

Shade in cocoa- A physiological perspective

Light, Temperature, Water

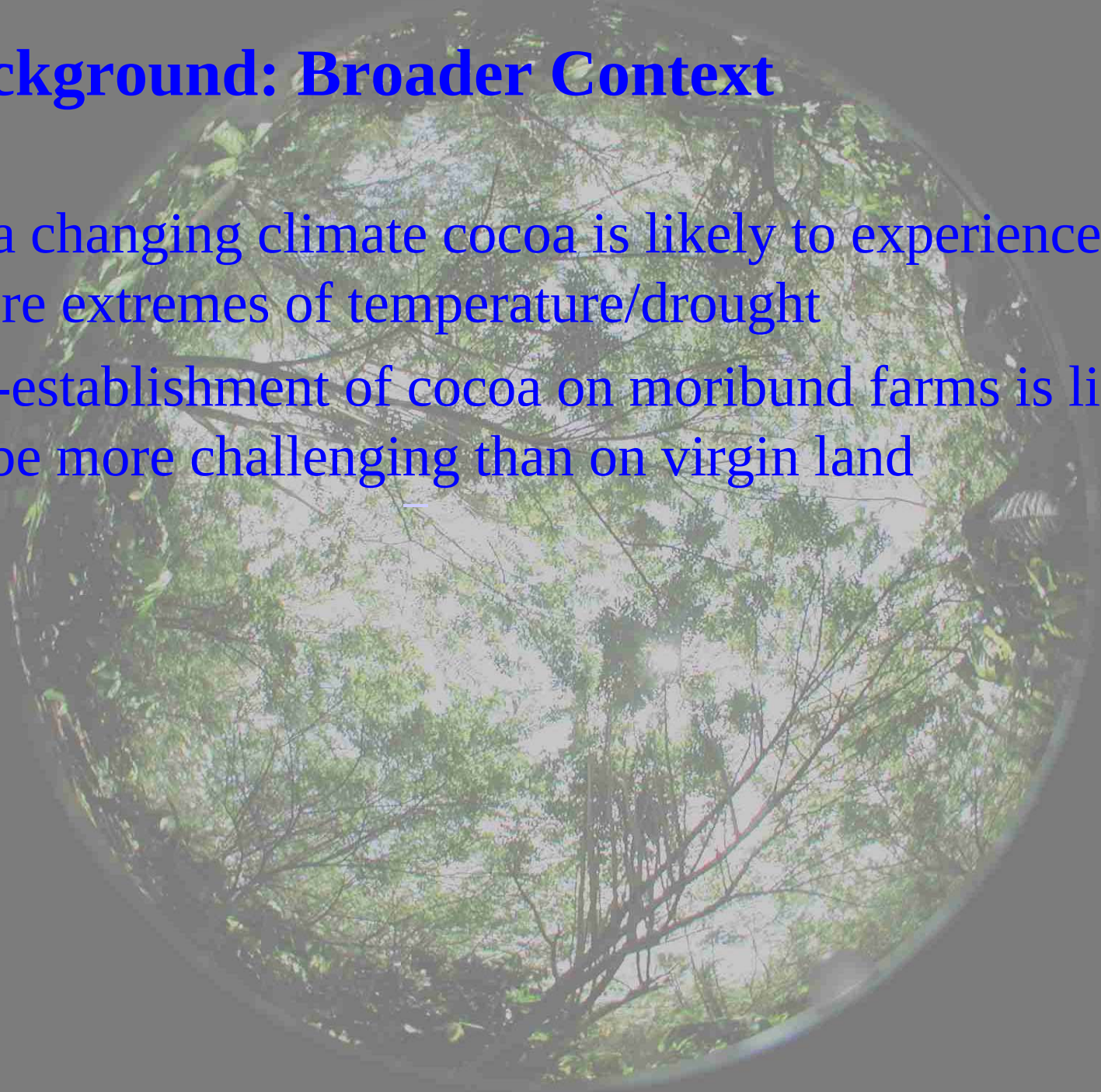
Andrew Daymond

Background: why and how shade is used

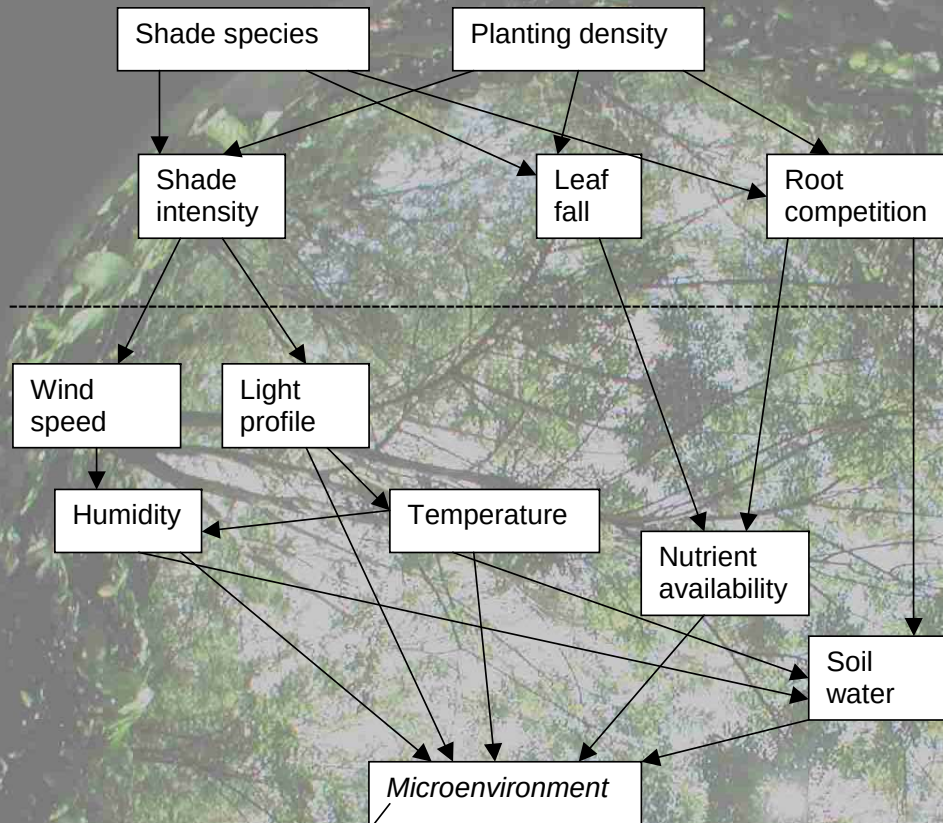
- Tendency in some regions towards using less shade
- Establishment difficult without shade
- Sometimes a perceived need to maintain a level of shade above mature trees
- Shade removal sometimes impractical
- Legal constraints
- Intercropping with species of economic value

