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Thermo-tolerance of photosynthesis in legumes: Mapping QTLs for photosynthetic traits in cowpea under heat stress

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Legume Innovation Lab

Feed the Future Innovation Lab for Collaborative Research on Grain Legumes

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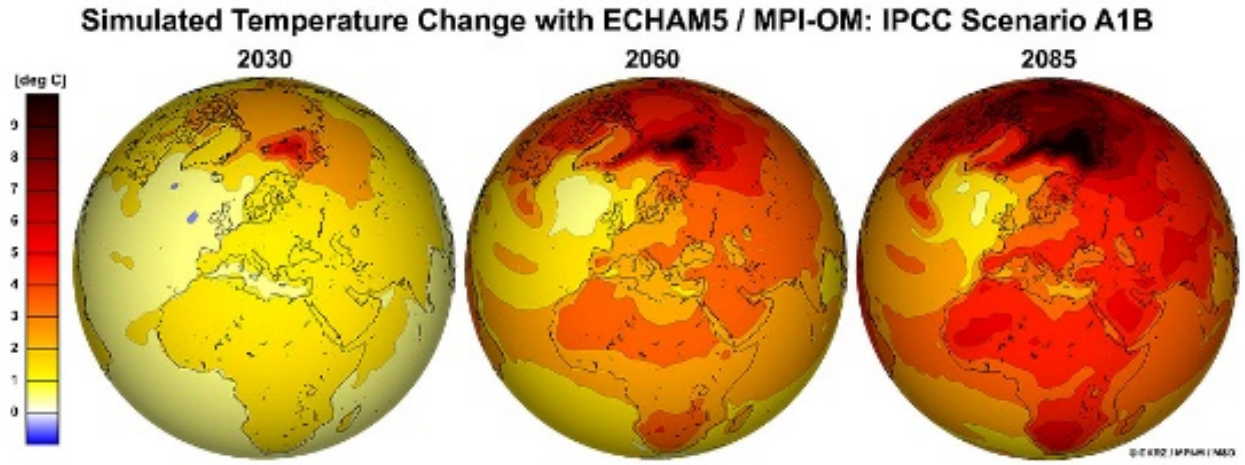
Introduction



- Global mean temperatures projected to rise by 0.3 ^{o}C – 4.8 ^{o}C by the end of 21st century (IPCC 2014).
- World population estimated to reach > 9 billion by 2050
- Heat stress tolerant crops would be needed to feed the population

Why grain legumes and photosynthesis?

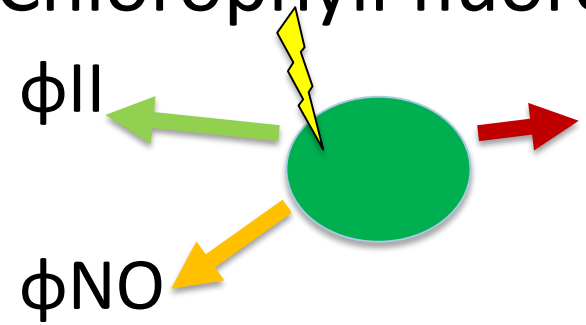
- Photosynthesis is critical for crop productivity
  - Sensitive to high temperature (HT)
- Grain legumes
  - Protein and income
  - Soil fertility improvement

Development of plants with robust photosynthesis under heat stress

- Study photosynthesis in different legumes with differing tolerance to heat stress and establish mechanisms of tolerance of these legumes
- Identify natural variation in photosynthesis under heat stress and map loci (QTLs) controlling such traits.

Photosynthetic parameters assayed

- Chlorophyll fluorescence



– NPQt

qEt (Photoprotection)

qIt (Photo-inhibition)

DEPI

MultispeQ

SPAD/ Relative Chlorophyll Content

Mapping of QTLs for photosynthetic traits under normal and heat stress conditions in cowpea by HTP phenotyping

Parents: CB27 x IT82E-18

RIL population size: 87

Treatments:

