Evaluation of Leaf Heat Tolerance of Germplasm in the UC Davis Almond Breeding Program

Matthew E. Gilbert[1*] and Nicolas Bambach[2]
Project Cooperators:
Tom Gradziel[1] and John Preece[3]
[1] UC Davis, Dept. of Plant Sciences;
[2] UC Davis Dept. Land, Air and Water Resources;
[3] USDA, Davis
*(530) 572-7846 megilbert@ucdavis.edu

Supported by the Almond Board of California project number 12-HORT21-Gilbert, and by UC Davis College of Agriculture and Environmental Sciences.

Overview of the project

Crops are susceptible to heat damage under conditions where a low transpiration leads to hotter leaves e.g. increasing salinity or severe deficit irrigation. In the early part of the growing season heat damage to leaf photosynthetic capacity would have especially large effects on yields.

Thus, it would be useful to introgress germplasm with high heat tolerance into current almond breeding populations. Such germplasm must first be found amongst available breeding lines or wild germplasm available at the USDA National Clonal Germplasm Repository.

Objectives

1) Establish a protocol for a high throughput, and appropriate, tool for measuring leaf heat tolerance .
2) Determine the quantitative impact that a high heat tolerance has on photosynthetic performance.
3) Evaluate if tradeoffs exist that prevent the incorporation of heat tolerance into commercial germplasm.
4) ***Provide a ranking of leaf heat tolerance of 100 almond genotypes*** and related species available to almond breeding programs.

1) A protocol for measuring heat tolerance

Time frame: August-September 2014
A protocol was tested and tuned to allow rapid measurement of heat tolerance of up to 50 varieties in a day (one replicate). The measurement is based upon dark adapted chlorophyll fluorescence of photosystem II providing an estimate of longterm damage after a leaf is exposed to high temperatures produced by a controlled water bath.
Result: ***Almond (two varieties) had high temperature tolerance relative to other species***, and in practice a 2°F difference in temperature tolerance could be detected.

2) How do almonds respond to high heat?

Time frame: June – October 2014
Leaf photosynthetic capacity was monitored continuously on outdoor pot grown plants and field grown Nonpareil almonds under drought conditions.
Result: ***photosynthetic damage occurs under moderate daily air temperatures (95F) as a result of the combined effects of high leaf temperature (113F), water stress and high light.*** Recovery was slow (~5 days), but did occur (Fig. 2).

Photos: scaffolds and photosynthesis monitoring system (cylinders) in the field at UC Davis.
Treatments were irrigated or under drought for most of summer 2014; chlorophyll fluorescence, gas exchange and water potentials were measured over the season to establish when and how heat caused damage.

How hot is hot?

Photosynthetic measurements on leaves exposed to varying temperatures in the field show ***damage is recoverable below leaf temperatures of 110F*** (Fig. 3). Under water stress, leaf temperatures may reach these levels at ambient temperatures of 95F.

