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# Investigations into poor fruit set

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Ken Cockshull, Warwick Crop Centre

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TGA Conference 22 September 2022

# Tomato: investigations into poor fruit set

*Rob Jacobson, Dave Chandler, Ken Cockshull & Gill Prince*

**Rob Jacobson** Science  
**Consultancy** into  
Practice

british<sup>🍅</sup>  
TOMATO GROWERS' ASSOCIATION

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# The Team's Objectives

- Improve our understanding of poor fruit set linked to use of Bta:
  - Studying Bta activity and flower development.
- Identify means of improving pollination by Bta.
- Failing that.....
- Provide new evidence to NE for the risk assessment of using 'non-native' *Bombus terrestris* in the UK.

# Project background

- Fruit miss-set problems started with adoption of Bta.
- More common during very hot weather (and other periods of 'stress'?).
- Poor intrinsic performance of Bta.
  - Very poor flight activity in the glasshouse.
  - Colonies are small and do not develop.
- Made worse by environmental stress on the plant?
- Environmental stress on the bee?

**Bta more likely to fail if any factor is sub-optimal.**



# Bumble bee environmental safety: a review of all relevant literature

*Journal of Apicultural Research*, 2019  
<https://doi.org/10.1080/00218839.2019.1637238>



## REVIEW ARTICLE

### **Are there risks to wild European bumble bees from using commercial stocks of domesticated *Bombus terrestris* for crop pollination?**

David Chandler\*, Emily Cooper and Gill Prince

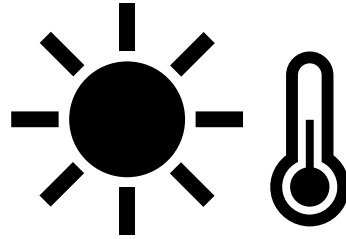
*Warwick Crop Centre, School of Life Sciences, University of Warwick, Wellesbourne, Warwick, United Kingdom*

*(Received 20 March 2019; accepted 25 June 2019)*

- Thorough and impartial study (AHDB - PE O26)
- Insufficient evidence to support claims that Btt/Btd were harmful to wild UK Bta.
- Hybridisation exists between mainland ‘sub-species’.
- Genetic structure of Bta is complex with significant variation within the British Isles.

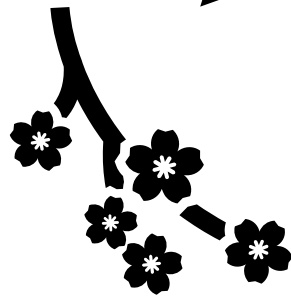
# Investigating causes of poor fruit set

Environmental stress (high temperatures)