Heat stress: 45/35 °C day/night

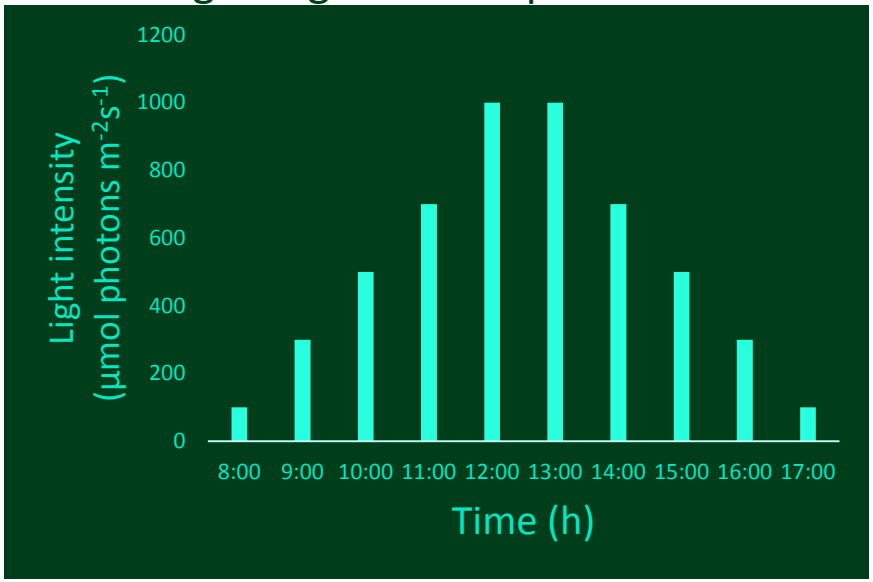
Control: 30/20 °C

RH: 15-40%

Acclimation temperature: 33/20 °C

Photoperiod: 10 h

Light regime for experiment



Germination and seedling establishment (11 days)
Regular reach-in chamber

Acclimation + Phenotyping (1+5 days)
DEPI chamber

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

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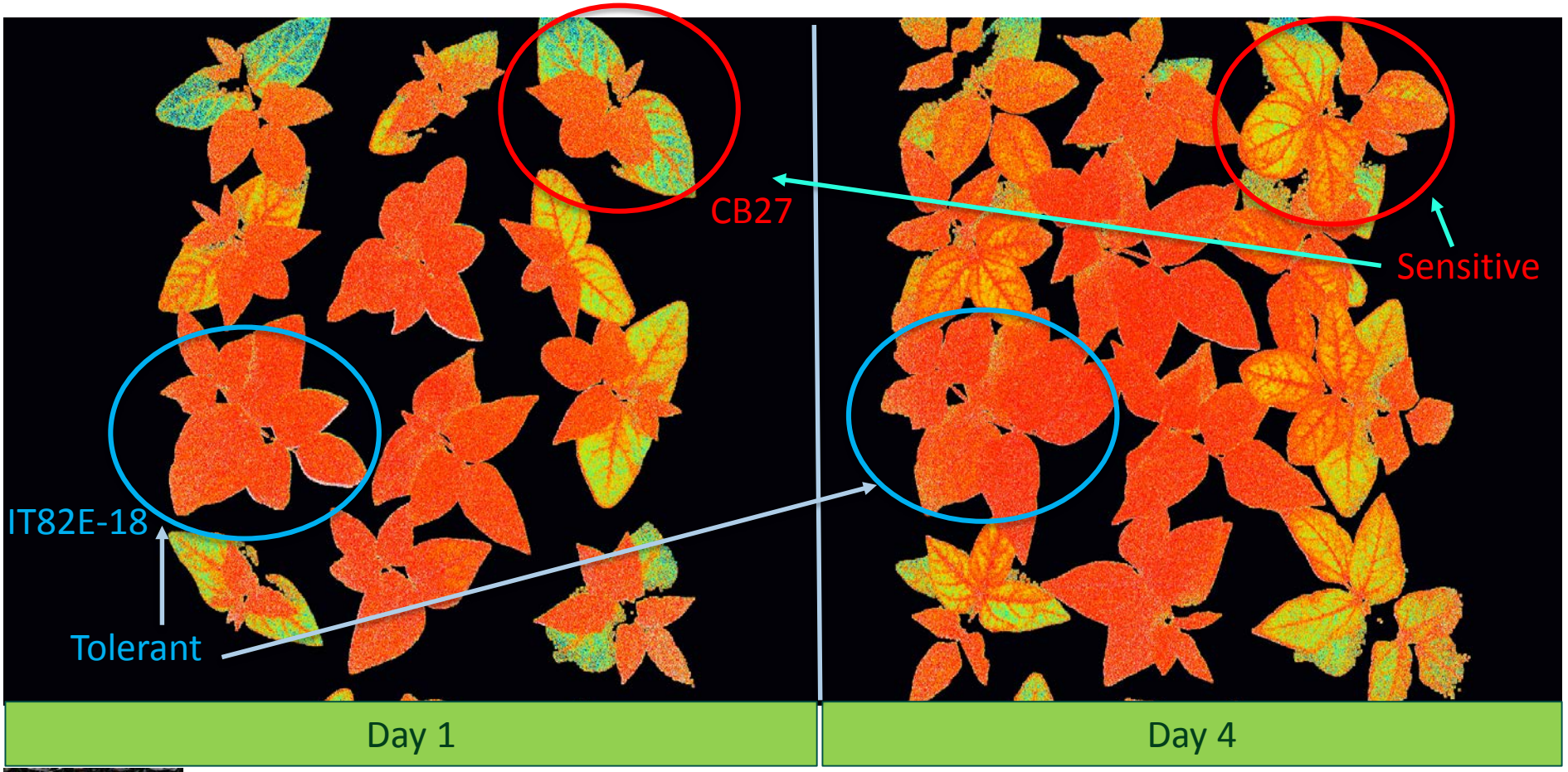
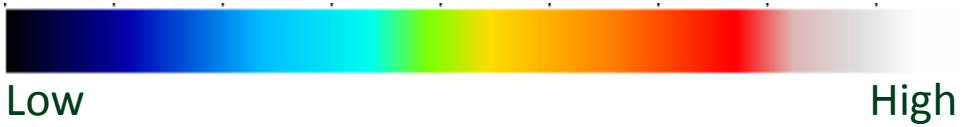
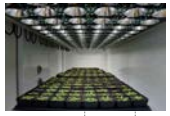
Photosynthetic efficiency (ϕII) under heat stress