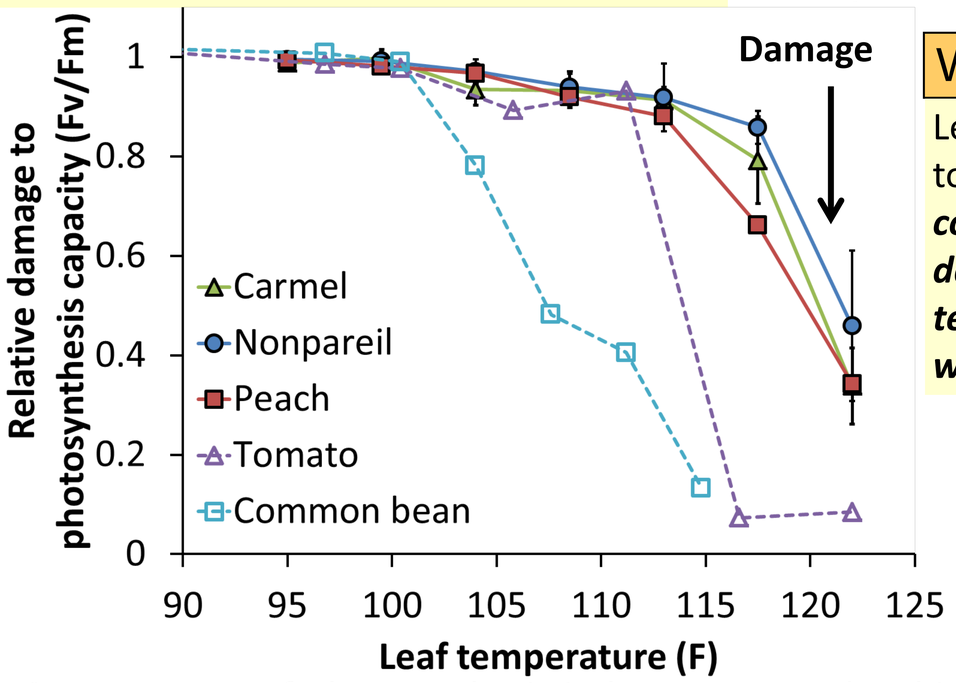
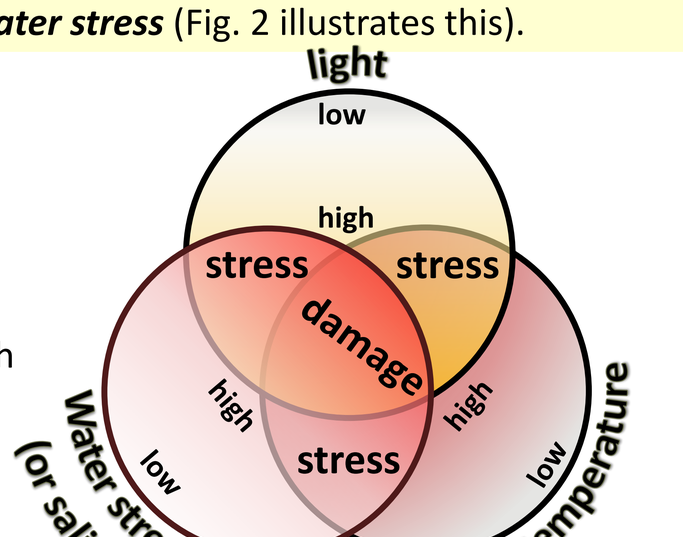


Fig. 1 Damage of photosynthesis in leaves exposed to high temperatures, including beans and tomato for comparison.

When does heat = damage?

Leaves are stressed or damaged in response to a variety of environmental factors. ***The conditions with the highest chance of damage occurs when high light, high air temperature combines with some form of water stress*** (Fig. 2 illustrates this).



