



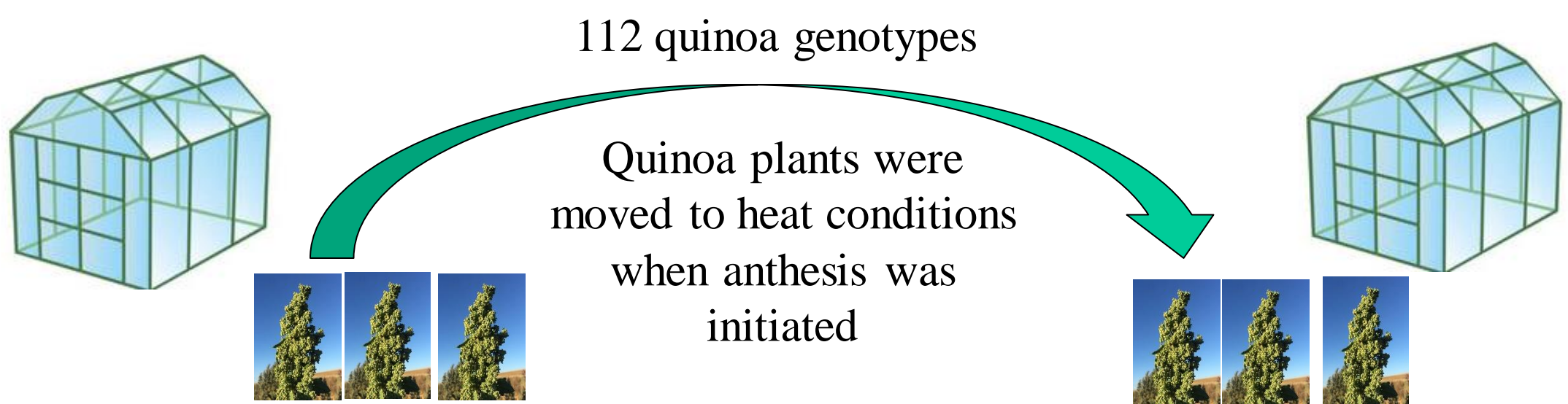
Abstract

Quinoa is a nutritionally dense annual seed crop originating from the Andes Mountains of South America. Sensitivity to high temperatures has been reported as a serious obstacle to the global expansion of quinoa. Temperatures above 35° C during anthesis have been shown to significantly reduce quinoa grain yield. The objective of this study was to evaluate heat tolerance in diverse quinoa genotypes. 112 genotypes were evaluated at anthesis for 12 days in a greenhouse simulation experiment with a maximum temperature of 40° C for 2 hours/day. Leaf greenness index (LGI) was quantified using a SPAD meter for each genotype. Of the original 112 genotypes, 68 produced seeds under heat-stressed conditions. The genotype “Kaslaea” produced the highest yield (9.93 g/plant) and the genotype “Cahuil” had the largest seed (3.37 mm²) under greenhouse conditions. A set of eight genotypes were selected based on LGI for a subsequent field trial. Four (Baer, QQ74, Pison, and BGQ 352) were potentially heat tolerant with a mean LGI decrease of 19.31 between day 12 and day 0, and four (17 GR, 3 UISE, La Molina and Japanese Strain) were considered heat sensitive with a LGI reduction of 60.11. Our results will validate the capacity to generate a new tool for phenotyping quinoa at high temperatures.

Objectives

- Evaluate heat tolerance in diverse quinoa genotypes
- Determine different tools to evaluate heat stress in quinoa

Methods



Control conditions: Average temperature of 20.3 °C during the night and 26.7 °C during the day

High temperature conditions: The night temperature (10:00 pm to 6:00 am) was constant (average temperature of 23.5° C). The day temperature started with 22° C at 6:00 am, and increased 1° C at every hour up to 9:00 am. Afterwards, at every hour up to 2:00 pm, the temperature was increased 3° C until it reached ~40° C from 2:00-4:00 pm and then decreased gradually.

