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Carbon Use Efficiency: Adaptation to Changing Environments

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Carbon Use Efficiency: Adaptation to Changing Environments

10 chamber gas exchange system

Jonathan Frantz and
Bruce Bugbee

Crop Physiology Lab
Utah State University


12 chamber system in greenhouse

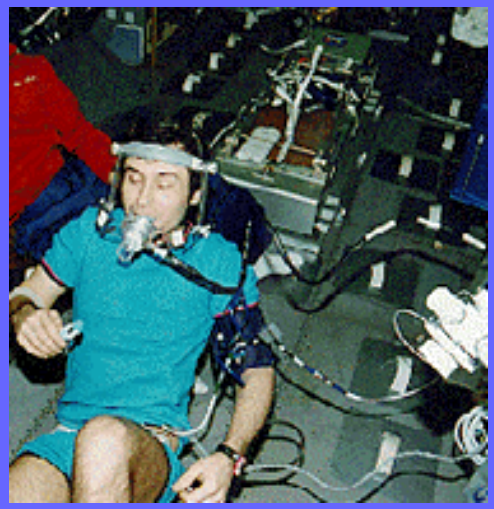
Carbon use efficiency

Animals

$$\frac{\textbf{weight gain}}{\textbf{Food input}}$$

Carbon use efficiency

Animals



Humans

$$\frac{\text{weight gain}}{\text{food input}}$$

$$\frac{\text{Work output}}{\text{Food input}}$$

Carbon use efficiency

ANIMALS

PLANTS

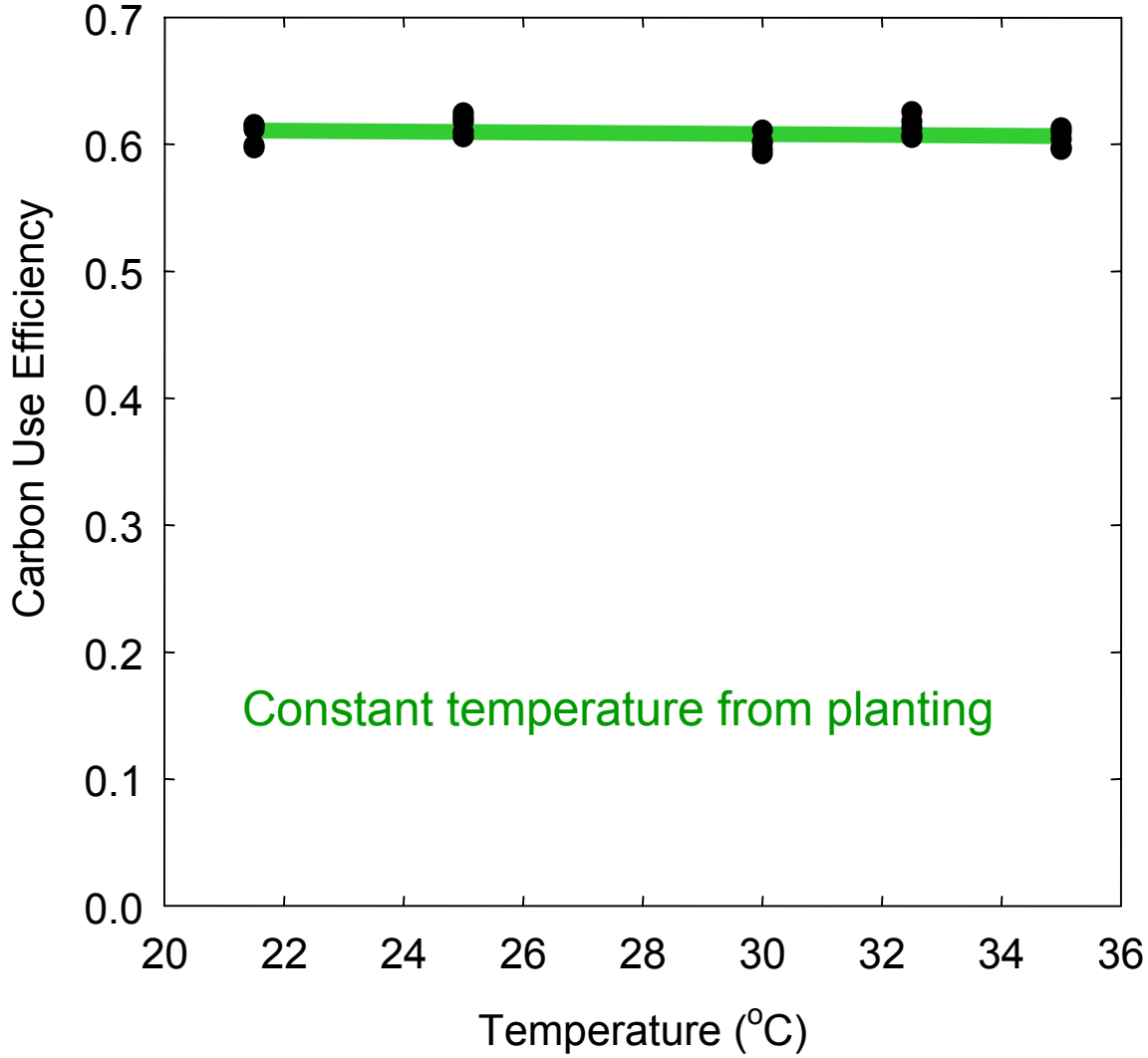
$$\frac{\textbf{weight gain}}{\textbf{food input}}$$

