Basic Plant Physiology with Emphasis on High Temperature Effects

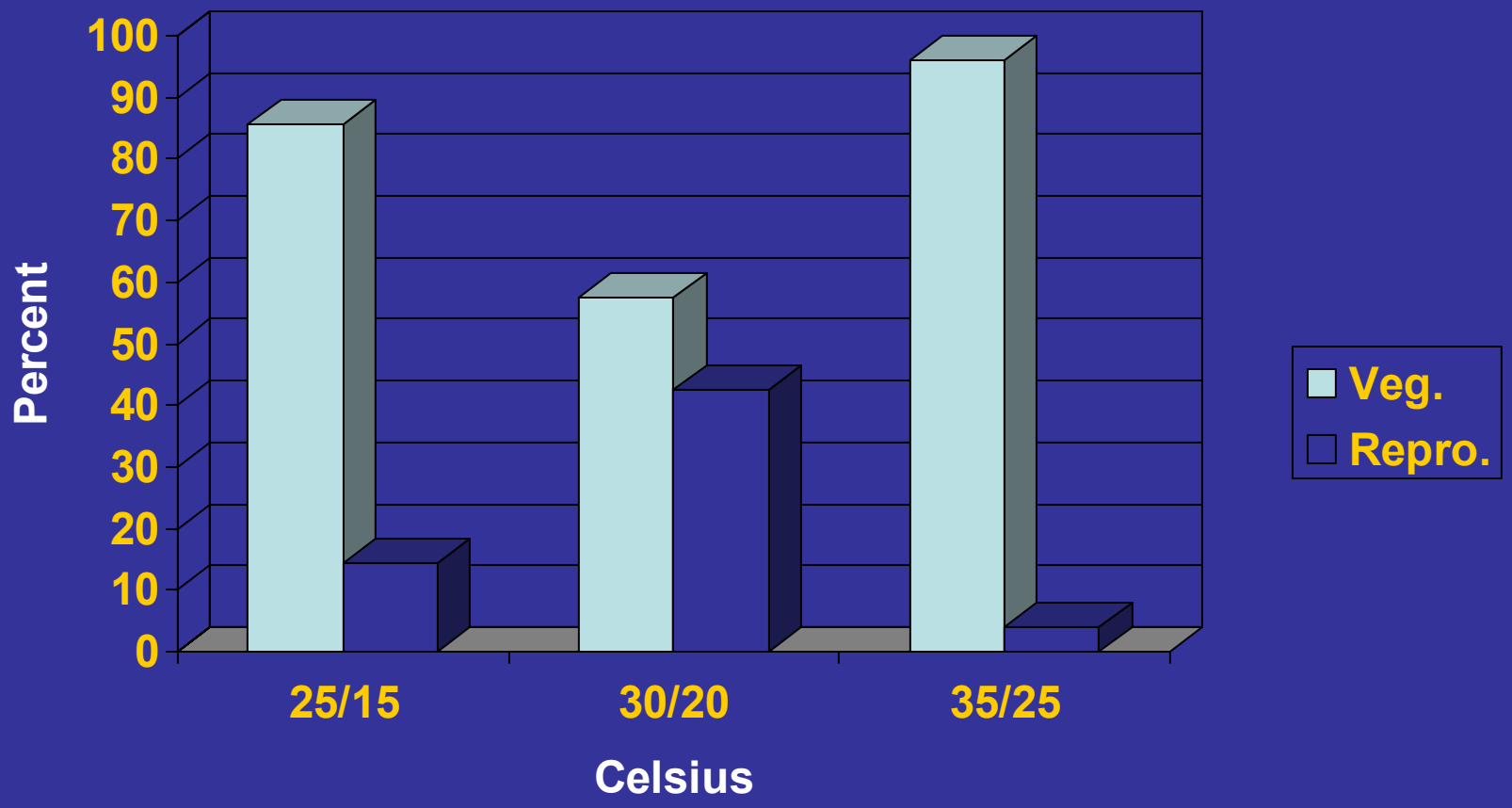
Dan Fromme
Texas Cooperative Extension
Texas A&M University

Introduction

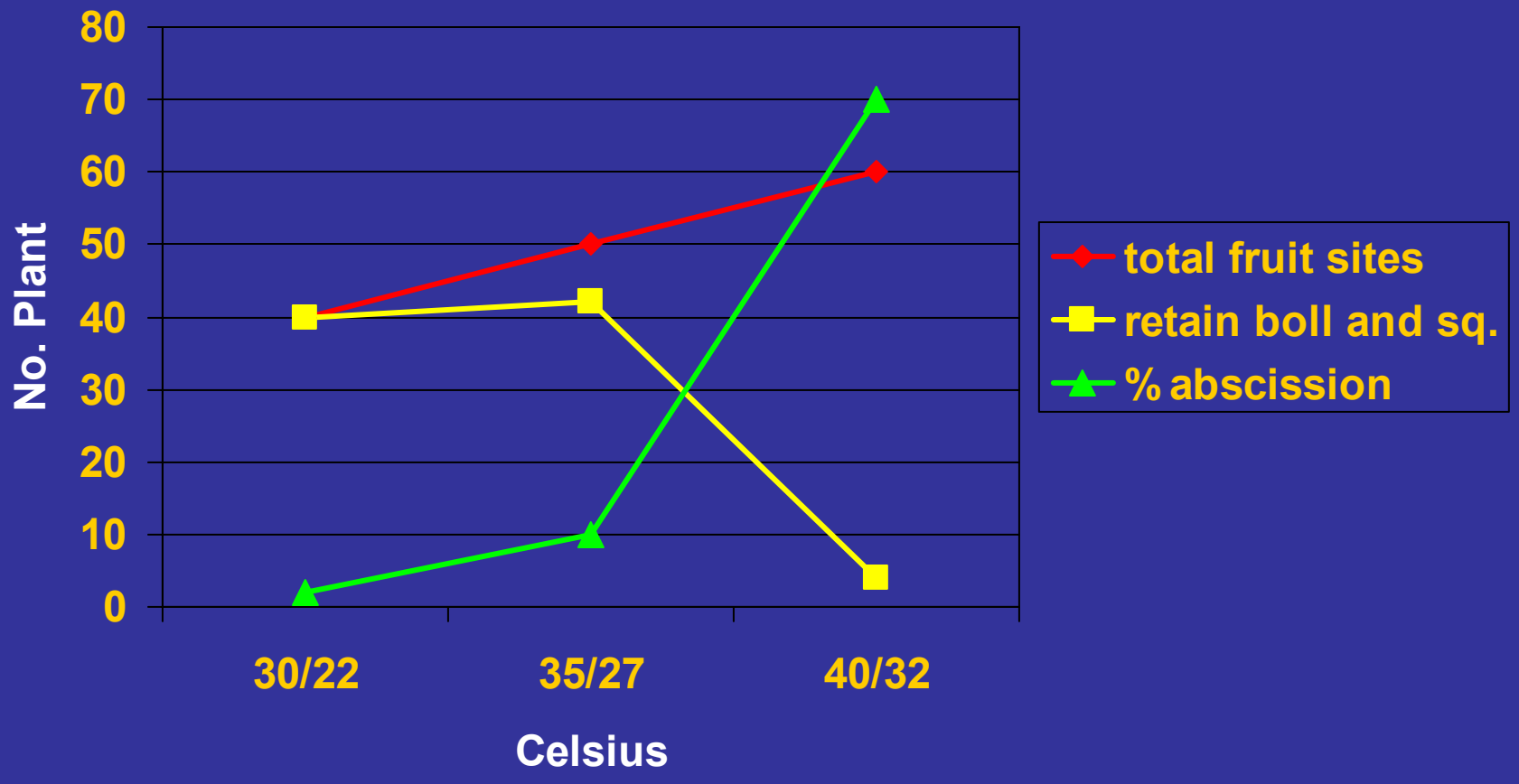
- Cotton requires warm days and relatively warm nights for optimum growth and development (V.R. Reddy, 1991).

- Cotton grows as a perennial shrub and requires warm days and warm nights for optimum growth and development (Fryxell, 1986).