- ✓ **Leaf Greenness Index (LGI)** Minolta SPAD-502 M
- ✓ **Days to flowering**
- ✓ **Plant height (cm)**
- ✓ **Dry weight/plant (g)**
- ✓ **Seed yield (g/plant)**
- ✓ **Harvest index**

Results

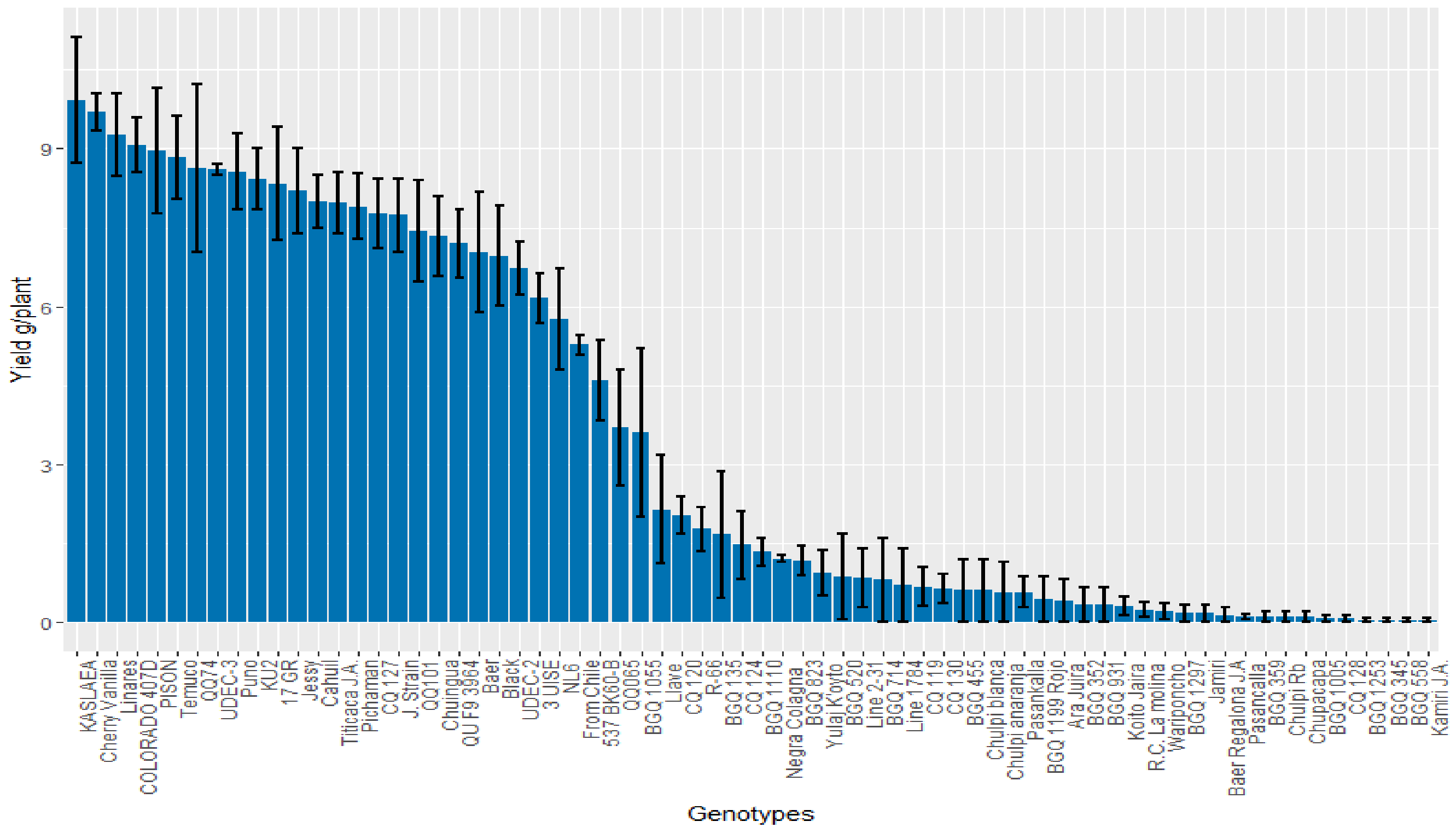


Figure 1. Yield (g/plant) of the 68 quinoa genotypes that produced seeds in high temperature greenhouse conditions