Background: Broader Context

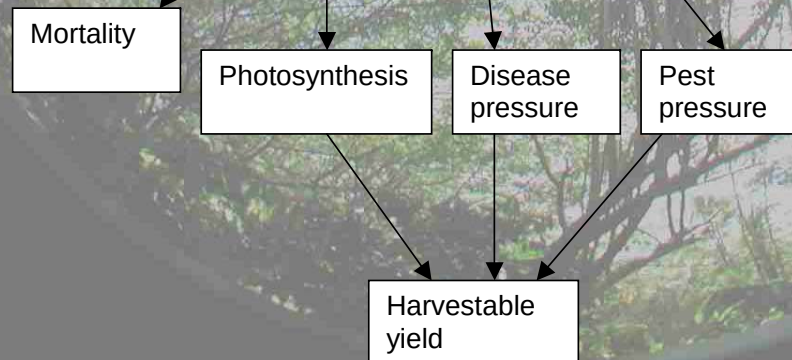
- In a changing climate cocoa is likely to experience more extremes of temperature/drought
- Re-establishment of cocoa on moribund farms is likely to be more challenging than on virgin land



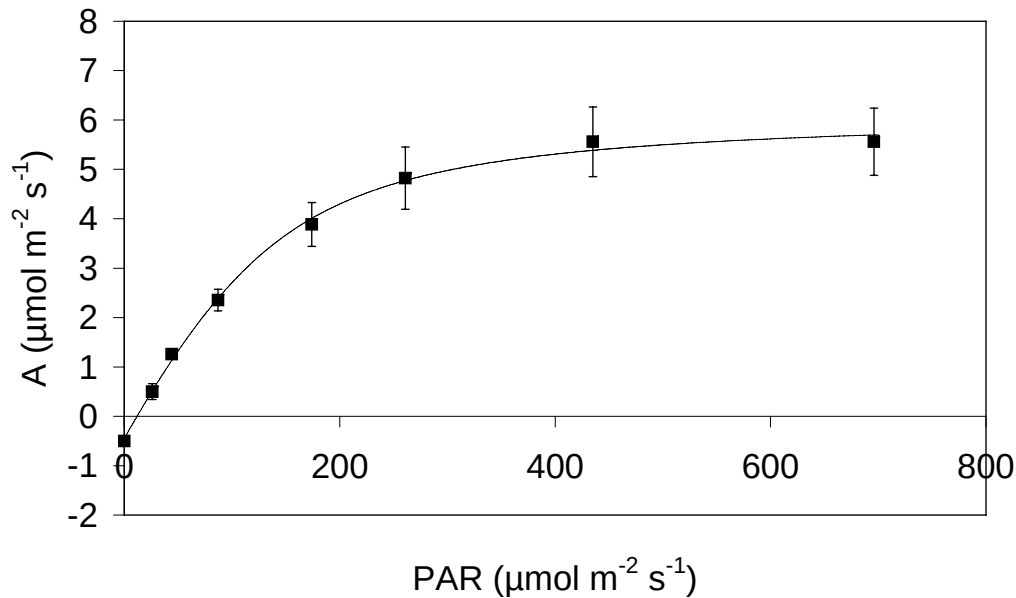
SHADE



COCOA



Light- leaf level



Cocoa has:-

- Low light compensation point
- Low light saturation point
- Light is not usually a major limiting factor to assimilation in young cocoa

