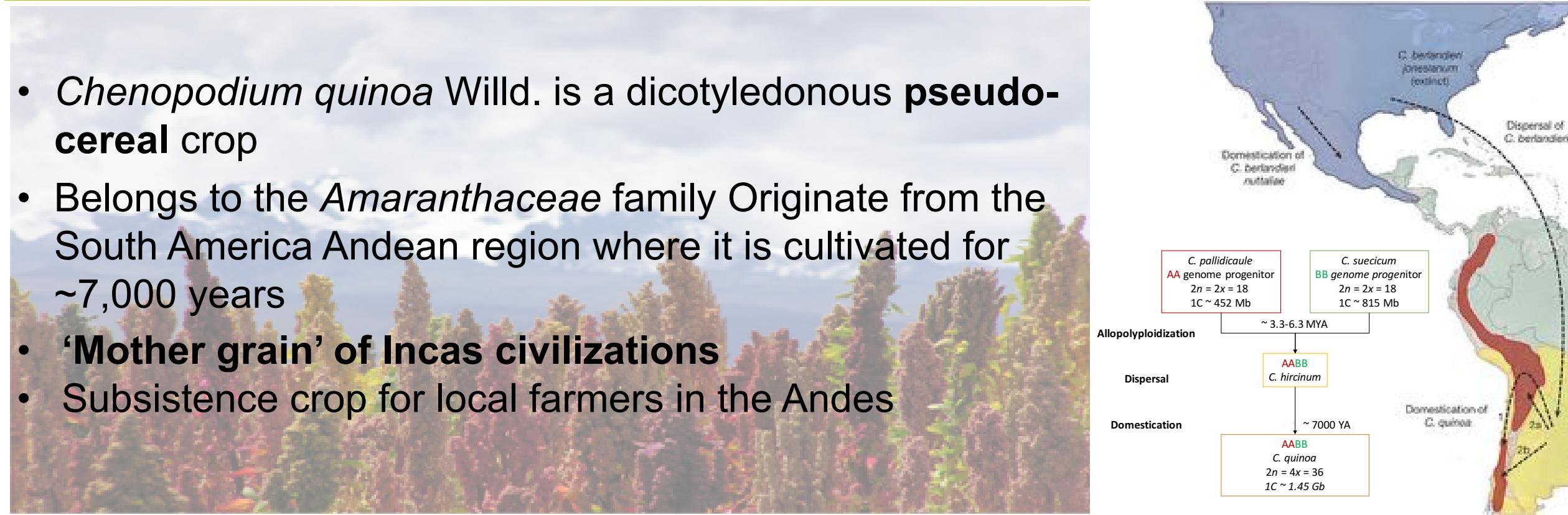


Uncovering the wild genetic diversity in *Chenopodium* spp. for improvement of heat stress tolerance in quinoa.

Quinoa's Origin

- Chenopodium quinoa* Willd. is a dicotyledonous **pseudo-cereal** crop
- Belongs to the **Amaranthaceae** family. Originate from the South America Andean region where it is cultivated for ~7,000 years
- 'Mother grain' of Incas civilizations
- Subsistence crop for local farmers in the Andes



A 'super grain' of the future



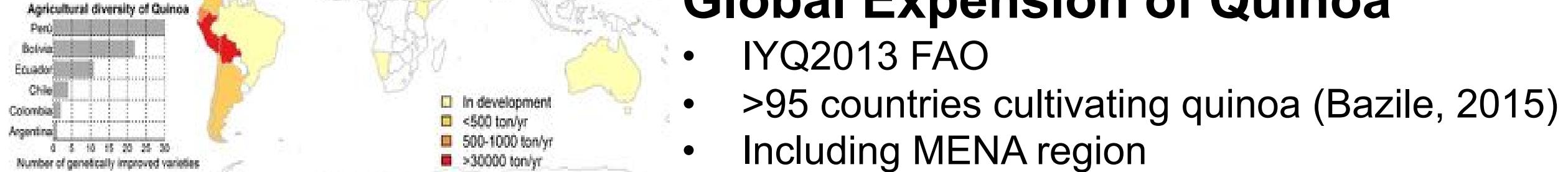
A nutricious – high yielding crop

- Good balance between oil (4–9 %), protein (16 %) and carbohydrates (64 %)
- High content of **essential amino acids**, rich in **vitamins, minerals and fibers**
- High starch content & gluten free



