

Quality Standards in Controlled Environment: Implications for the User

Laurence Benjamin
Quality Manager
Rothamsted Research



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Introduction

- Exploration of consequences of failure of QC in relation to temperature control
- Future of QA for Controlled Environment (CE) Experiments



Introduction – Laurence Benjamin

- Quality Manager of Rothamsted Research
 - Explaining requirements of sponsors to research staff
 - QA Advice
 - Auditing
- Researcher in plant physiology, agronomy and mathematical ecology



Rothamsted Research



CE

Soil
Science

Insectary

Plant
Pathology
and
Microbiology

Biomathematics

Plant &
Invertebrate
Ecology

Biological
Chemistry

Plant
Science



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Controlled Environment at Rothamsted Research



Approach

- Compare the effects of temperature difference for three contrasting models
- Temperature differences small – not likely to be noticeable to operator
- Simulations use inputs that are typical for CE



Calabrese Vernalization

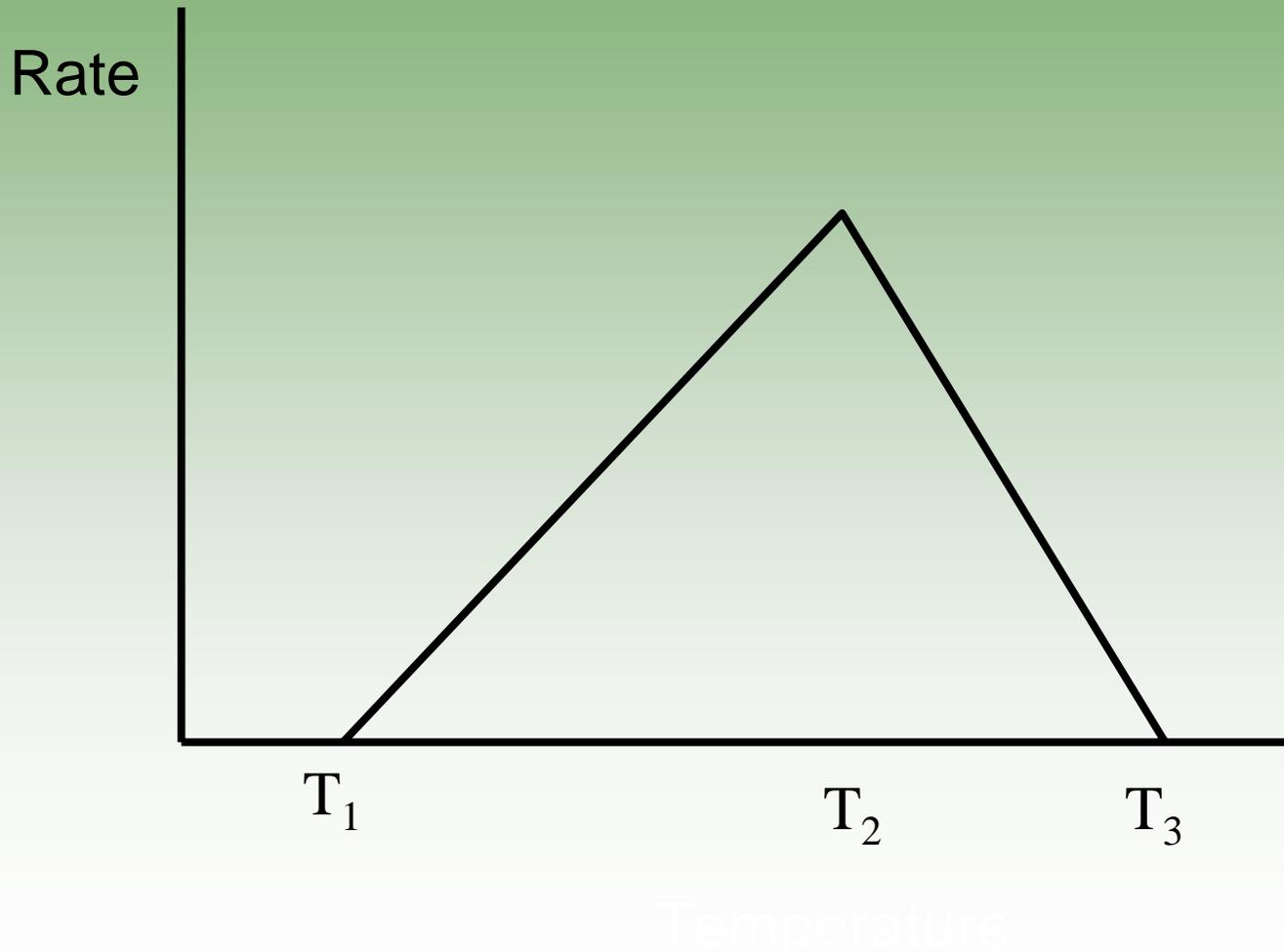
Wurr et al. (1995)