Photosynthetic light response curve: SCA6

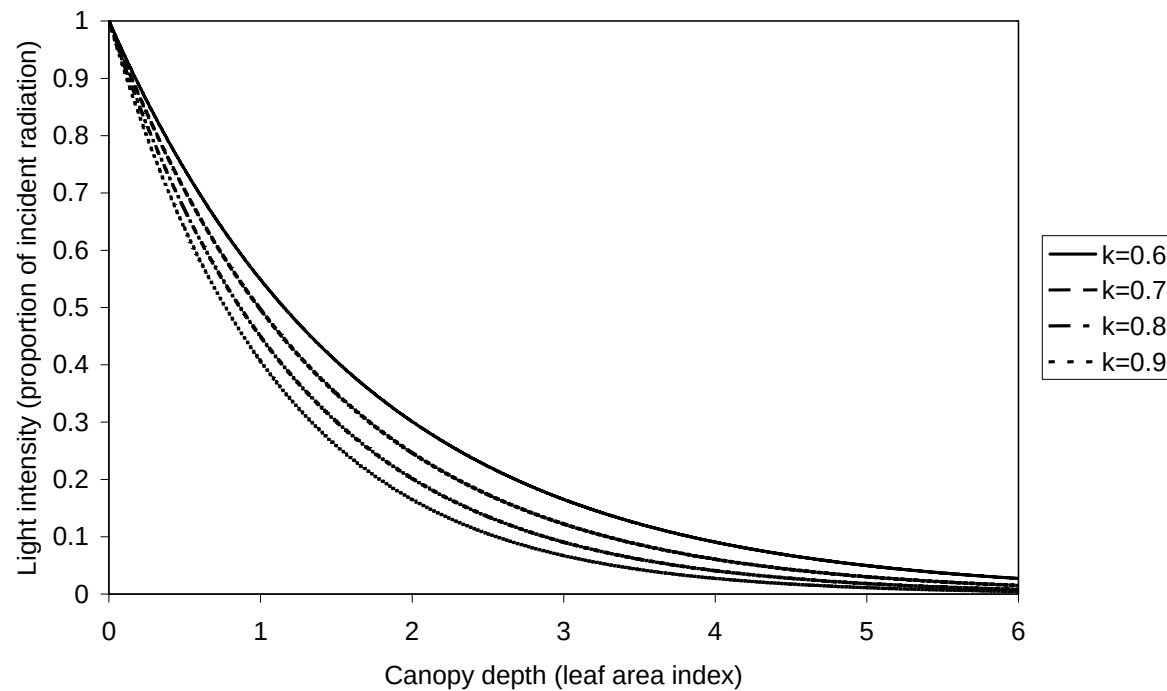
Canopy Perspective



Light penetration
dependent on: -

1. Leaf area index
(variety, age, density)
2. Size and arrangement
of the leaves

Genetic variation in
canopy characteristics:
Daymond *et al.*, (2002)