A crop for marginal lands & harsh environments

- Grow in **poor soils**, from sea level to 3,000 masl., from 2° North latitude to 47° South latitude
- Drought tolerant** (require 5X less water than rice, 2.5X less than maize to produce 1kg of seeds)
- Tolerant to Frost** (down to -8°C) & **Salinity** (sustains 20-30% sea water irrigation)



Global Expansion of Quinoa

- IYQ2013 FAO
- >95 countries cultivating quinoa (Bazile, 2015)
- Including MENA region

Limitations



Sensitive to high temperatures

- Optimum growth temp. between 20-25°C (similar to wheat and barley)
- Yield penalties with av. Temp. >32-35°C**
- Strong limitation to quinoa expansion

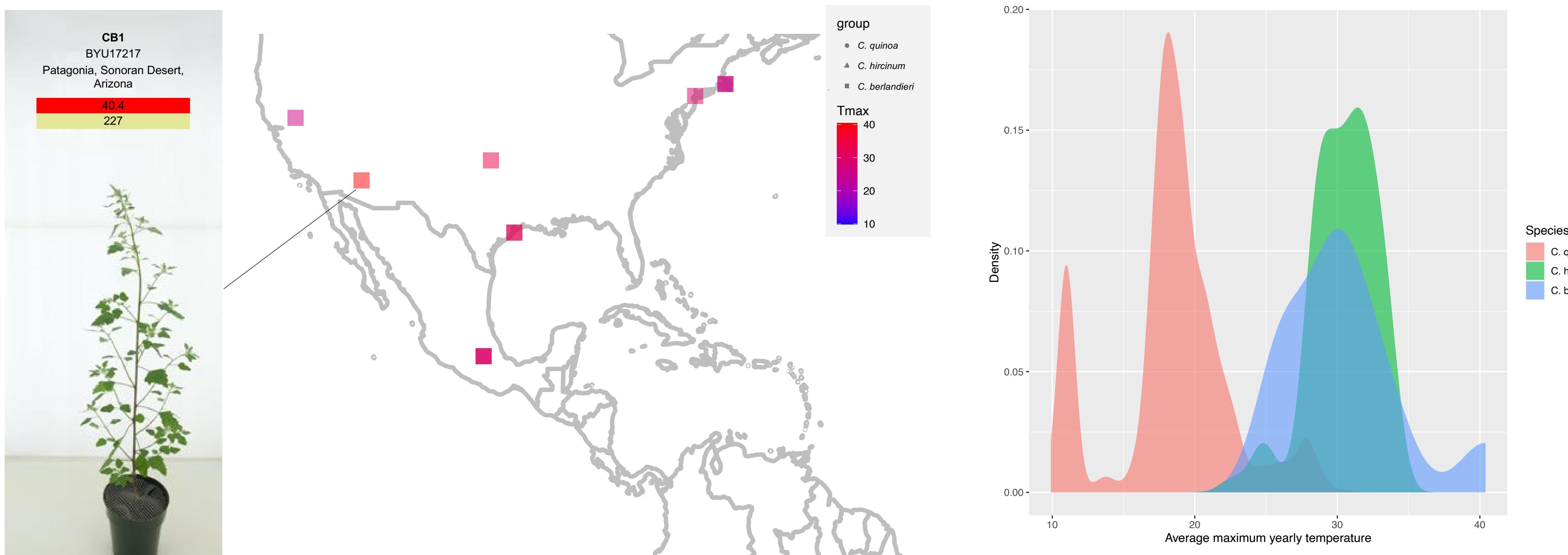
Elodie Rey^{1*}, Rameesha Mangattu Parambil¹, Hongwei Ren¹, Puneet Paul², Ute Roessler³, Daniel Bertero⁴, David E. Jarvis⁵, Peter J. Maughan⁵, Erick N. Jellen⁵, Ikram Blilou¹, Vanessa Melino¹ and Mark Tester¹.