**New:** High temp reduces pollen production?  
Varietal differences?

**New:** Temperature stress on Bta?



**New:** Bee genetics: 'native' bees

Inherently low Bta bee activity



Poor pollination

# Effect of high temperature on tomato pollen: scientific literature

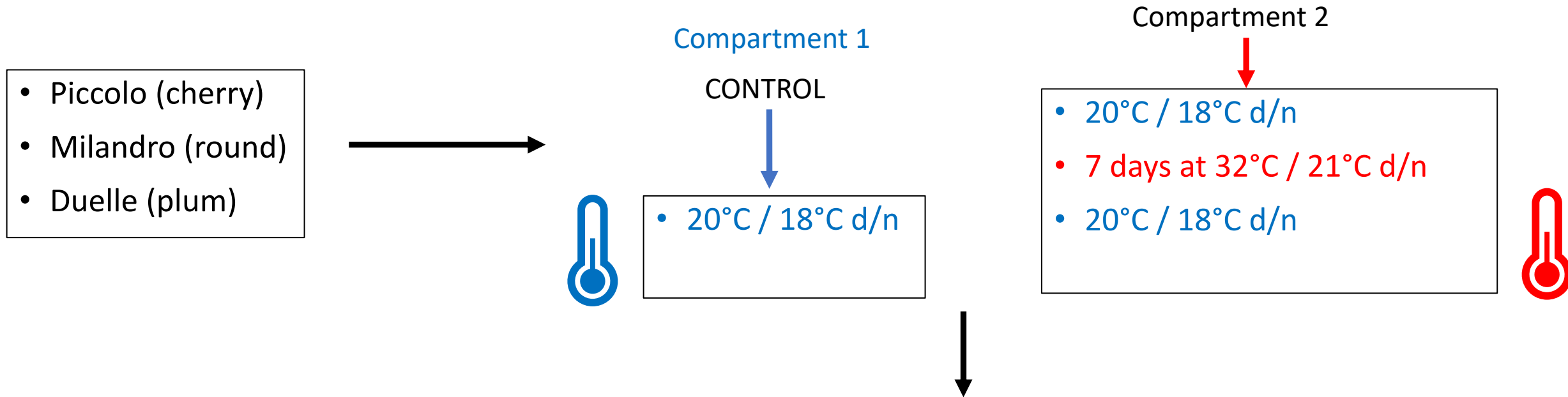
- In the USA, elevated day / night temperatures reduced fruit set in determinate, field-grown cultivars.
- Reduced pollen production & viability.
- Period of greatest sensitivity was 13 - 7d before anthesis.
- Pollen formation began 13 d before anthesis



# Piccolo Flower at Anthesis



# Glasshouse experiment: Effect of high day temperature on tomato pollen



- Sampled 10 flowers per cultivar that had reached anthesis on Days: 0, 9, 15, and 21 from the start of the high day temperature.
- Counted the number of pollen grains per flower and estimated pollen viability.
- When fruit had developed, we counted the number of seeds per fruit.