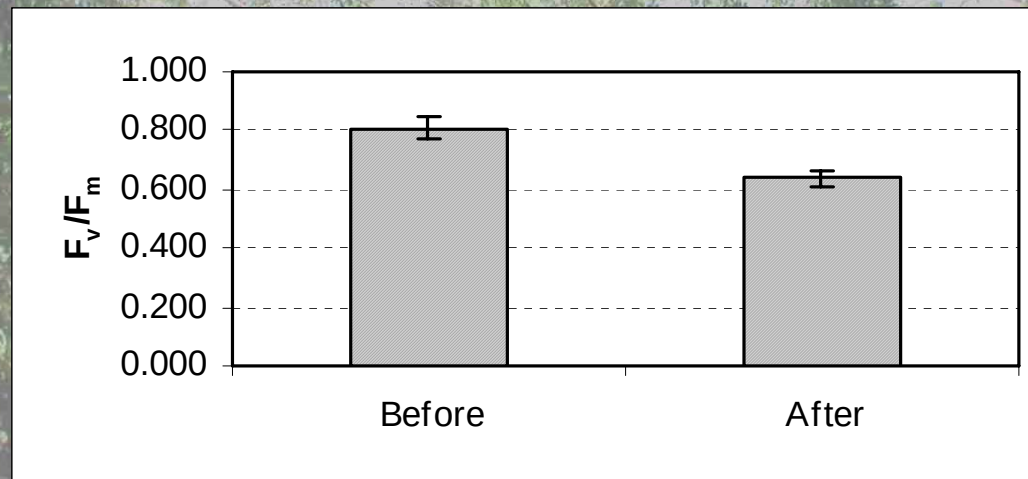


Lower value of 'k' =
more open canopy

Light penetration through canopies with
different extinction coefficients

Photo-inhibition

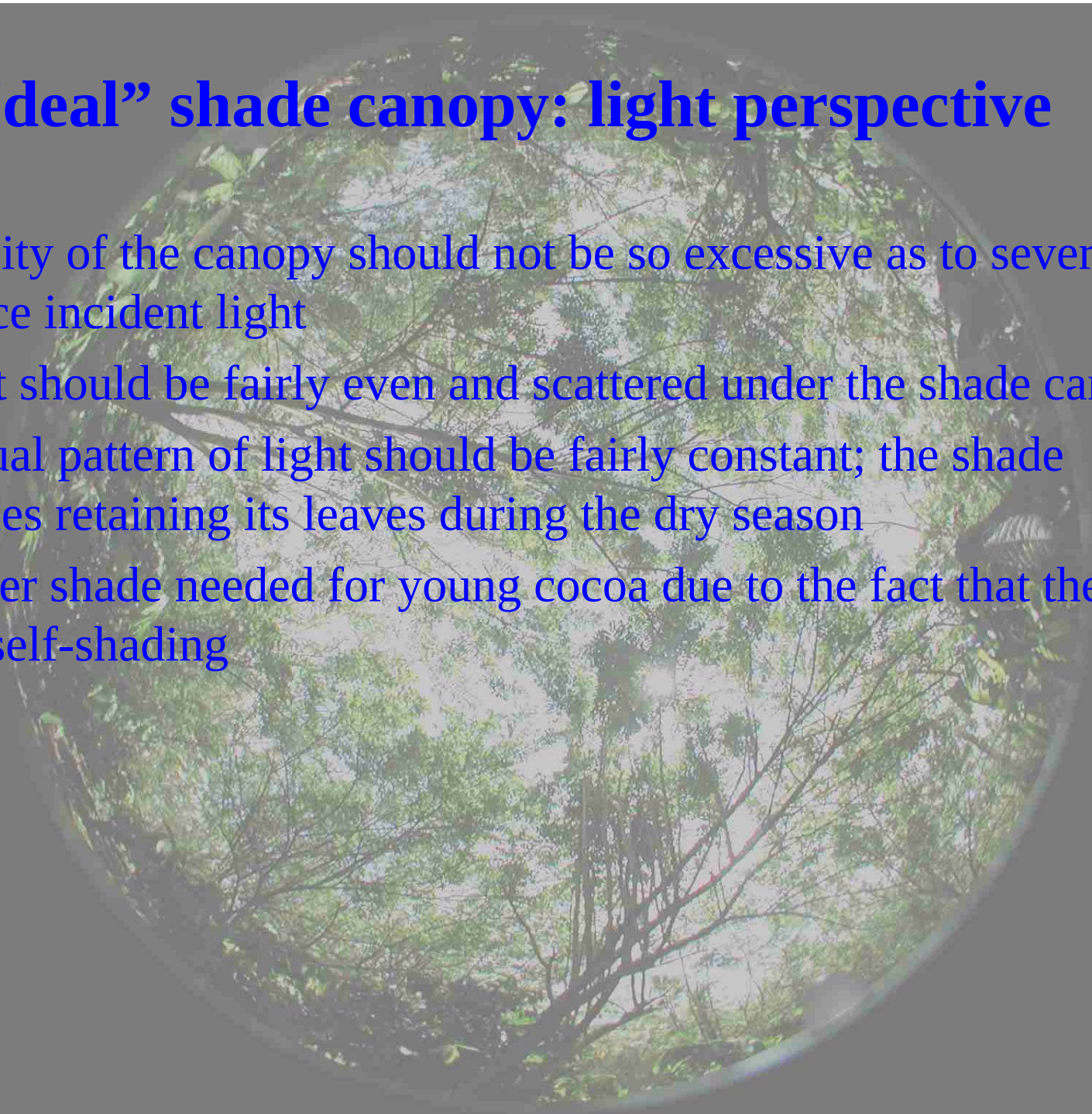
- A reduction in photosynthetic efficiency is seen after exposure to high light intensities
- Photo-inhibition often reversible- a suppression of photosynthetic efficiency typically being observed during the middle part of the day



The effect of 15 minutes light exposure
(PAR= 2000 $\mu\text{mol m}^{-2} \text{s}^{-1}$) on PSII activity;
clone = SCA 6

“Ideal” shade canopy: light perspective

- Density of the canopy should not be so excessive as to severely reduce incident light
- Light should be fairly even and scattered under the shade canopy
- Annual pattern of light should be fairly constant; the shade species retaining its leaves during the dry season
- Higher shade needed for young cocoa due to the fact that there is less self-shading



Adaptation to the Light Environment



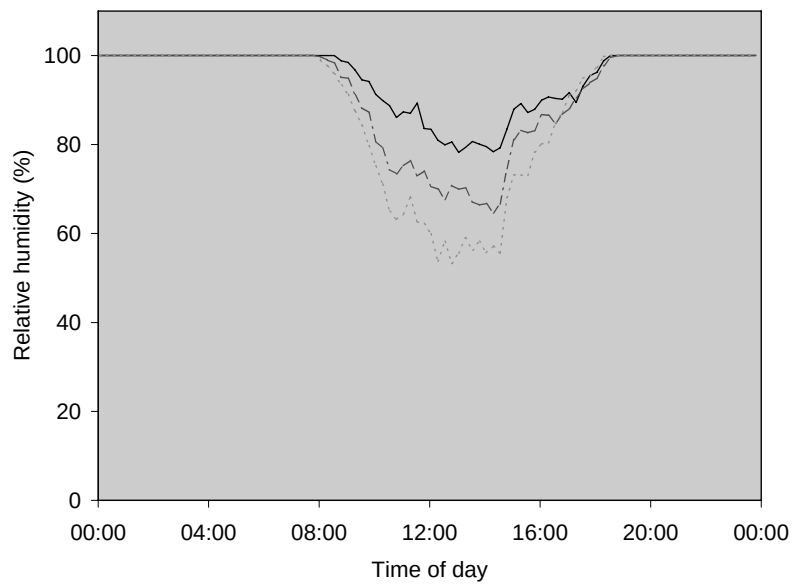
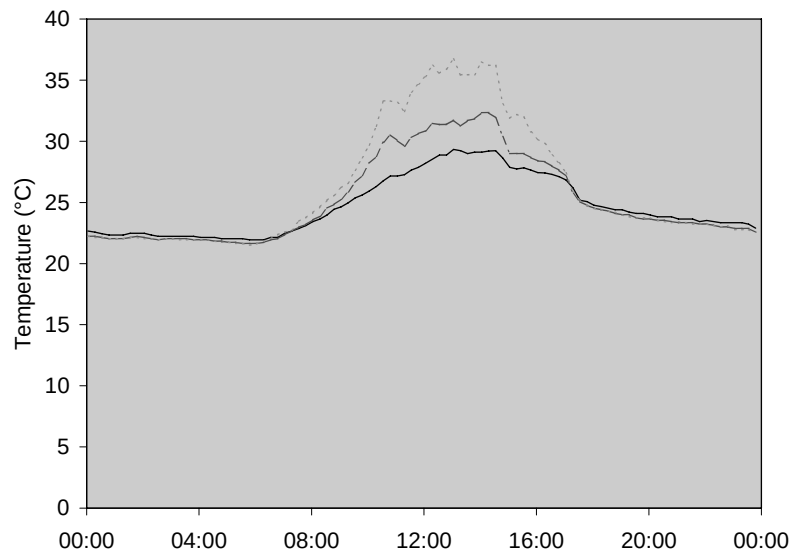
Growing in full sunlight