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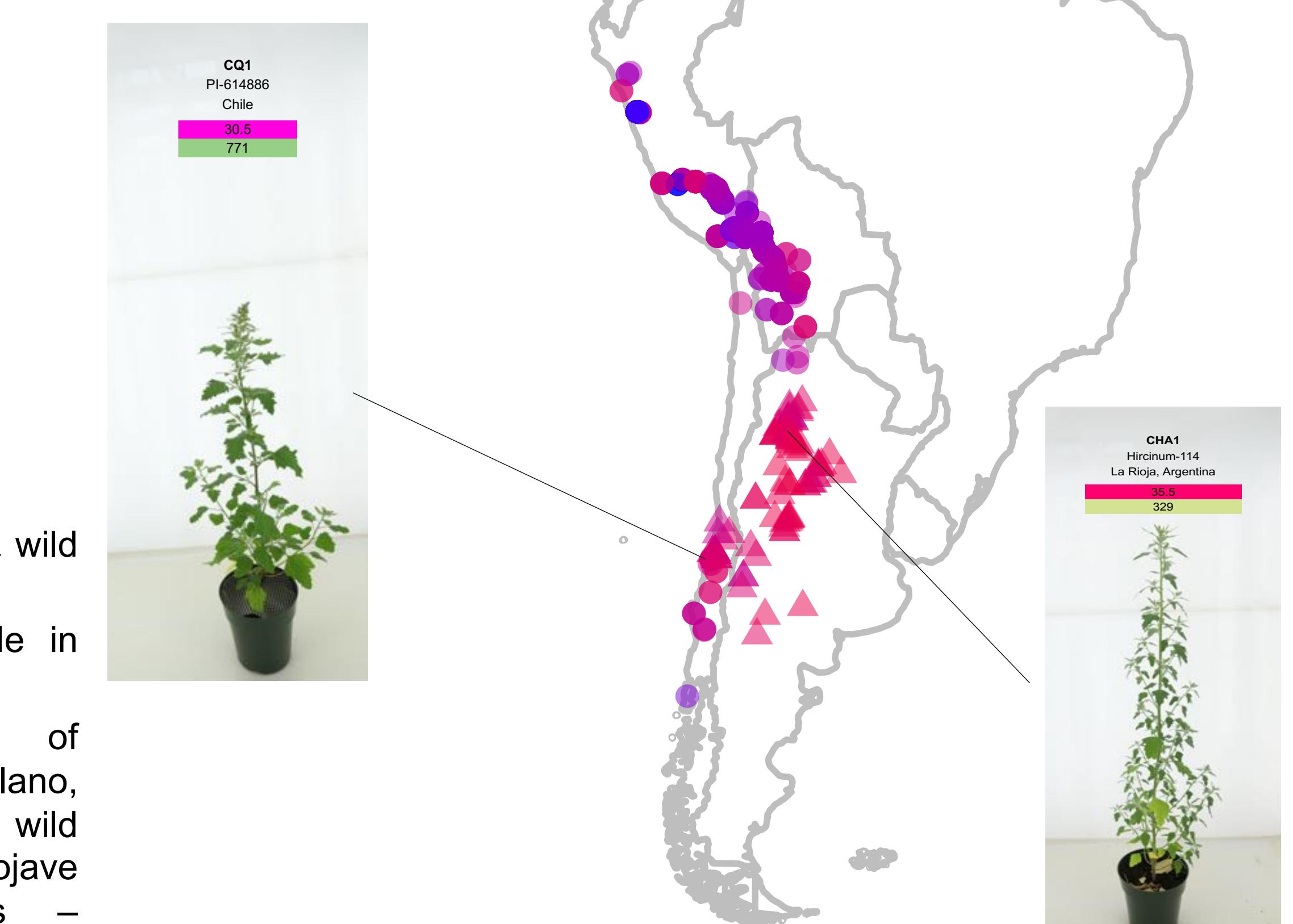
A rich reservoir of genetic diversity for adaptation to climate changes

- C. berlandieri* and *C. hircinum* are from warmer niche environments in South and North America than quinoa
- We hypothesize that they **possess previously unexplored mechanisms of adaptation to high temperatures**, not present in cultivated quinoa



Germplasm diversity

- Over 16,422 accessions of quinoa & wild relatives
- ~1300 accessions publicly available in ex-situ genebanks
- Diversity of eco-environments** of cultivated quinoa (Valley, Altiplano, Salares, Coastal, Tropical) and wild relatives species (Sonoran & Mojave Desert, La Rioja and Ceres – Argentina...)

