



Environmental Factors

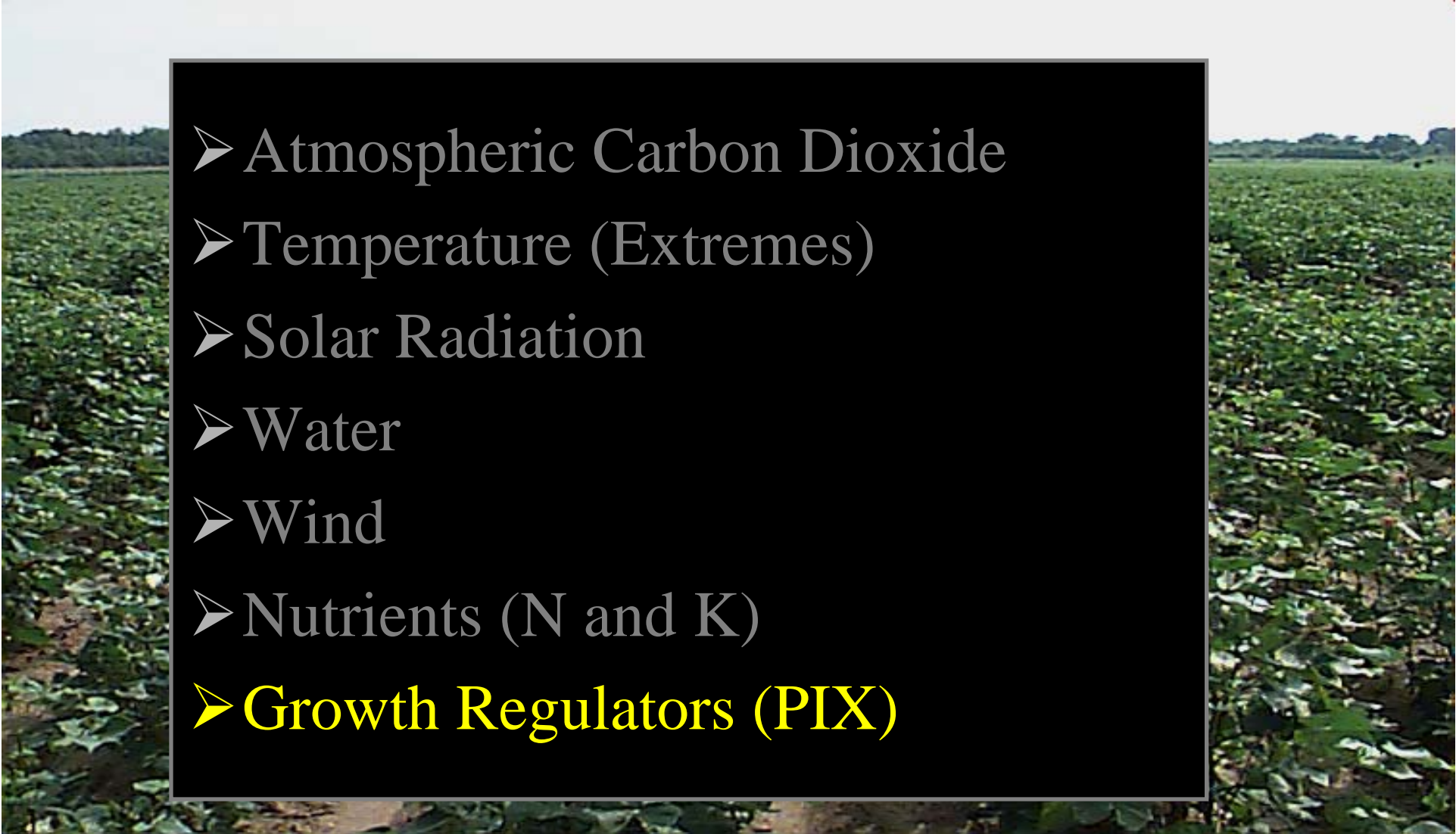
Special Topics – Mepiquat Chloride (PIX)

K. Raja Reddy

Krreddy@pss.msstate.edu



Environmental and Cultural Factors Limiting Potential Yields

- 
- Atmospheric Carbon Dioxide
 - Temperature (Extremes)
 - Solar Radiation
 - Water
 - Wind
 - Nutrients (N and K)
 - **Growth Regulators (PIX)**

Developing and Validating a Model for a Plant Growth Regulator

Developing and Validating a Model for a Plant Growth Regulator

We will explore:

- Why do we need models?
- Demand for crop models
- Timeline for information flow
- Developing and validating a plant growth regulator model:
 - Background information on MC.
 - Exploring primary effects of MC on cotton
 - Designing the critical experiment to quantify the responses
 - Developing a model
 - Validating or testing the model in the real world situations

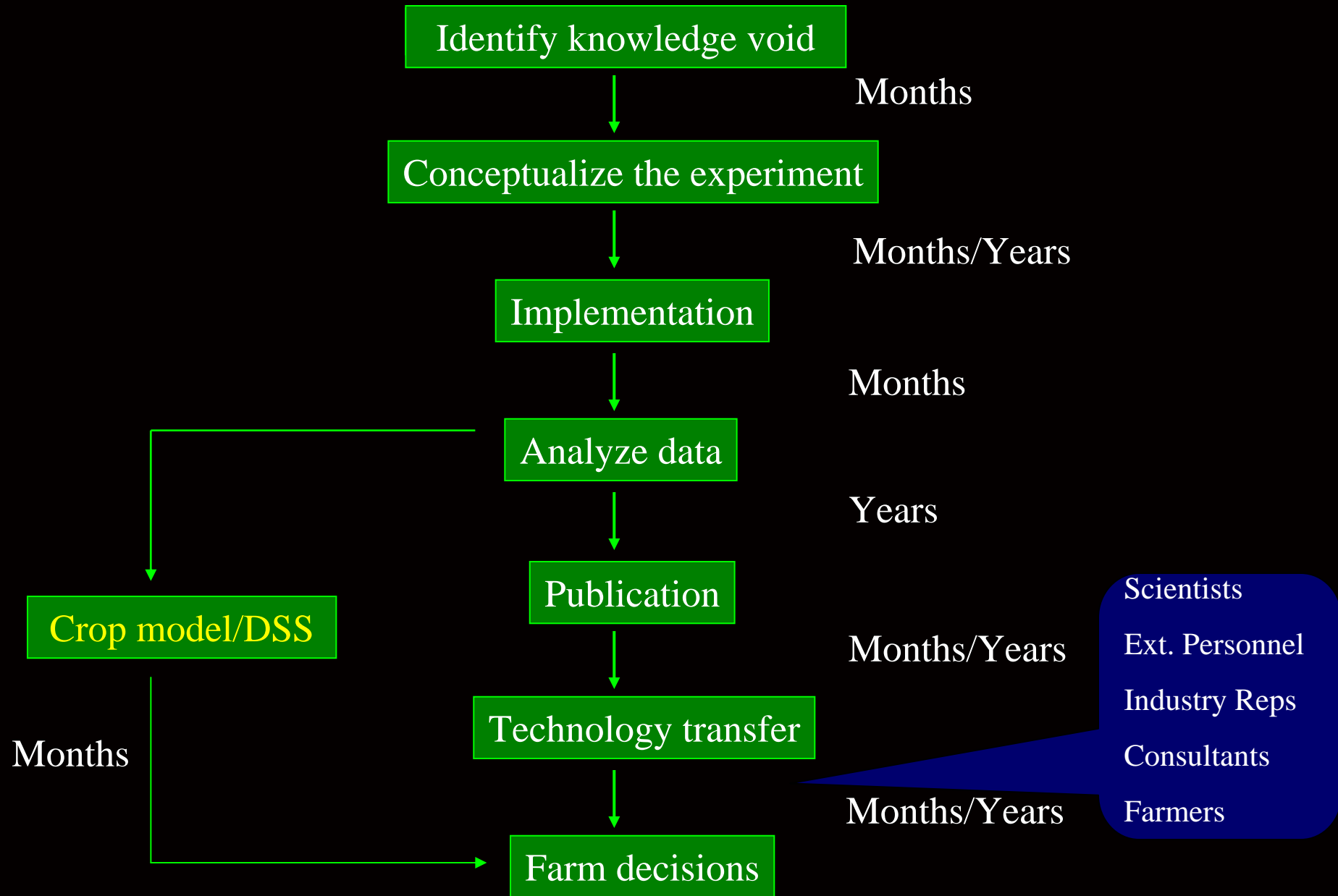
Why do we need models?

- Provide quantitative description and understanding of biological problems.
- Help pinpoint where knowledge is lacking.
- Design critical experiments.
- Synthesize knowledge about different components of a system.
- Summarize data.
- Transfer research results to users.

Demand for Crop Models

- **Farm management** (e.g. irrigation, fertilization and harvest scheduling).
- **Resource management** (e.g. several Govt. agencies and private comp. use)
- **Policy analysis** (e.g. the USDA funds for soil and conservation activities based on estimates of the USLE, $A = R * K * LS * C * P$), where A = average annual soil loss, R = rainfall and runoff factor, K = soil erodibility factor, LS = slope and steepness factor, C = cropping-management factor, and P = erosion control management factor.
- **Production forecasts** (e.g. global, regional and local forecasts).
- **Research and development** (e.g. research priorities and guide fund allocations)
- **Turning information into knowledge** (e.g. recently, information overflow is there virtually in every area including agricultural research).