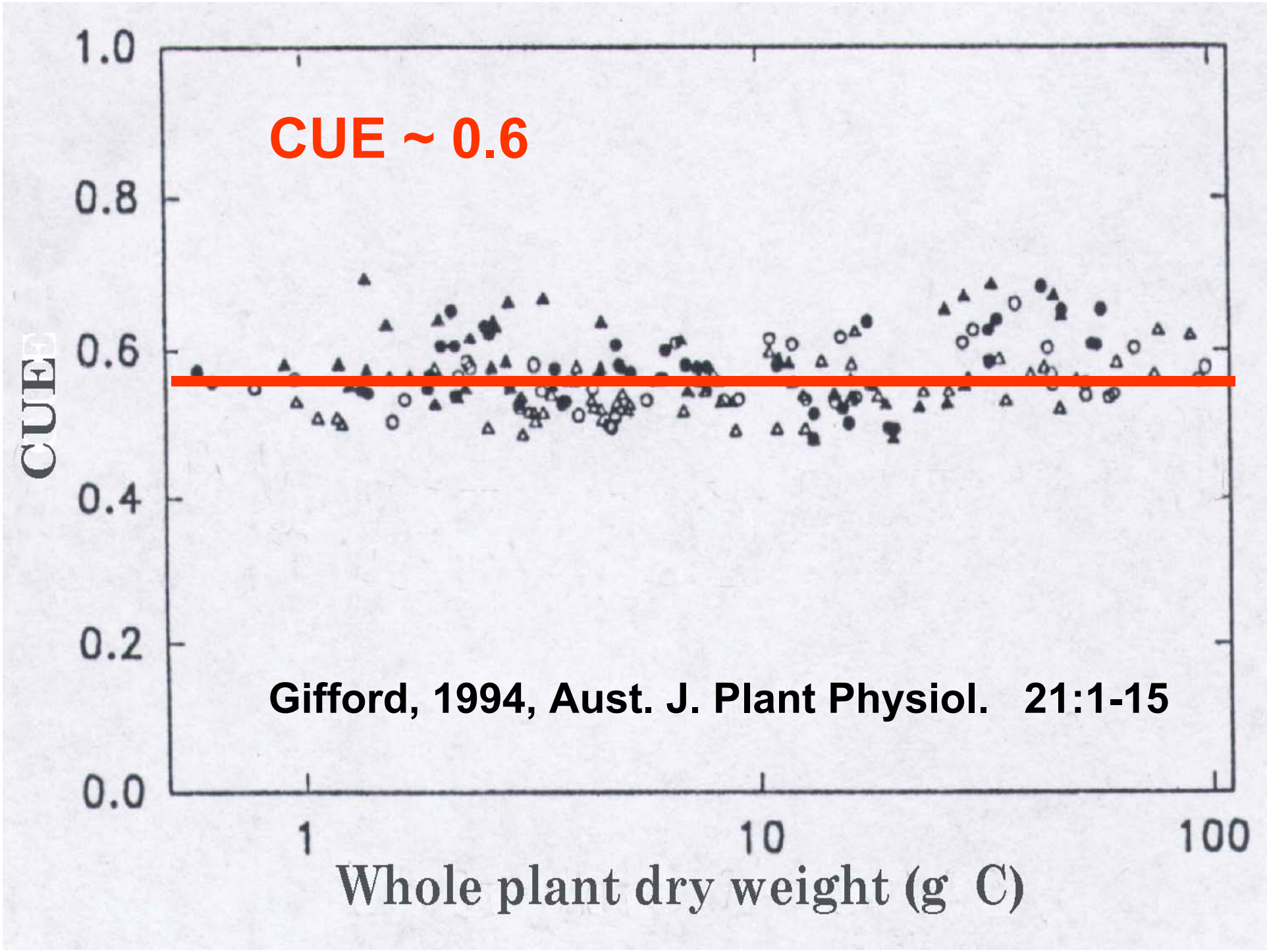
5 to 20%

$$\frac{\textbf{weight gain}}{\textbf{gross photosynthesis}}$$

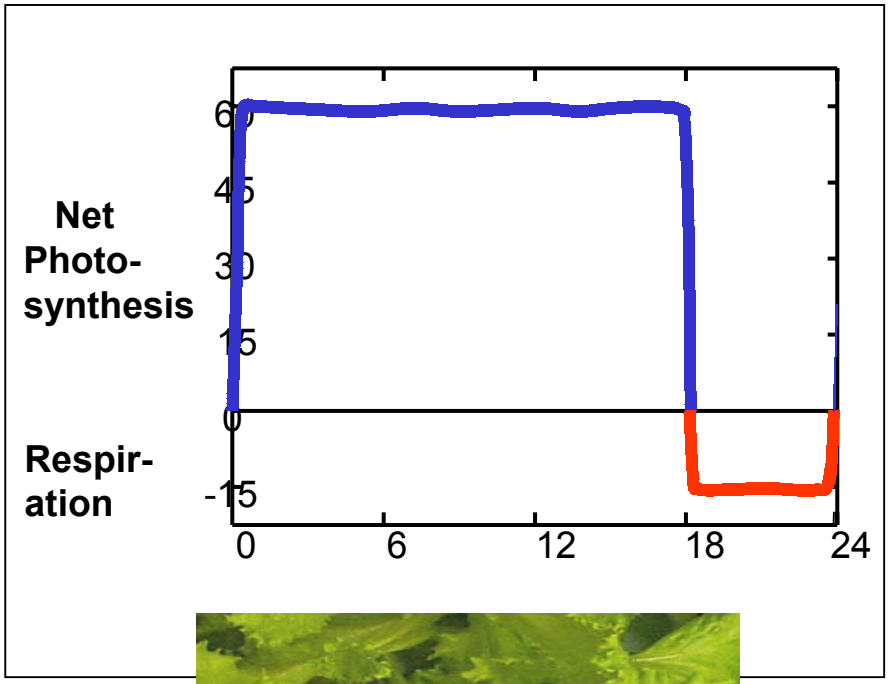
~ 60%

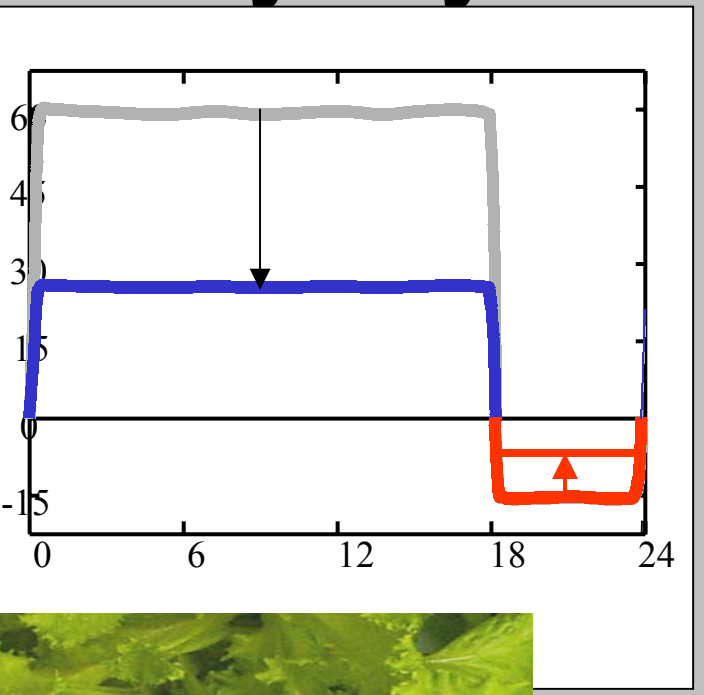
LETTUCE


0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Carbon Use Efficiency
Constant temperature from planting
20
22
24
26
28
30
32
34
36
Temperature (°C)

