Lecture 20 -- Sub Optimal Temperatures, Cold / Freezing

Air Temperatures

ABOVE OPTIMAL
decrease photosynthesis
increase in mitochrondrial resp.
increase in photorespiration

In soil:
increase in root respiration
lower cytokinin synthesis
decline in water and nutrient uptake

BELOW OPTIMAL
decreased photosynthesis
decreased respiration
less ATP production
decreased hormone synthesis
slowdown in metabolism

in soil:
lower root respiration
decreased ATP production
decreased nutrient uptake

other effects on physiology

Tomatoes grown under optimal temperatures (27/23) vs. high temperature conditions (35/23) from seedling stage. Fruit set % is lower under high temperatures ranging from 0 (heat tolerant) to 100% (heat sensitive) of control.

Fruit set of tomato genotypes under normal and heat-stress growing conditions

Genotype	Fruit set (%) Temp 27/23 C	Fruit set (%) Temp 35/23 C
Flordadade	45	46
Duke	54	13
Longkeeper	41	0

Why lower fruit set?

The best hypothesis implicates a lack of viable pollen at high temperatures. High temperatures decreases pollen viability (less pollen germination) and decreases ovule longevity. Extremely high temperatures may also affect pollen tube growth.

All, or any one of these factors may significantly decrease fertility.

Temperature and pollination effects on fruit set and development of rabbiteye blueberry

Main effect	Fruit set (%)	Avg. fruit wt (g)	FDP (day
Temperature (C)			
Day/night			
26/21	63.9 b	1.5 b	85 b
26/10	83.2 a	1.7 a	88 ab
29/10	71.4 ab	1.4 b	90 a

Fruit set increases when night temperatures are low, with an increase in fruit size. This may be related to more effective fertilization or less efficient respiration leaving more carbohydrates for fruit set, size and development.

Temperature effects on growth and reproductive development in green pepper

	Temperature (C)	
	27/22	27/17
Leaf area (m^2/plant)	0.216	0.154
Total DW (g/plant)	15.0	14.0
Reproductive DW (g/plant)	4.0	6.0

27/22 day/night vs 27/17 day/night (10 h photoperiod). There was an increase in vegetative growth and decreased reproductive growth (primarily decreased fruit number) when night temperatures were high. Note: no change in dry weight. This is indicative of differential effects on vegetative vs. reproductive sinks.

Note also, cardinal temperatures higher for vegetative growth.

In Grape:

photosynthates preferentially translocated to vegetative shoot apicies at the expense of flower / fruit clusters when exposed to 40/20 vs. 29/15 for four days.

Effects also seen at elevated temperatures due to photosynthesis vs. respiration imbalance.

HIGH TEMPERATURE INJURY

Plants will experience metabolic imbalance.

DESSICATION – transpiration rates increase and water loss is a problem, leading to wilting. Stomata close and decrease available CO_2.

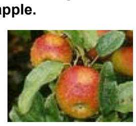
bark is removed where heat has destroyed cambium

HIGH TEMPERATURE INJURY

SUNSCALD – direct heat injury to trunks and fruit. In trunks, high temps kill cambium, especially on thin-barked trees like birch. Also, if trees are pruned heavily and previously shaded wood is exposed, cambium can be injured.

bark is removed where heat has destroyed cambium

On fruit, causes discolored areas and provides entry for pests and pathogens. Best examples in tomato and apple.

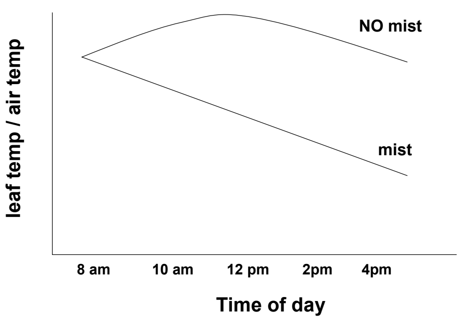


Methods for Alleviating Excess Heat Load

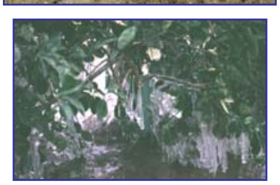
1. SHADE – used for high cash crops (ornamentals), typically a cloth or lathe house. Shading decreases leaf temperature, not air temperatures. ALSO DECREASES photosynthesis rate.
2. GREENHOUSE- whitewash, fans, evaporative coolers (where humidity allows).
3. OVERHEAD IRRIGATION– as water evaporates heat is absorbed. Cools plant body, but encourages disease.

leaf temperatures can be 5-10 degrees higher than air

HEAT – air vs. leaf temperatures, and overhead irrigation



Damage of citrus trees by sprinkler system



Heat Stress and Acclimation

Most plants are able to survive extended periods 10-60 (minutes) above 45°C (120°F), except for pollen and flowers.

Some CAM plants can survive with closed stomates, dissipating their heat by re-radiation. In some cases such plants can tolerate 65°C.

Most C3 and C4's rely on transpiration rate and re-radiation, so heat stress is a problem in arid climates with high PPF or in drought conditions– as stomata close there is less ability to dissipate heat.

Also, humidity and air speed are important. HOW?

Heat Stress and Acclimation

Plants well adapted to high temperatures often have morphological features that allow them to avoid excess heat.

1. **REFLECTIVE LEAF HAIRS & WAXES**
2. **LEAF ROLLING**
3. **LEAF ORIENTATION CHANGES**

Developmental and tissue specificity

The strategy and degree of implementation is often dependent upon age of the plant, developmental stage or tissue. Potato plants on right… one shows leaf rolling from heat stress, the younger plant does not.

All strategies decrease the surface incident to solar radiation, thereby decreasing leaf temperature.
Plants adapted to cool climates generally are less tolerant to long term exposure to high temperatures.
In many plant species brief exposure to sublethal heat stress can induce acclimation to subsequent heat stress– induced thermotolerance.