Floral initiation occurs when apical diameter, D , is 0.49mm

Increase in diameter is dependent on the current diameter and temperature, T .



Wigwam Temperature Function



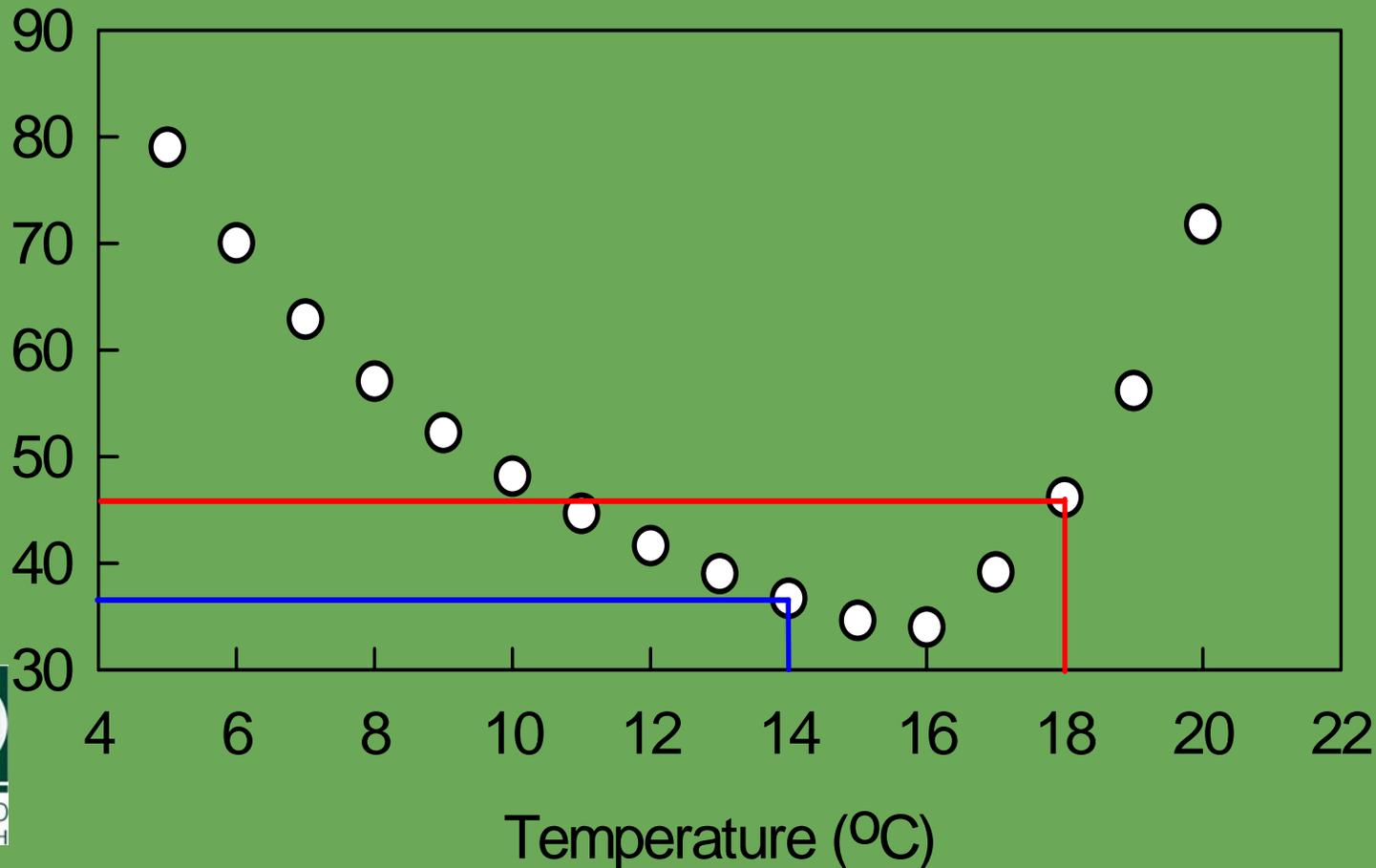
Calabrese Vernalization Temperature Function