# HIGH DAY TEMPERATURE AND FLOWER DEVELOPMENT

Period of sensitivity to **HDT** is thought to be  13 to 7 days before anthesis

**Day 0 = Start of High Day Temperature**

Period of sensitivity 

Normal day temperature 

High day temperature 

Sampled flowers that were at anthesis on Day 0



Sampled flowers that were at anthesis on Day 9



*2 days in zone*

Sampled flowers that were at anthesis on Day 15



*6 days in zone*

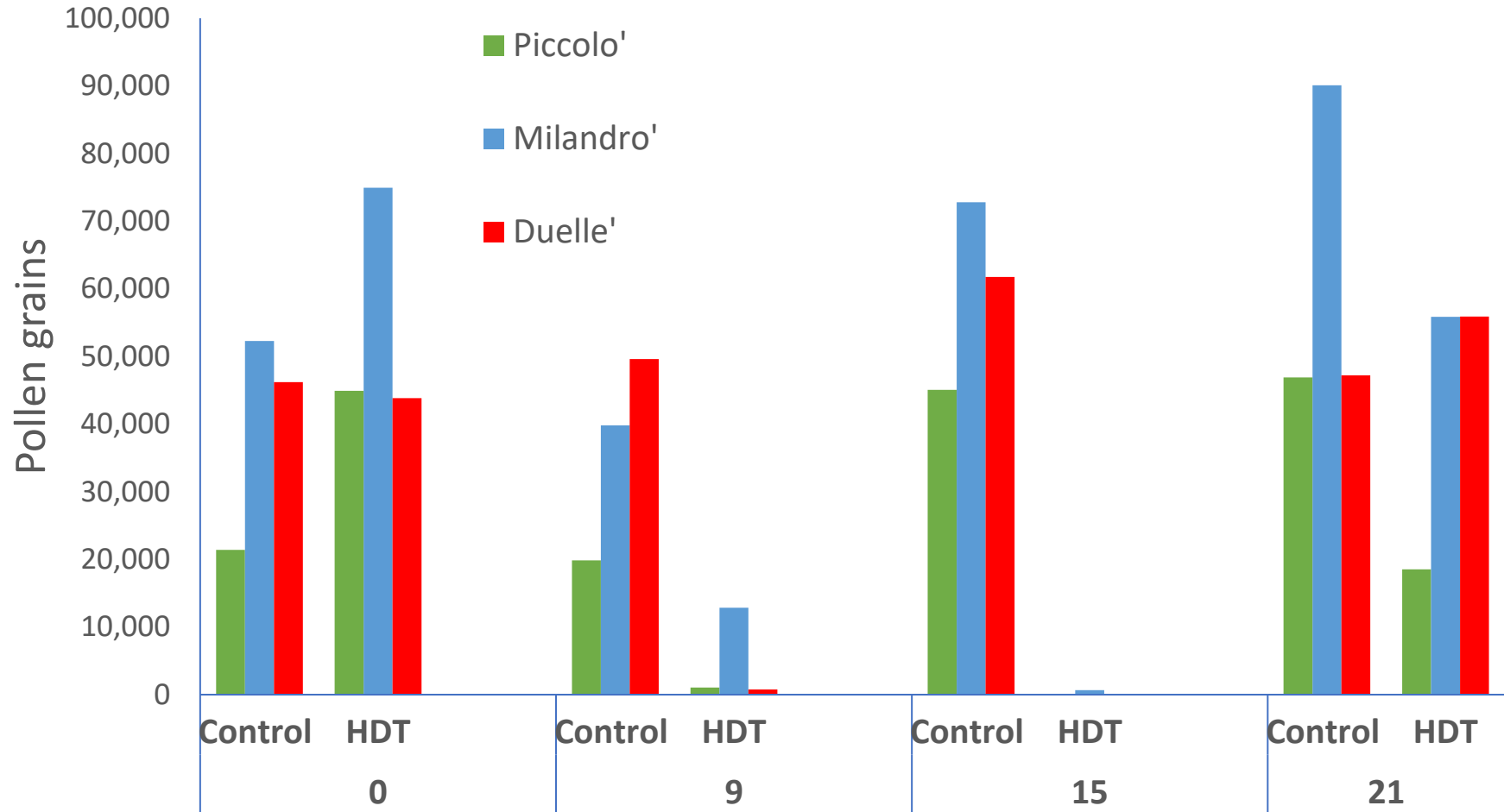
Sampled flowers that were at anthesis on Day 21



*0 days in zone*

# Effect of HDT on pollen grains per flower

- Day 0 sample taken before HDT treatment began. The samples did not differ significantly
- Pollen production severely restricted by HDT treatment in samples taken on Days 9 and 15.
- Pollen production in these two samples was significantly less than in the control for all three cultivars.



# Average seed counts per fruit

	Day	0	9	15	21
Control	Piccolo	87	81	71	73
	Milandro	111	122	117	111
	Duelle	85	79	73	66
High Day	Piccolo	75	22	0	75
Temp.	Milandro	126	49	7	128
	Duelle	74	1	1	67

- High day temperatures reduce seed counts for sample day 9 & 15.
- *Day 9 = 2 days in the (theoretical) high temp. sensitivity zone.*
- *Day 15 = 6 days in the zone.*
- *Day 21 = 0 days in the zone*

Piccolo

Milandro

Duelle

C5  
(High day  
temp)



C4  
(control)

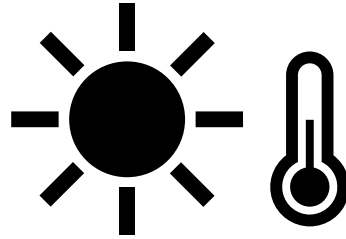


# CONCLUSIONS

- High day temperature reduced pollen production but had much less effect on pollen viability.
- High day temperature reduced fruit set.
- Flowers had to receive the high day temperature treatment between 13 and 7 days before anthesis.
- All three cultivars were affected to some degree.
- The problem could become more serious if the present direction of climate change is sustained.