Timeline for Information Flow



Timeline for Information Flow

Results



Researcher

Ext. Personnel

DSS

Reports

Box: 1

Box: 1

Specify conditions

Box: 1

Reports

Box: 1

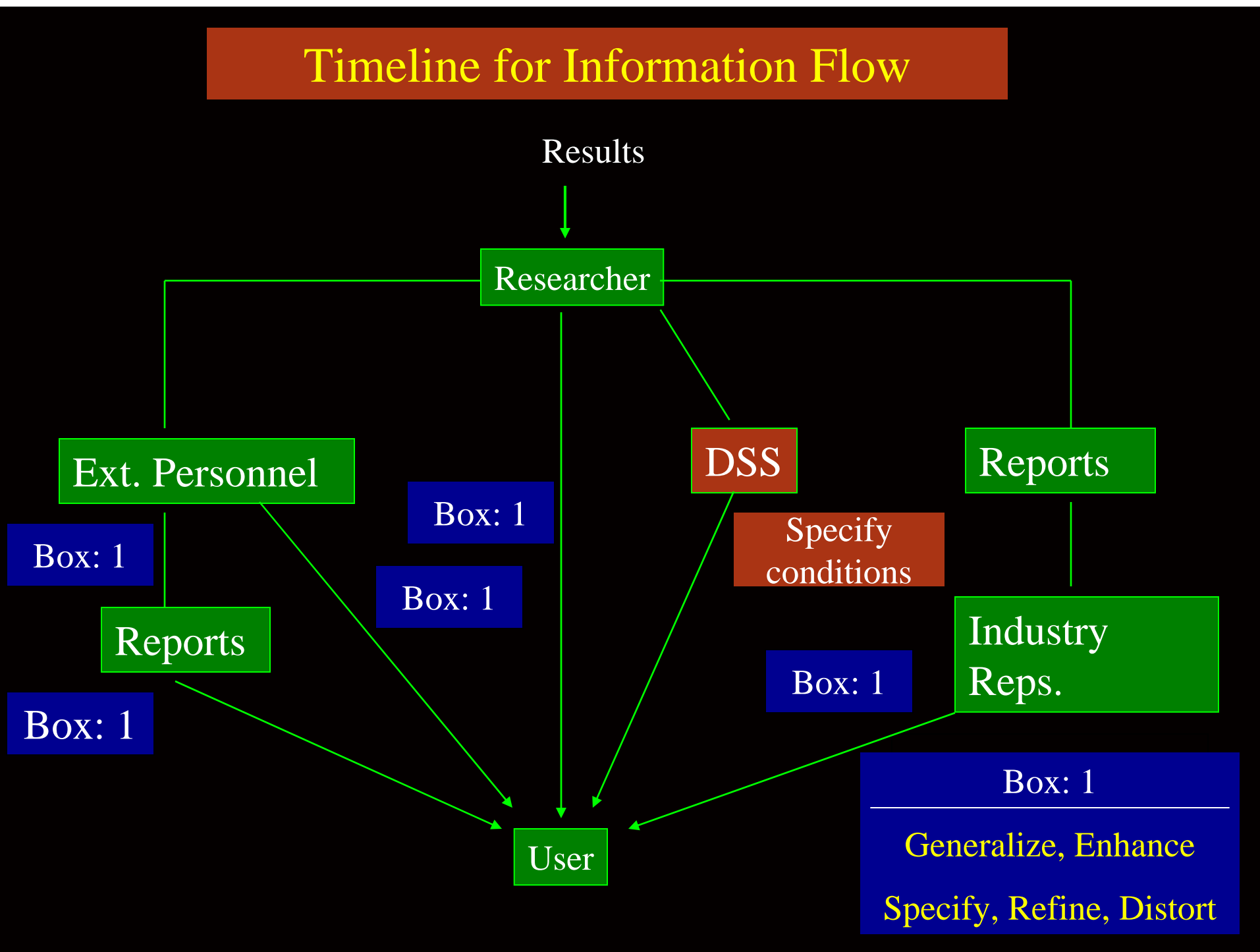
Industry Reps.

Box: 1

Box: 1

User

Generalize, Enhance
Specify, Refine, Distort



Plant Growth Regulators in Agriculture

Introduction and Background

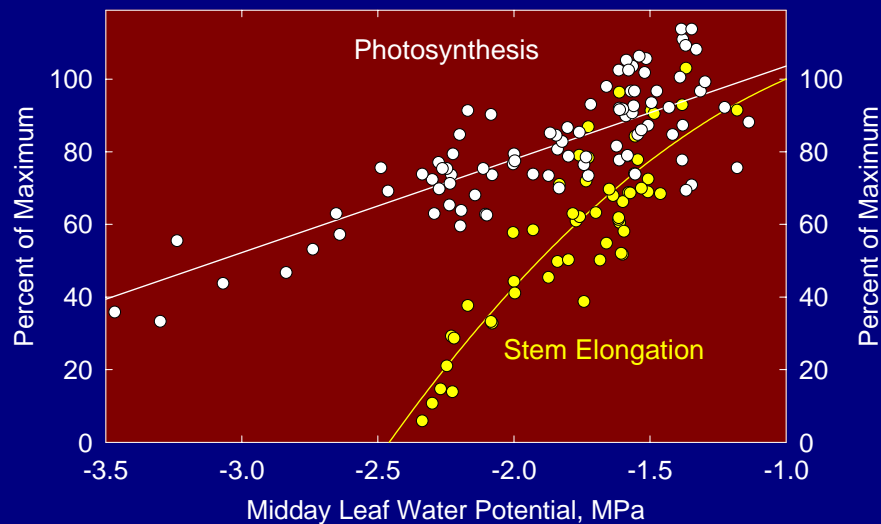
Control of vegetative growth is a goal of many cotton growers, particularly in irrigated and well-fertilized production systems.

Plant Growth Regulators in Agriculture

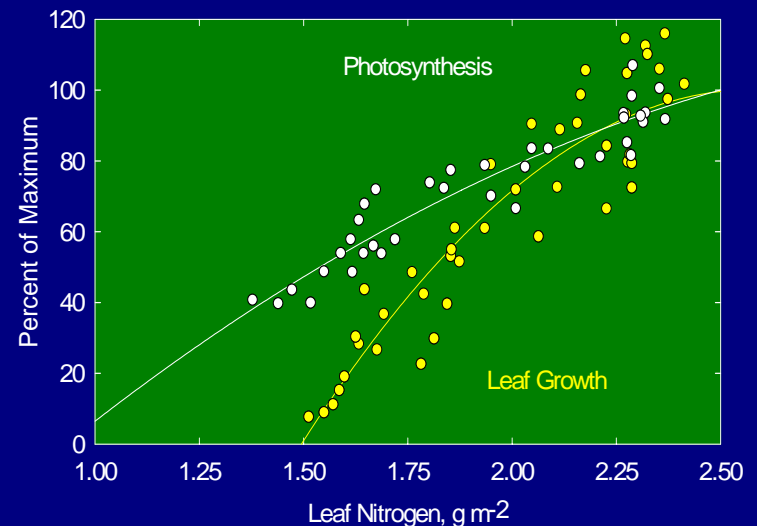
Introduction and Background

Growth control through stressing the crop (water or nutrients) has been shown to limit yield potential.

Photosynthesis, Vegetative Growth - Environment
Response to Drought



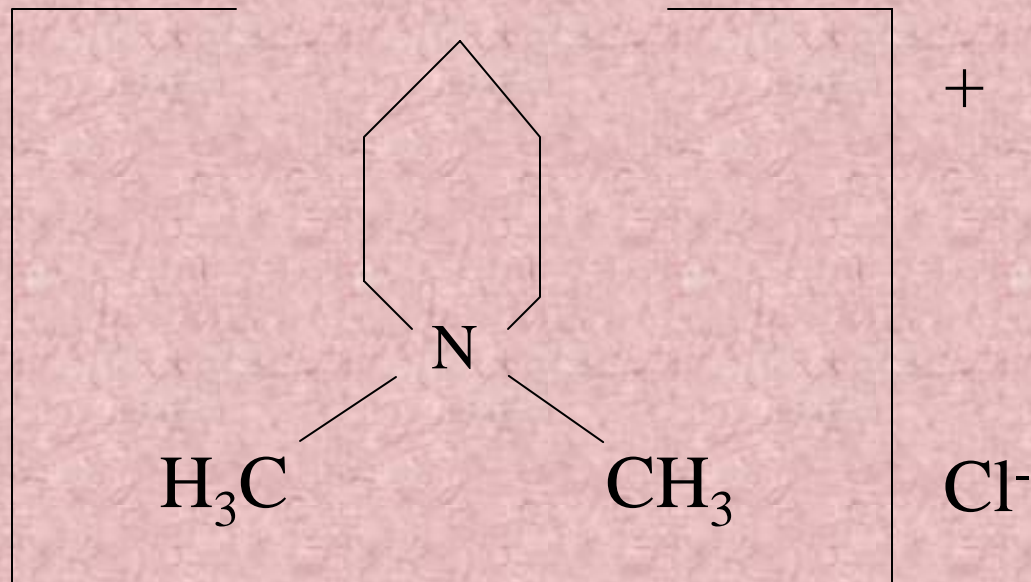
Photosynthesis, Vegetative Growth - Environment
Response to Fertilization - Nitrogen



Plant Growth Regulators in Agriculture

Introduction and Background

- Pix or Mepiquat chloride provides the cotton producer a tool to achieve proper balance between vegetative growth and reproductive growth without without limiting yield potential.
- Mepiquat chloride or PIX contains the active ingredient 1, 1 dimethylepiperidium chloride.



Plant Growth Regulators in Agriculture

Introduction and Background

- MC is included in the group of chemicals of inhibitors of the biosynthesis of gibberlic acid.
- The chemical is taken up mainly by the green parts of the plant.
- It is systemic in nature, and is translocated both upwards and downwards through both xylem and phloem.
- It is very stable in the plant tissue, and is lost only due to, or along with, abscission of plant parts.

Plant Growth Regulators in Agriculture

Introduction and Background

- Many studies were conducted for the last two to three decades on MC and its effects on cotton growth and development.
- These studies have shown that MC suppresses vegetative growth by shortening the internodes and thus affecting plant height, and reducing the number of nodes and leaf area and photosynthesis.
- Yield responses to MC however, were inconsistent; from increases to no effect to decreases.

Pix was applied at match-head square.

Pictures and plant height were taken 4 weeks after treatment.

All treatments were well-watered and well-fertilized.