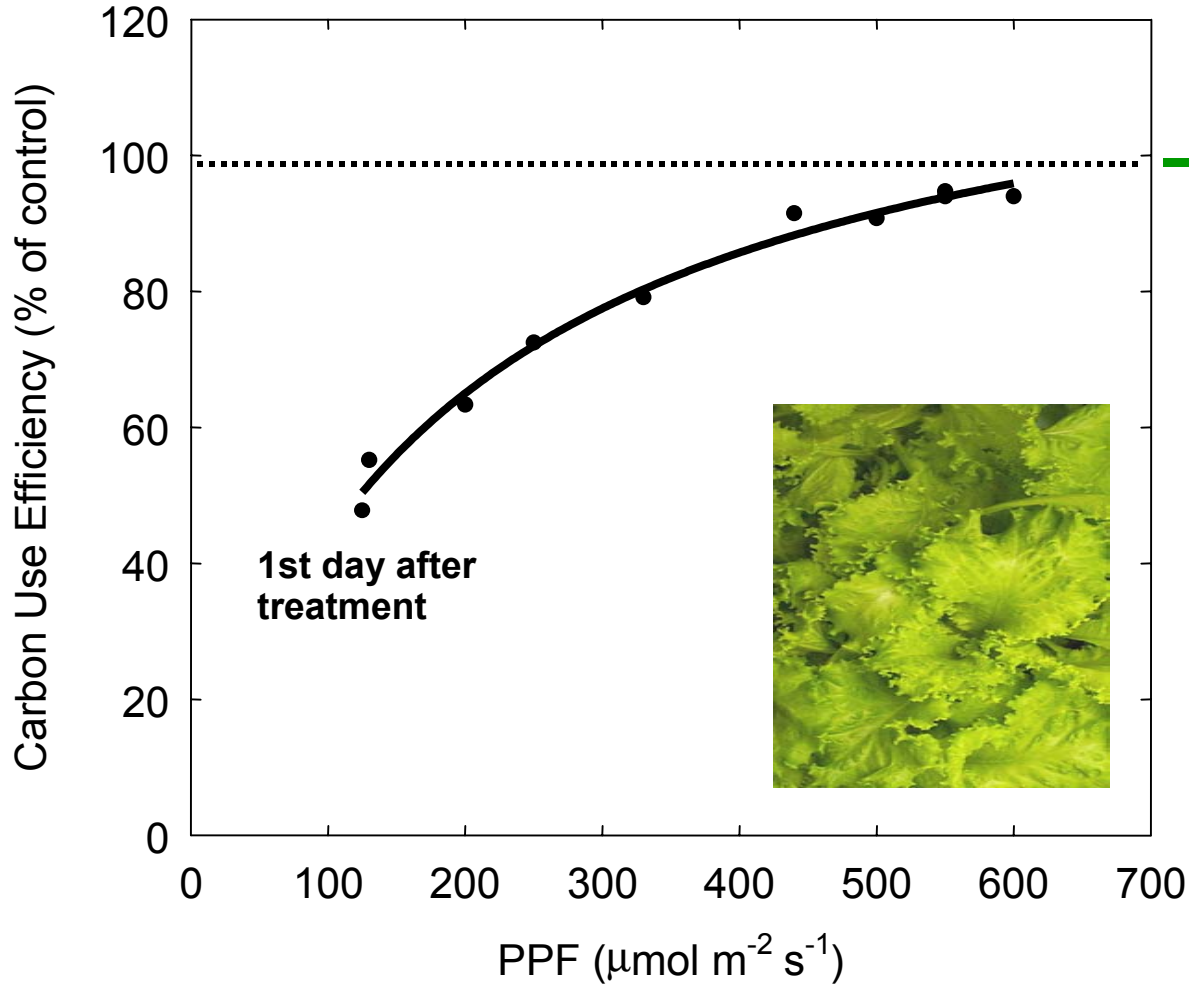

CUE ~ 0.6
1.0
0.8
0.6
0.4
0.2
0.0
CUE
1
10
100
Whole plant dry weight (g C)
Gifford, 1994, Aust. J. Plant Physiol. 21:1-15