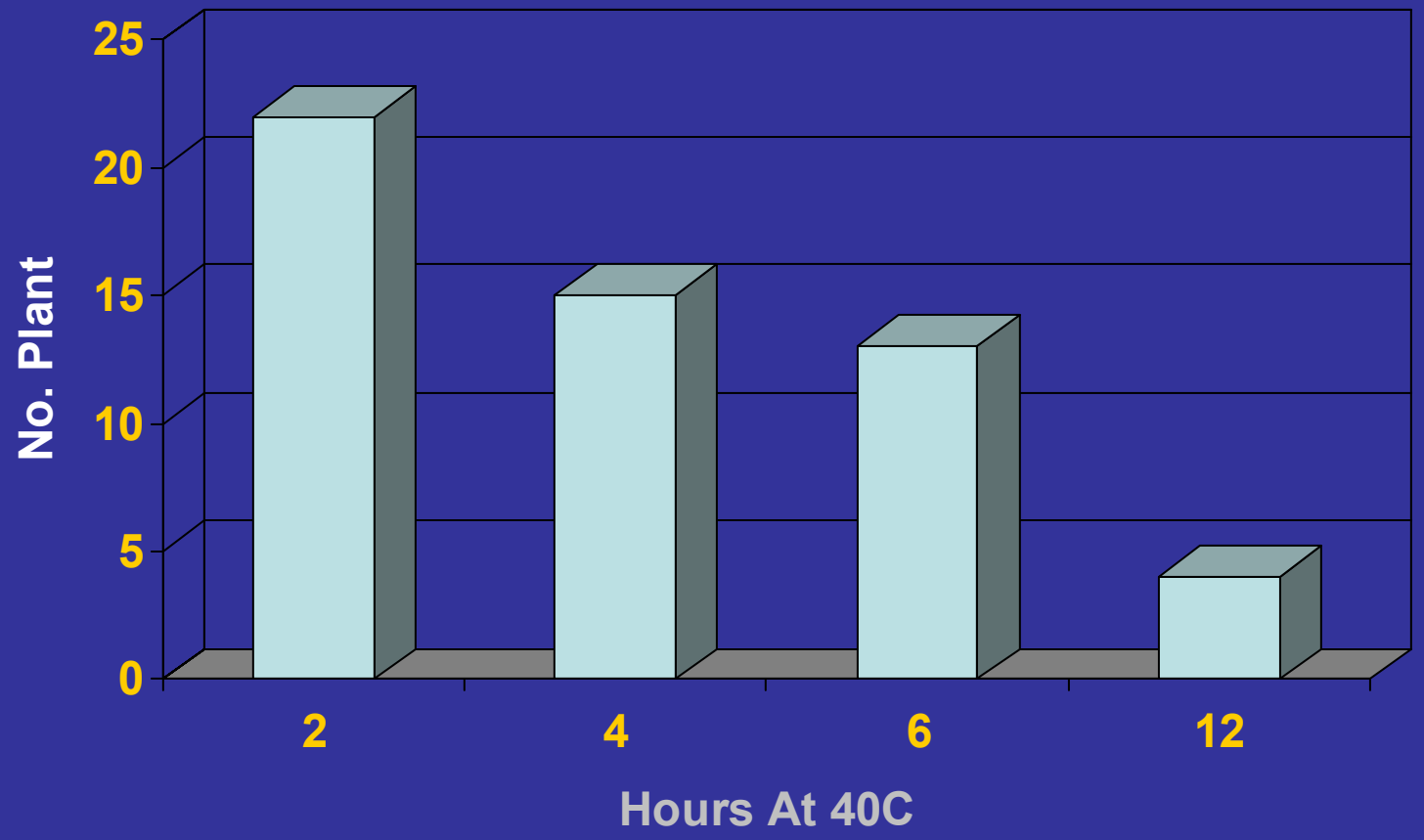
Effects of Temperature on Biomass During Fruiting (V.R. Reddy, 1991)



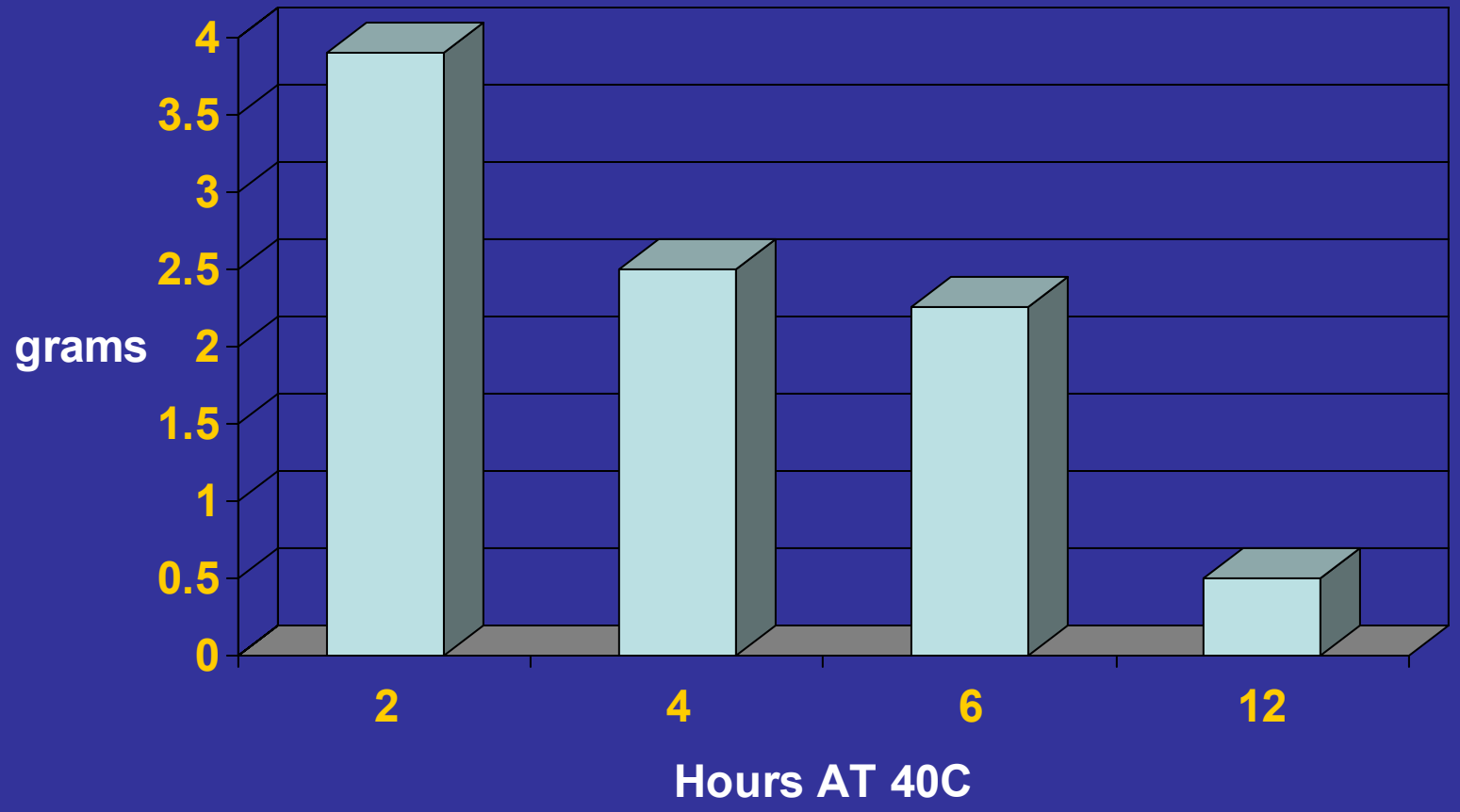
Effect of Temperature on Fruiting (K.R. Reddy, 1992)