No PIX

16 oz PIX/a

Height, 56 in

33 in

Plant Growth Regulators in Agriculture

Introduction and Background

- These erratic yield responses to MC are probably due to many reasons.
- Amounts and timing of application of the chemical depend on plant size, growth rate, and changing growing conditions caused by unpredictable weather after the chemical application.

Developing a Model for Plant Growth Regulator

Requirements:

1. Quantitative information on the effects of MC on cotton.
2. A simulation model that can provide cotton responses to environmental and management practices.

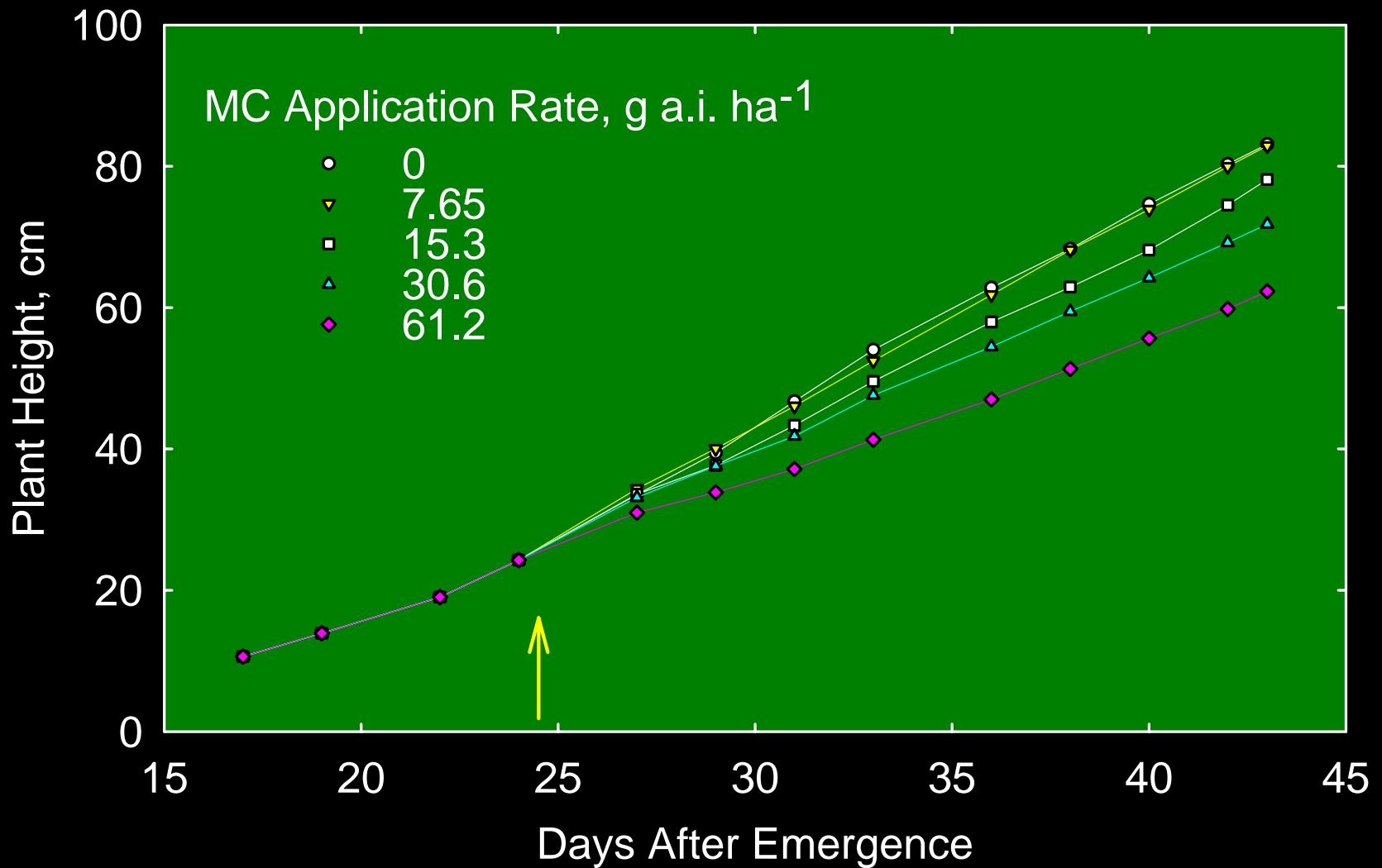
Designing that Critical Experiment

- We need an experiment where other environmental factors that limit the responses of crop growth should be eliminated or controlled.
- All treatments should be well-watered and well-fertilized. Also, the radiation and temperatures should be ideal for cotton growth.
- We also need to conduct the experiment where we should also minimize the competition from within the plant processes such as supply and demand.
- In other words, the experiment should be conducted when the crop growth is linear and when the sink demand is minimal.

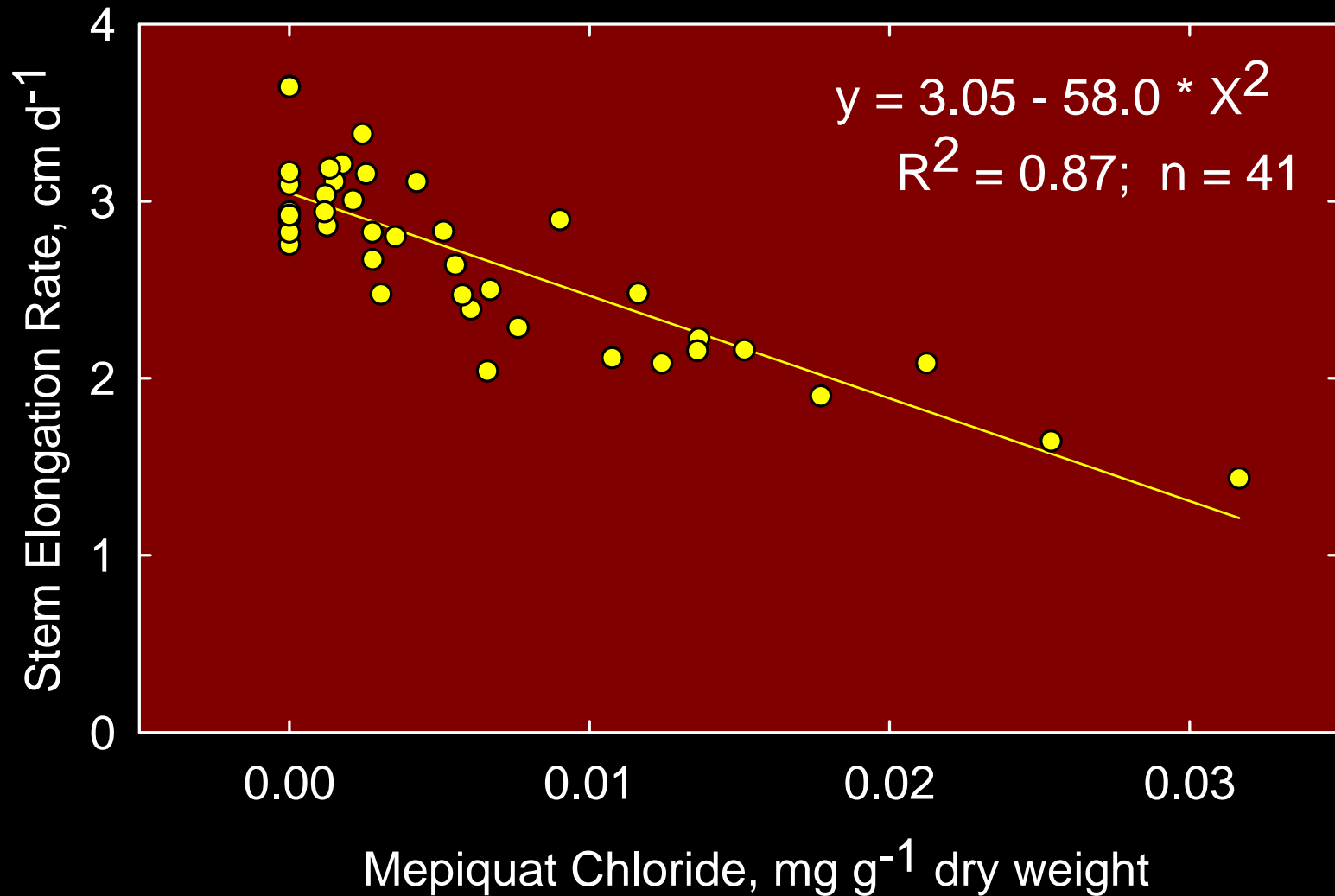
Designing that Critical Experiment

- We need to apply several concentrations of MC to cover a wide range that can account for even the multiple applications of MC in the field situations
- We need to collect whole plant dry weights regularly to calculate MC concentration on a tissue dry weight basis.
- We also need to collect the primary cotton responses to MC more frequently to generate rate parameters as functions of MC in the tissue.