Sunny days → Cloudy days



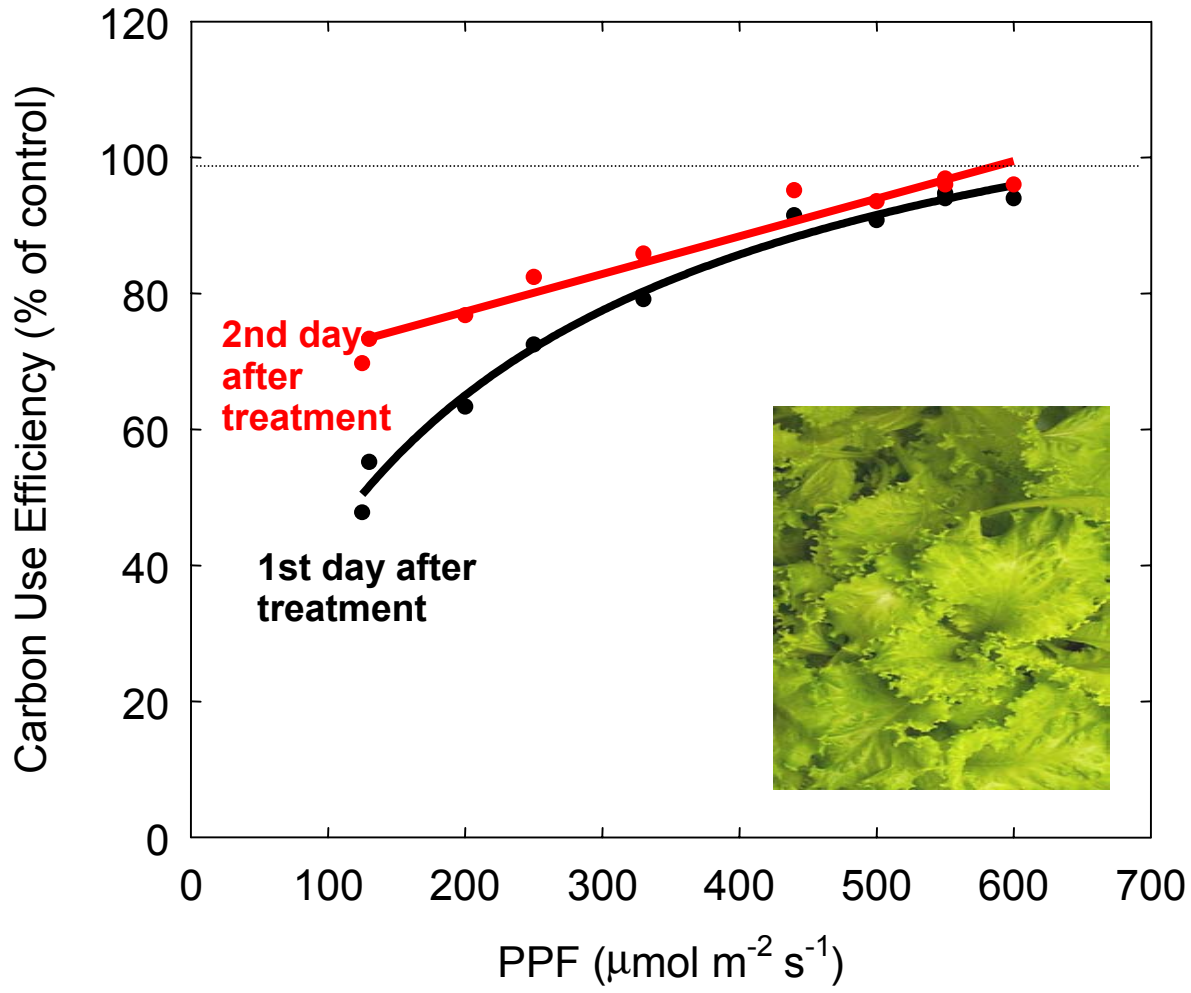


Carbon use efficiency

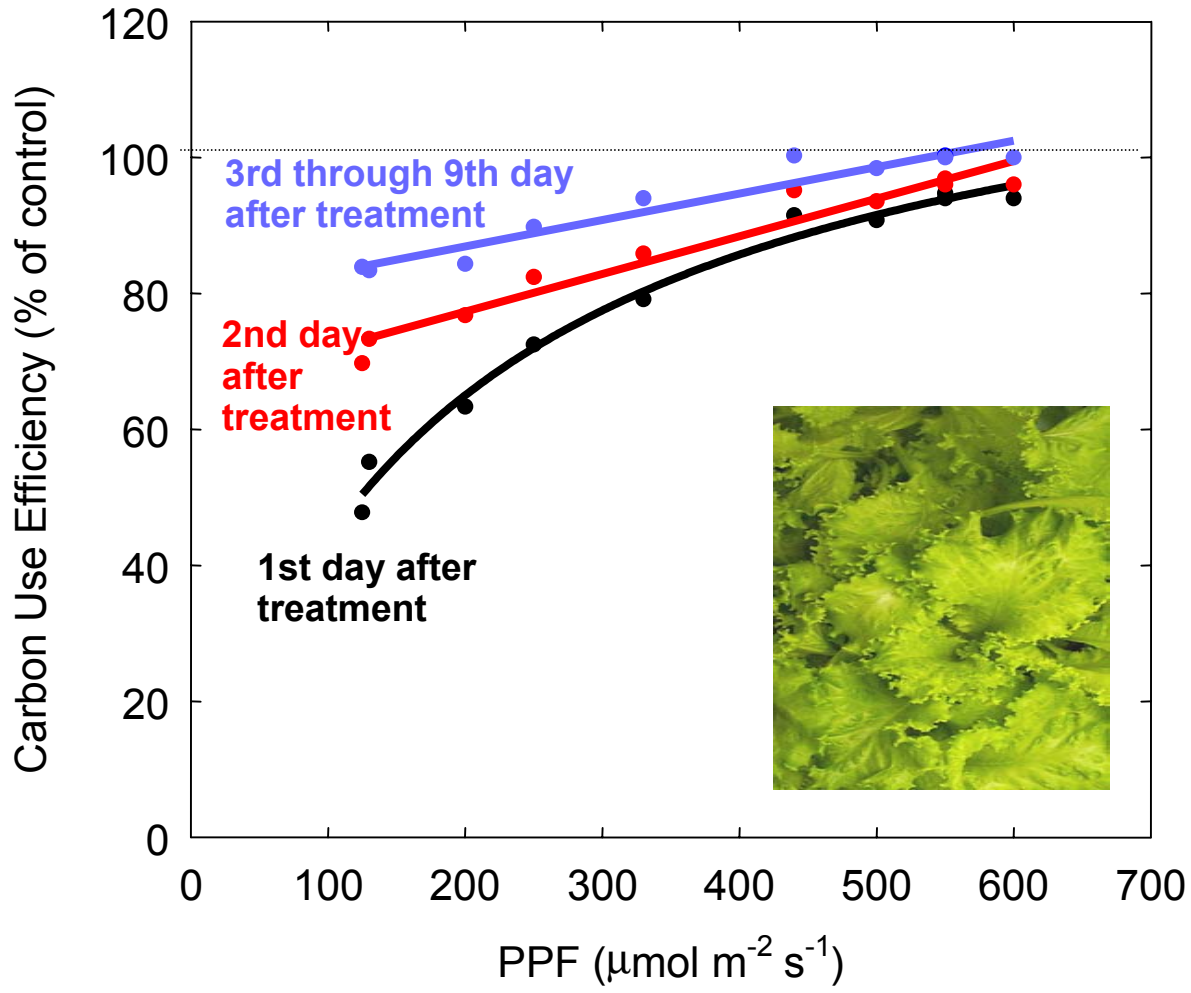


- 60%

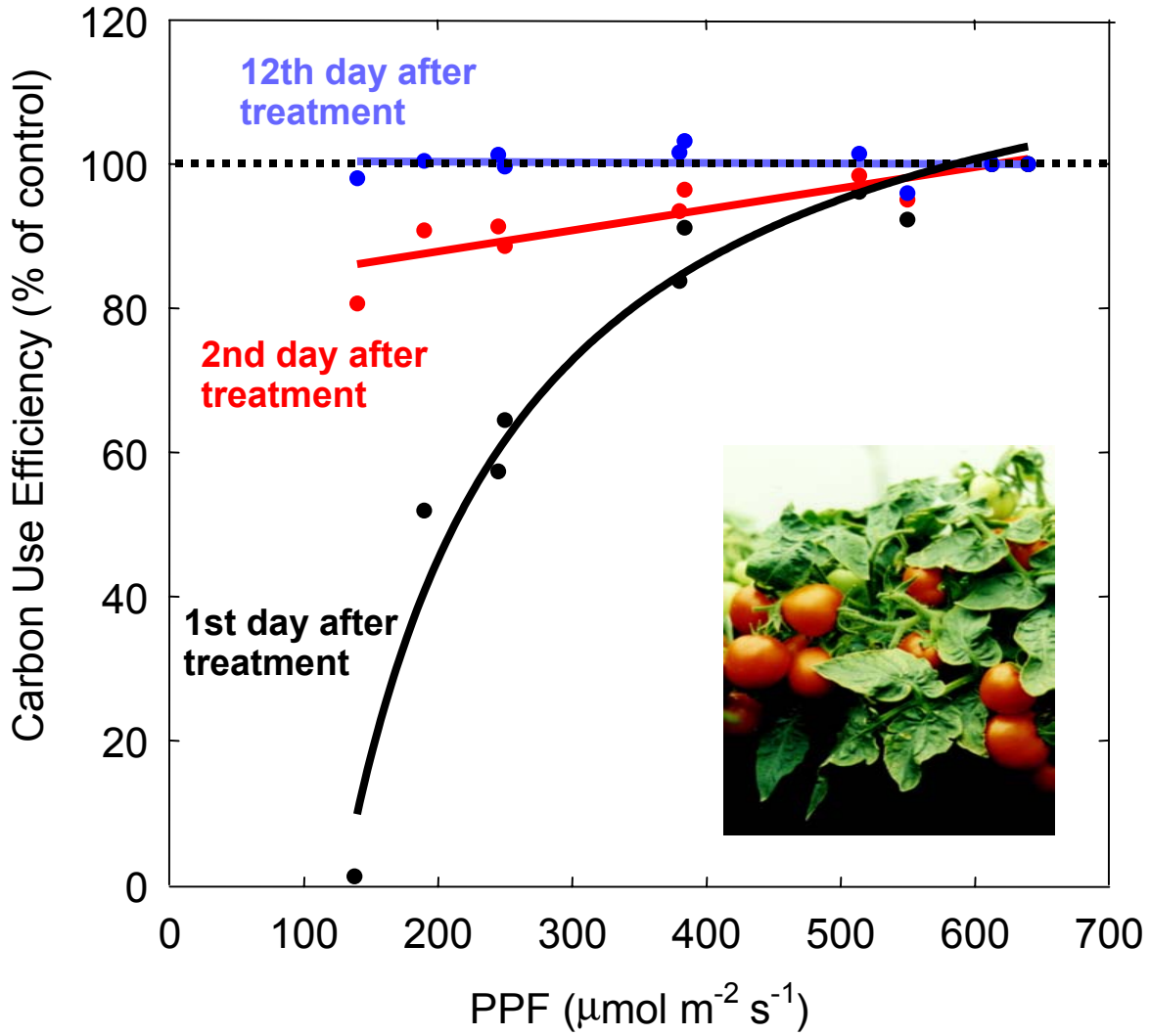
Carbon use efficiency