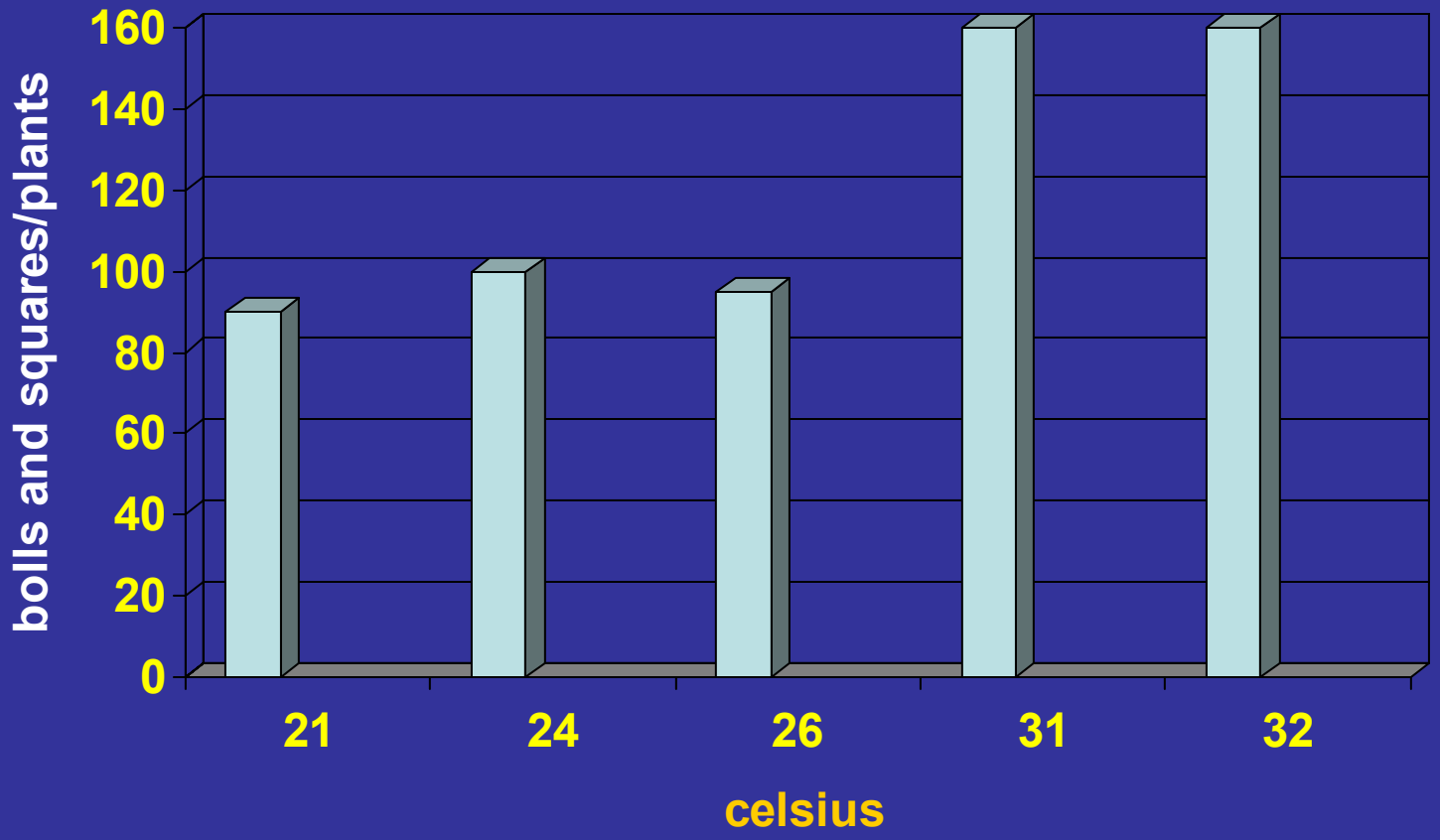
Effect of Hours per Day at 40C on Boll Numbers (K.R Reddy, 1992)



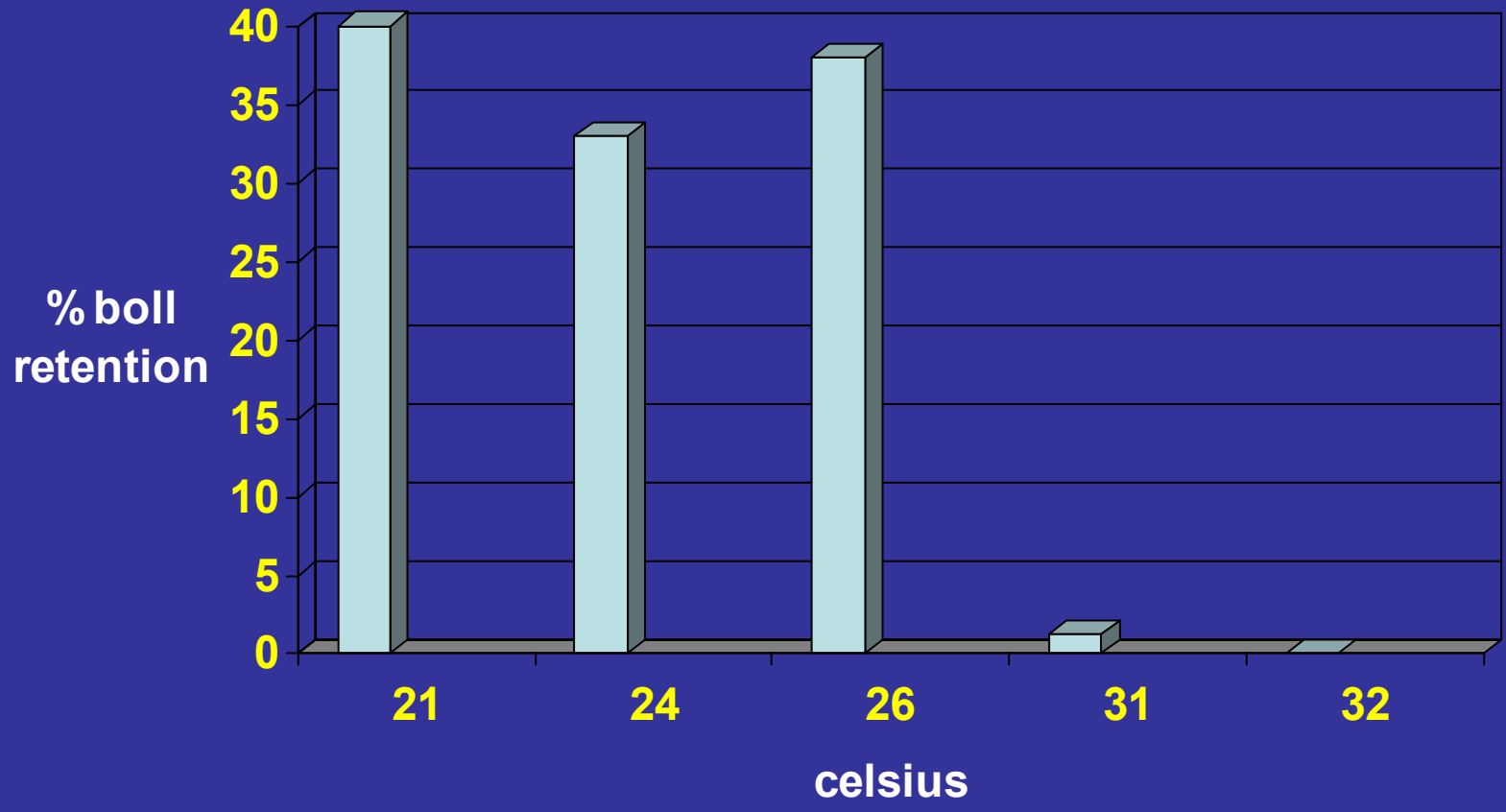
Effect of Hours per Day at 40C on Boll Weight (K.R. Reddy, 1992)



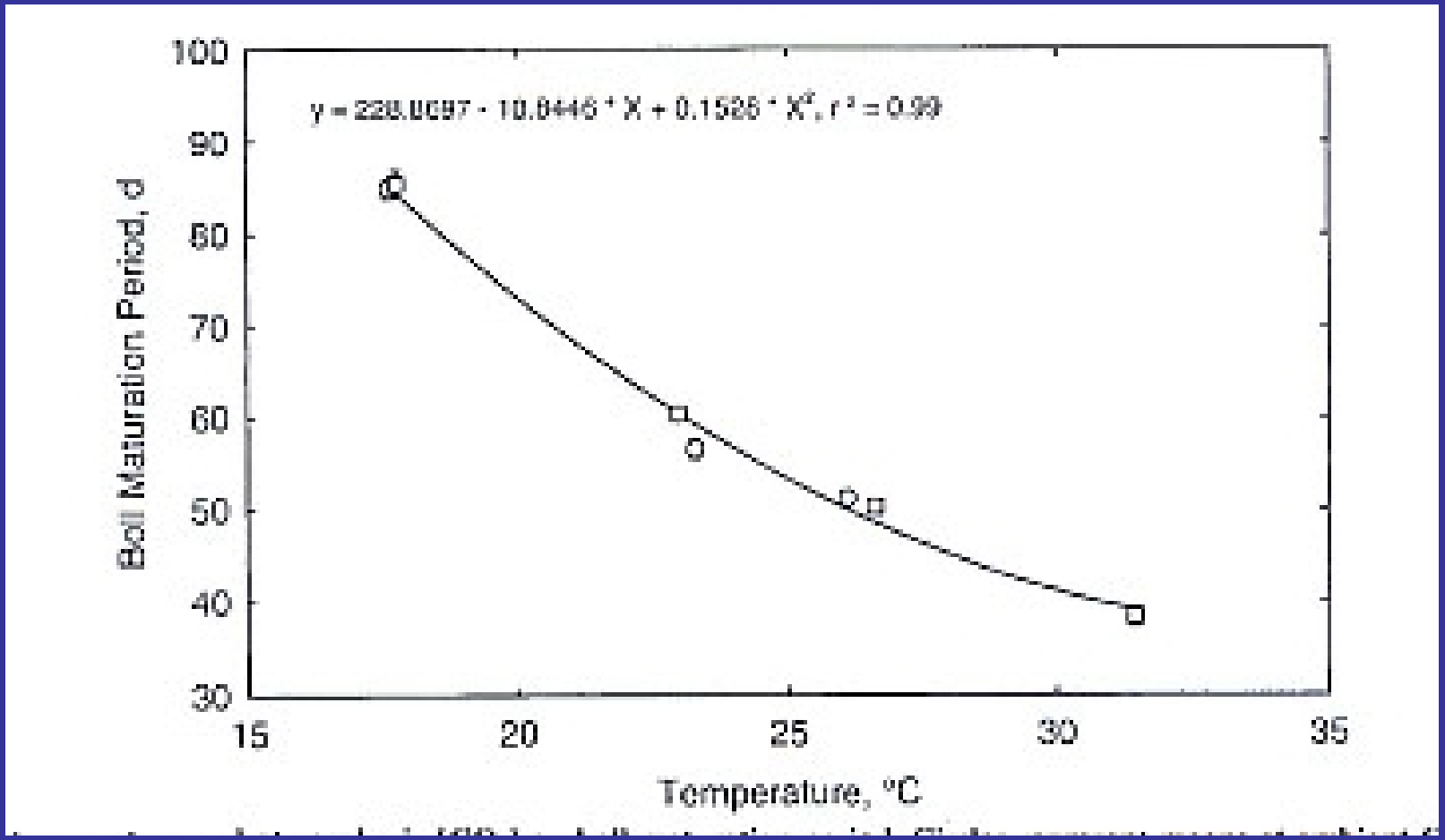
Bolls & Squares Produced Per Plant- Average Temperature from Emergence to Boll Maturity (K.R. Reddy, 1999)