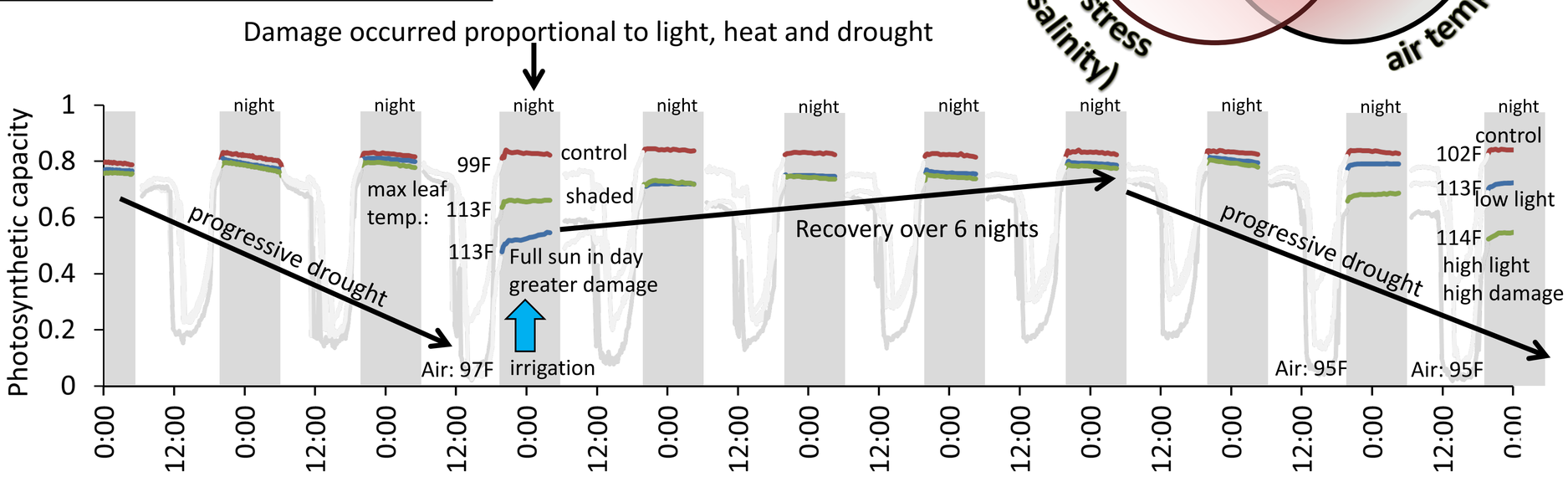


Fig. 2 Ten days of measurements showing response of photosynthetic capacity (measured at night) to combinations of drought, varying light and high temperature in outdoor potted Nonpareil almonds.

3) Are there tradeoffs?

Time frame: May –July 2015
Test possible tradeoffs between high heat tolerance and:

- low temperature tolerance due to differing lipid composition requirements
- water use, as low water users will need high leaf heat tolerance

4) Ranking heat tolerance of 100 almond genotypes

Time frame: May –July 2015
Species and genotype selection, approx.:

- 10 *Prunus* species
- 30 almond genotypes, USDA diversity collection
- 50 genotypes, almond breeding program
- 10 commercial varieties in field trials
  - These varieties will be measured over time and at various sites.

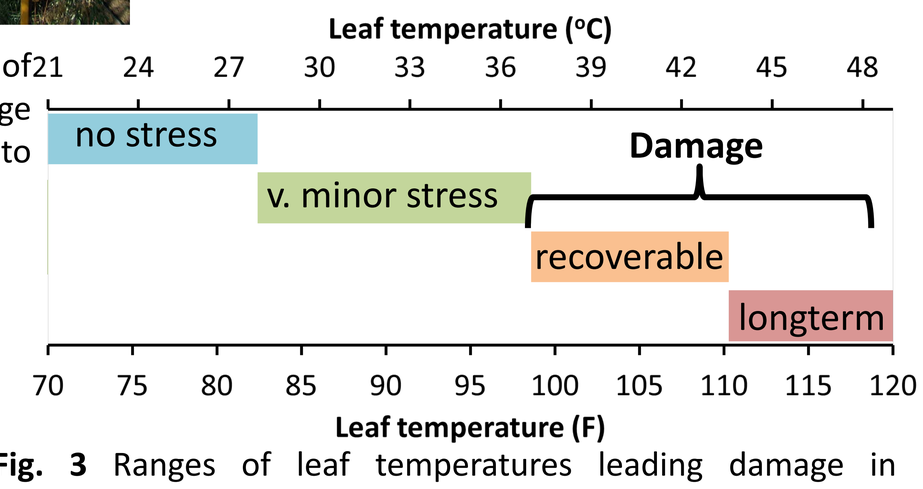


Fig. 3 Ranges of leaf temperatures leading damage in *Nonpareil* almonds from field work on leaf photosynthesis recovery from combinations of high heat and light.