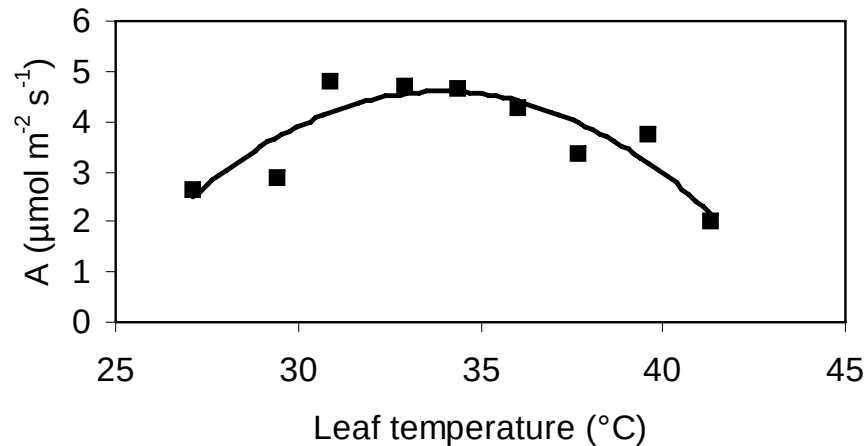
- Use of appropriate variety/ density

Growing under shade

- Use of variety with high photosynthetic efficiency at lower light level
- Use of variety with an open canopy architecture and/ or pruning to allow light to penetrate the lower canopy layers

Temperature and humidity





Response of photosynthetic rate
in cocoa to temperature

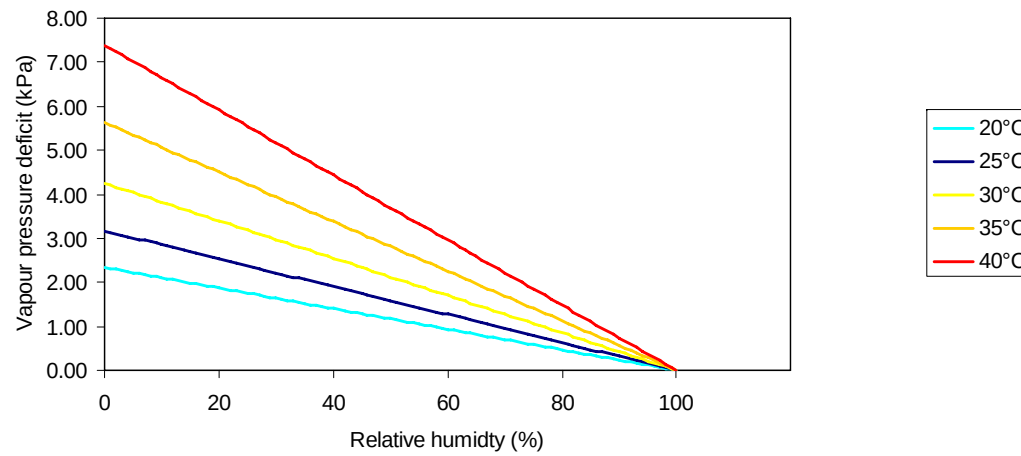
High temperatures:-

Net photosynthesis
inhibited by:-

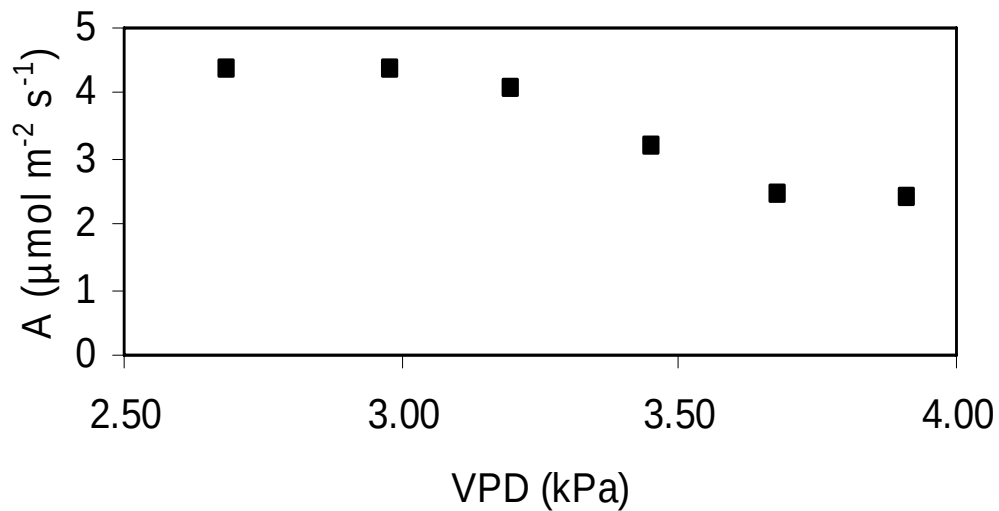
- Higher respiration rates
- Reduced photosystem II activity
- Stomatal closure (indirectly)