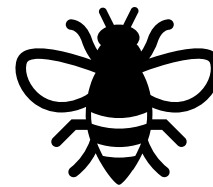
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Inherently low Bta bee activity



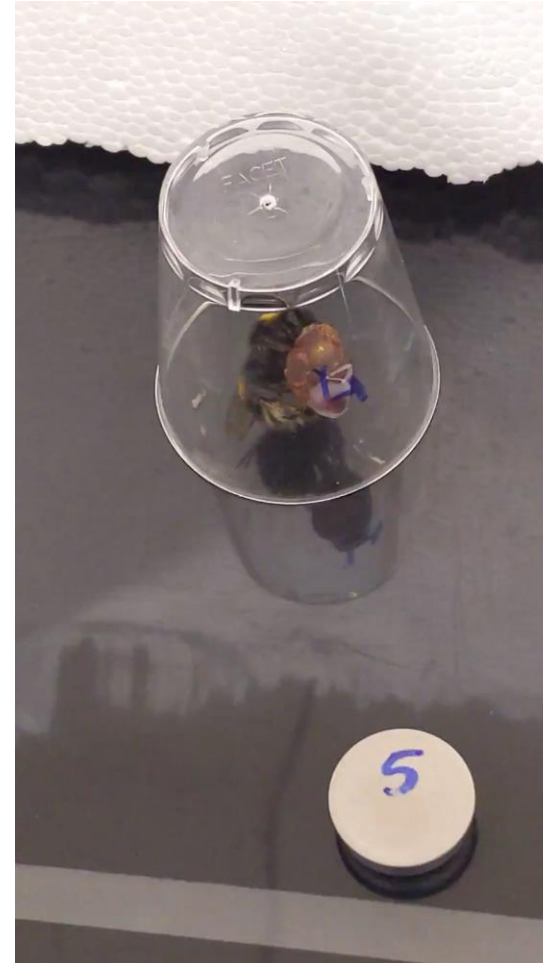
Poor pollination



# Response of Bta & Btt to increased temperature

Sub species	Mean (SE) temperature, start of fanning (°C)	Mean (SE) lethal temperature (°C)
Bta	31.6 (0.40)	43.0 (0.58)
Btt	31.9 (0.59)	43.1 (0.35)

- Bees fan their wings when heat stressed.
- Data suggest no difference in Bta and Btt to heat stress.
- But could be other differences (e.g. flight activity, navigation?)



(Moreira et al., Mol. Ecol., 2015).

## 4. Genetic structure of *B. terrestris* populations

Population genetic structure of *Bombus terrestris* in Europe: Isolation and genetic differentiation of Irish and British populations

ANTÓNIO S. MOREIRA,\*†<sup>1</sup> FINBARR G. HORGAN,†<sup>2</sup> TOMÁS E. MURRAY†<sup>3</sup> and THOMAS KAKOULI-DUARTE\*

\*Institute of Technology Carlow, Kilkenny Road, Carlow, Co. Carlow, Ireland, †Teagasc, The Agriculture and Food Development Authority, Oak Park Research Centre, Carlow, Co. Carlow, Ireland