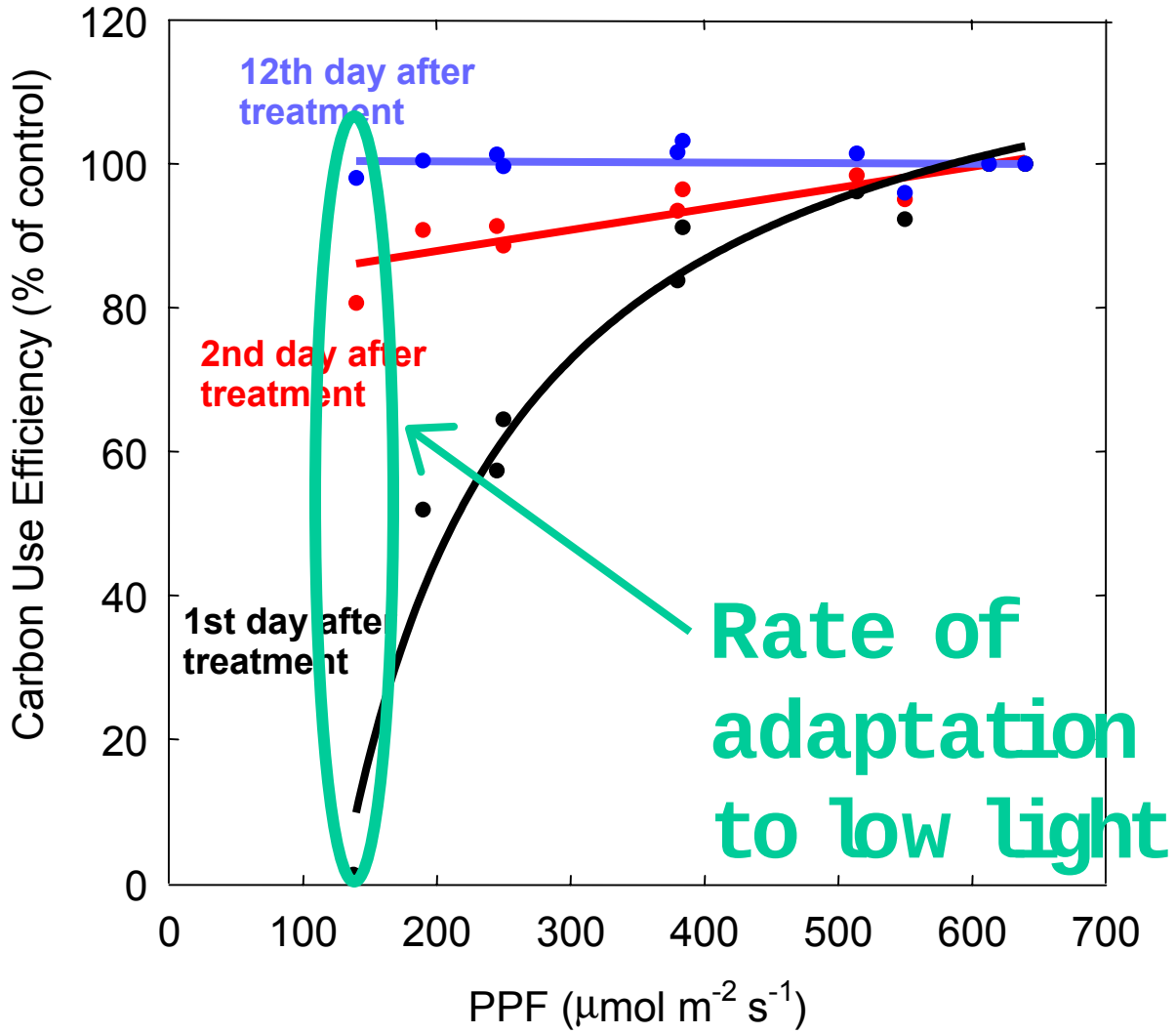
Carbon use efficiency

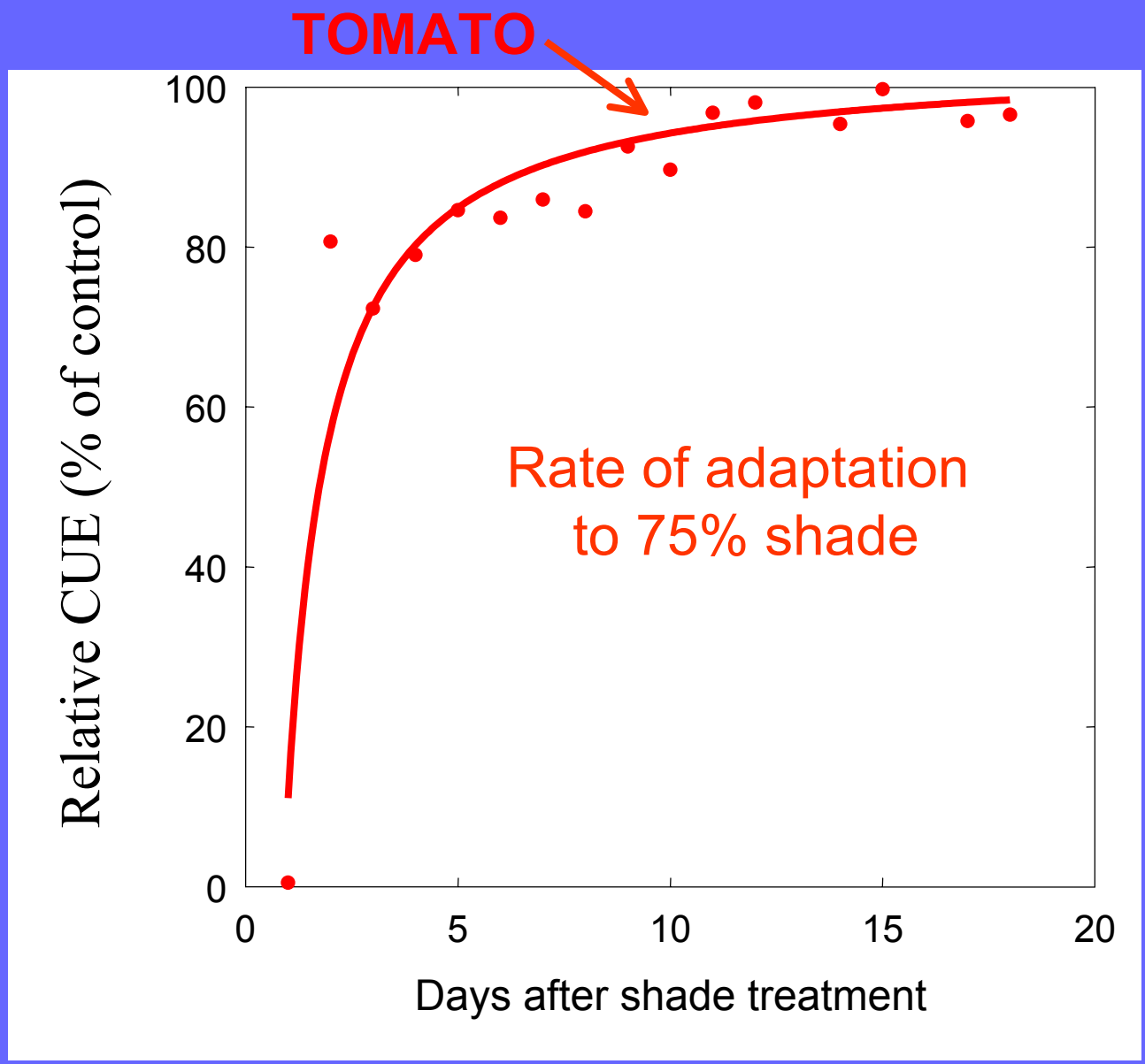


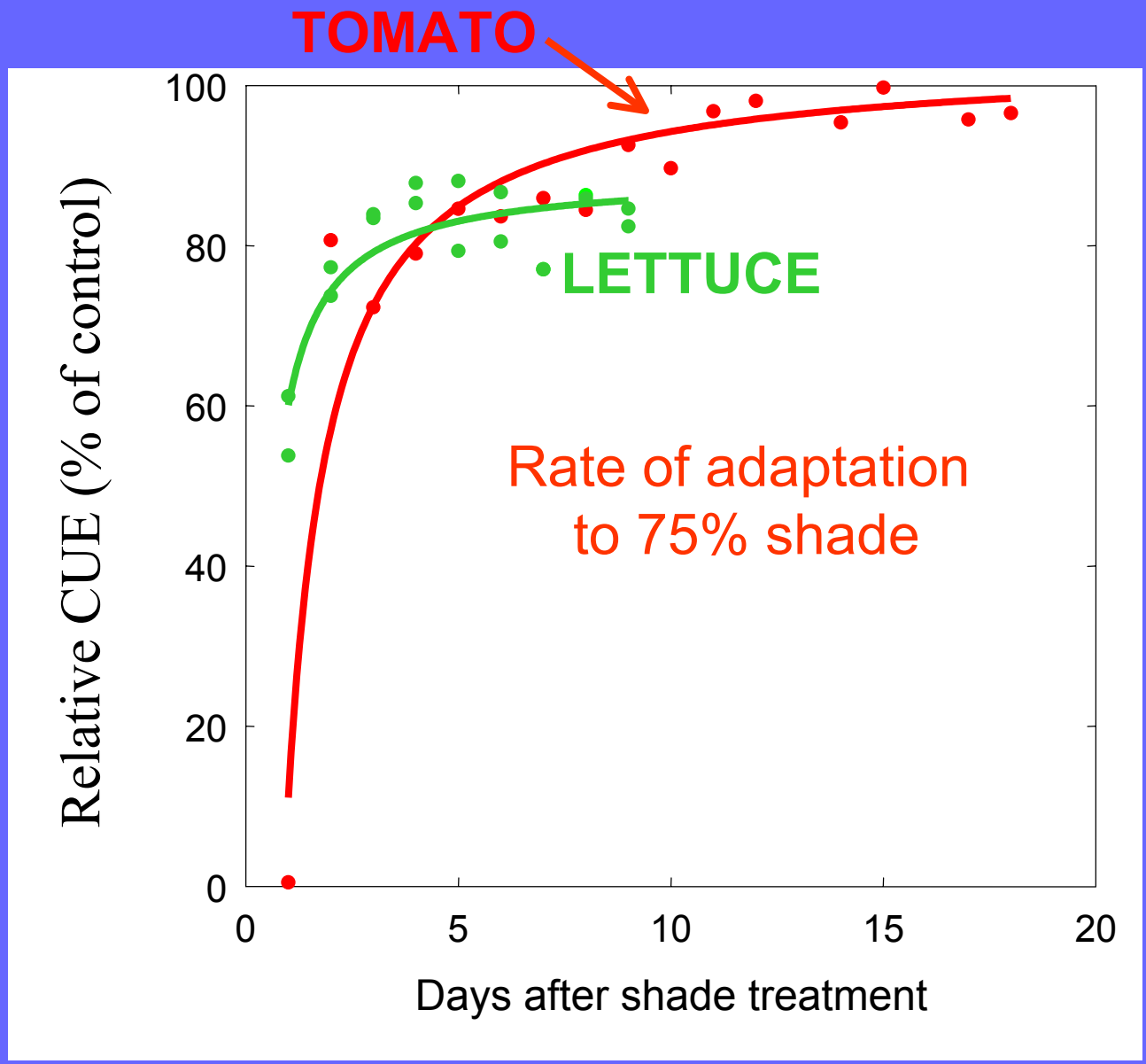
TOMATO - vegetative growth



TOMATO

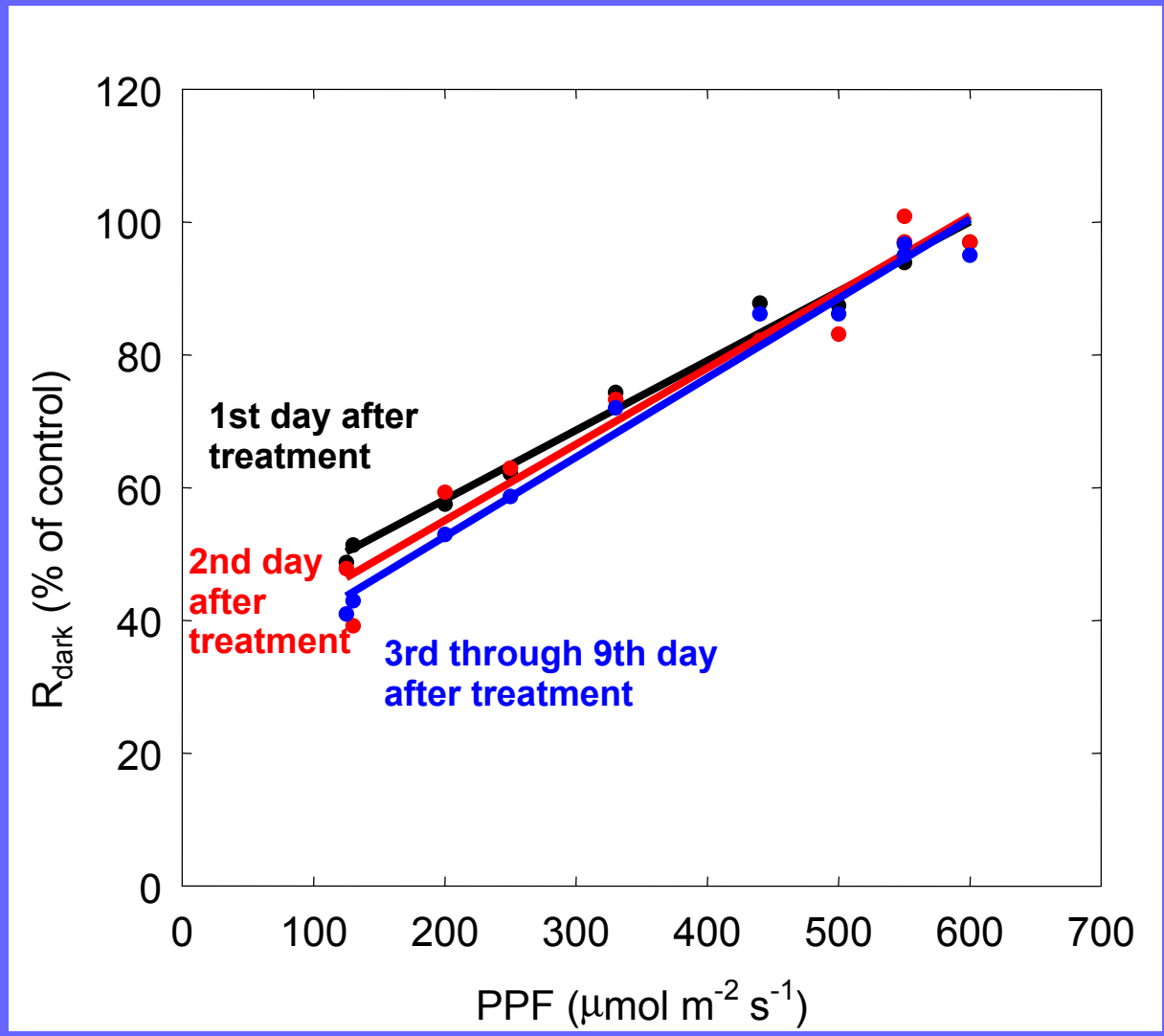

120
100
80
60
40
20
0
0
100
200
300
400
500
600
700
Carbon Use Efficiency (% of control)
PPF (µmol m-2 s-1)
12th day after treatment
2nd day after treatment
1st day after treatment
Rate of adaptation to low light