A wigwam temperature function was used, with cardinal temperatures of T_1 , T_2 and T_3 with values of -2.8, 15.8 and 23.6 °C.



Relation between Temperature and Days to Vernalization in Calabrese (Wurr *et al.*, 1995)

Days to Vernalization



Time to Flowering in Pansy Adams *et al.* (1997)

Days to flowering, f , is an inverse function of photoperiod, P , and effective temperature, T_e .

$$\frac{1}{f} = a + bT_e + cP$$

where a , b and c are constants.



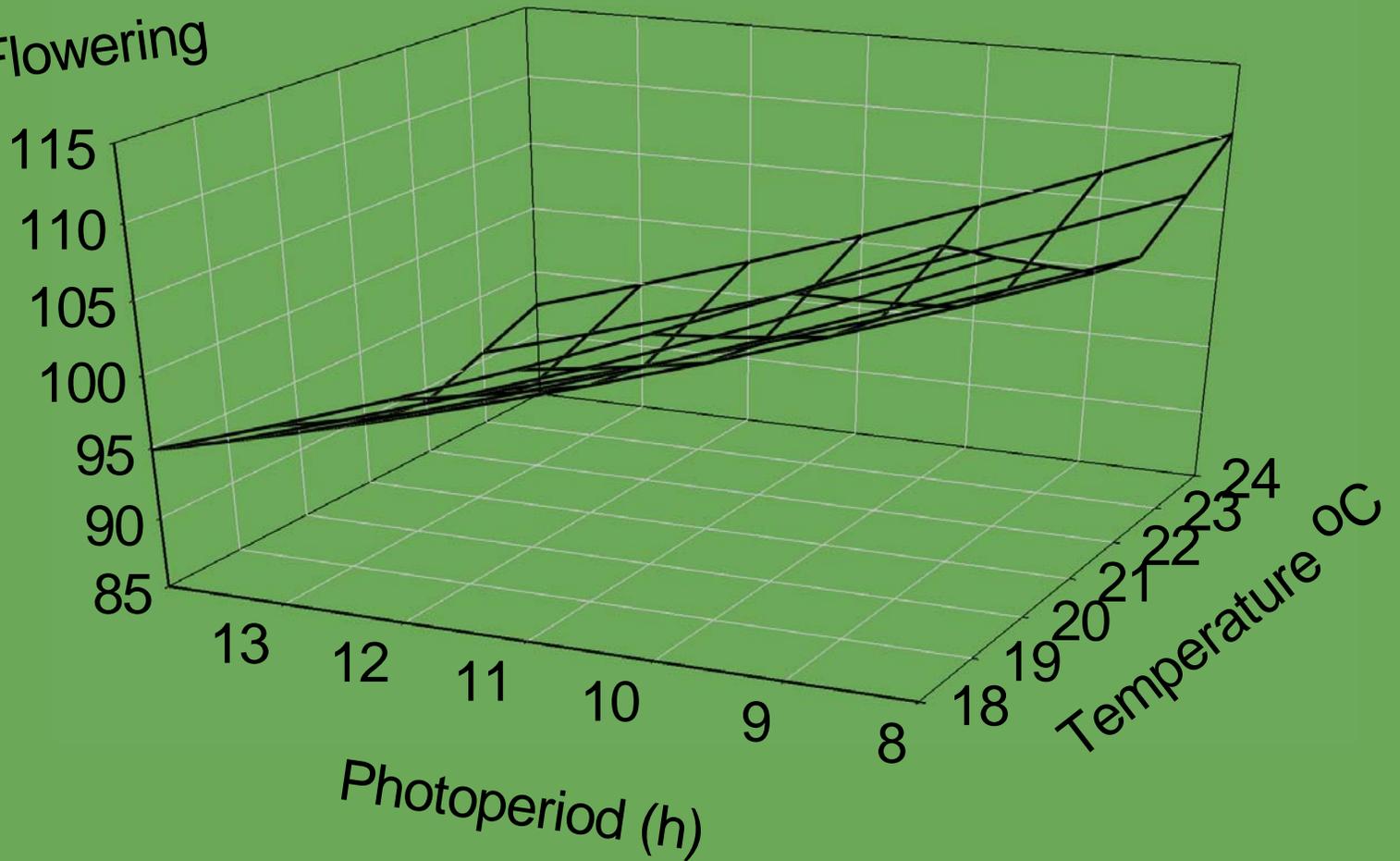
Flowering in Pansy:- Temperature Function

