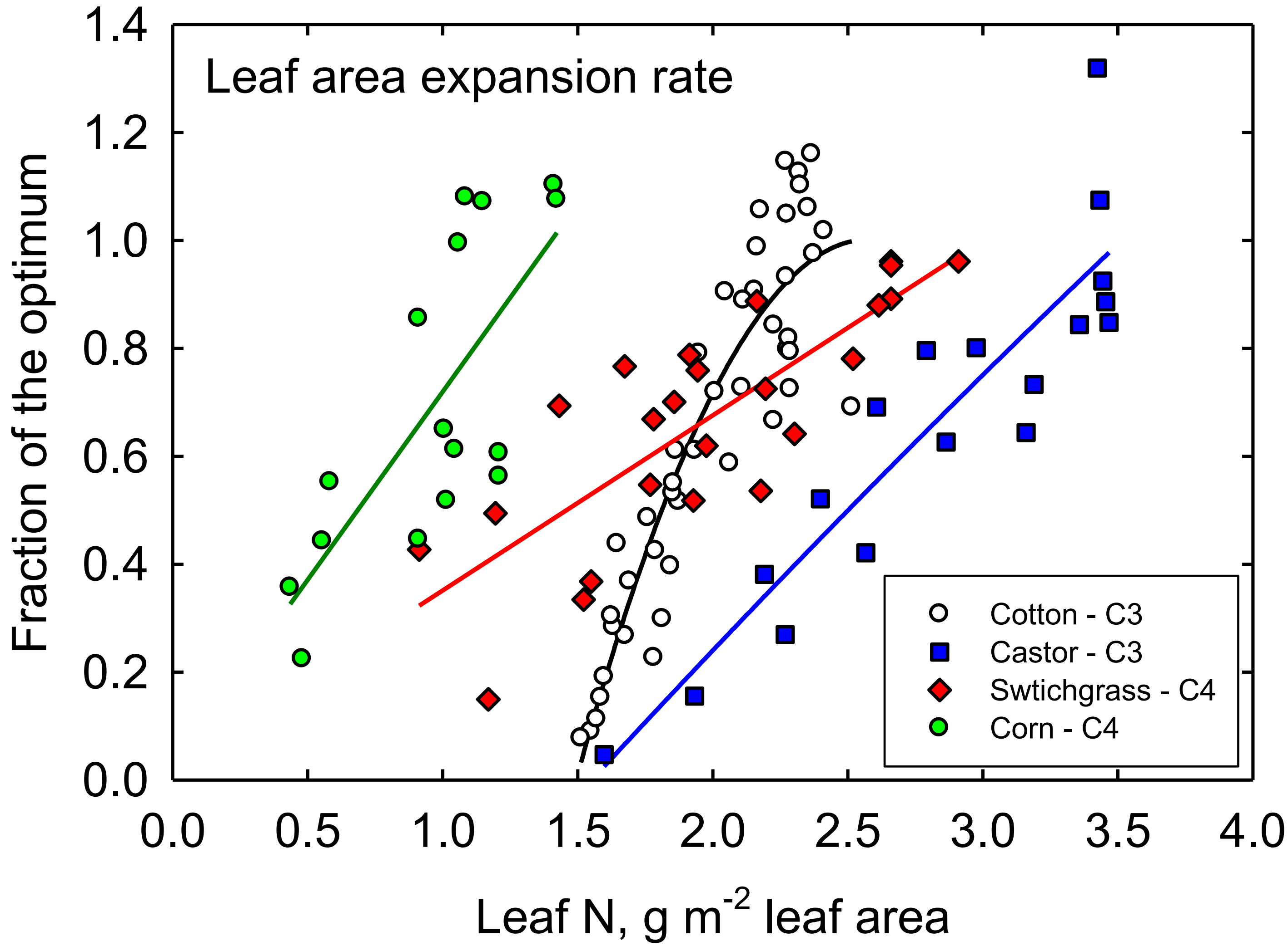
Can we apply cotton algorithms for other crops?