TOMATO
Relative CUE (% of control)
100
80
60
40
20
0
0
5
10
15
20
Days after shade treatment
Rate of adaptation
to 75% shade

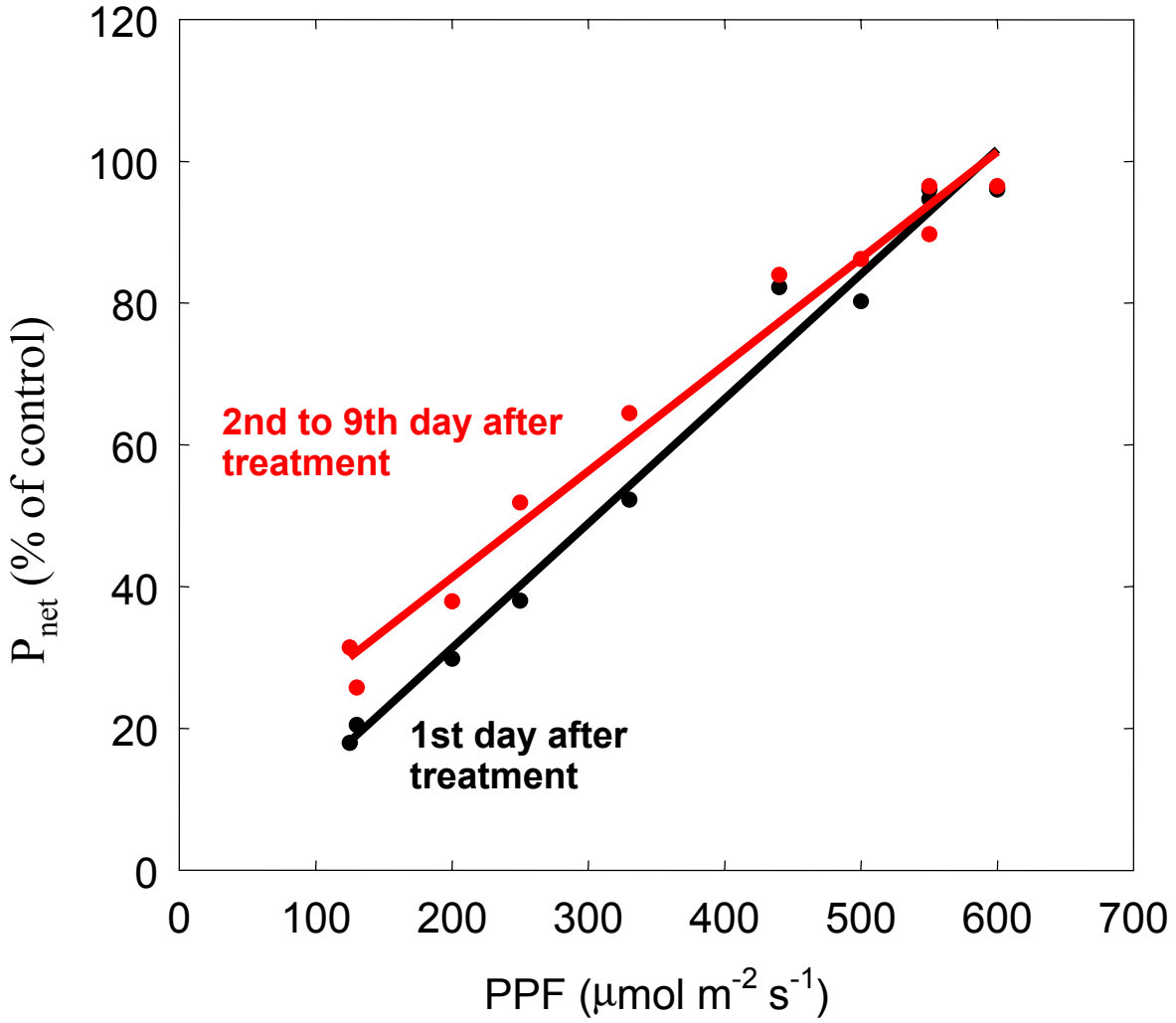

TOMATO
LETTUCE
Rate of adaptation
to 75% shade
Relative CUE (% of control)
Days after shade treatment
0
20
40
60
80
100
0
5
10
15
20

- Most shade adaptation occurred within two days during vegetative phase
- Up to 12 days were required for complete adaptation
- species adapted differently