Yield also affect by:

- Higher wilting rates
- Small bean size

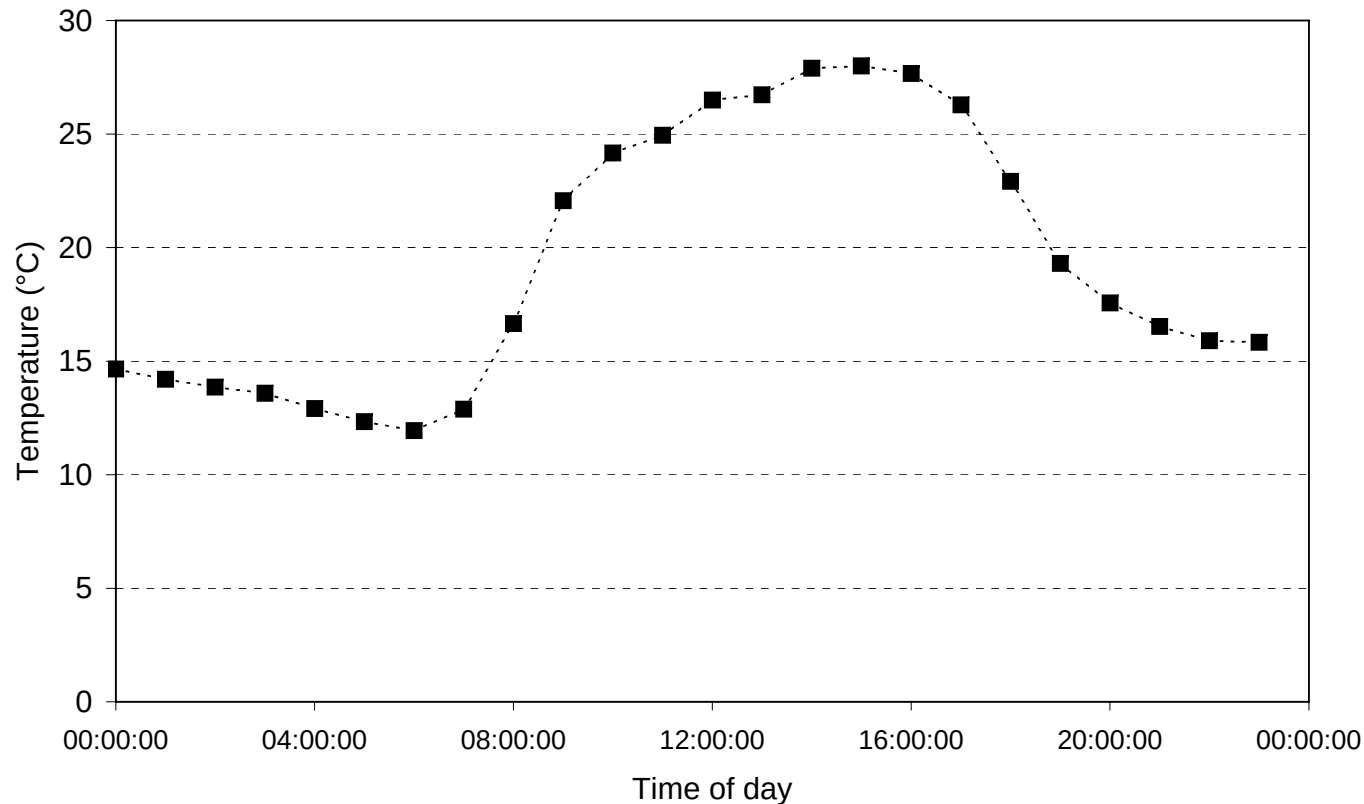


Photosynthetic rate
reduced at a higher VPD
due to stomatal closure



Response of photosynthetic rate in
cocoa to vapour pressure deficit

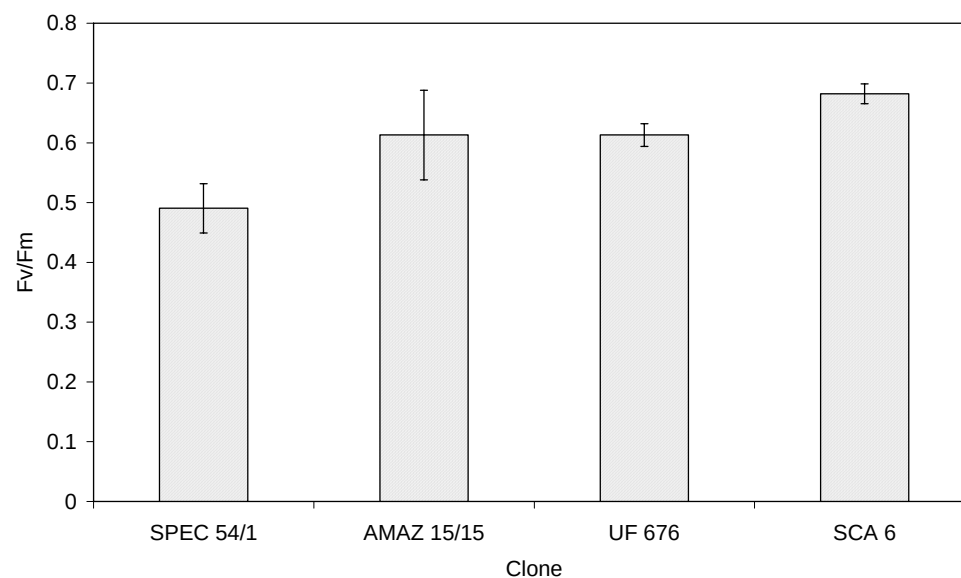
Shade can potentially also ameliorate cold temperatures



Diurnal variation in temperature, 28/07/98. Nr Itajuípe, Bahia, Brazil

Adapting to high temperatures/ high vapour pressure deficit