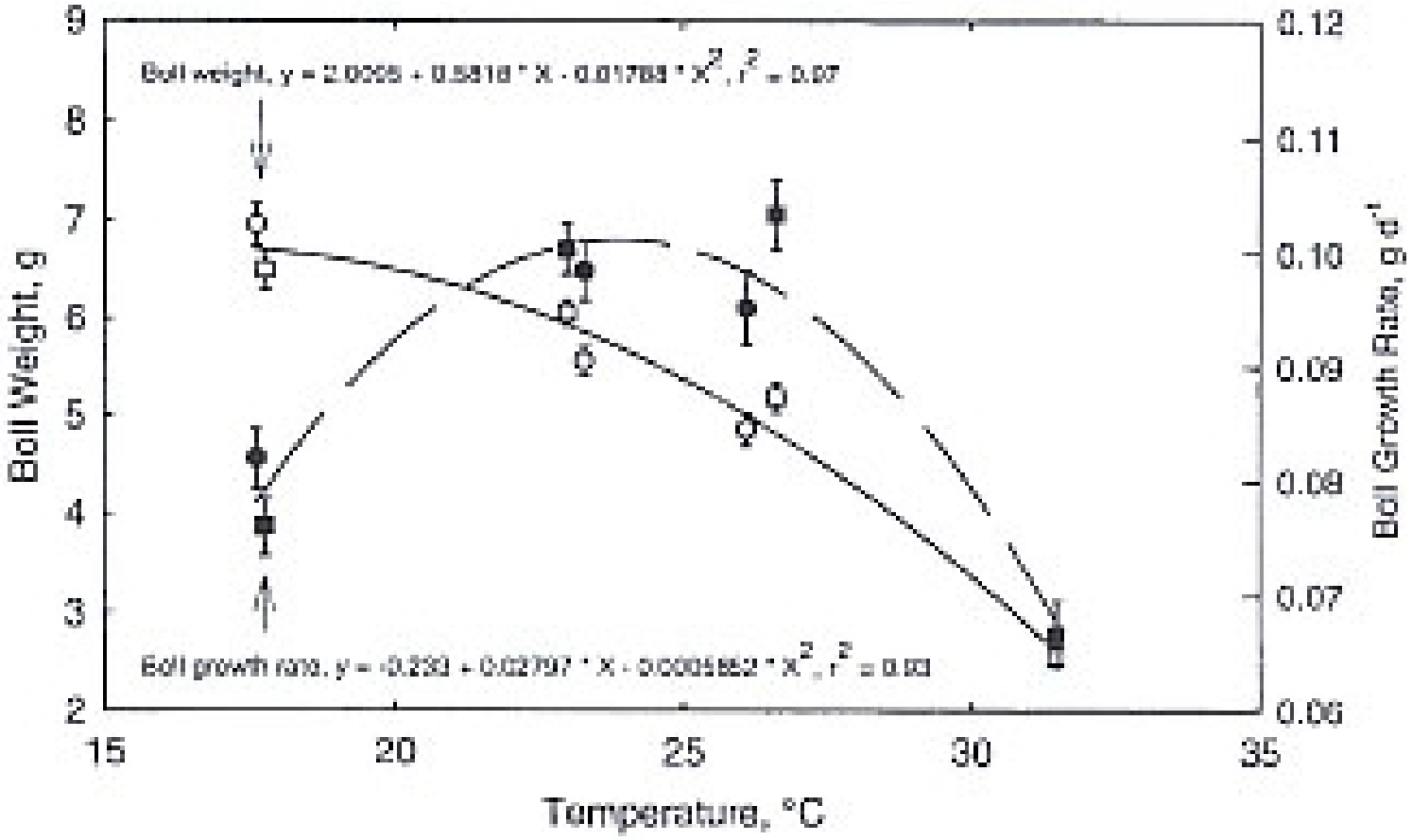
Percent Boll Retention - Average Temperature from Emergence to Boll Maturity (K.R. Reddy, 1999)



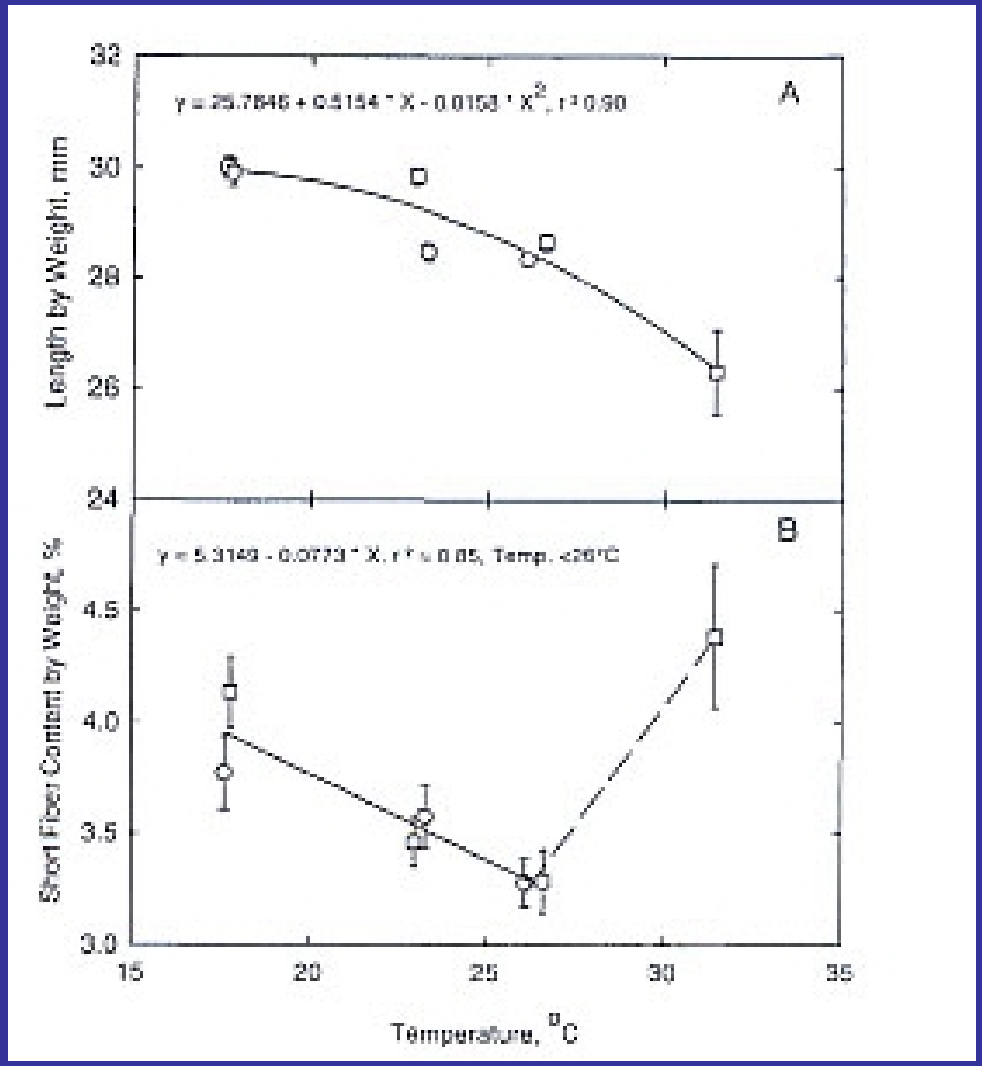
Influence of temperature on boll maturation period. Temperatures were averages from flowering to open bolls. (K.R. Reddy, 1999)



Influence of temperature on boll growth rate and mature open boll weight. Temperatures were averages from flowering to open bolls. (K.R Reddy, 1999)



Influence of temperature on fiber length by weight, and short-fiber content by weight. Temperatures were averages from flowering to open bolls. (K.R. Reddy, 1999)