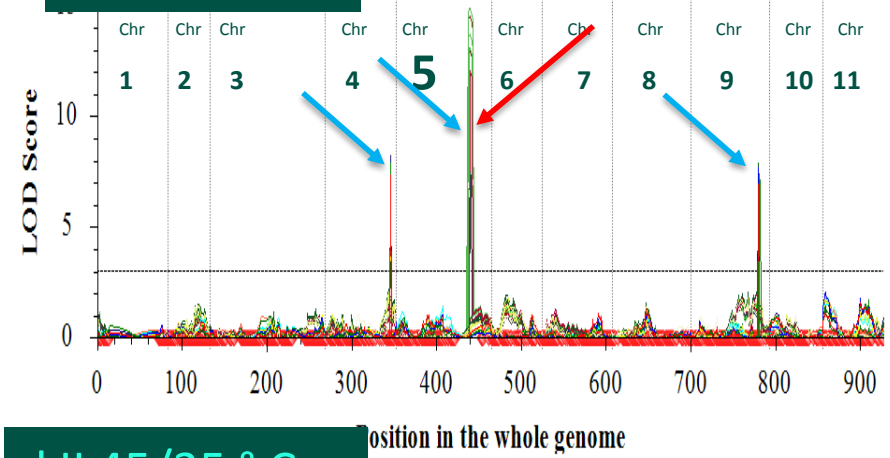




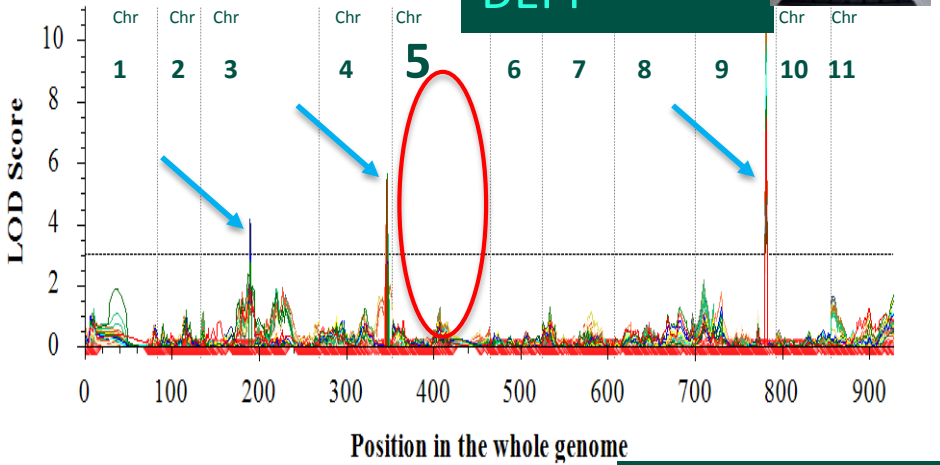
QTLs for Photosynthetic efficiency (ϕII) under heat stress and normal growth conditions