- Shade may be used to ameliorate excessive temperatures and vapour pressure deficits
- Some genotypes appear to be more hardy to extremes of temperature (Daymond & Hadley, 2007)

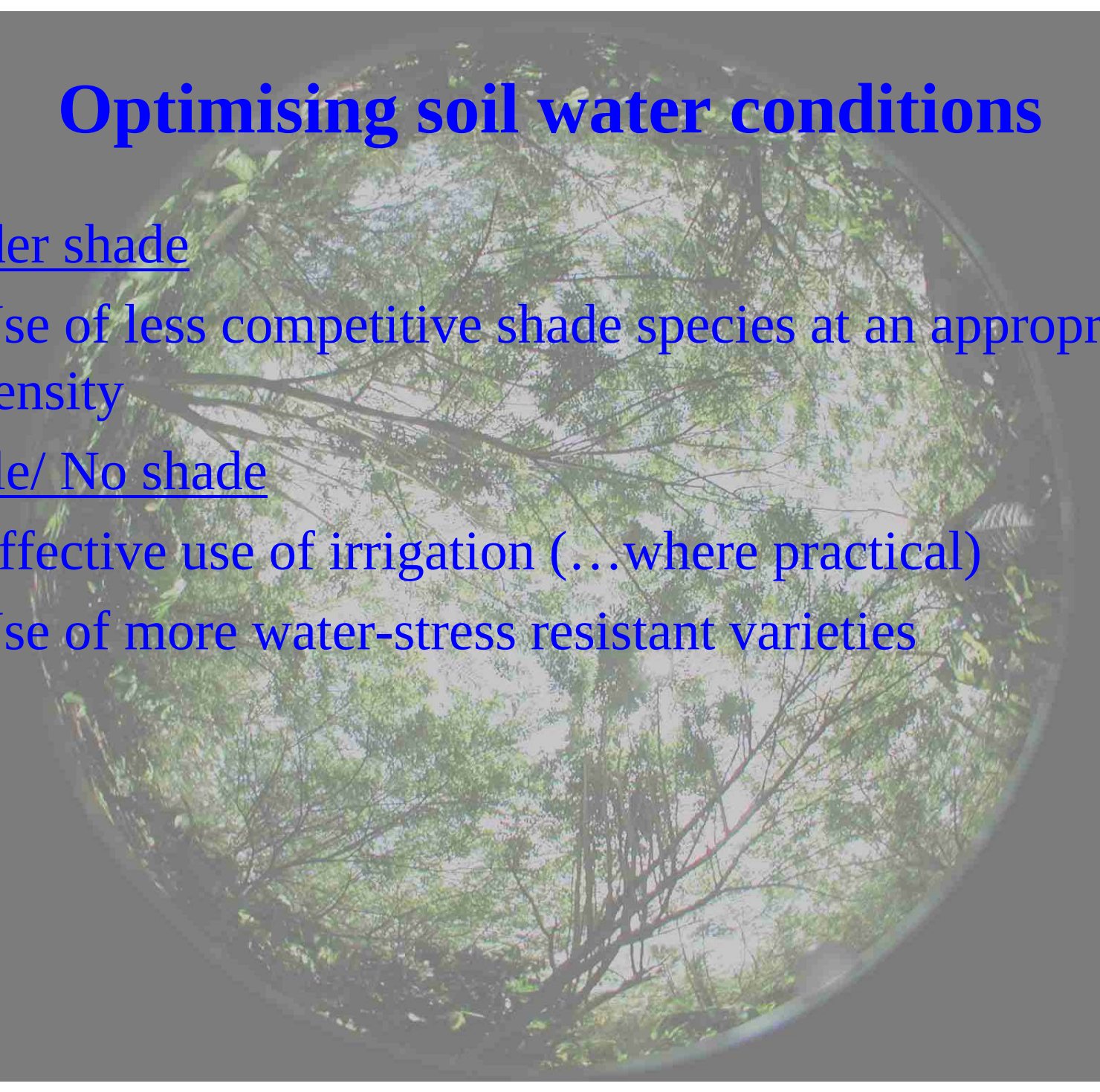


Efficiency of PSII of 4 clones after a heat shock event

Water

- Shade has the potential to minimise water loss through evapo-transpiration
- Conversely, the shade species also has the potential to compete for water with the cocoa