N-Deficient ⟷ N-Sufficient

Can we apply cotton algorithms for other crops?

N and several crops – Leaf area expansion rates



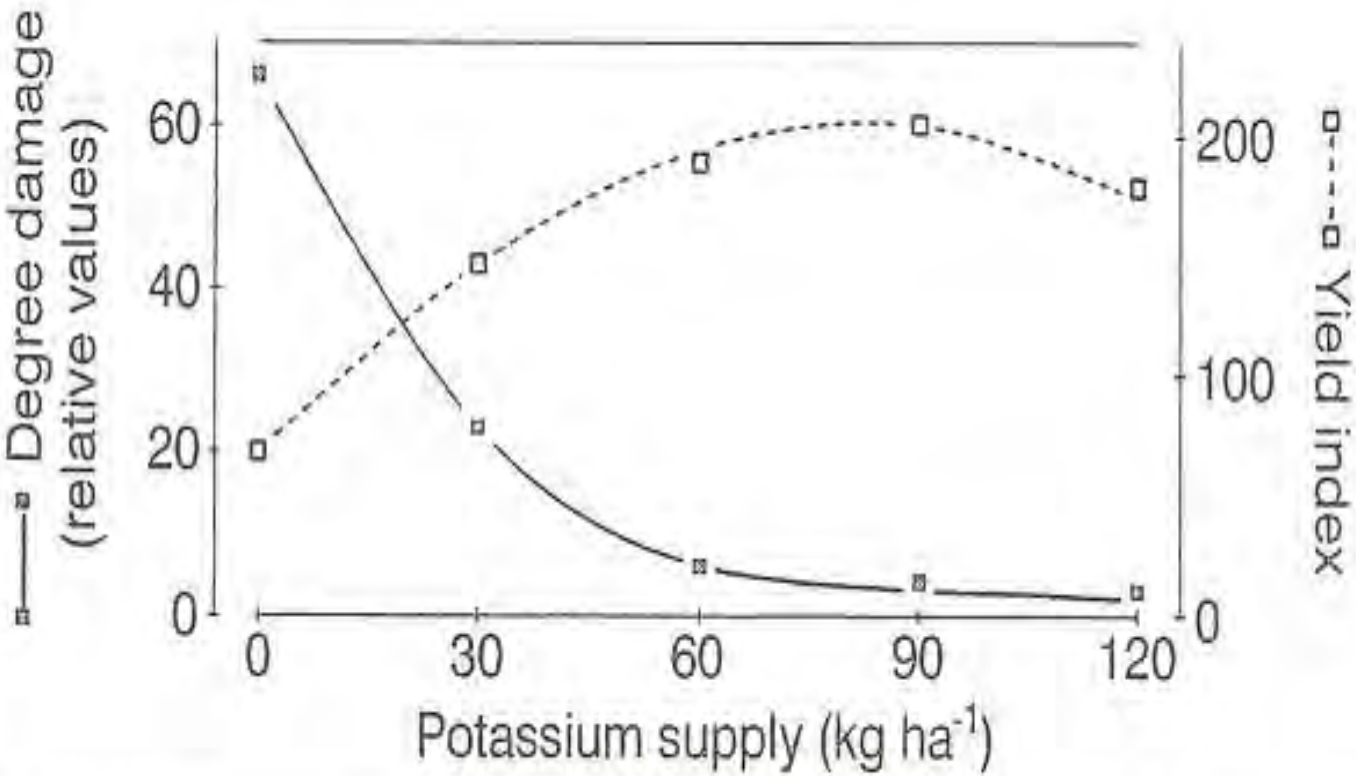
N-Deficient ⟷ N-Sufficient

Summary and Conclusions

Nitrogen Responses across Species and Processes

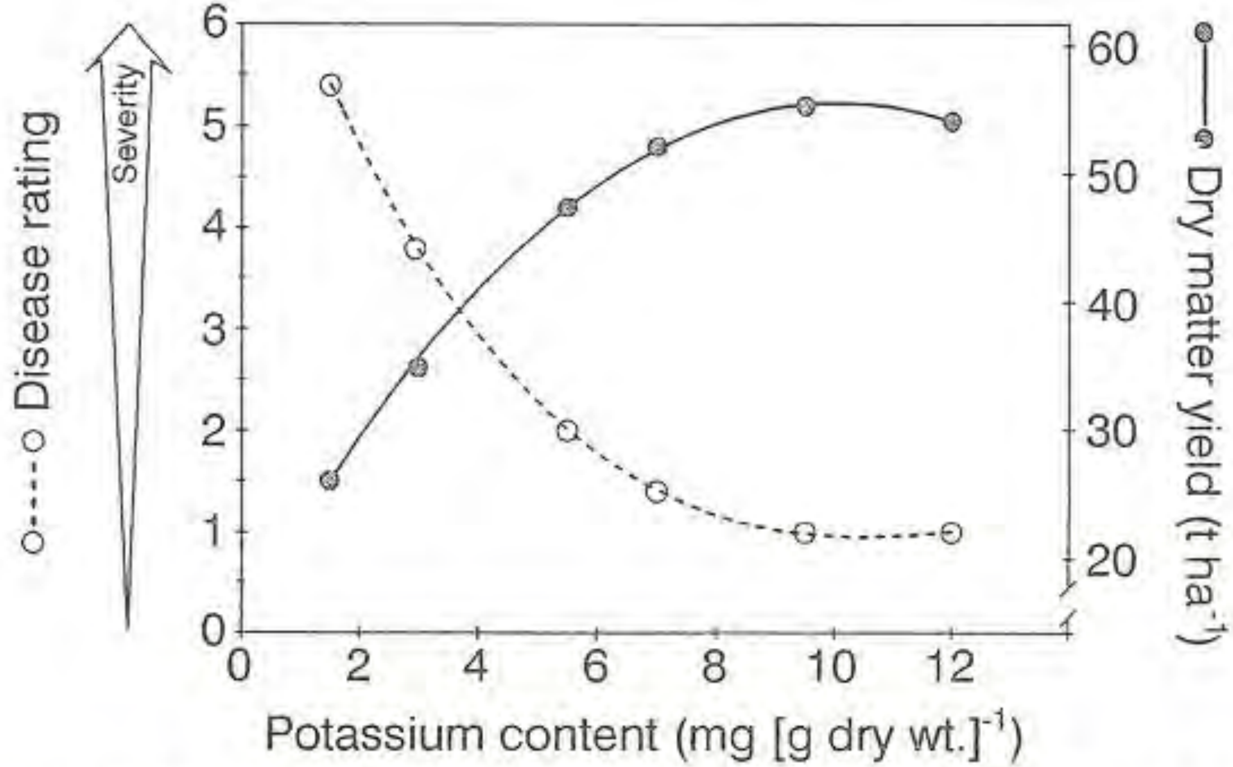
- Functional algorithms varied among crop species and even among crop species within a functional physiological group such as C_3 or C_4 species.
- Functional algorithms varied among crop processes for a given species.
- Among the growth, developmental and physiological processes, leaf growth was more responsive to leaf N than other processes in almost all crops.
- N also affects cell division and cell elongation process leading to a cascade of effects on several processes in plants, and finally yield.