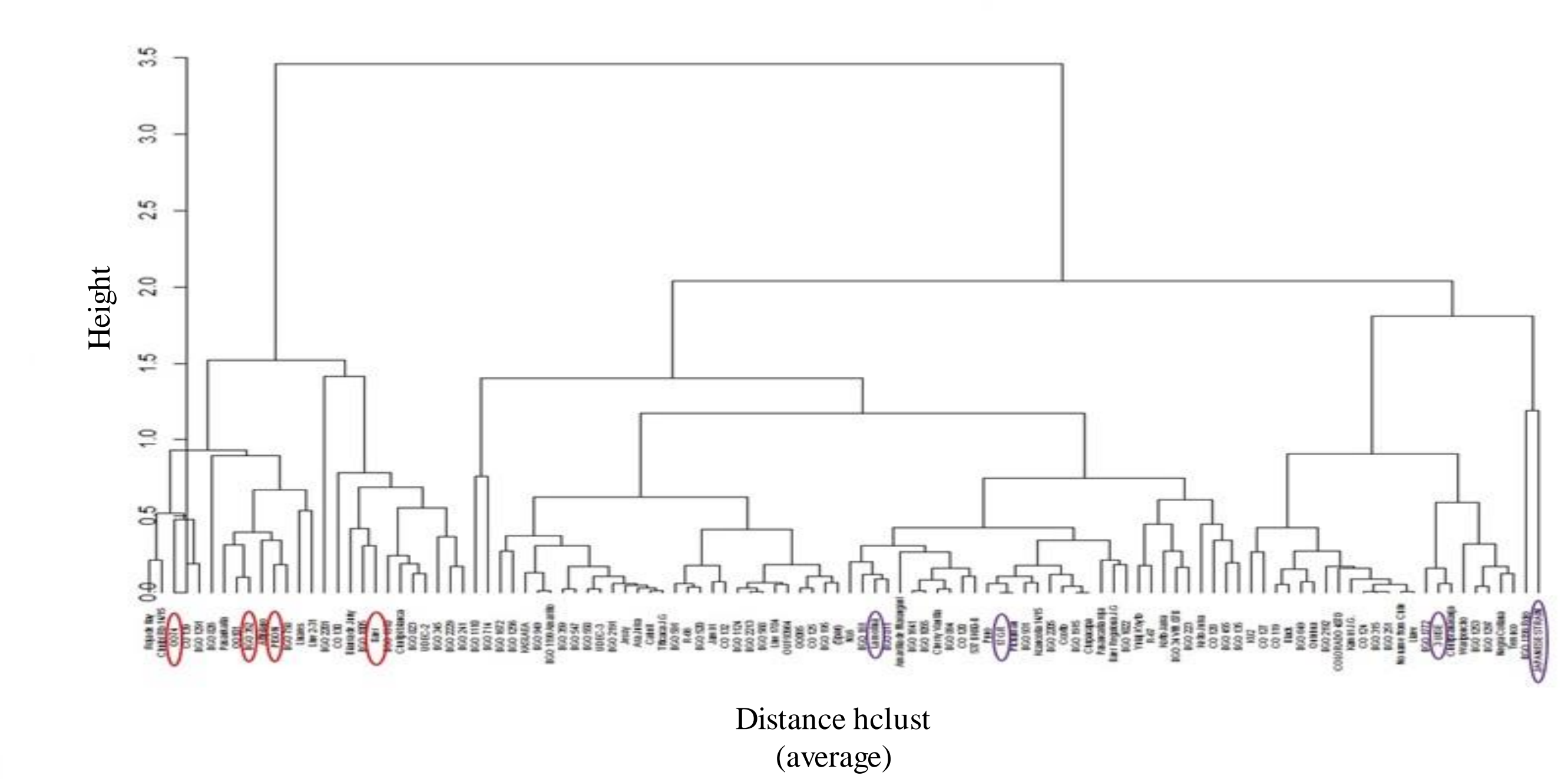


Figure 2. Cluster dendrogram for 112 genotypes of quinoa grown in high temperatures based on LGI, yield, and harvest index.