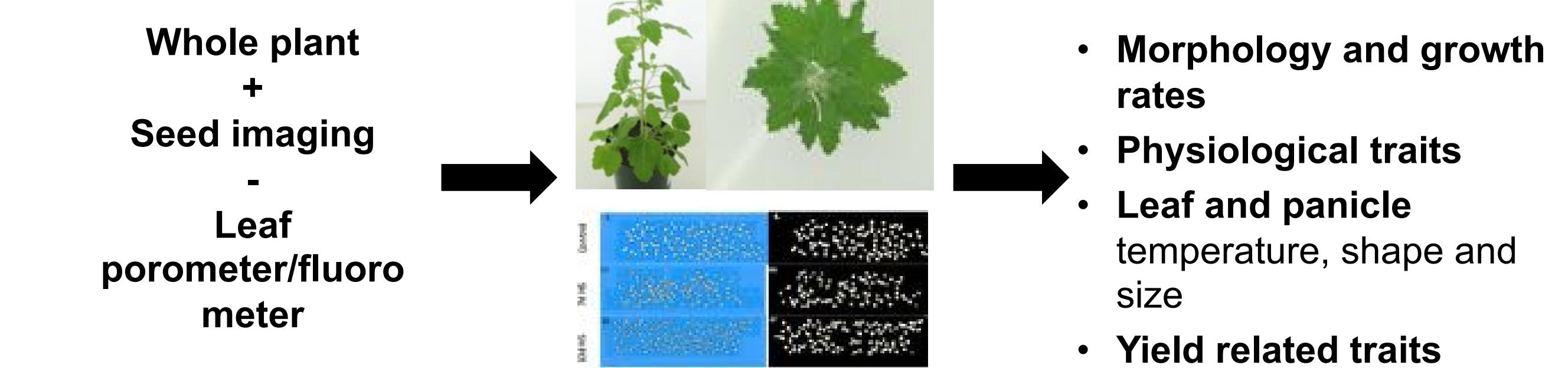


Genomic resources

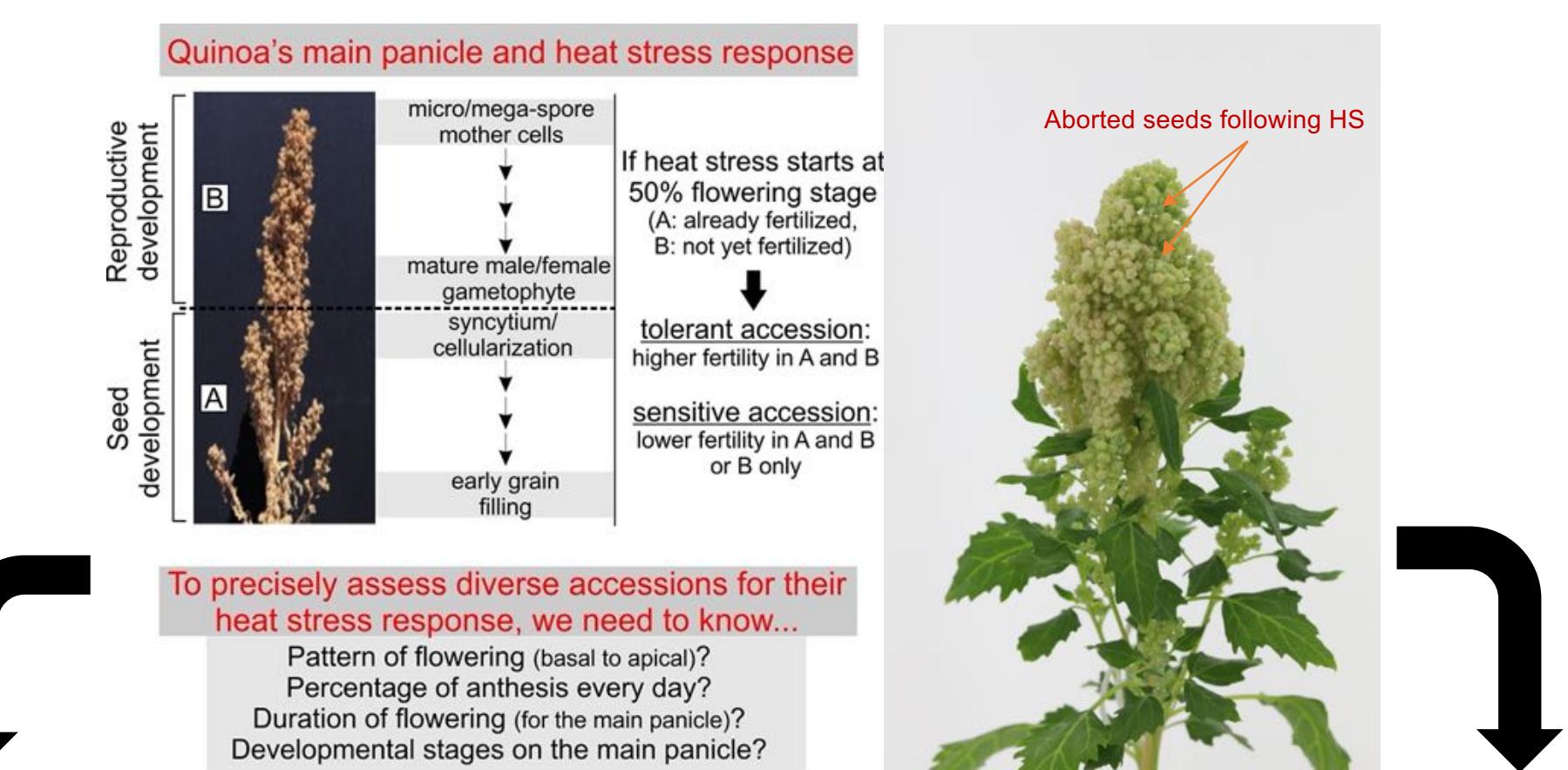
- Updated **chromosome scale reference genome**
- PacBio Hi-Fi (30X) sequencing for **eight quinoa lines** covering the genetic structure of quinoa population
- 8X Illumina re-sequencing of 990 quinoa accessions, 82 *C. hircinum* genotypes from Argentina, 11 *C. hircinum* genotypes from Chile, and 18 genotypes from *C. berlandieri*