Potassium Supply and Plant Growth



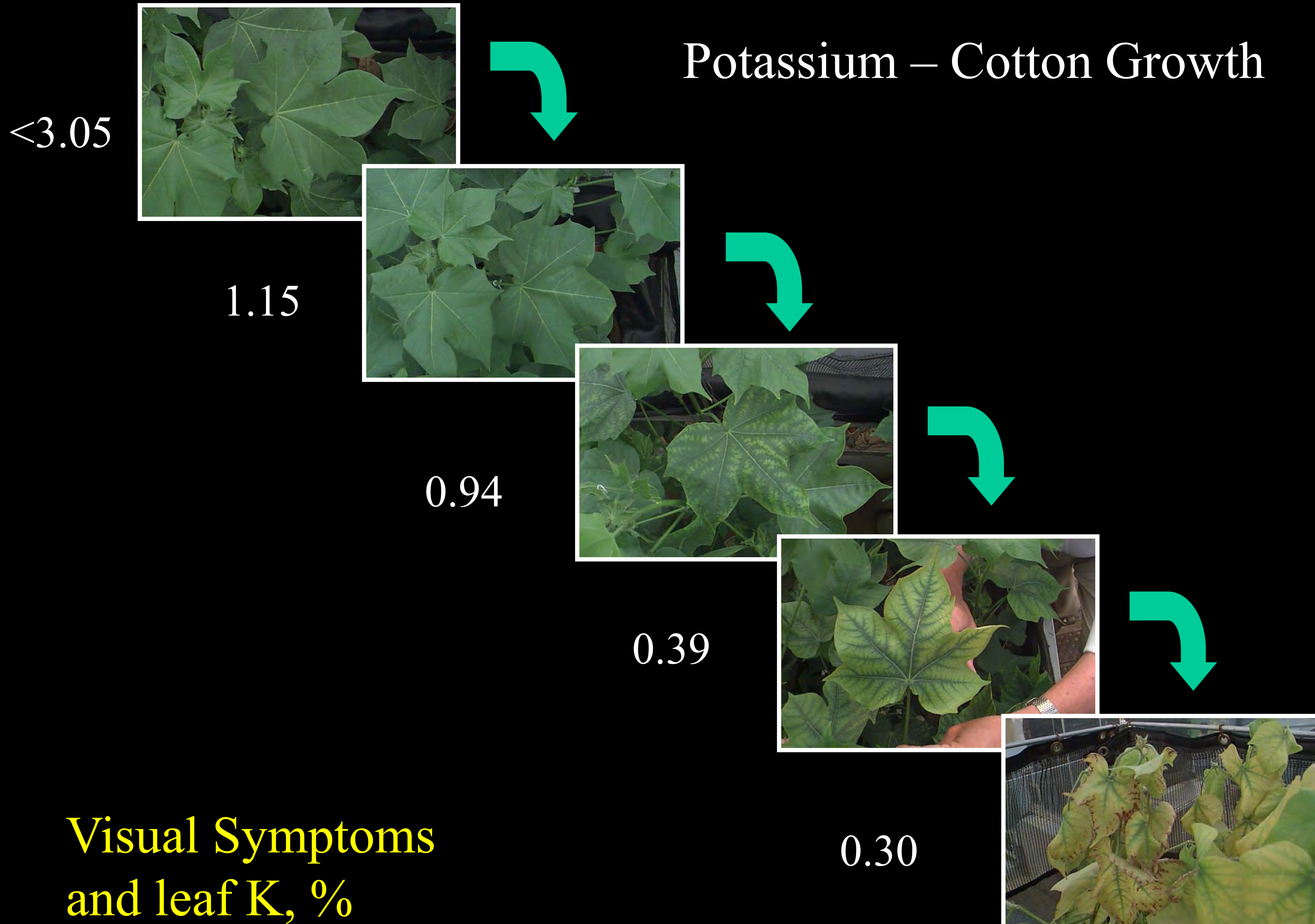
7 Effect of potassium supply on grain yield of wetland rice and incidence of stem rot ithosporium sigmoideum). Basal dressing of nitrogen and phosphorus constant at 120 and 60 kg ha^{-1}, respectively. (Based on Ismunadji, 1976.)