Optimising soil water conditions

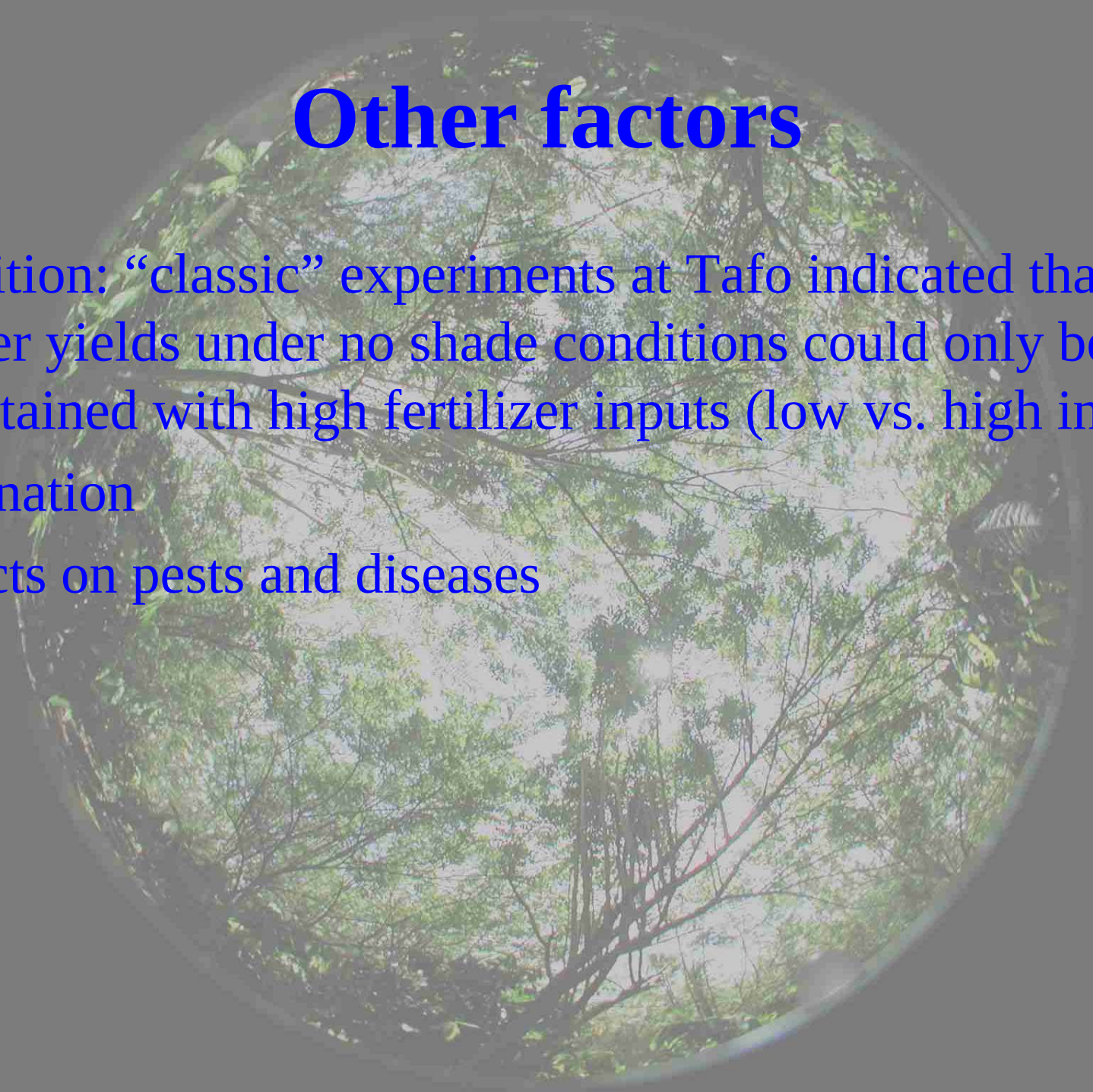


Under shade

- Use of less competitive shade species at an appropriate density

Little/ No shade

- Effective use of irrigation (...where practical)
- Use of more water-stress resistant varieties



Other factors

- Nutrition: “classic” experiments at Tafo indicated that higher yields under no shade conditions could only be maintained with high fertilizer inputs (low vs. high inputs)
- Pollination
- Effects on pests and diseases

**Stable
Environment**

**Harsh
Environment**

**Increasing shade
requirement**

**Need for shade partially offset
by husbandry and planting
material**

[P&D considerations may over-ride the above]

Conclusion

- Shade can be considered to ameliorate the cocoa micro-environment
- In terms of optimising the physiological performance of cocoa, the optimal shade level will depend on how harsh the local climate is
- There is the potential, in part, to adapt to high or low shade conditions through husbandry and/or planting materials
- In a changing environment, shade may have a role in protecting against extreme conditions

Current projects on shade/ water stress

- Field establishment of cocoa clones through improvement of agro-ecological conditions: Kofi Acheampong (CRIG/Reading)
- Use of economic shade tree species to maximise farmers' incomes (CRIG/Reading/Cadbury/GCGRA collaboration)
- Genetic variation in the response to water stress in relation to establishment (CRIN/Reading) Kayode Olufemi