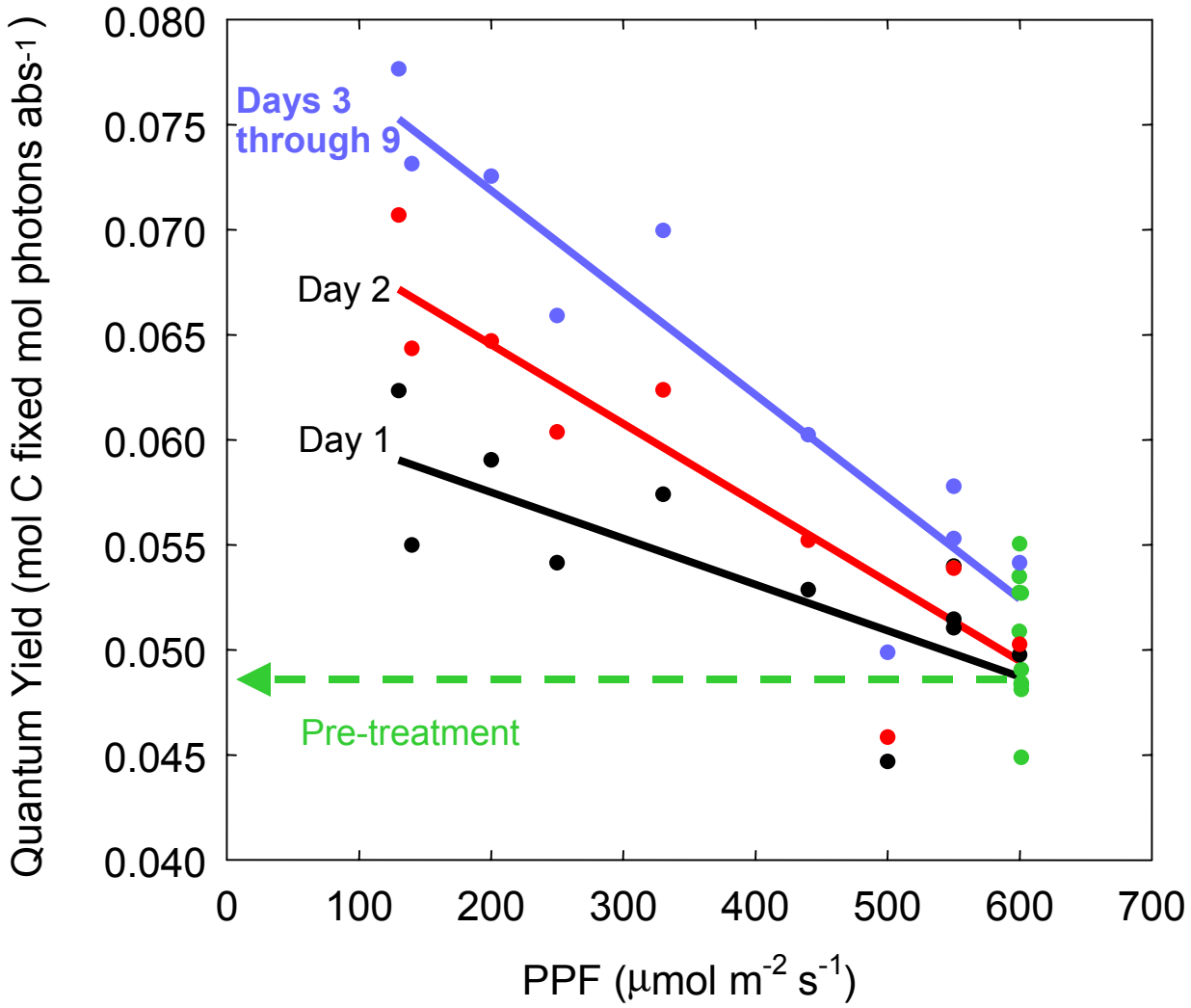
Lettuce respiration

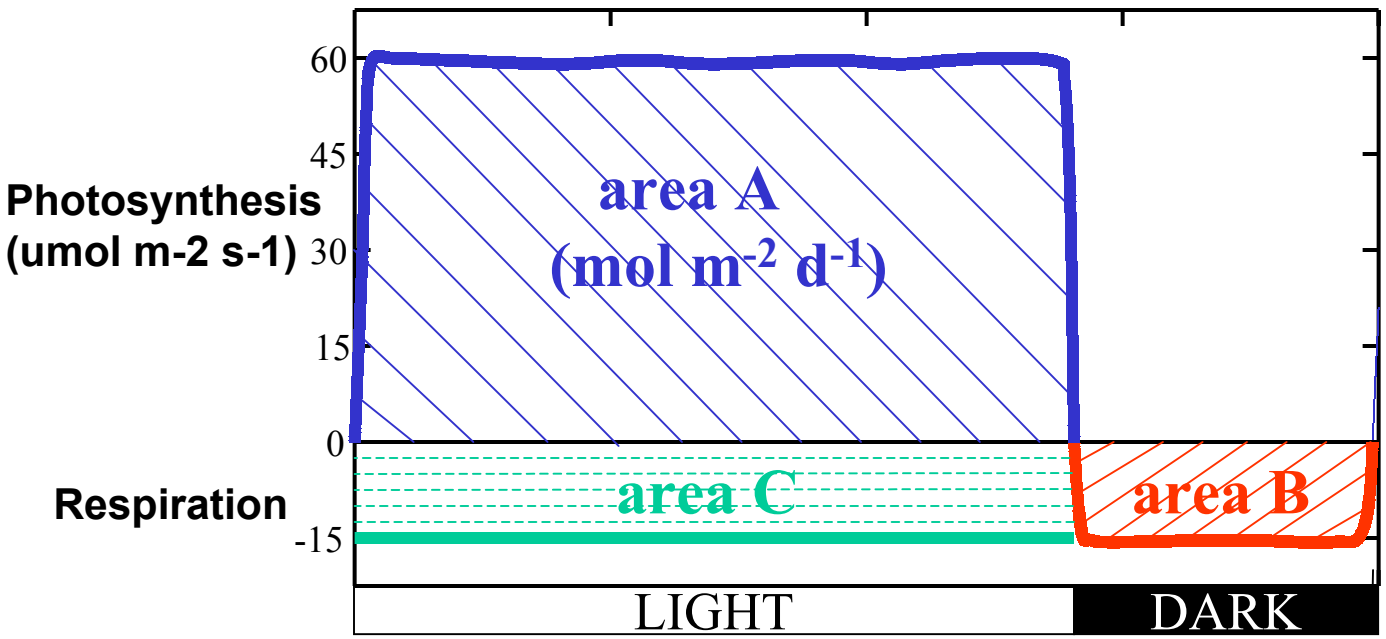


LETTUCE


120
100
80
60
40
20
0
0
100
200
300
400
500
600
700
P_{net} (% of control)
PPF (µmol m^{-2} s^{-1})
2nd to 9th day after treatment
1st day after treatment

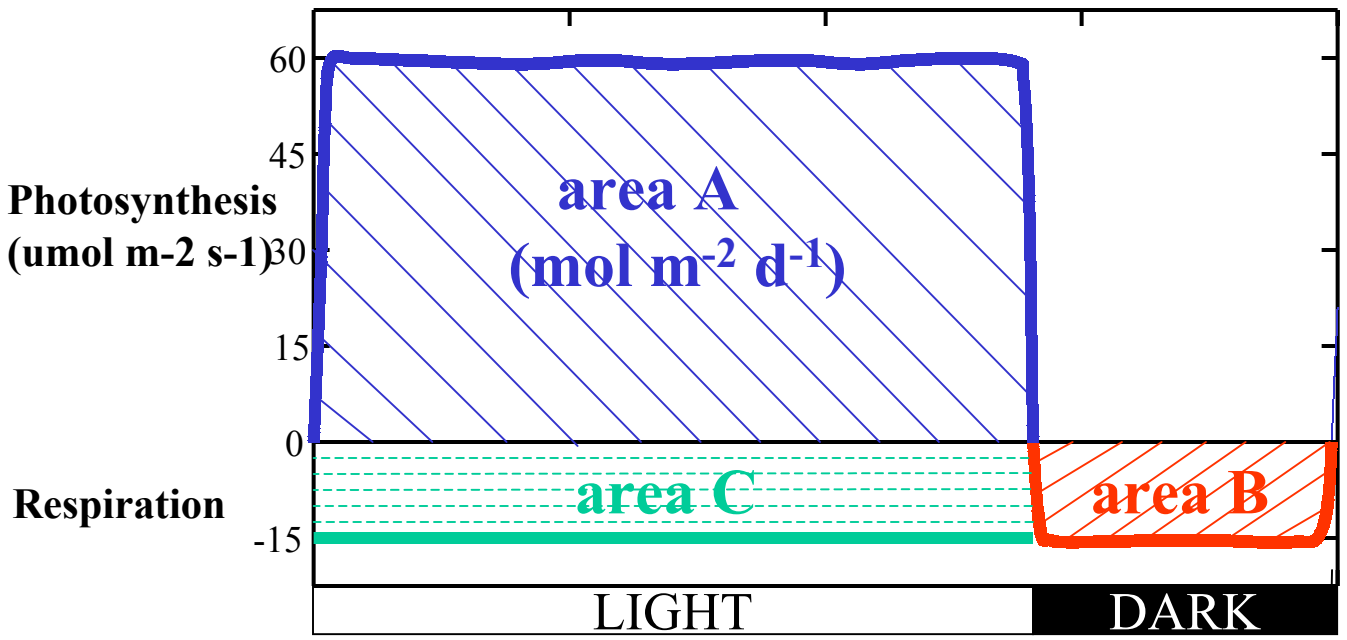
LETTUCE


Quantum Yield (mol C fixed mol photons abs-1)
0.080
0.075
0.070
0.065
0.060
0.055
0.050
0.045
0.040
Days 3
through 9
Day 2
Day 1
Pre-treatment
0
100
200
300
400
500
600
700
PPF (µmol m-2 s-1)



area A - area B = Daily Carbon Gain

Respiration occurs in both the day and night



area A - area B = **Daily Carbon Gain**

area A + area C = **Daily Gross Photosynthesis**

$$\text{Carbon Use Efficiency} = \frac{\text{Daily Carbon Gain}}{\text{Daily Gross Photosynthesis}}$$