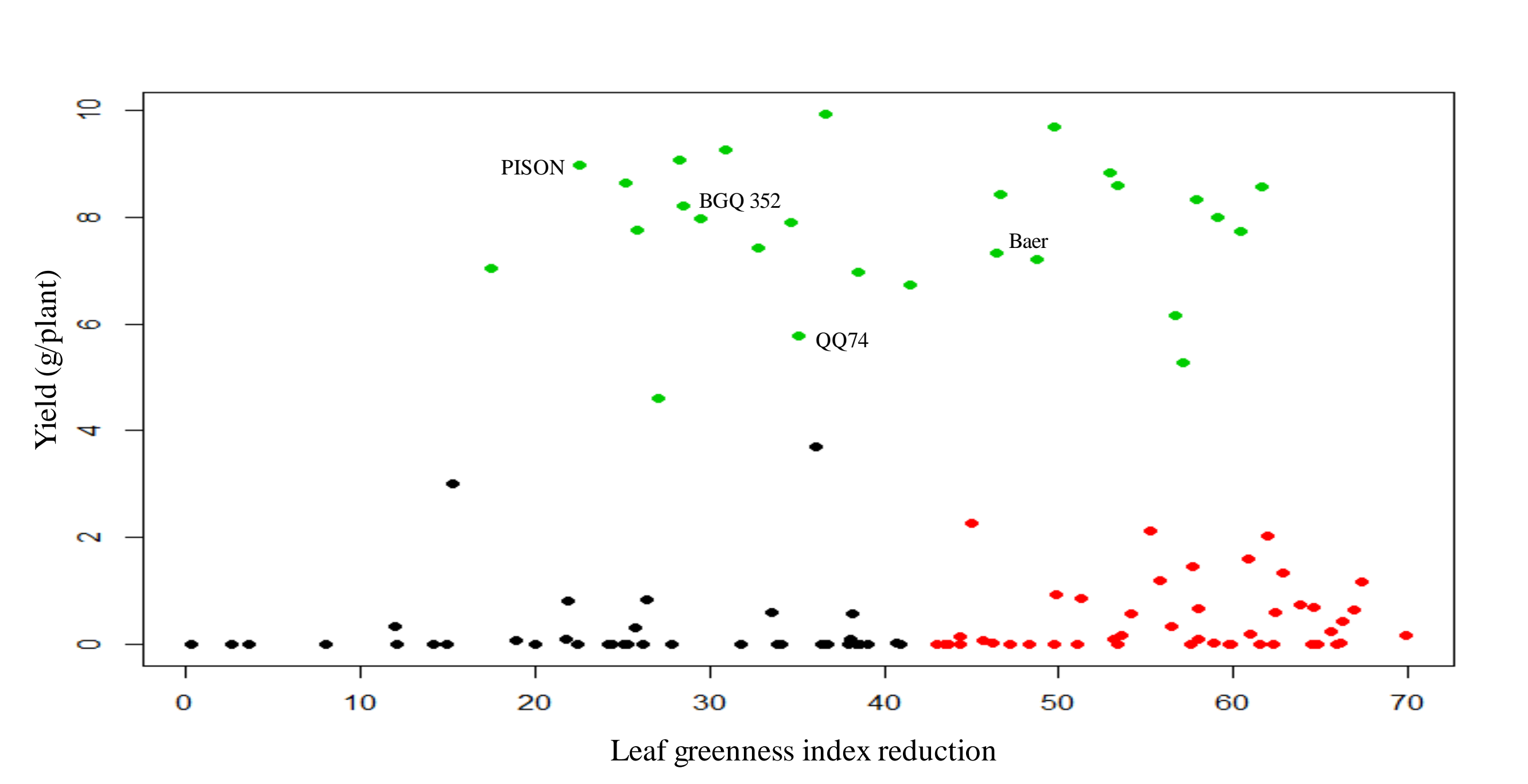


Figure 3. Cluster plot between leaf greenness index reduction and yield of 112 genotypes of quinoa grown in high-temperature greenhouse conditions. Cluster 1 (Green), Cluster 2 (Black), and Cluster 3 (Red). Pison, QQ74, Baer, and BGQ 352 are potential heat tolerant genotypes