Mepiquat Chloride - Cotton Growth Temporal Trends in Plant Height

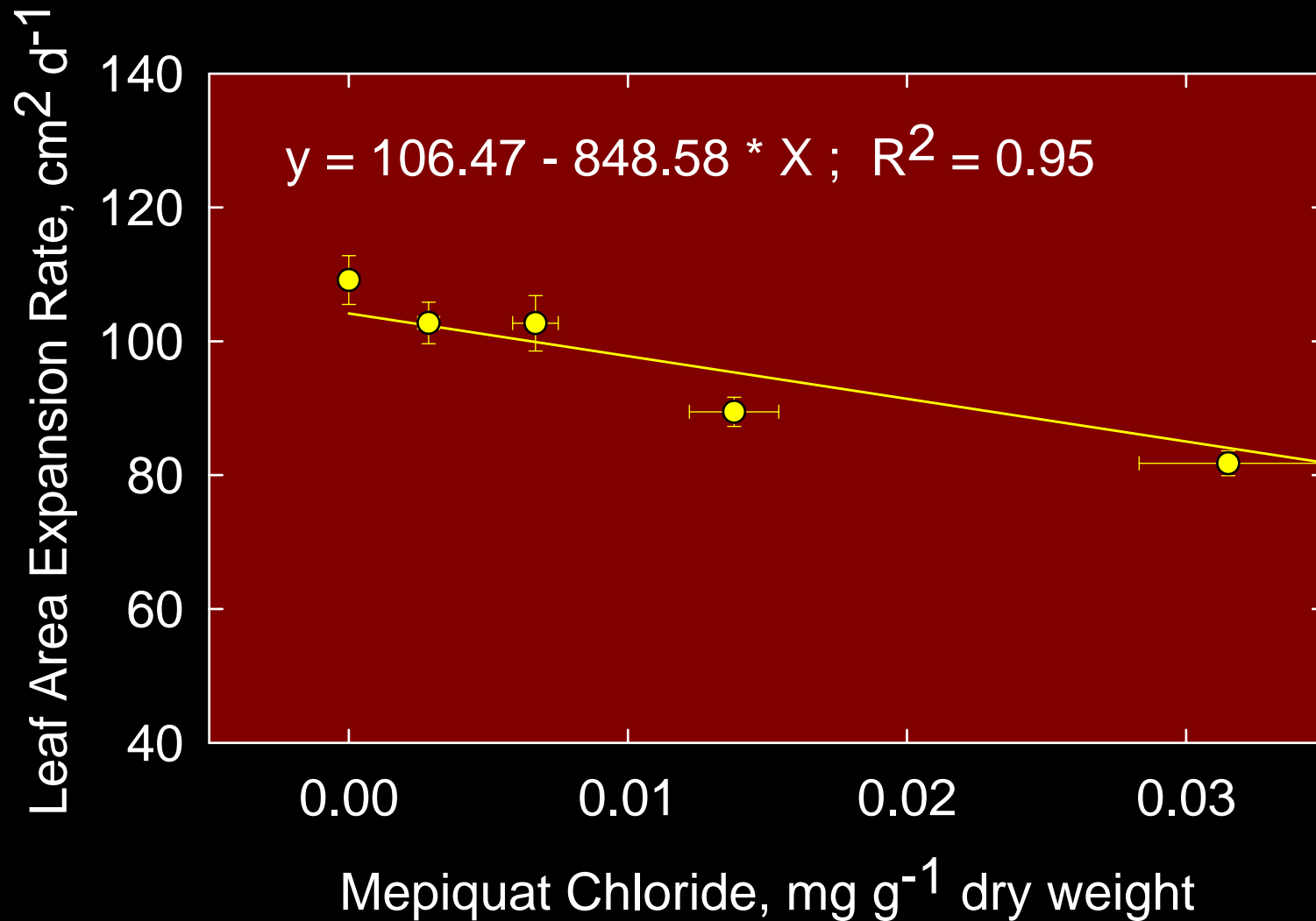


Mepiquat Chloride - Cotton Growth Plant Height - Stem Extension Rate

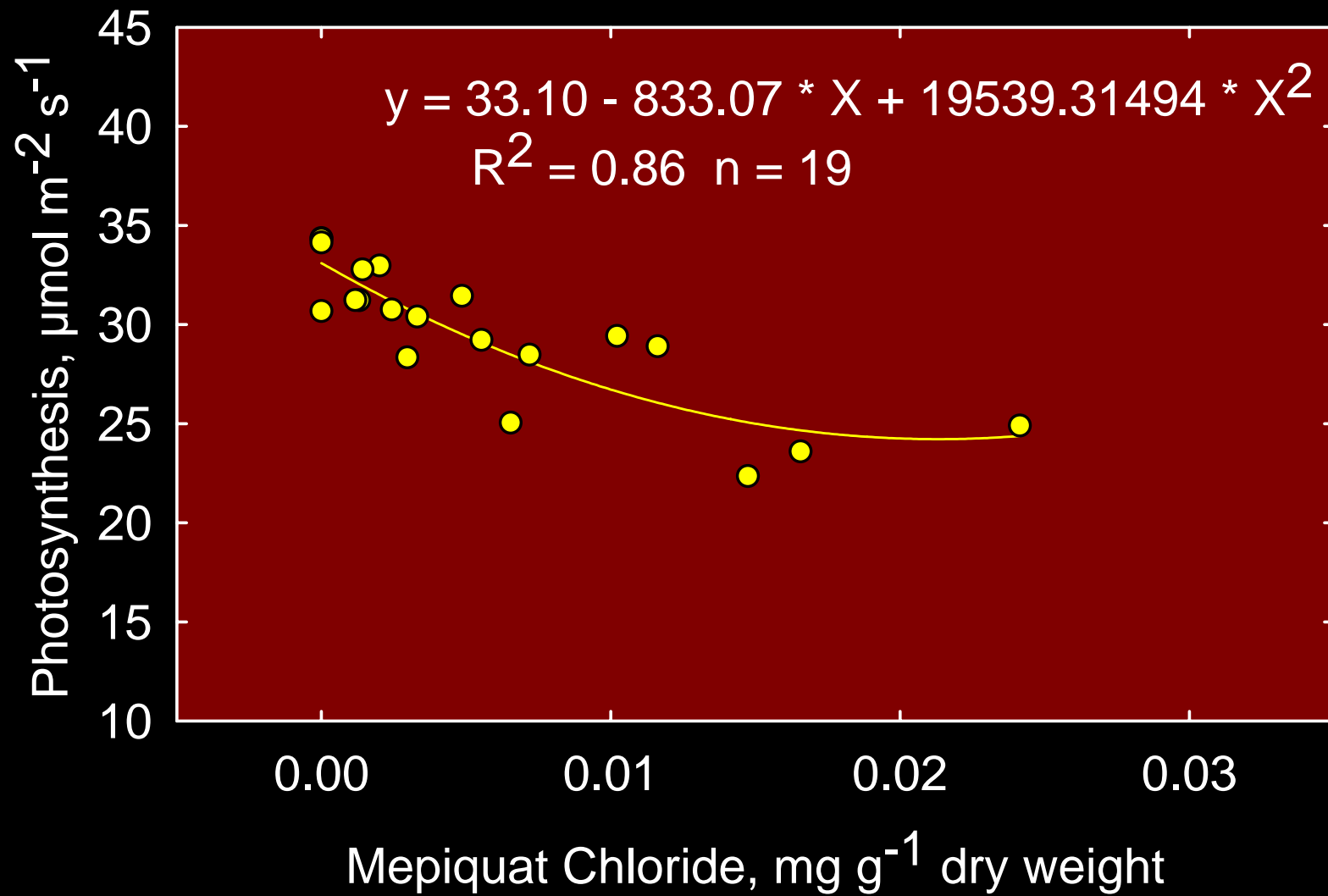


Mepiquat Chloride - Cotton Growth

Leaf Area Development



Mepiquat Chloride - Cotton Growth Photosynthetic Rate



Model Development

We assumed that MC:

- enters the plant through leaves.
- systemic in nature and moves freely throughout the plant (O'Neal., 1988)
- will be lost only due to abscission of plant parts or root death.
- no interaction between water deficits and MC, and cultivars respond similarly to MC (Reddy et al., 1992, Fernandez et al., 1992, Schott and Schroeder, 1979).

Calculation of MC in the Plant

- When MC is applied, the simulation model, GOSSYM, calculates the amount of the chemical intercepted by the plant canopy based on the method of application.
- If the chemical is applied as broadcast method, the amount of the chemical intercepted by the canopy is calculated based on the light interception algorithms developed by Baker et al. (1978).
- If the MC is applied as a banded application on the top of the row, then the intercepted chemical is assumed to be 90% of the applied chemical.
- If MC is applied on the crop previously treated with MC, then the amount of the chemical is added to any of the existing concentration and the number of applications are updated and summed.

Calculation of MC in the Plant

The simulation model, GOSSYM, is used to calculate plant dry weight and weight loss due to abscission of plant parts and root sloughing on a daily basis.

$$\text{MCLOS} = \text{DEADWT} * \text{MCCON}$$

$$\text{MCPLT} = \text{MCPLT} - \text{MCLOS}$$

IF [DAYNUN.EQ.MCDAY(IMC)] THEN

IF BANDED THEN

$$\text{MCPLT} = \text{MCPLT} + (19068 * \text{MCPPA}(\text{IMC}) * 0.90 / \text{POPPLT}$$

ELSE

$$\text{MCPLT} = \text{MCPLT} + (19068 * \text{MCPPA}(\text{IMC}) * \text{INT} / \text{POPPLT}$$

ENDIF

$$\text{IMC} = \text{IMC} + 1$$

$$\text{MCCON} = \text{MCPLT} / \text{PLTWT}$$

Calculation of MC in the Plant

The simulation model, **GOSSYM**, is used to calculate plant dry weight and weight loss due to abscission of plant parts and root sloughing on a daily basis.

MCLOS = The amount of MC lost due to abscission of plant parts.

DEADWT = The amount of plant material lost on a daily basis.

DAYNUM = The day of simulation

MCDAY = The date of MC application

IMC = The number of applications of MC during the growing season.

MCPA = The amount of MC applied in pints per acre.

INT = The fraction of MC intercepted by the crop.

POPPLT = The number of plats per acre.

MCPLT = The amount of MC in the plant tissue.

PLTWT = The plant dry weight

MCCON = The concentration of MC in mg per gram dry weight.

19068 = The factor that converts pints per acre of 4.2%-strength MC into mg per acre of active ingredient.