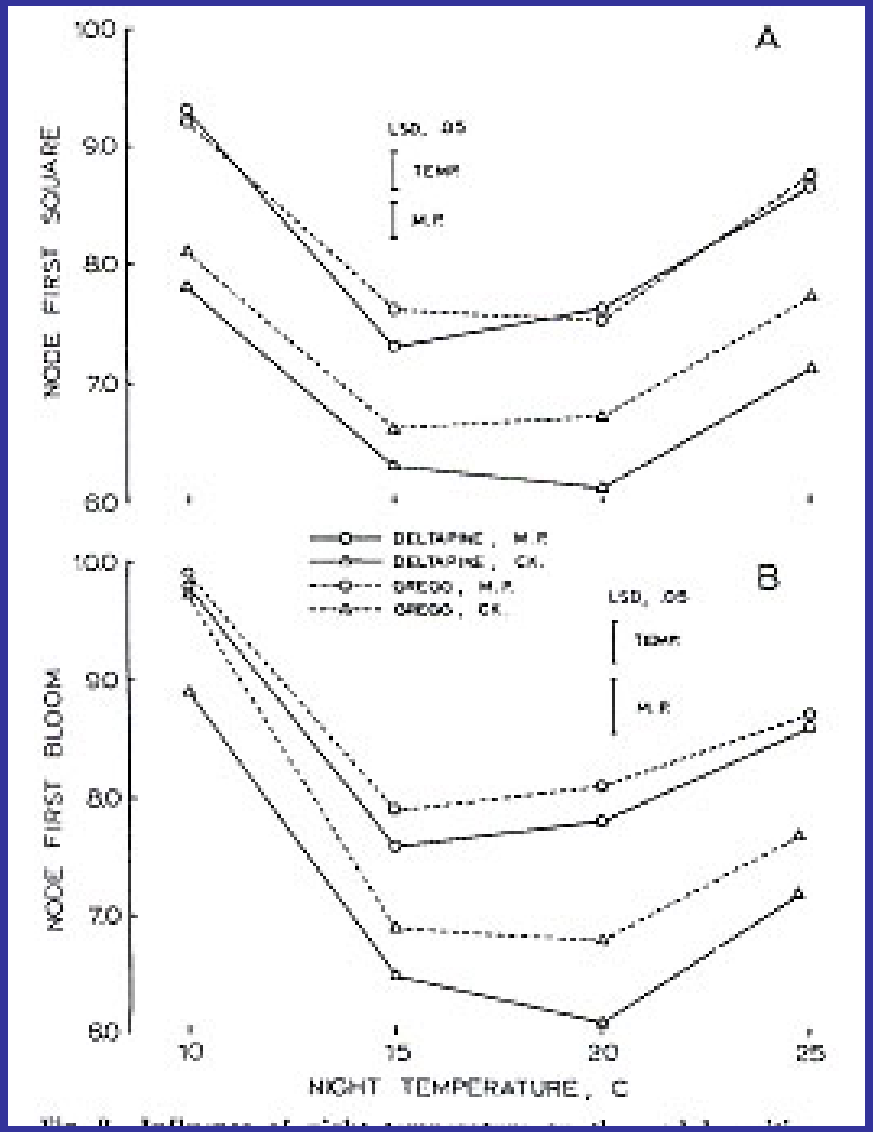
Effect of Night Temperature on Micronaire Value (Gipson, 1970)

Night Temp. (C)	Acala 1517 BR-2	Stoneville 7A	Lankart 57	Stripper 31	C.A. 491
27 (81)	4.08	4.28	4.44	5.33	3.88
21 (70)	4.08	3.89	3.71	5.70	3.46
15 (59)	3.13	2.94	3.65	4.57	3.57
11 (52)	2.51	2.44	3.08	3.36	2.85

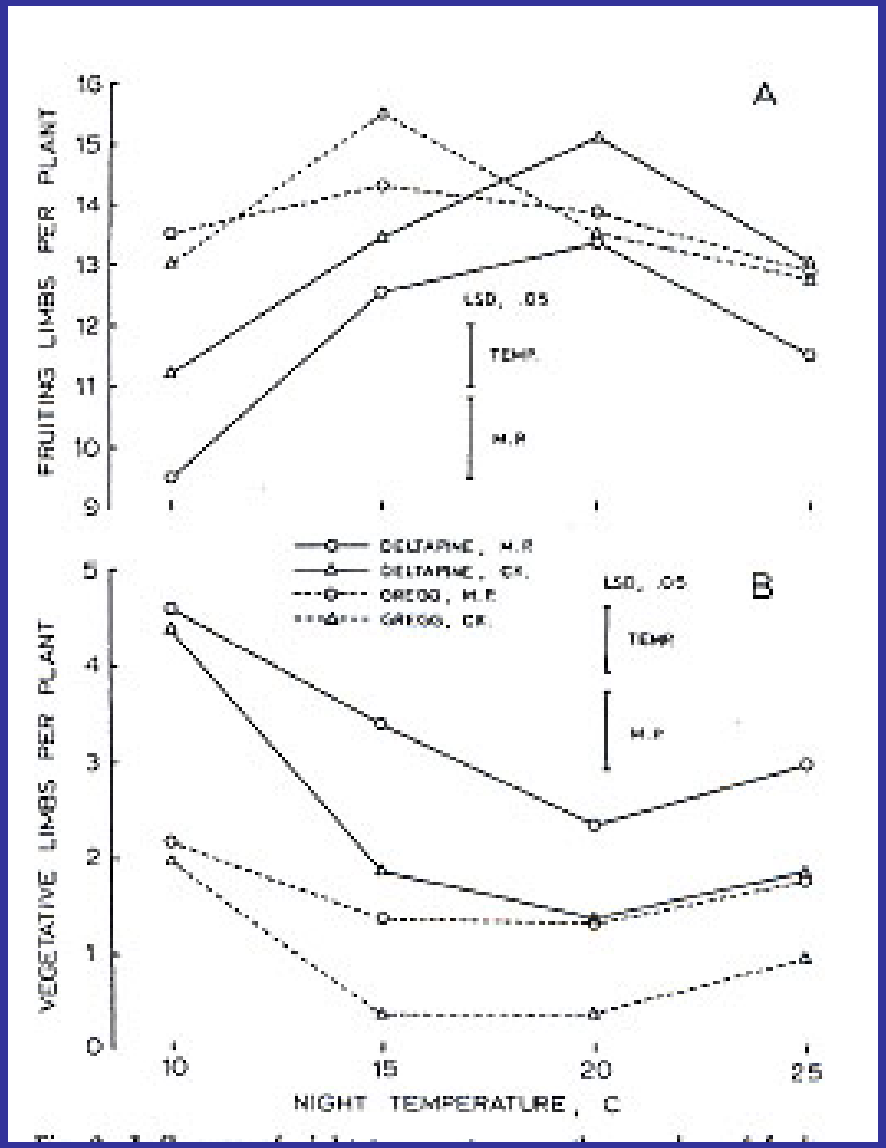
Night Temperatures

- Night temperatures influence early fruiting and vegetative development in cotton (Jack Gipson, 1974).
  - First fruiting node is one to two nodes higher if night time temperatures are very low or very high.

Influence of night temperature on the nodal position of first square and blooms of two varieties (Gipson, 1974)



Influence of night temperatures on the number of fruiting and vegetative limbs per plant of two varieties (Gipson, 1974)



Pollen Sterility and Temperature

- Temperatures above 38C or 100F at 15-17 days before anthesis increases the sterility of pollen (Meyer, 1969)