The effective temperature, T_e , was taken as the difference between the temperature, T , and the optimal temperature, 21.7 °C.



Relation Between Photoperiod Temperature and Days to Flowering in Pansy (*Adams et al., 1997*)

Days to Flowering



Effect of Temperature on Days to Flowering in Pansy at Two Contrasting Photoperiods

Photoperiod	Temperature	Days
8	21	106
8	19	111
8	23	108
14	21	90
14	19	93
14	23	91



Growth of Wheat, Kropff and van Laar *et al.* (1993)

A canopy net photosynthesis model



Kropff and van Laar *et al.* (1993)

1. Respiration increases exponentially with temperature
2. Gross photosynthesis is a function of LAI, summated over the depth of the canopy.
3. Canopy height is a logistical function of accumulated temperature
4. Maximum photosynthetic rate is a linear function of temperature

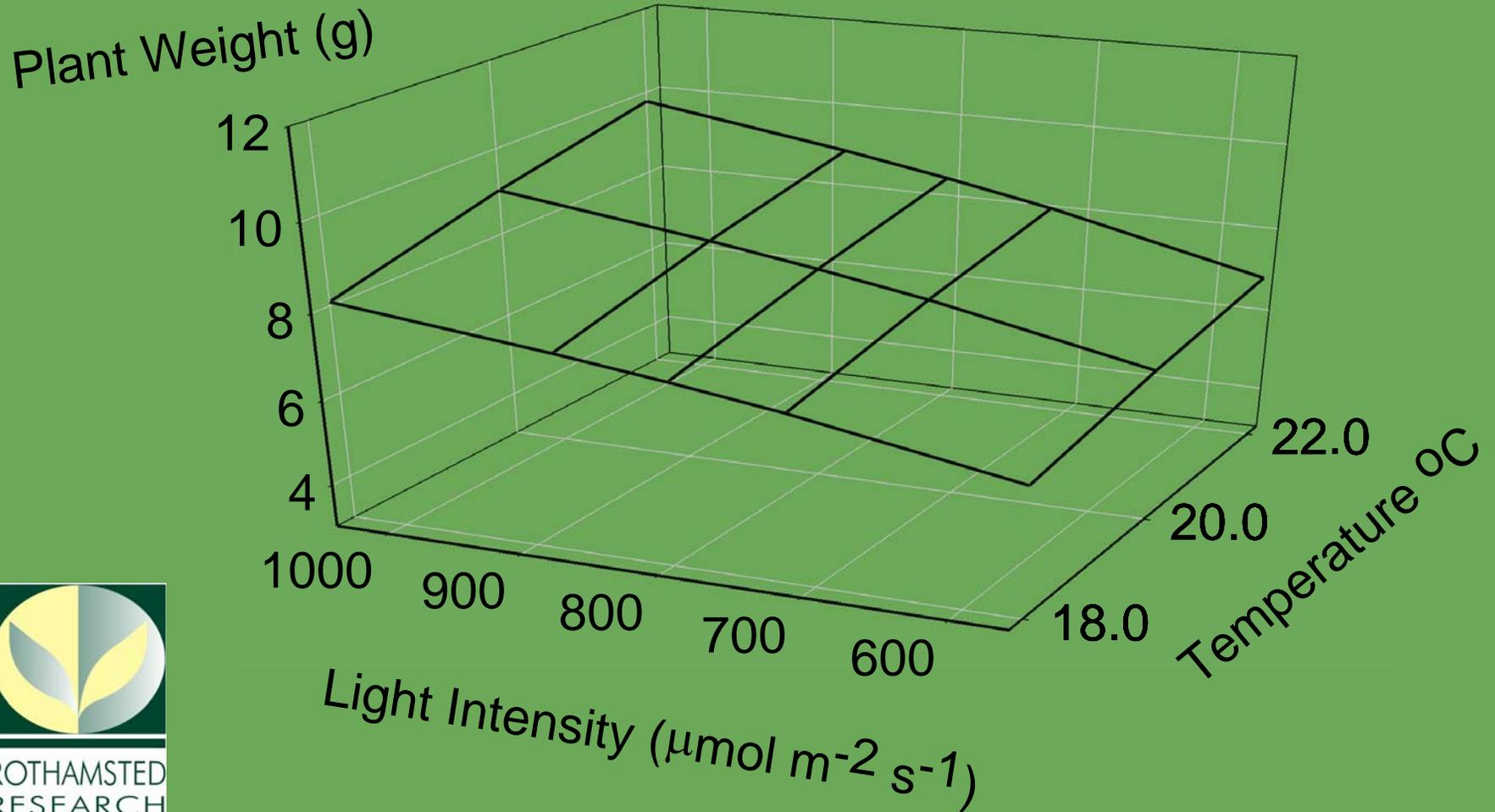


Special Conditions for CE

1. Incident radiation is constant throughout the day
2. 90% of radiation is diffuse
3. Angle of direct radiation is vertical
4. Irradiance is low (compared with full sunlight ($800 \mu \text{ mol m}^{-2} \text{ s}^{-1}$))
5. Day length is constant (14h)
6. Night temperature is a fixed amount below day temperature ($5 \text{ }^{\circ}\text{C}$)



Relation Between Light Intensity, Temperature and Plant Weight in Wheat (Kropff and vanLaar, 1993)



Implications

1. If flowering takes 55 rather than 50 days and 7 runs are expected per year, then $7 \times 5 @ \$20/\text{day} = \700 cost.
2. Three replicates will take 15 days longer - \$300 extra running costs @ \$20 per day (single cabinet use)
3. Large rep-to-rep variation if 3 cabinets run simultaneously.
4. Repeatability of experiments.
5. Calibration is ~ \$200 for each cabinet (4 sensors @ \$50/sensor)



Future of QA – The Science

Ever more exacting science

<http://www.metabolomics.bbsrc.ac.uk/projects.htm>

‘Rothamsted Research provides the Metabolite Profiling service to the UK *Arabidopsis* community’

‘A service for growth in controlled environment and metabolite profiling of selected mutant lines is offered’



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Sponsor Expectations

Greater expectation for Quality Assurance

- Sponsors stipulating standards for the 'Science Process' –
 - Joint Code of Practice for Research in UK (http://www.defra.gov.uk/science/documents/QACoP_V8.pdf)
 - 'where specialist facilities are used, they must be regularly checked and maintained...all equipment must be calibrated if necessary...'
 - iso 9001
 - auditing



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