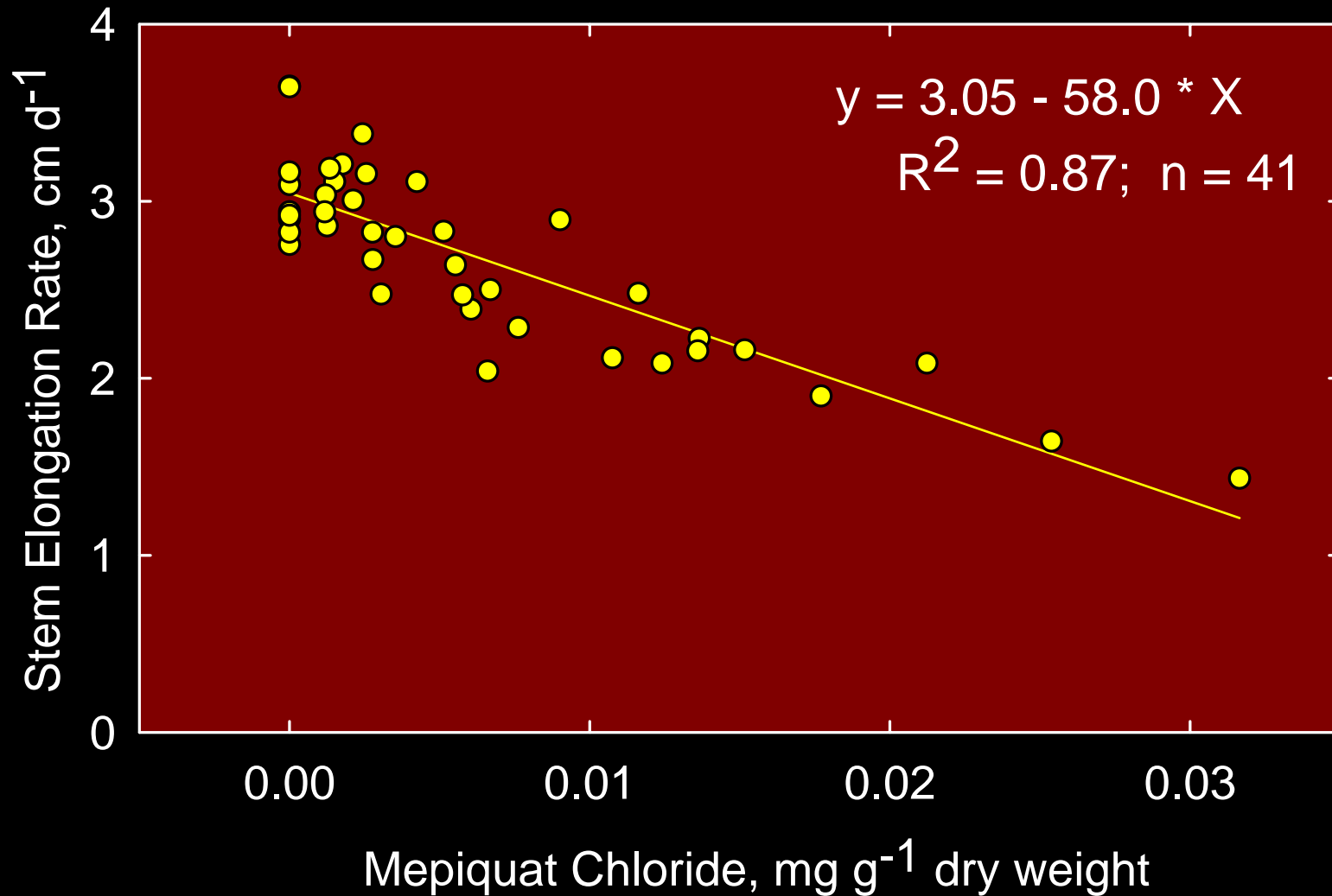
Calculation of Reduction Factors

The next step in the model is to calculate MC reduction factors

Based on the literature and from the experiments specifically designed to generate a quantitative database, the primary effects of MC are on:

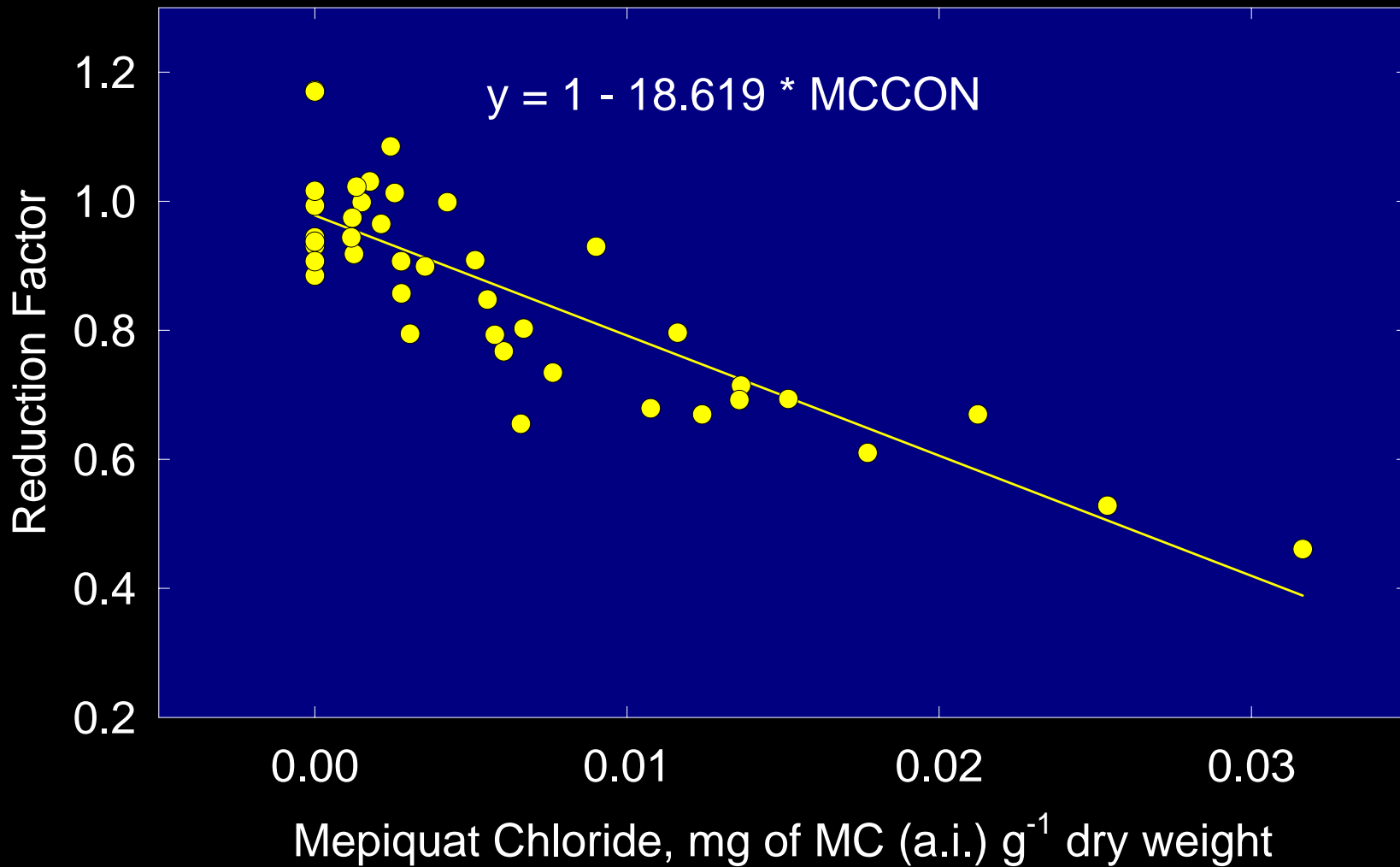
- Stem elongation
- Leaf area expansion
- Photosynthesis

Mepiquat Chloride - Cotton Growth Plant Height - Stem Extension Rate



Mepiquat Chloride - Cotton Growth

Calculating reduction factor for stem extension rate



Calculation of Reduction Factors

Based on our database, we now can calculate MC reduction factors assuming that potential stem elongation rate, leaf expansion rate and photosynthesis rate are equal to one:

$$\text{MCDZ} = 1 - 18.618 * \text{MCCON}$$

$$\text{MCDA} = 1 - 7.774 * \text{MCCON}$$

$$\text{MCDPN} = 1 - 25.167 * \text{MCCON} + 590.286 * \text{MCCON}^2$$

MCDZ = The reduction factor for the rate of stem elongation.

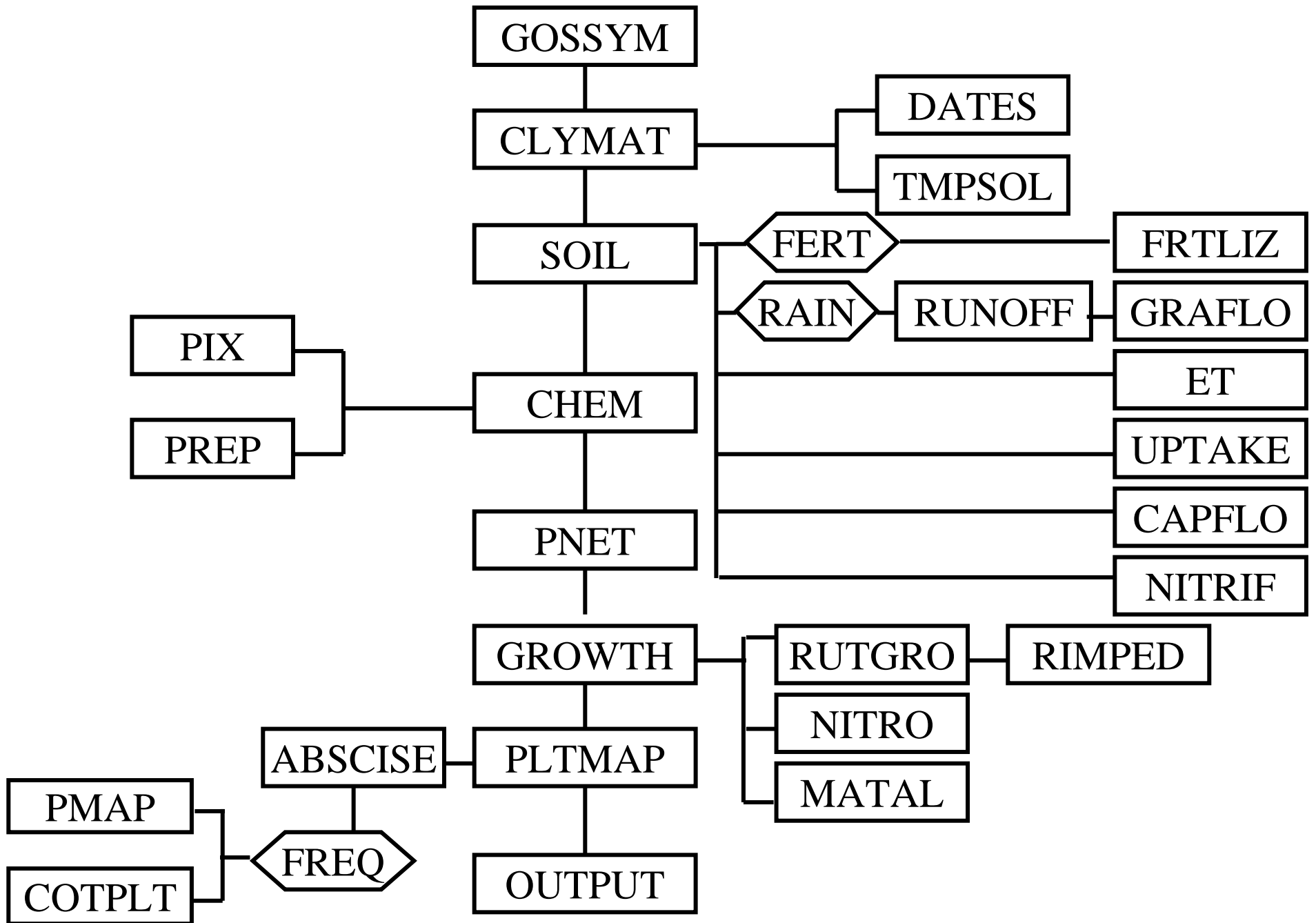
MCDA = The reduction factor for the rate of leaf area expansion.