ϕII 45/35 ° C DEPI

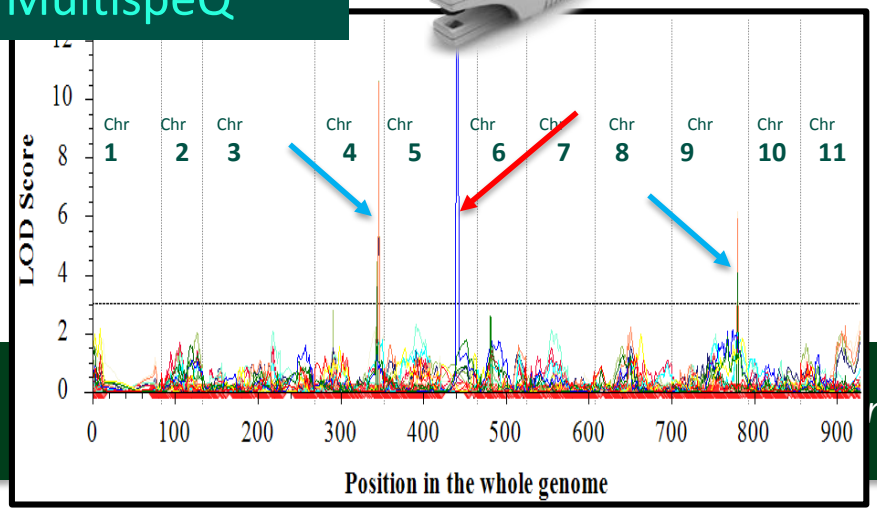




ϕII 30/20 ° C DEPI



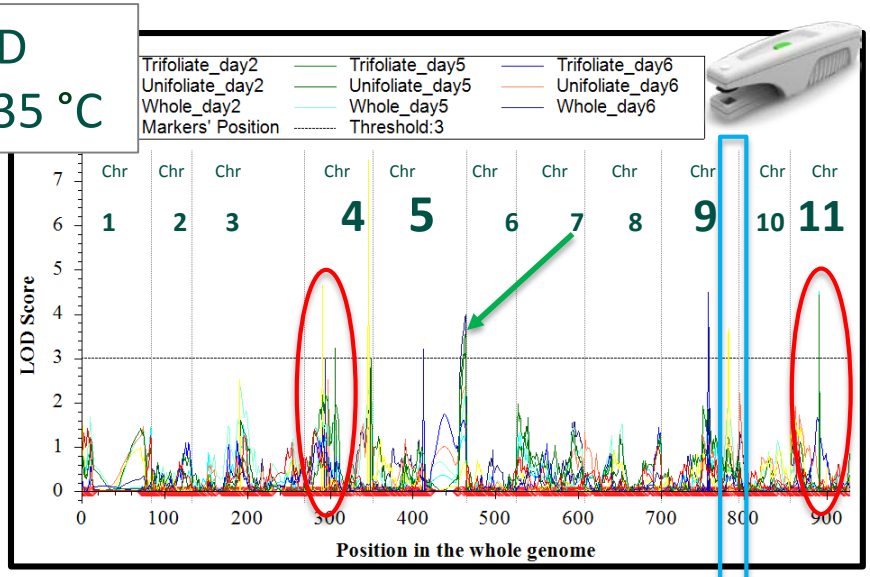
ϕII 45/35 ° C MultispeQ



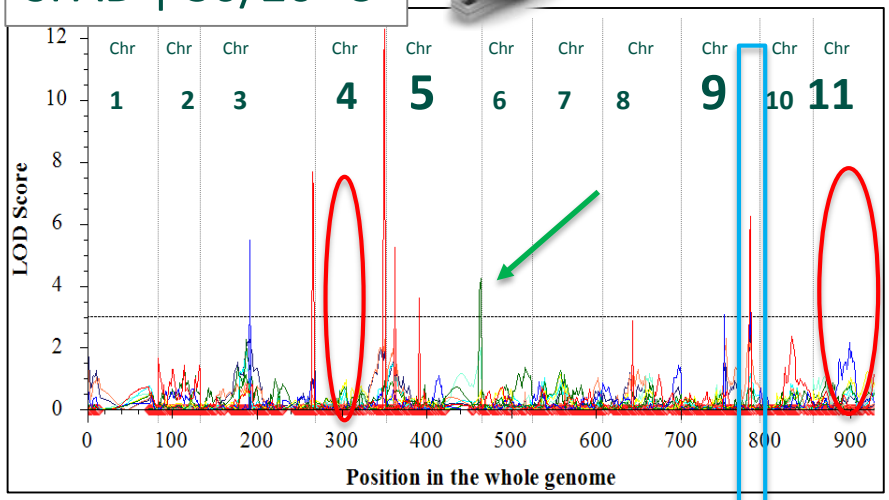
ϕII 30/20 ° C MultispeQ

Possible linkage between SPAD/ Relative Chlorophyll content, photoprotection (qEt) and biomass QTL