Understand to Improve

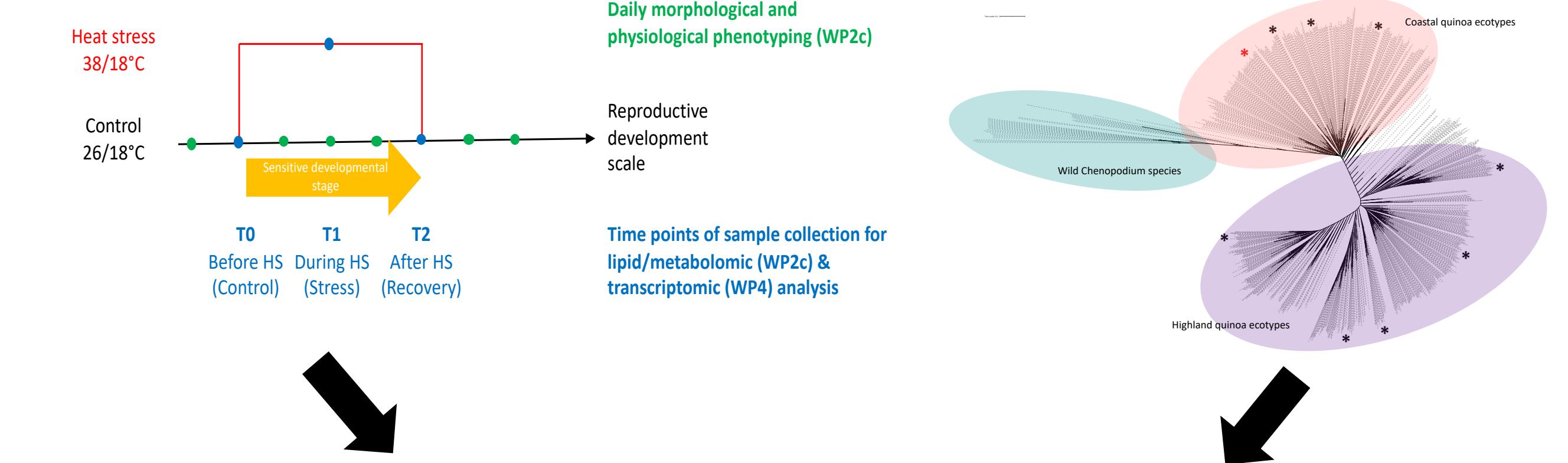
1. Characterization of the Heat Stress Response (HSR) in a sub-collection of quinoa, *C. hircinum* and *C. berlandieri*



2. Identification of the heat sensitive/resistant reproductive tissue, age and duration through reproductive developmental biology



3. Developmental -omics phenotyping campaign



Molecular and physiological markers for HSR to inform breeding approaches and better adapt quinoa to warming environments

This work is funded by KAUST Competitive Research Grant