Potassium Supply and Plant Growth



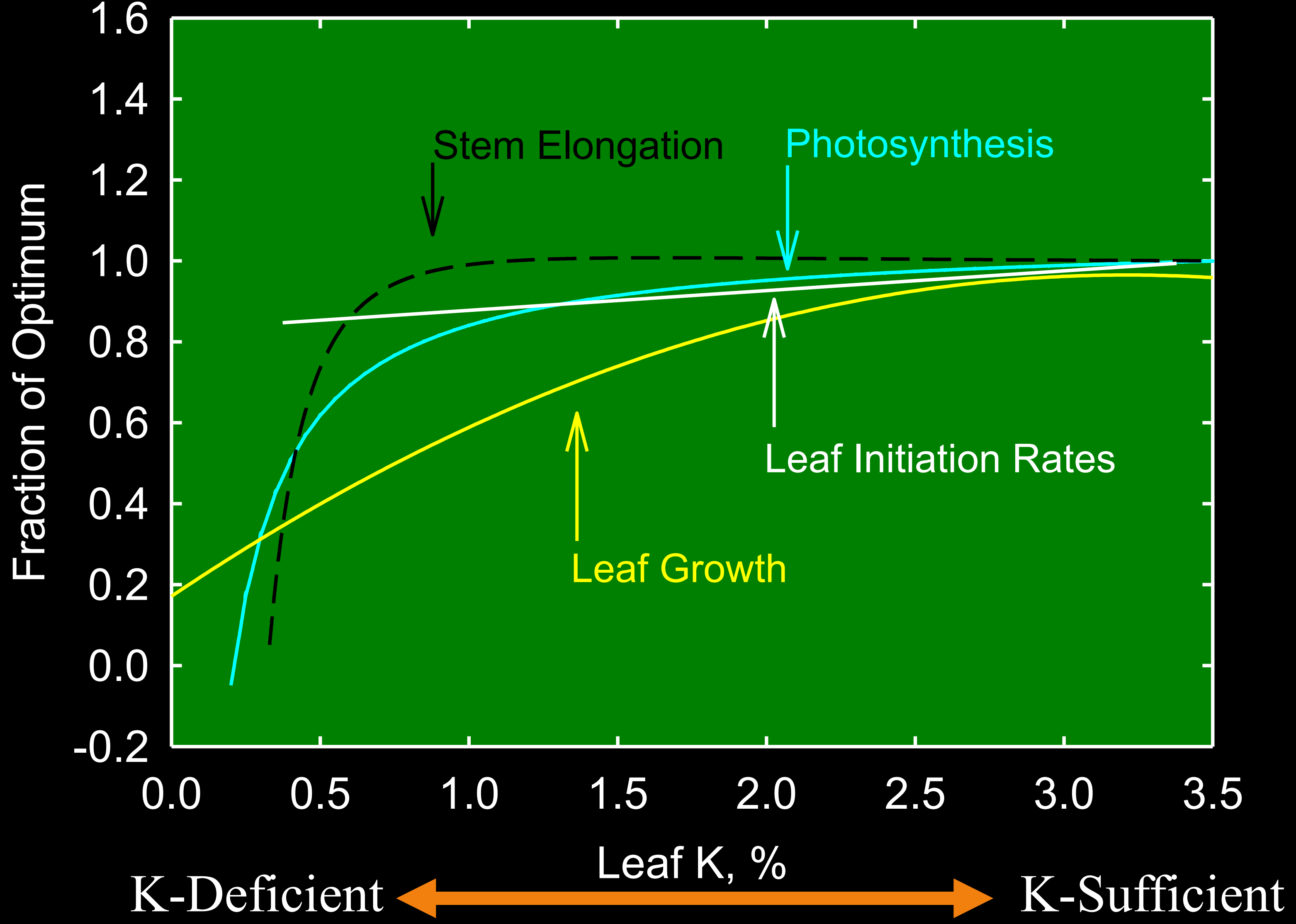
8 Severity of leaf spot disease (*Helminthosporium cynodontis*) and dry matter yield in l' bermudagrass (*Cynodon dactylon* L. Pers.) versus leaf potassium content. (Reproduced n Matocha and Smith, 1980, by permission of the American Society of Agronomy.)