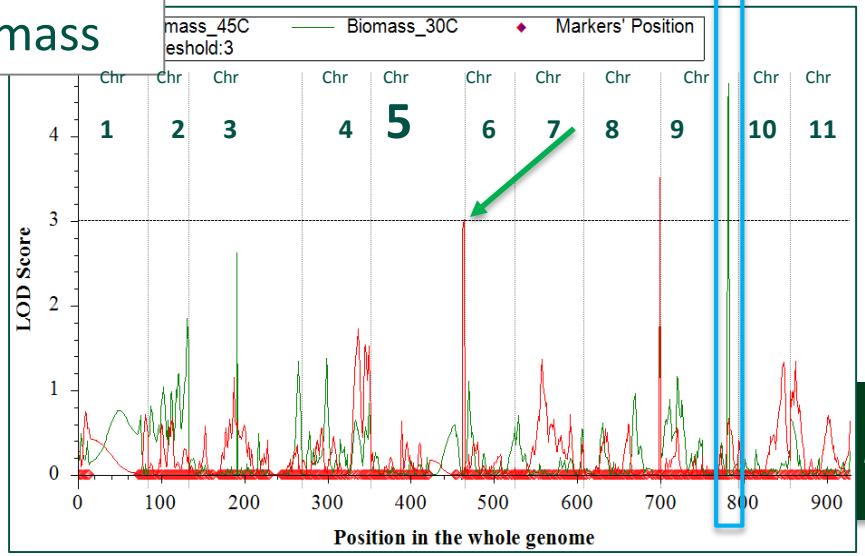
SPAD 45/35 °C



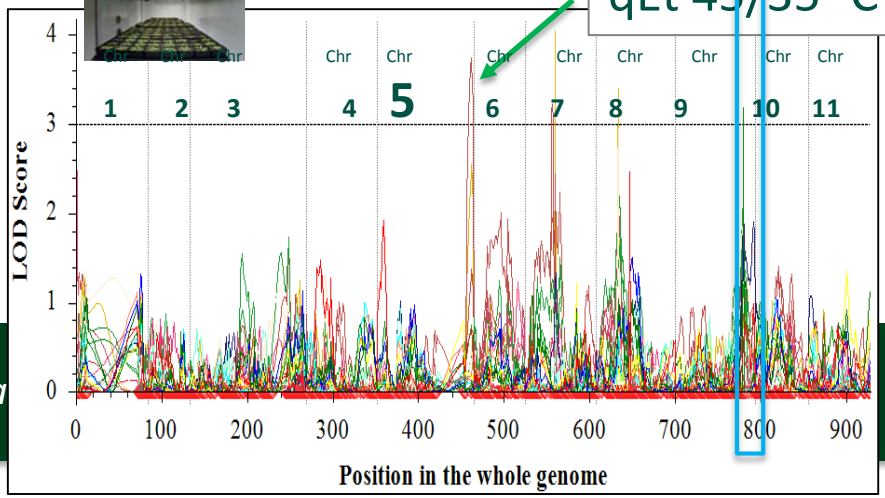
SPAD | 30/20 °C



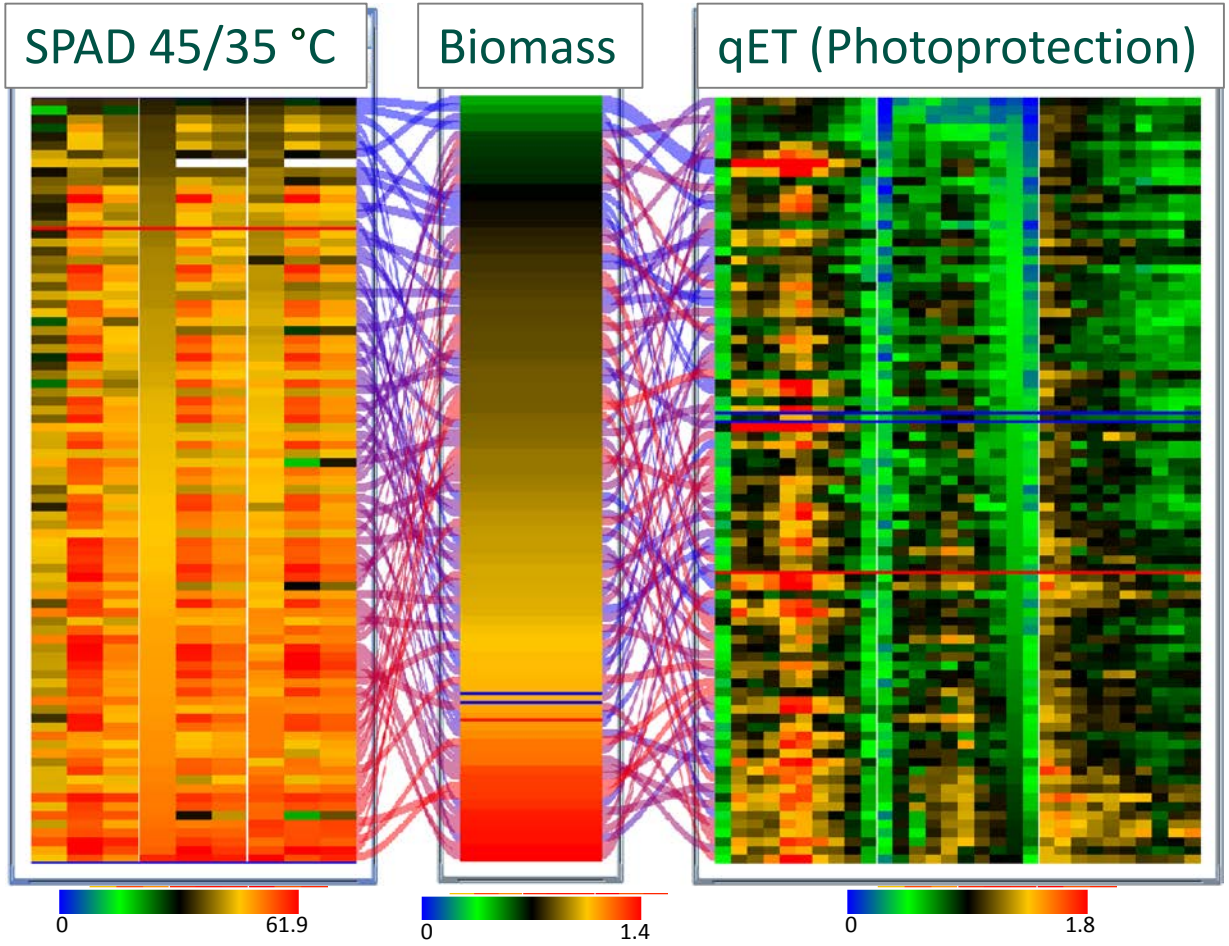
Biomass



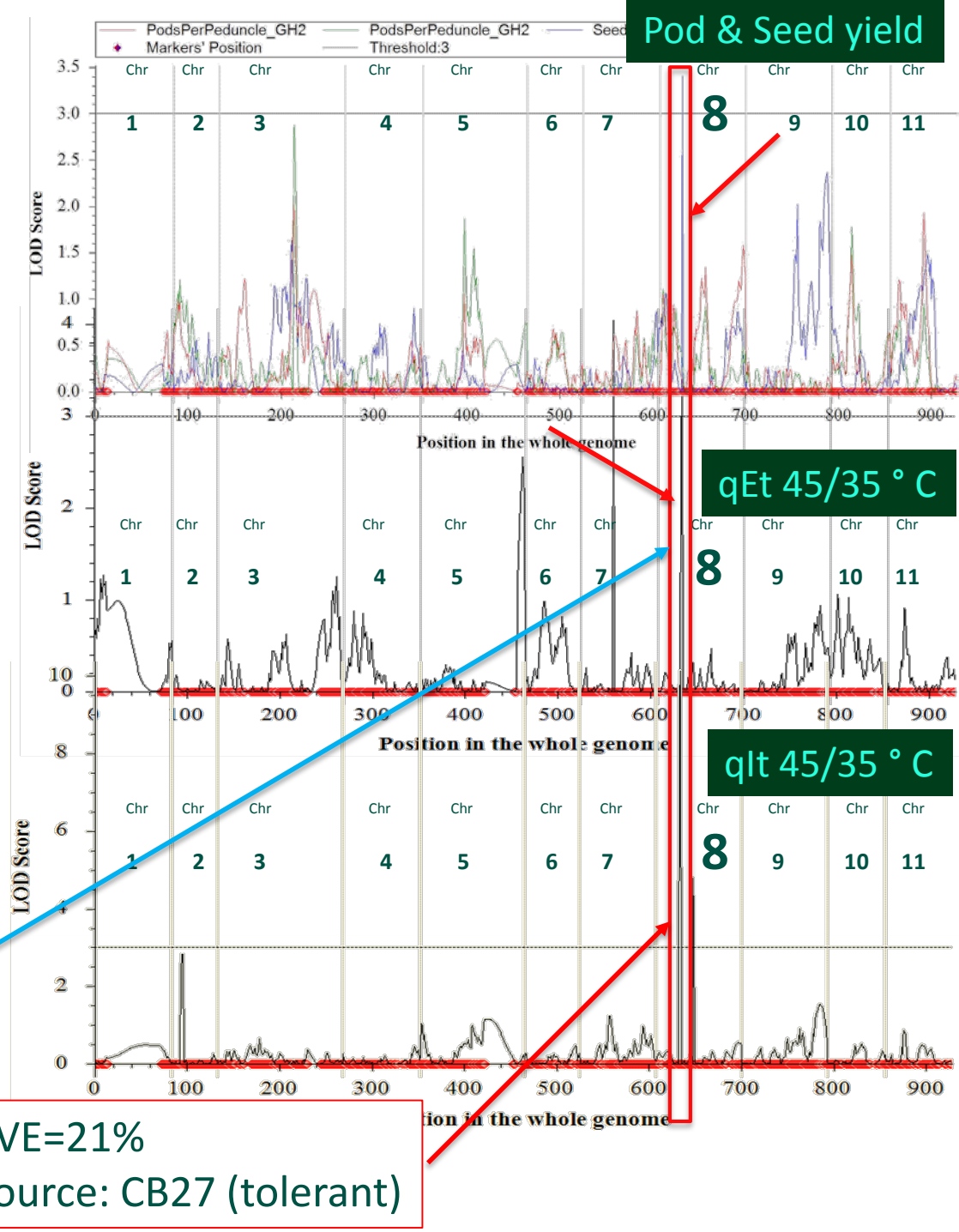
qEt 45/35 °C



Correlation between Biomass, chlorophyll content and qEt



Photoprotection (qEt) and photo-inhibition (qIt) QTLs may be controlled by the same locus as seed yield under heat stress



PVE=12%
Source: IT82E-18 (tolerant)

PVE=21%
Source: CB27 (tolerant)

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Take home message

- QTLs for photosynthetic traits under control and heat stress environments have been identified in cowpea
- QTLs for SPAD and photoprotection (qEt) map to the same loci as biomass under control and heat stress conditions
- The balance between photoprotection and photo-inhibition may be controlled by the same region as seed yield under heat stress
- Both DEPI and MultispeQ (PhotosynQ) are powerful phenotyping tools for photosynthetic traits and QTL mapping

Future directions

- Explore the possible connection between seed yield under heat stress and photo-protection and photo-inhibition
- Identify genes within the QTLs that have been mapped
- Determine mechanisms enabling tolerance of photosynthesis under heat stress in cowpea.

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