MCDPN = The reduction factor for the rate of photosynthesis.

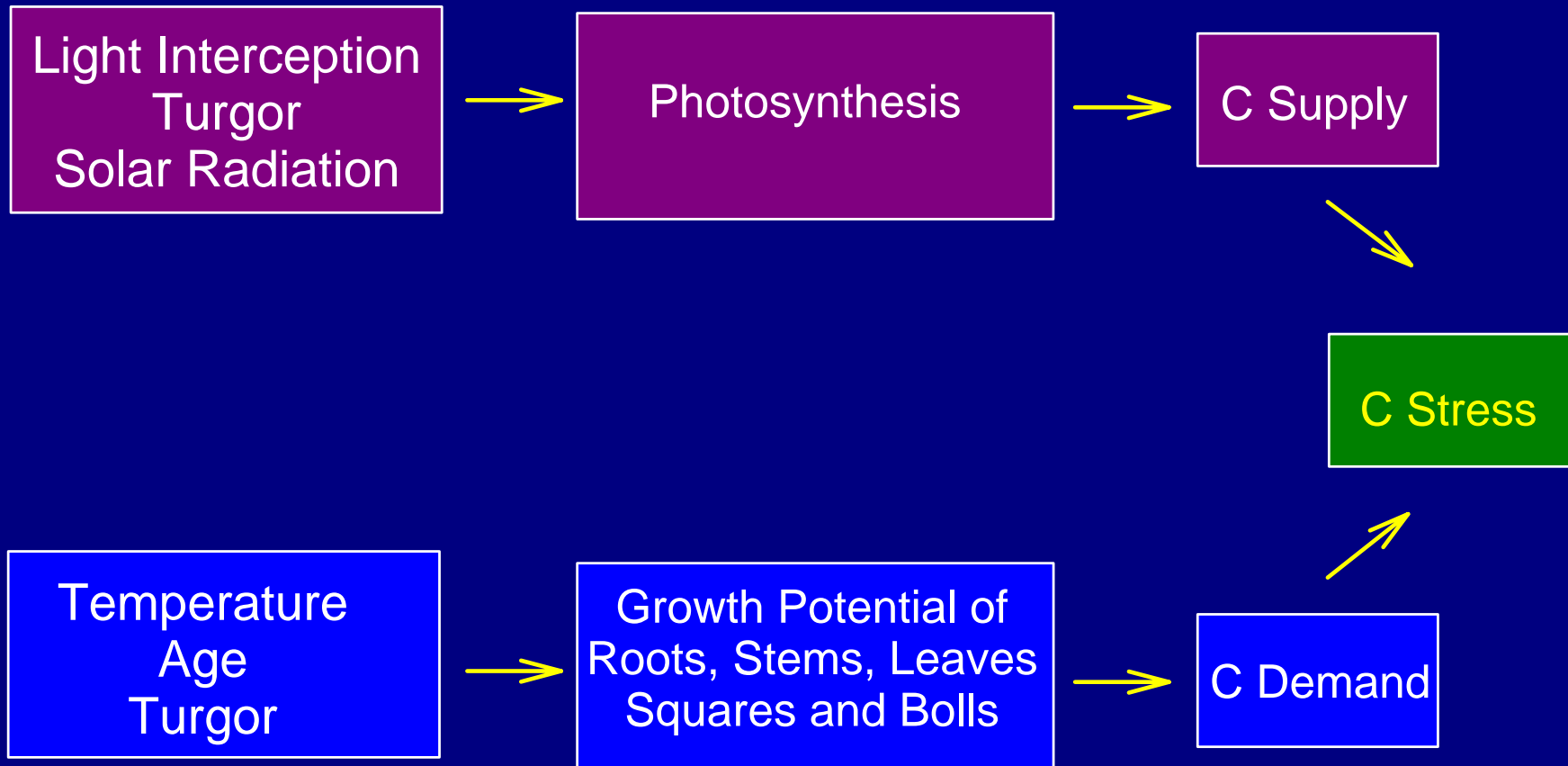
These reduction factors are used to decrease those parameters in various subroutines in the simulation model.

Validating the MC Model

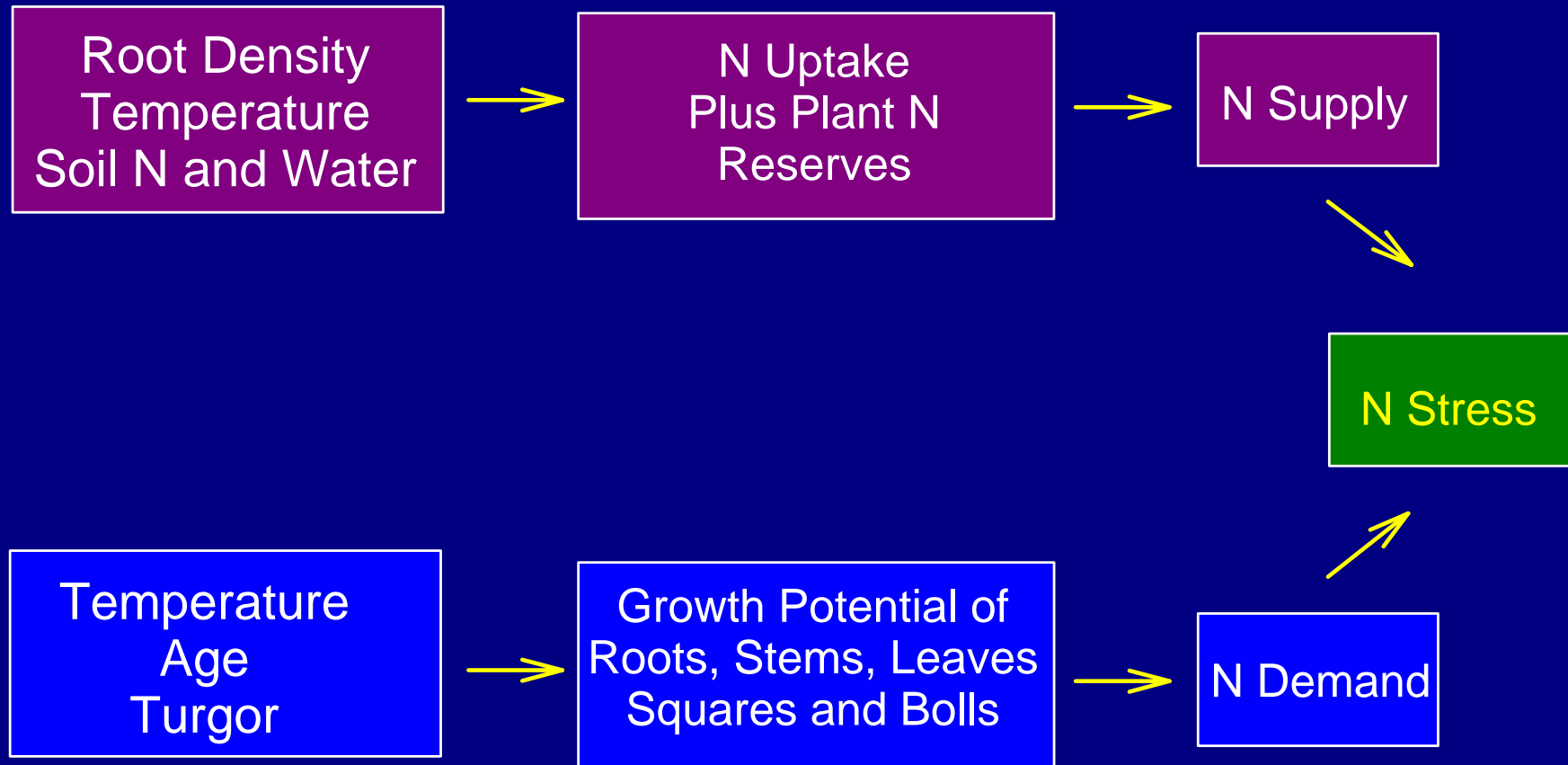
- ✓ We have incorporated these algorithms into the cotton simulation model, GOSSYM.
- ✓ The simulation model is mechanistic in nature and does a fairly good job in predicting cotton performance across a wide range of environmental (soil and weather) and management practices (nitrogen, water, PGR's and crop termination chemicals).
- ✓ The data sets used to compare comprised of a wide range of environmental conditions, a variety of cultural practices and diverse genetic resources.
- ✓ The data sets include a total of 50 cropping systems from 1989 to 1991.