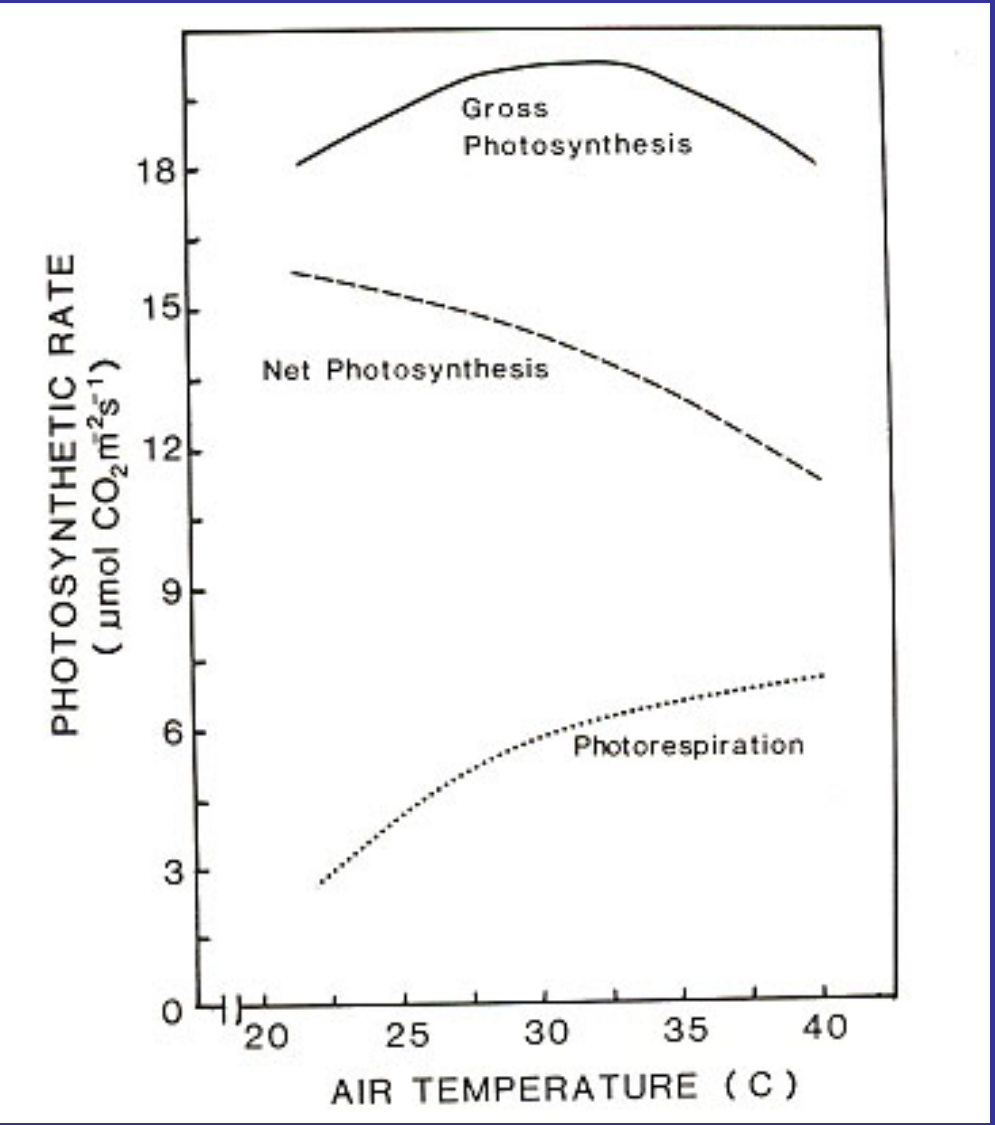
Solar Radiation and Temperature

- The optimum level for boll development varied with level of solar radiation, higher radiation levels lowering the optimum temperature (Mahon, 1972).
- High level of radiation at 580 calories per sq. cm. per day in southeast Australia as an average for the season, probably counteracts the lower temperature in this region (Mahon, 1972).
- It is however, feasible to grow 3,000 kg seed cotton per ha with as few as 2,250 GDD if the average level of solar radiation during the season is 580 calories per sq. cm. per day (Mahon, 1972).

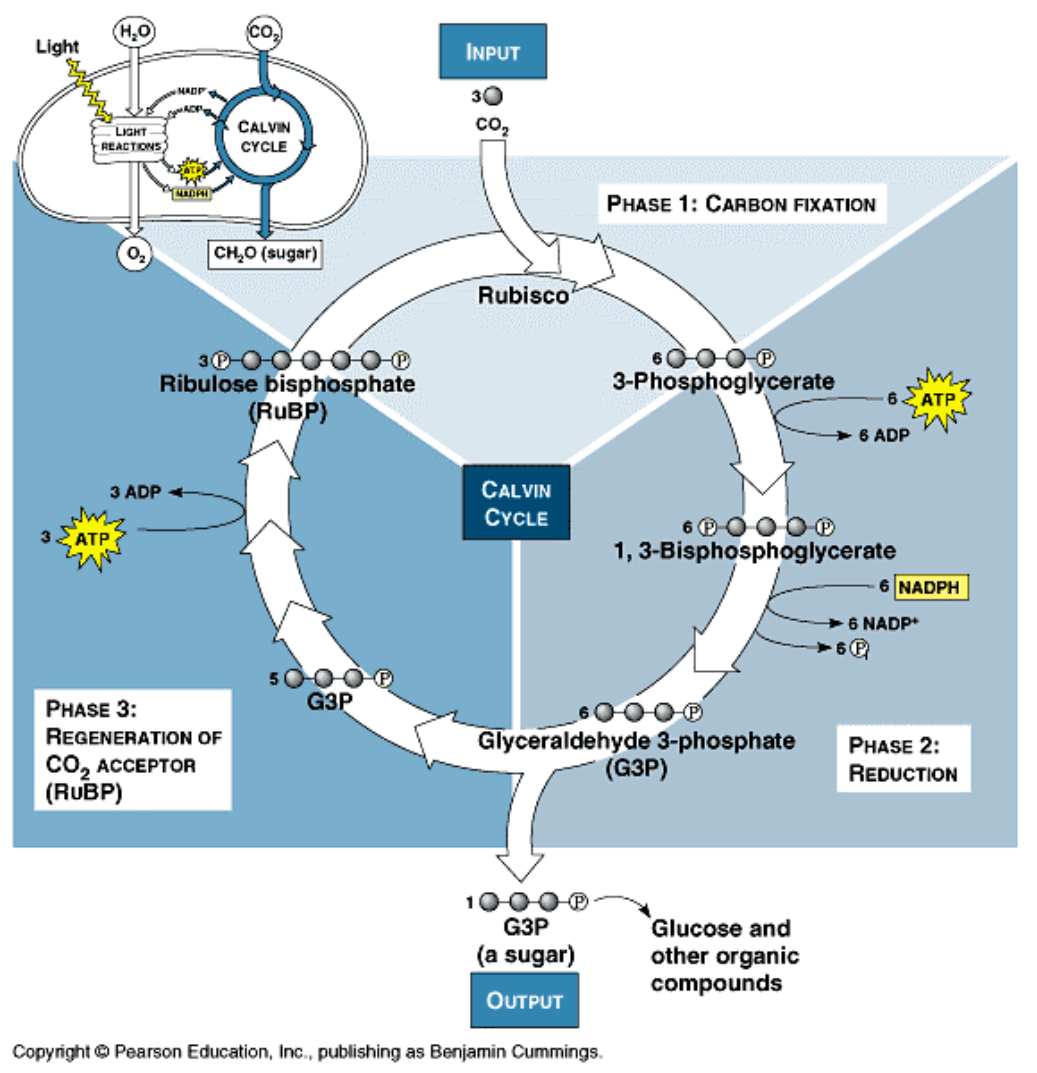
Metabolic Processes

- Photosynthesis
  - As day temperatures increase, net photosynthesis decreases and photorespiration increases.
  - Plant becomes less efficient in utilizing and assimilating carbon.
- Photorespiration
  - Rubisco is bound to O_2 instead of Co_2.
- Respiration
  - as temperatures increase, more energy is used for maintenance respiration and less is utilized in growth respiration.
  - Increasing night time temperatures in the summer cause more energy to be utilized in maintenance and less in growth respiration.

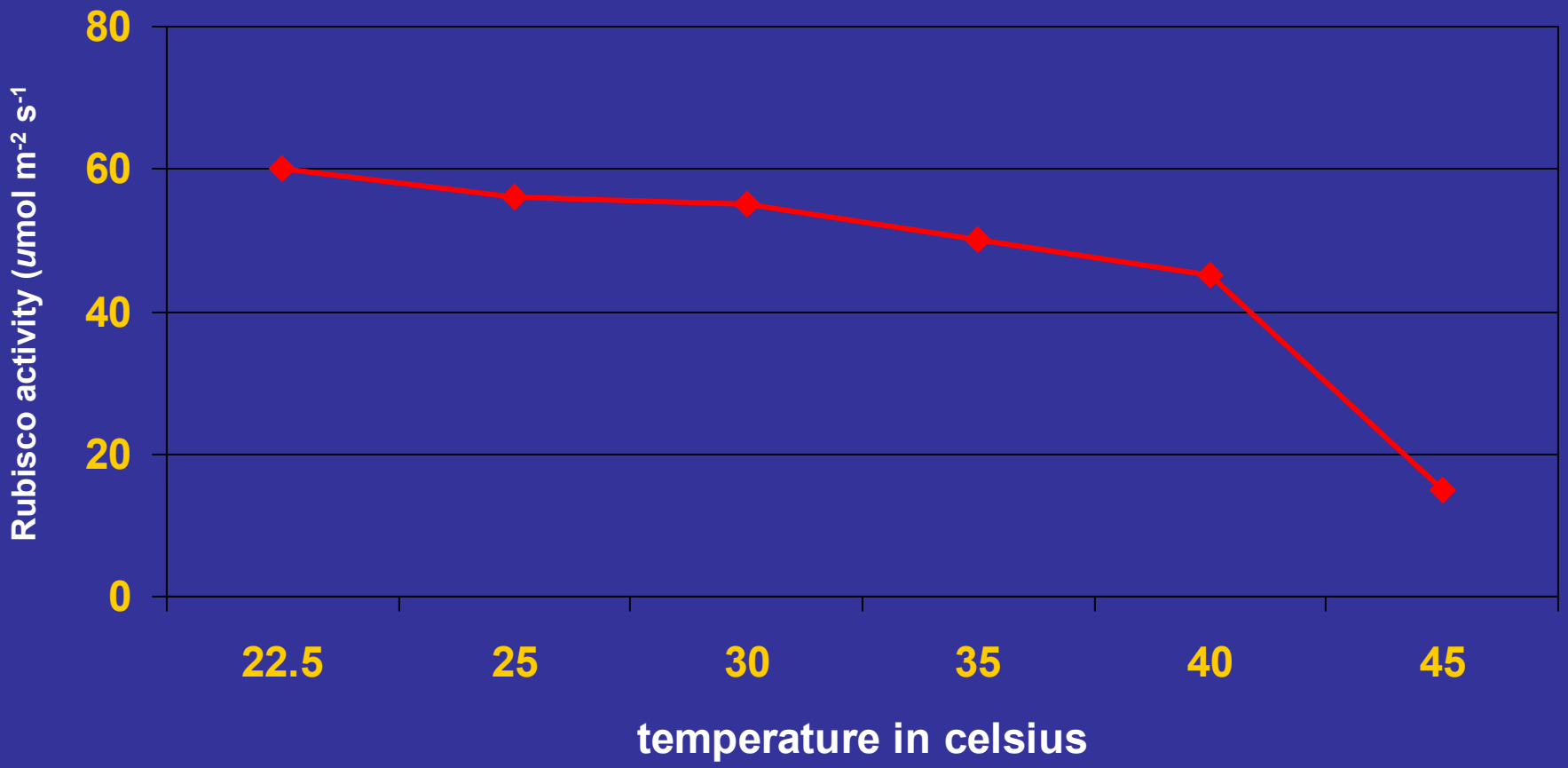
Photosynthetic Response of Individual Cotton Leaves to Increasing Air Temperature (Perry, 1983)