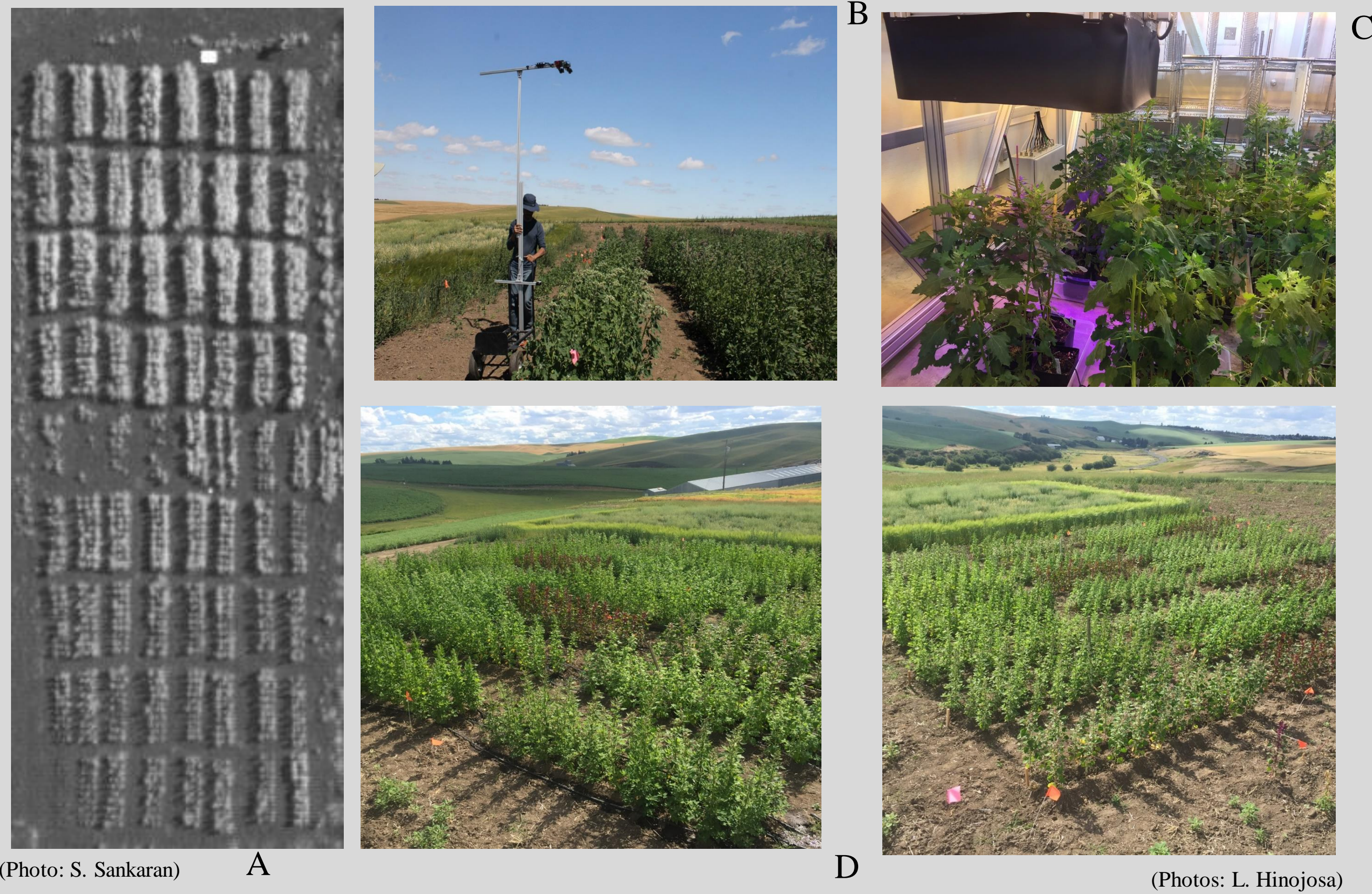
Results

- ✓ Sixty-eight quinoa genotypes produced seeds under the high-temperature treatment. The remaining genotypes (44) did not produce seeds.
- ✓ The highest yield was obtained with Kaslaea with 9.93 g/plant followed by Cherry Vanilla, Linares, Colorado 407, and Pison with 9.70, 9.27, 9.07, and 8.97 g/plant respectively (Figure 1).
- ✓ The mean LGI decrease for Baer, QQ74, Pison, and BGQ 352 was 19.31 from day 0 to 12, indicating their heat tolerance potential. The mean LGI decrease for 17 GR, 3 UISE, La Molina and Japanese Strain was 60.11, suggesting these could be potentially heat sensitive genotypes.
- ✓ Three cluster were differentiated using a cluster analysis based on LGI, yield, and harvest index. The four potentially heat tolerant genotypes identified localized in the first cluster. The genotypes 17 GR and Molina localized in the second cluster, and 3 UISE and Japanese Strain localized in the third cluster (Figures 2 & 3).

Conclusion

- The genotypes Baer, QQ74, Pison, and BGQ 352 are potential heat tolerant genotypes

Next Steps



Picture 2. A) An aerial near-infrared image of quinoa field trial; B) Field imaging with different sensors; C) Fluorescent imaging in WSU Phenomics Center; D) Quinoa field trial (left: irrigated conditions and right non-irrigated conditions)

Acknowledgements

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Picture 1. 112 genotypes of quinoa growing in greenhouse conditions

(Photos: L. Hinojosa)