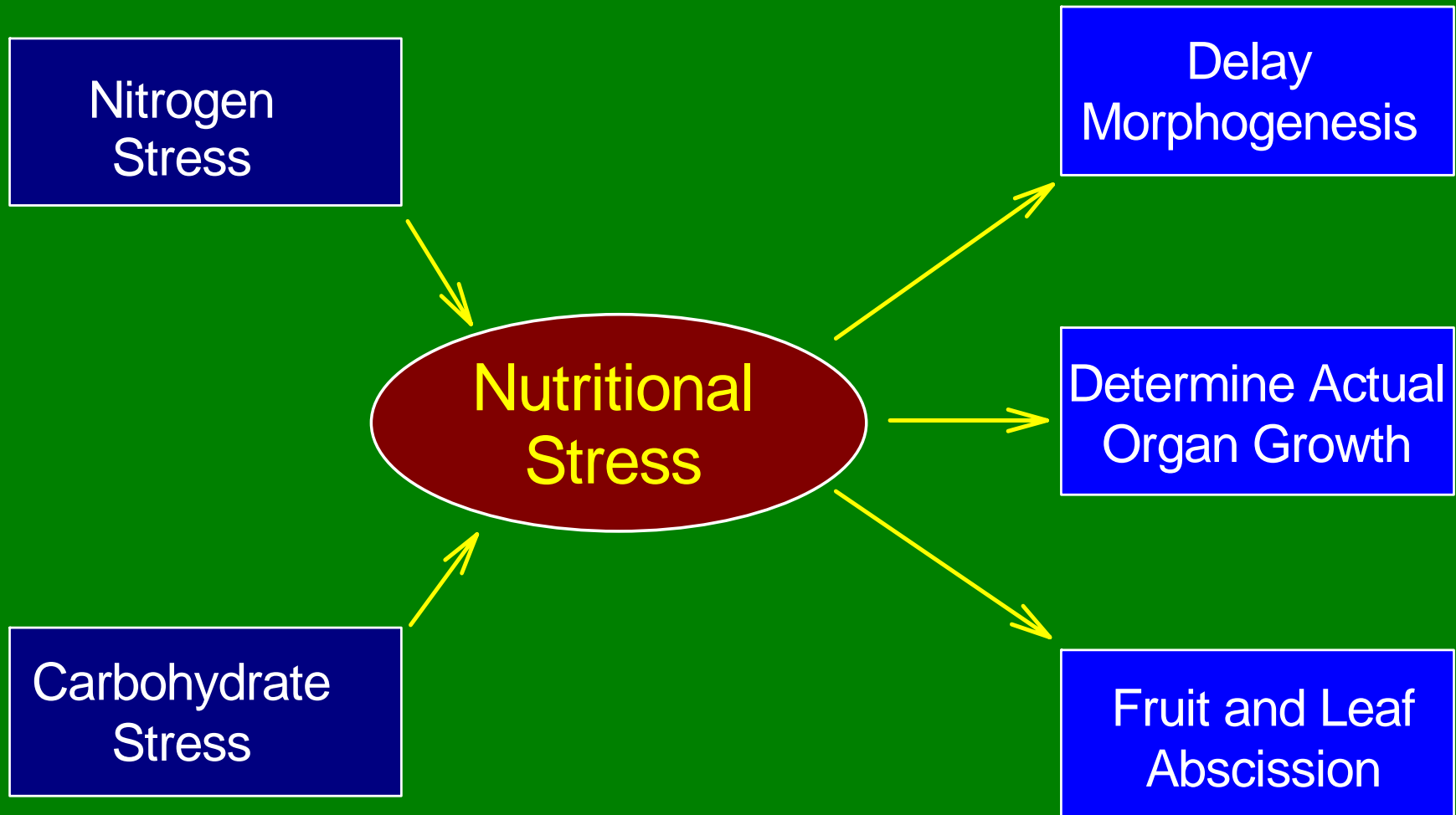
Carbohydrate Stress



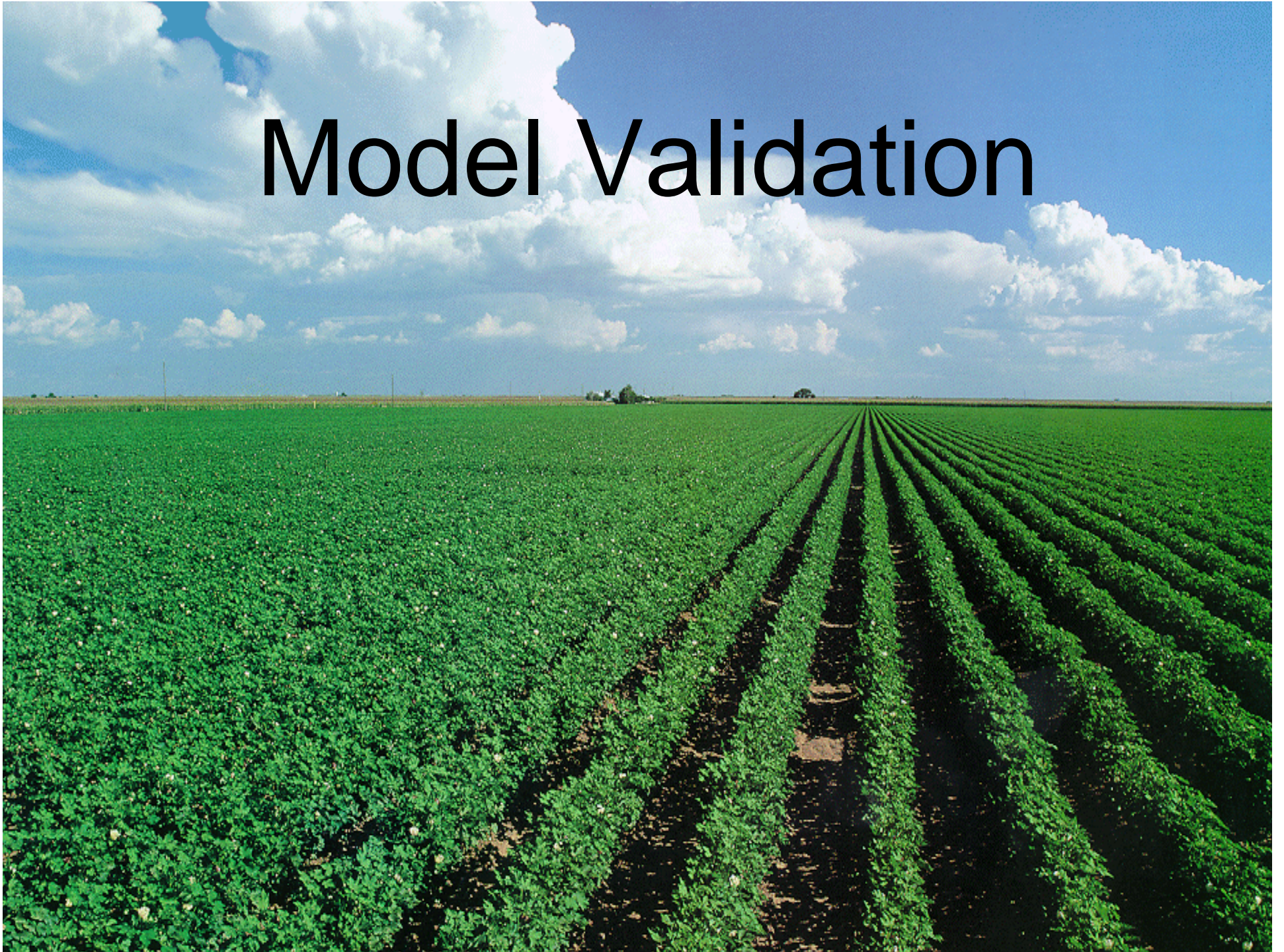
Nitrogen Stress



Nutritional Stress

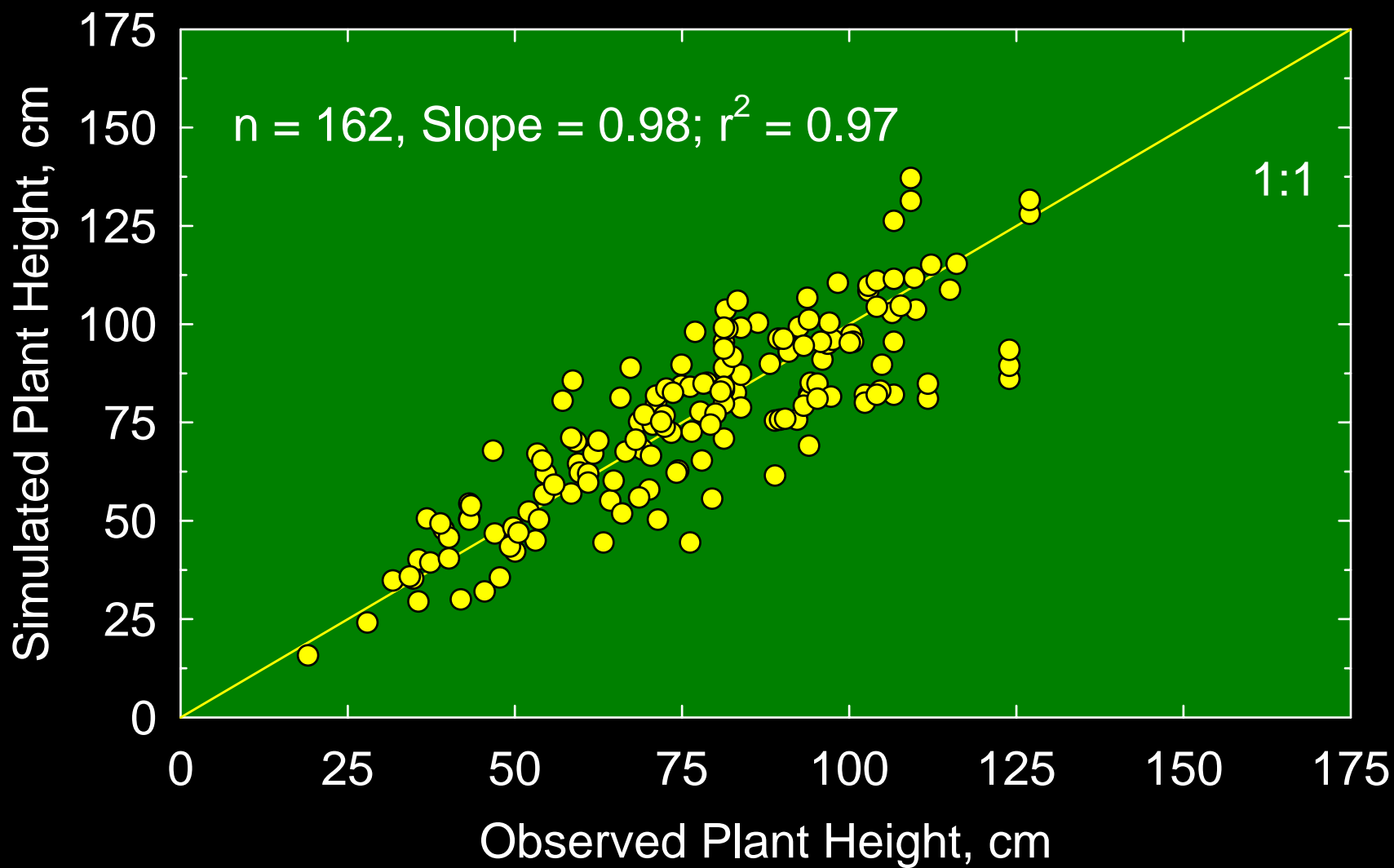


Model Validation



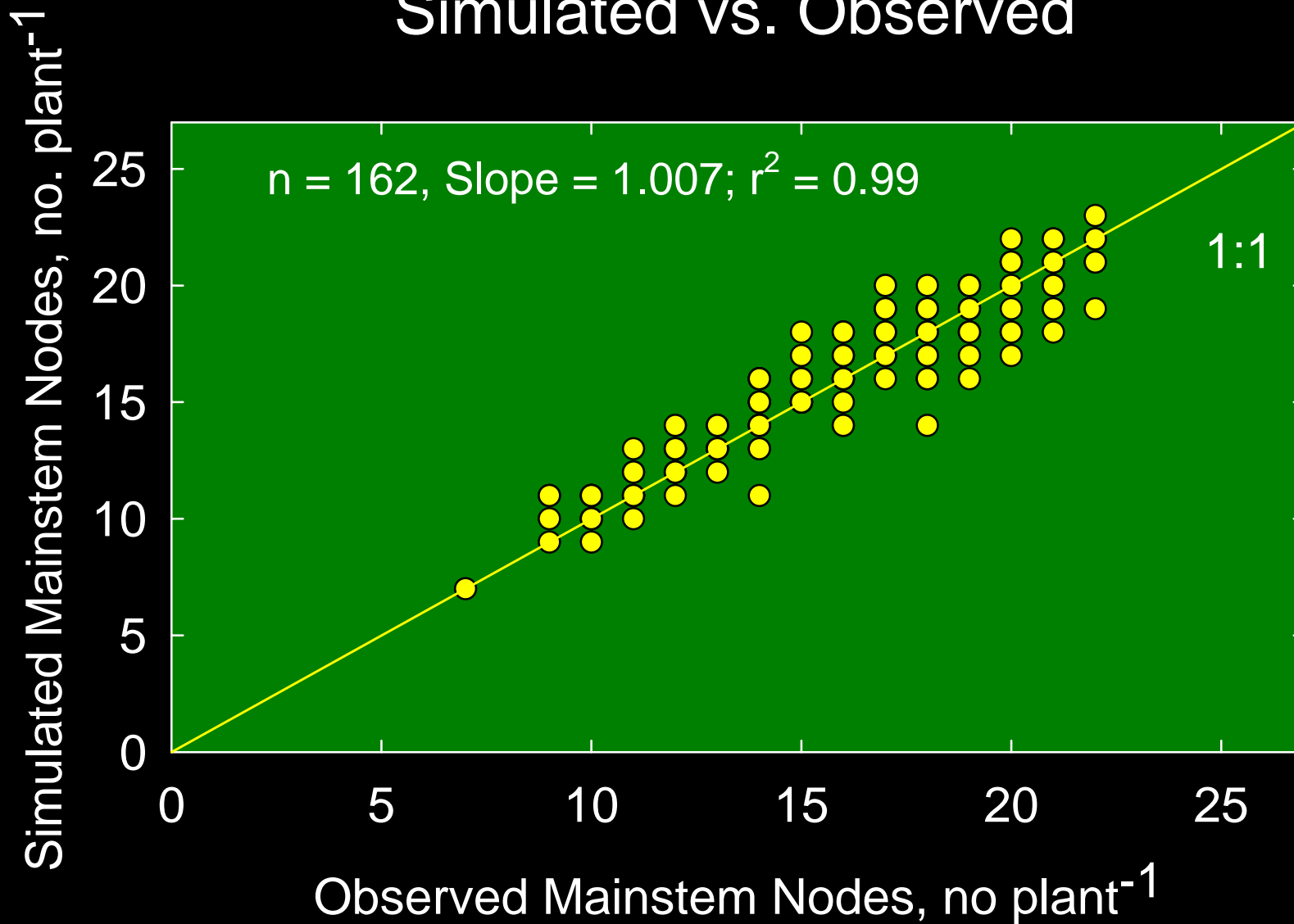
GOSSYM Model Predictions - Plant Height

Simulated vs. Observed



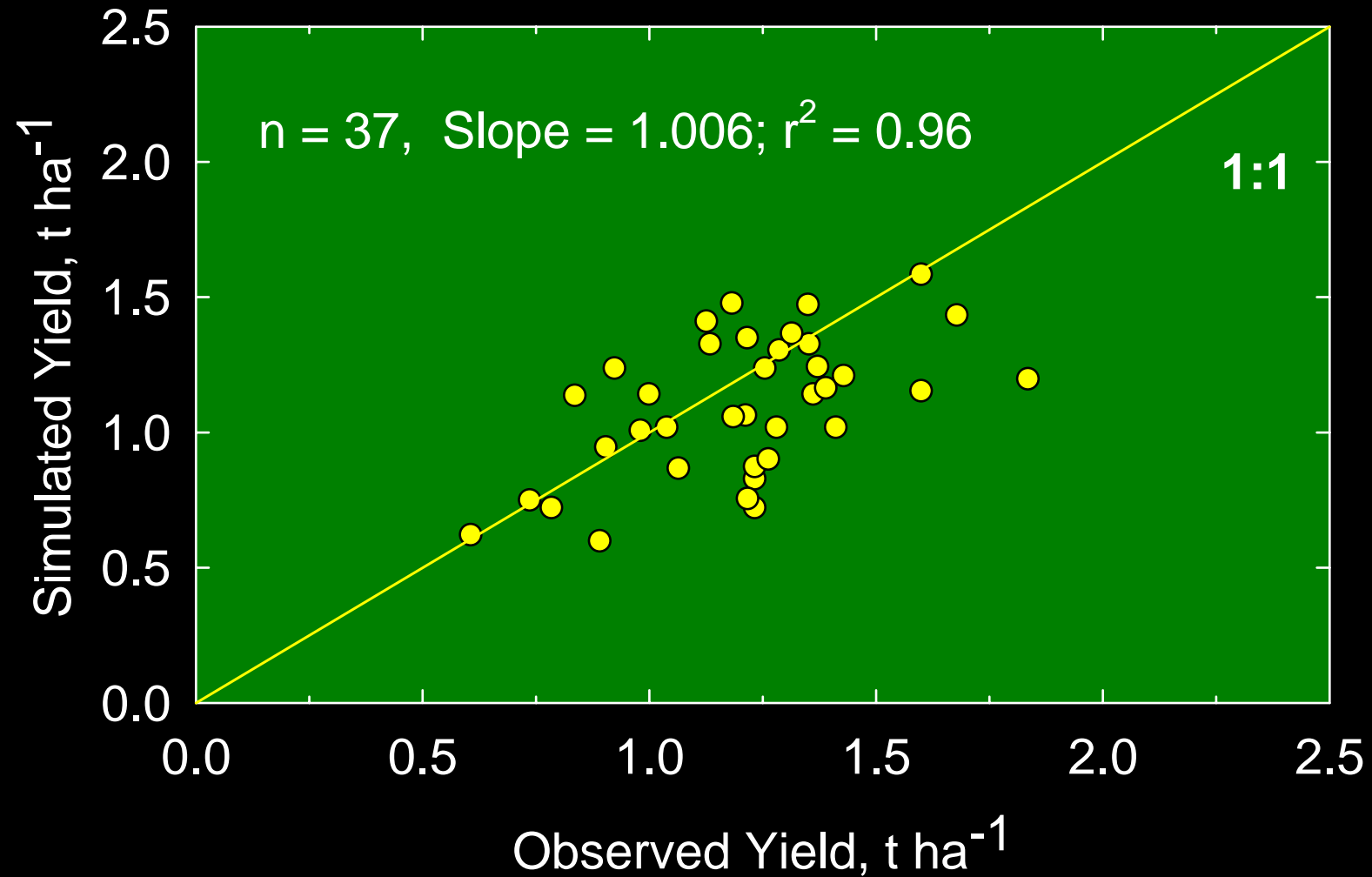
GOSSYM Model Predictions - Mainstem Nodes

Simulated vs. Observed



GOSSYM Model Predictions - Lint Yields

Simulated vs. Observed



Management Questions ???

Planting

Irrigation

Fertilization

Pesticide Application

Pix

Growth Stage Determination

Crop Termination

Management Answer . . . **Simulation Models**