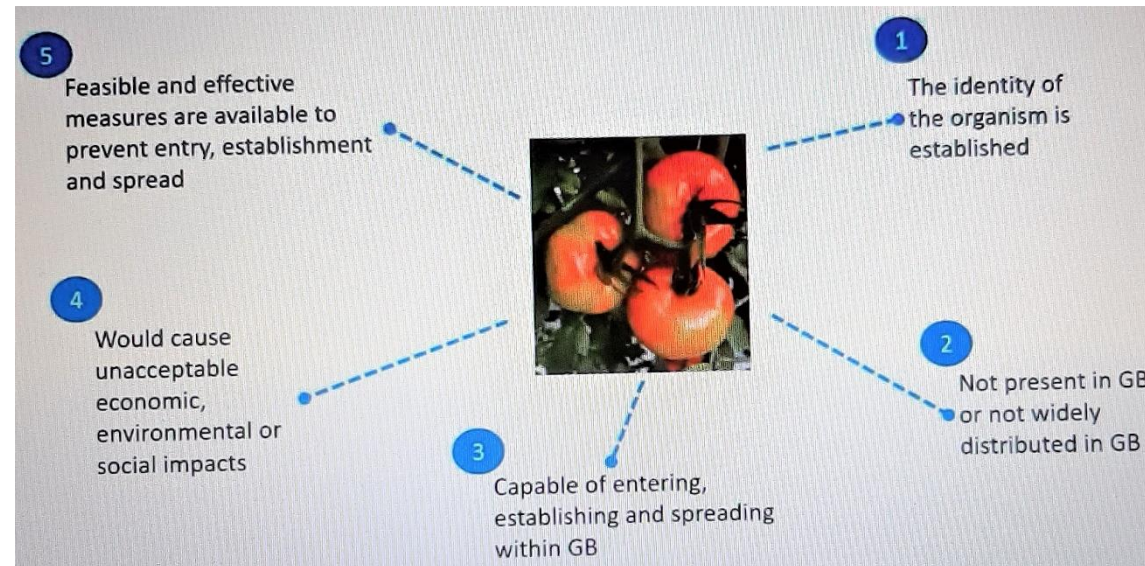
- Bta (UK) and Btt (Europe) are deemed to be separate subspecies.
- But research shows the distinction is not cut and dry.
- There are genetic differences between Bta and Btt.
- But an analysis of population genetics showed:
  - Natural gene flow between England & Euro
  - British & mainland Euro Bt clustered together. Irish Bt separate.
- Genetic analysis of mitochondria:
  - 2 'haplotypes', A & B.
  - A = common to Ireland & Britain
  - B: common to mainland Euro & in some populations in England.
- Suggests that Btt occurs naturally in England, at low levels, pre-dating its use as a pollinator, and mates with Bta.