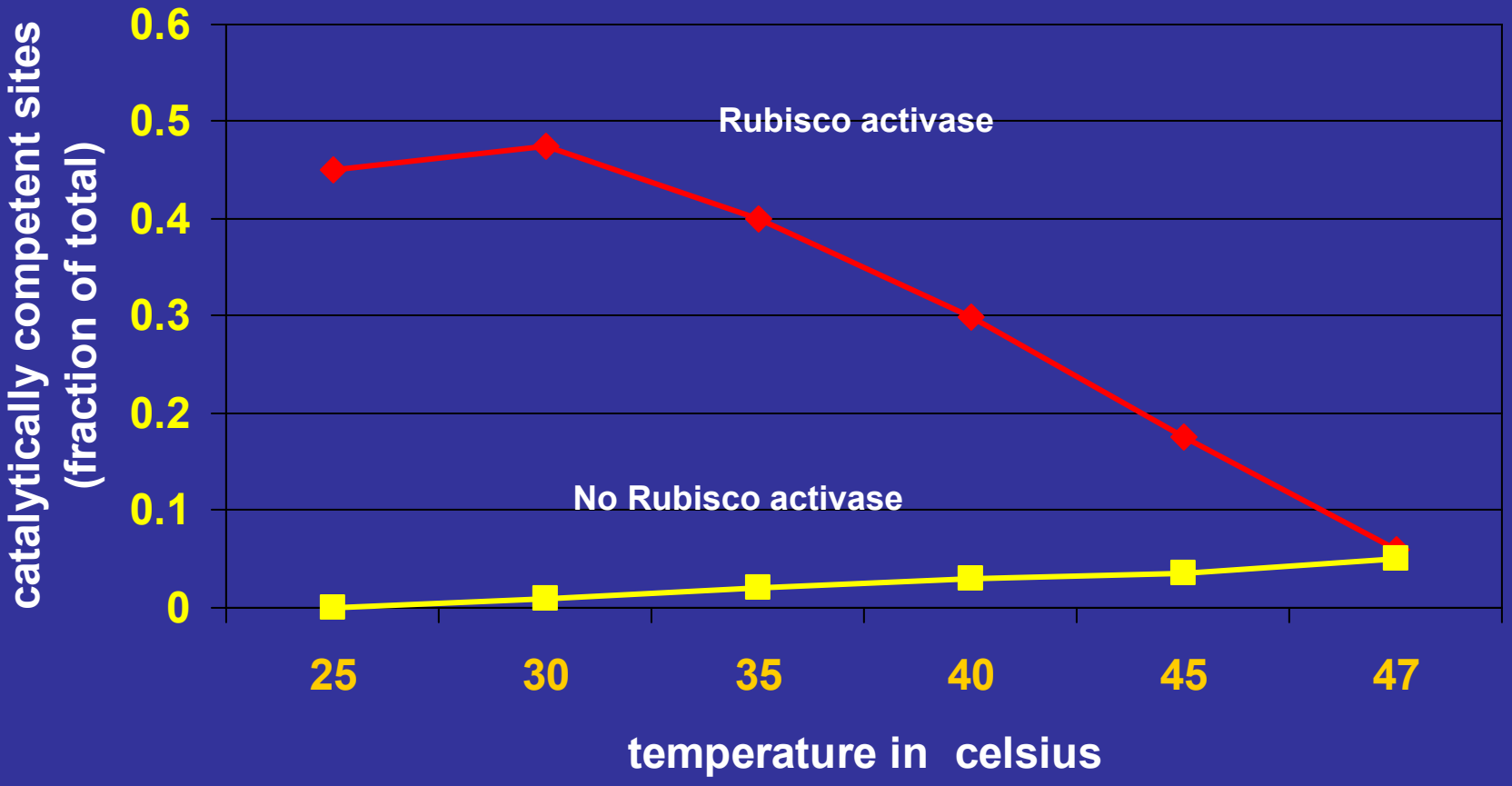
Photosynthesis



The Effect of Light Activation of Rubisco (Feller, 1998)



Effect of Temperature on Activation of Rubisco by Activase (Crafts-Brandner, 2000)



Contabescent Anthers

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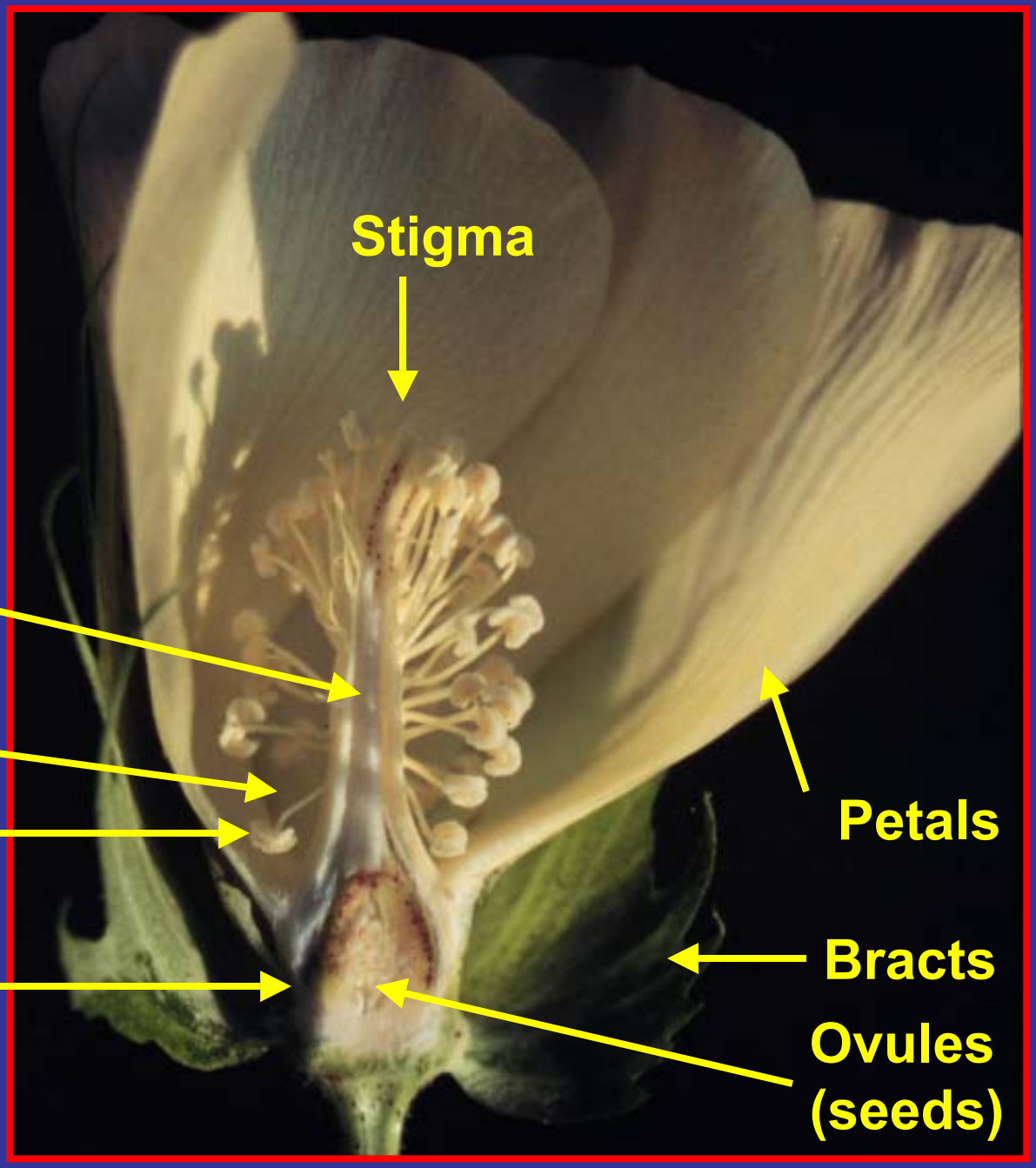


Pollen tube grows at a rate of several mm/h and is SENSITIVE to EVERYTHING.

