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)
The objectives of this lecture are to:

• Learn temporal trends in fertilizer usage (Major nutrients).

• Influence of major nutrients on plant growth and development.
Trends in U.S. Commercial Fertilizer Use
(Nitrogen, Potash and Phosphate)
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 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 diminishing 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 CO₂

![Graph showing the relationship between leaf nitrogen content and rate of leaf development under different CO₂ levels.](image-url)

- **X-axis**: Leaf Nitrogen, g m⁻²
- **Y-axis**: Rate of leaf development, 1/d⁻¹
- Different CO₂ levels indicated by filled circles (700 ppm) and open circles (350 ppm).
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 CO₂

RLER = Relative Leaf Expansion Rate

![Graph showing the relationship between leaf nitrogen and Relative Leaf Expansion Rate (RLER) for two CO₂ concentrations (350 ppm and 700 ppm)].
Nitrogen and Cotton Growth and Development

Stem elongation response to N and elevated CO$_2$

- Leaf Nitrogen, g m$^{-2}$
  - 1.25
  - 1.50
  - 1.75
  - 2.00
  - 2.25
  - 2.50
  - 2.75

- Stem Extension Rate, cm d$^{-1}$
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5

- Nitrogen levels:
  - 350 ppm
  - 700 ppm

Graph showing the relationship between leaf nitrogen and stem extension rate under different nitrogen and CO$_2$ treatments.
Nitrogen and Cotton Growth and Development

Stem Elongation Rate Response to N and elevated CO₂
Nitrogen and Cotton Growth and Development

Leaf photosynthetic response to N and elevated CO₂
Nitrogen and Cotton Growth and Development

Relative Rates of Photosynthesis

Relative Photosynthetic Rates vs. Leaf Nitrogen, g m\(^{-2}\)

- 700 ppm
- 350 ppm
Can we use one function for all processes in a given crop?

Functional relationships – cotton for growth and developmental processes

![Graph showing functional relationships between leaf nitrogen and growth processes.](image)

- Fraction of the Optimum
- Leaf Nitrogen, g m$^{-2}$ leaf area
- Leaf Growth
- Leaf Development
- Stem Growth
- Photosynthesis
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

Leaf photosynthesis

Leaf N, g m\(^{-2}\) leaf area

Fraction of the Optimum

- Cotton - C3
- Corn - C4
Can we apply cotton algorithms for other crops?

**N and Photosynthesis – Several Crops**

Leaf photosynthesis

**Leaf N, g m^{-2} leaf area**

Fraction of the Optimum

- Cotton - C3
- Castor - C3
- Corn - C4
Can we apply cotton algorithms for other crops?

N and Photosynthesis – Several Crops

Leaf photosynthesis

Leaf N, g m⁻² leaf area

Fraction of the optimum

- Cotton - C3
- Castor - C3
- Switchgrass - C4
- Corn - C4
Photosynthesis - Variability Among Species
Response to Leaf Nitrogen

Leaf Nitrogen, g m\(^{-2}\)

Photosynthesis, mg CO\(_2\) m\(^{-2}\) s\(^{-1}\)

Maize
Sorghum
Cotton
Sunflower
Rice
Soybean
Can we apply cotton algorithms for other crops?

**N and several crops – Stem elongation rates**

![Graph showing stem elongation rate vs. Leaf N, g m⁻² leaf area for various crops.](image)
Can we apply cotton algorithms for other crops?

N and several crops – Leaf area expansion rates

![Graph showing leaf area expansion rates for different crops.](image-url)
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.
Effect of potassium supply on grain yield of wetland rice and incidence of stem rot *Sphorium 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 `bermudagrass (Cynodon dactylon L. Pers.) versus leaf potassium content. (Reproduced in 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

Leaf K, %

Fraction of Optimum

Leaf Growth

Stem Elongation

Photosynthesis

Leaf Initiation Rates

Leaf K, %
Photosynthesis and Environment
Response to phosphorus – Sub-to supra-optimal supply of Pi
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.