Potassium – Cotton Growth



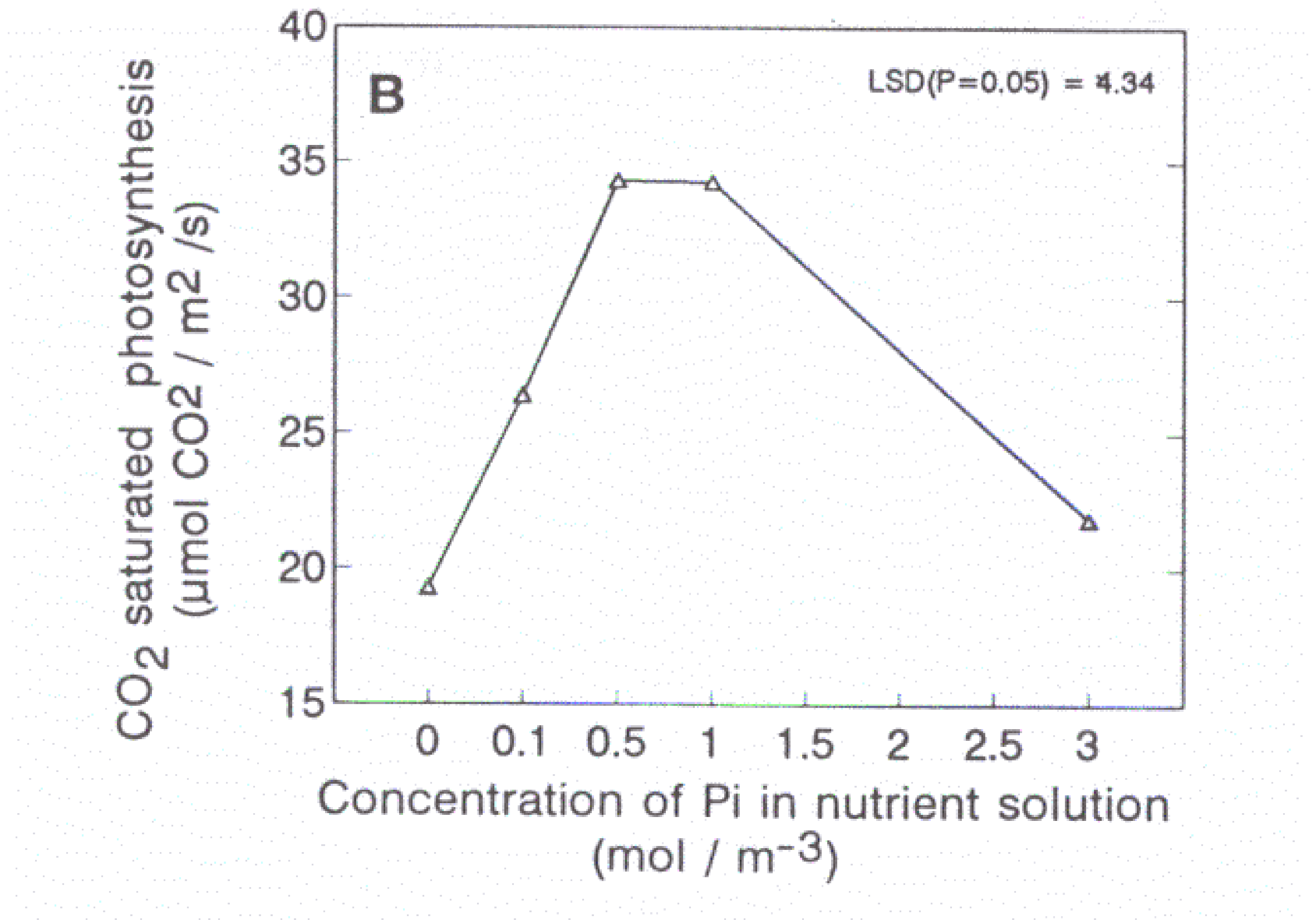
Visual Symptoms
and leaf K, %

Potassium and Cotton Growth and Development



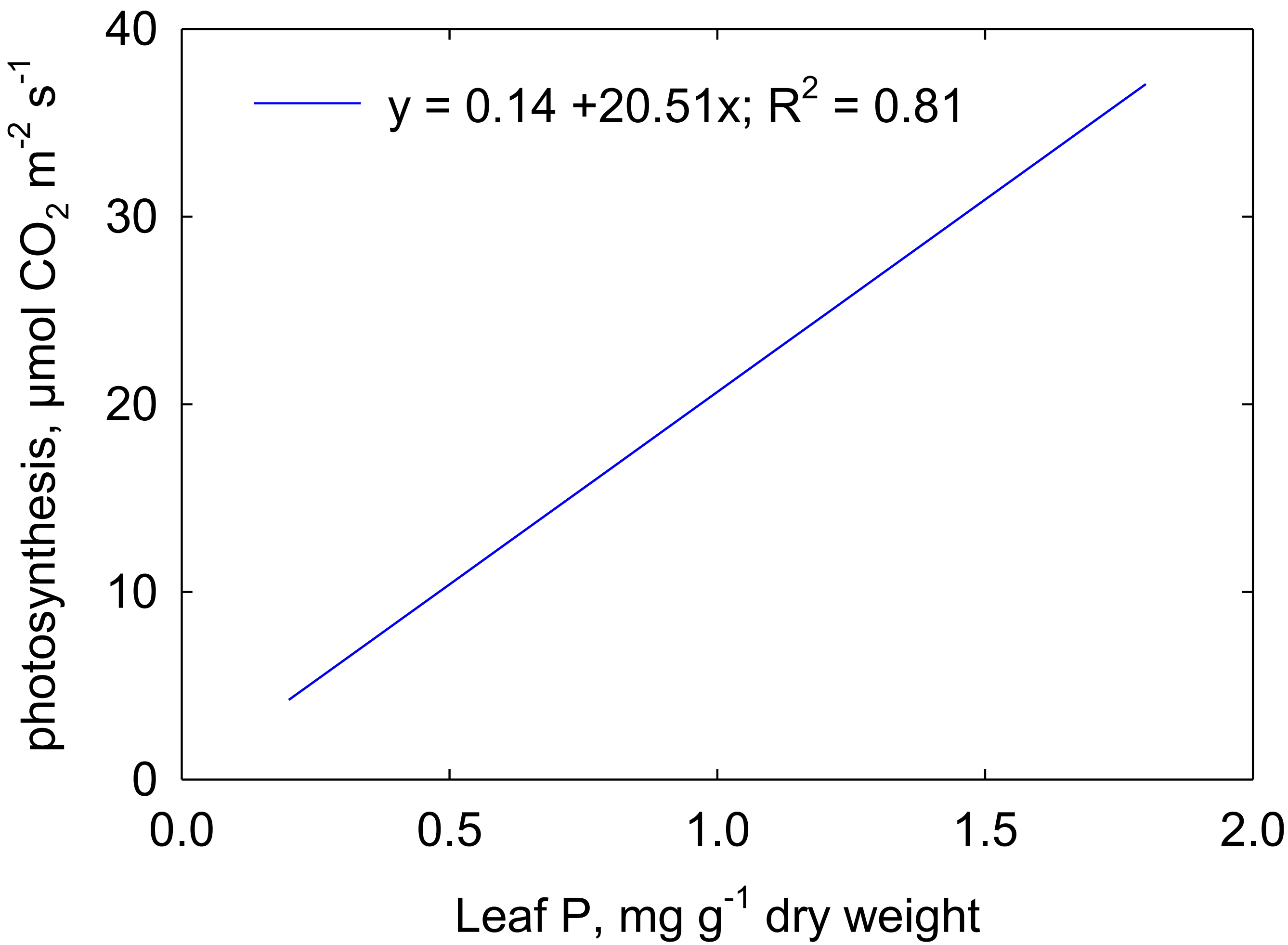
Photosynthesis and Environment

Response to phosphorus – Sub-to supra-optimal supply of Pi



Photosynthesis and Management

Response to Phosphorus Nutrition – Cotton



P-Deficient ⟷ P-Sufficient

Singh et al. 2013

Summary and Conclusions

Nutrient Responses across Species and Processes

- Functional algorithms or responses varied among crop species.
- Functional algorithms varied among crop processes for a given species.
- Similar to N effects, among the growth, developmental and physiological processes, leaf growth was more responsive to leaf K.
- The effects of P on various processes are less quantified to arrive a conclusion.