Tube enters micropyle and male gametes are released.

Parrot-Beaked Bolls

Contabescent Anthers

- Contabescent means wasting away gradually
- Balasubranmanyan and Rangaswari, 1946
  - Cause of malfunction was discussed
  - Suggested that contabescence was caused by high temperatures and arid conditions
  - Subsequently led to imperfect fertilization of ovules

Comparison of Randomly Selected Samples of Ten Normal and Ten Parrot Beaked Cotton Bolls

Attribute	Normal	Parrot-Beaked	Difference	t-test
Seed cotton wt / boll (g)	5.26	3.68	1.58	<0.001
Locules / boll	4.30	4.30	0.00	>0.05
Seeds / boll	25.30	14.60	10.7	<0.001
Motes / boll	2.70	6.10	3.40	<0.05
Undeveloped locules / boll	0.00	1.80	1.80	-------
Seeds / developed locule	5.88	5.82	0.04	>0.05

Varietal Susceptibility to Parrot Beak

Variety	Origin	Parrot Beaked Bolls (%)
Coker	U.S.A	18.70
Auburn	U.S.A	21.30
Empire	U.S.A	26.20
DPL Smoothleaf	U.S.A	23.70
Fox 4	U.S.A	21.00
Rex Smoothleaf	U.S.A	25.55
Stoneville 7A	U.S.A	15.55
Carolina Queen	U.S.A	27.70
L.S.D		
P = 0.01		8.29
P = 0.001		11.80

Effect of Sowing Date on Parrot Beak Percent, 1965-66

Sowing Date	Parrot Beak %	Mean max. temp. during flowering °F	Flowering Period
Dec. 7, 1965	28.25	95.07	Feb. – Apr.
Dec. 7, 1966	26.25	94.60	Feb. – Apr.
Mar. 4, 1966	4.50	90.00	Mid May – July
Apr. 1, 1966	9.25	89.70	Mid June-Aug.
L.S.D			
P = 0.05	5.69		
P = 0.01	8.19		
P = 0.001	11.99		

Effects of Water Stress on Percentage of Parrot Beaked Bolls in Dry Season; Rex Smoothleaf, 1967

Watering Frequency	Seed cotton / boll (g)	Bolls / foot of row	Parrot beaked (%)	Seed cotton yield
7 day int.	4.84	20.50	8.73	2852
26 day int.	5.82	17.07	11.13	2862
35 day int.	4.86	16.33	13.86	2199
40 day int.	4.47	14.70	20.66	1895
L.S.D				
P = 0.05	0.68	1.67	3.8	393
P = 0.01	1.26	3.03	8.6	722

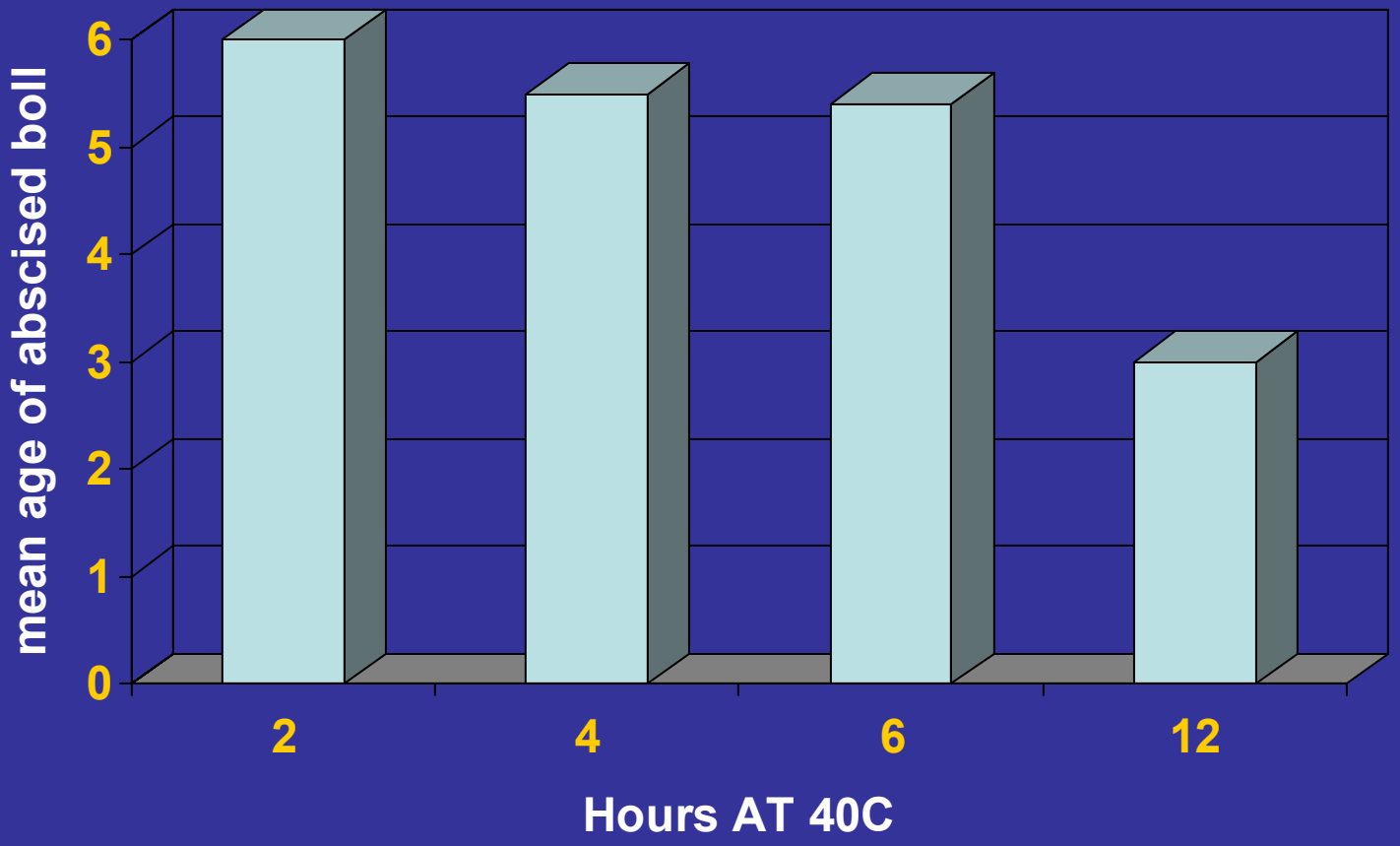
Management Implications

- Heat unit calculations
  - Upper temperature threshold
  - Above optimum temperatures
  - Solar radiation
  - Humidity
- Planting date
- Water management
- Plant population
- Varieties

Summary

- Above optimum temperatures have a significant impact on the growth and development of the cotton plant.
- 86 to 90F are optimum temperatures for both physiological and metabolic processes during the boll maturation period.
- A warmer or longer growing season (more accumulated heat units) does not necessarily mean that the crop yield will be higher-continuous excessive high daily temperatures can result in crop stress and affect the plant-water status (Sevacharian, 1983).
- Knowing how a cotton field reacts to temperature stress helps crop managers solve and explain what is happening to our clientele.

Effect of Hours per Day at 40C on Age of Abscised Bolls (K.R. Reddy, 1992)



Upper Limit Threshold/Calculation of Heat Units

- Maximum temperatures during much of the growing season are above the optimum temperatures resulting in less than maximum growth (Kerby).
- The use of heat unit growth models without upper temperature thresholds results in an overestimation of the favorableness of the growing season and the time required to complete various physiological events (Kerby).
- A warmer or longer growing season (more accumulated heat units) does not necessarily mean that the crop yield will be higher-continuous excessive high daily temperatures can result in crop stress and affect the plant-water status (Sevacharian, 1983).

Influence of Temperature on micronaire values. Average temperature from first flower to first open boll (K.R. Reddy, 1999).