# Defra's definition of a quarantine species.....

5. Bees naturally fly over from Euro mainland. But commercial queens are contained within hive.

1. Bt sub-species not as distinct (gene flow with mainland Euro).



4. Assumed by NE but no evidence of detrimental effects.

3. English Channel is not a barrier to bumblebees.

2. Euro haplotypes naturally occur in England.

Thanks to everyone involved



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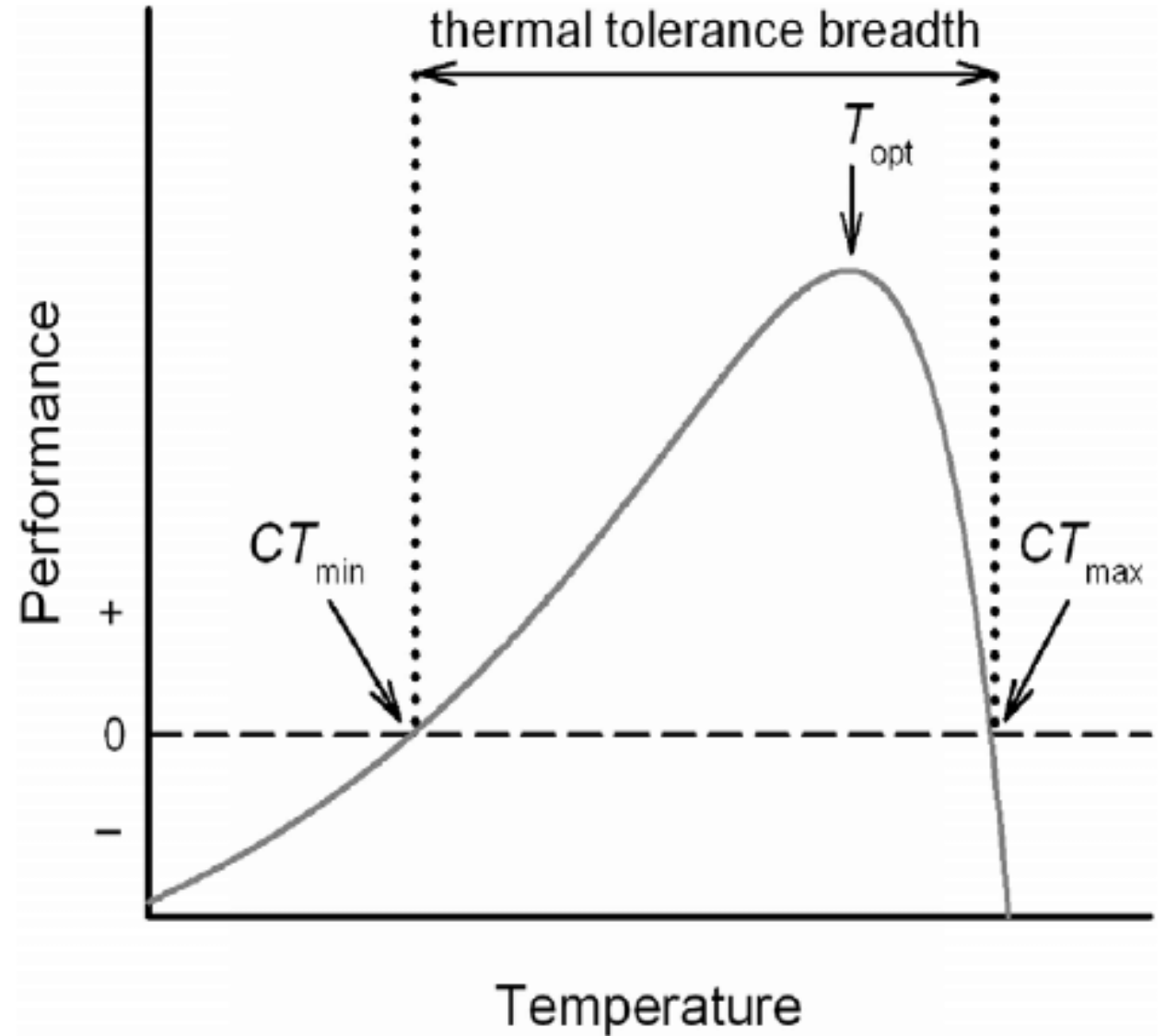
Extra slides to help with questions

## Future Work – effect of HDT on pollen

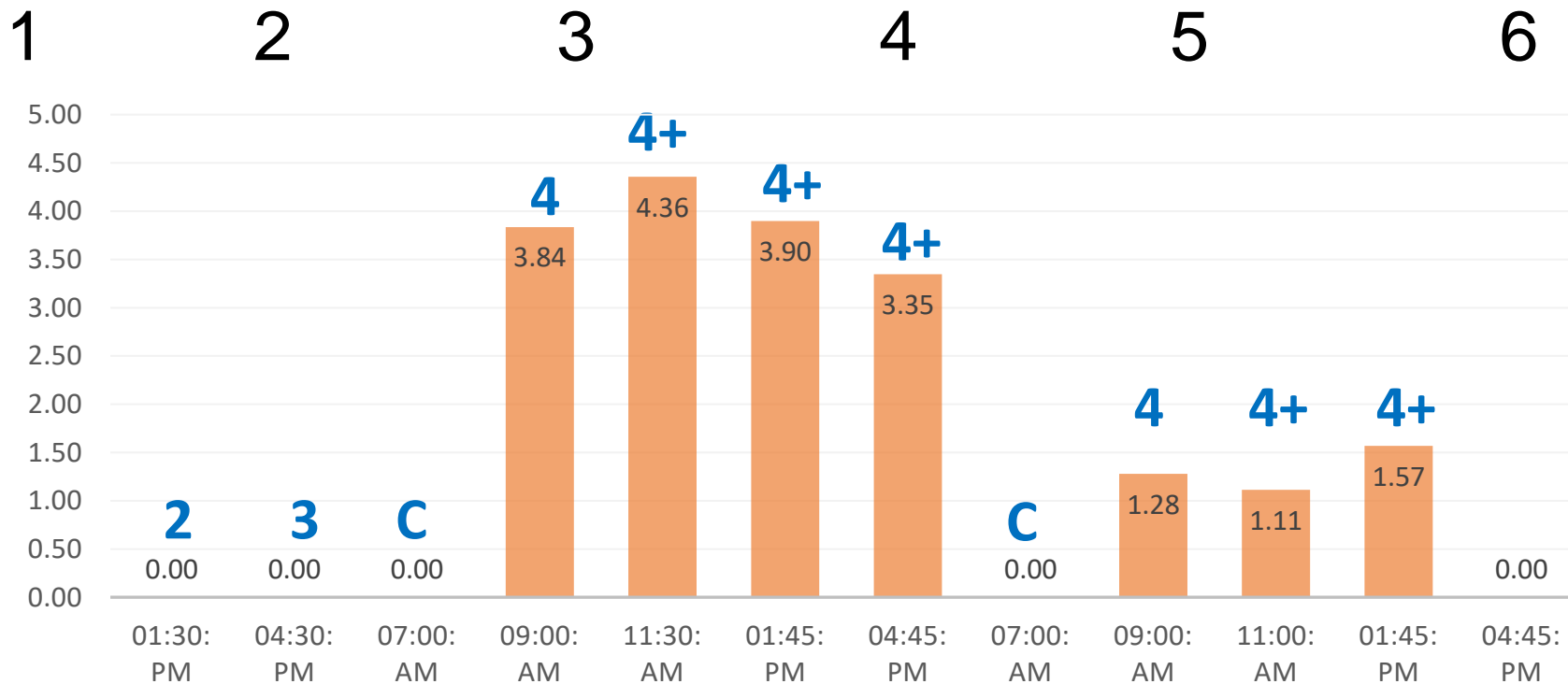
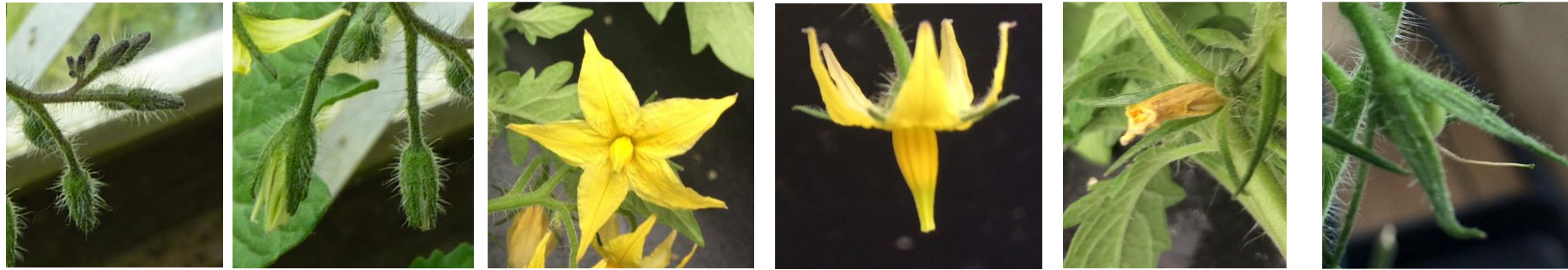
- Does the high day temperature have to be maintained all day?
- What is the impact of different high day temperatures?
- Are there any factors that can lessen the effect of a high day temperature?

# Effect of high temperature on plants

- Even small increases past the optimum can be detrimental.



# Piccolo flower / pollen development over 48 hour period (Most pollen produced on first day of full reflex)



**C = CLOSED**

■ grains per flower (log10)



