**International Quinoa Conference 2016:**

Quinoa for Future Food and Nutrition Security in Marginal Environments

*Dubai, 6-8 December 2016*

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# Phenotyping the combined effect of heat and water stress on quinoa

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# Introduction

## Quinoa research at ICBA

- Diversification of production systems has been ICBA's main strategy to sustain agricultural and economic growth in marginal/salt-affected areas
- Several exotic crops (forage as well as food crops) were studied for local adaptation and yield potential under saline and heat-stressed conditions and promising crops/genotypes identified

**Forages**
- Pearl millet
- Sorghum
- Barley
- Triticale
- Fodder beet
- Buffel grass
- Sesbania

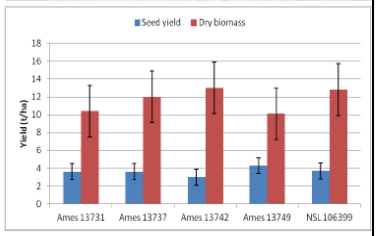
**Other crops**
- **Quinoa**
- Mustard
- Safflower
- Cowpea
- Guar
- Amaranth
- Castor

Among food crops, Quinoa ranked very high in terms of local adaptation and grain yield potential – hence regarded as a promising alternative crop for the region

# Introduction

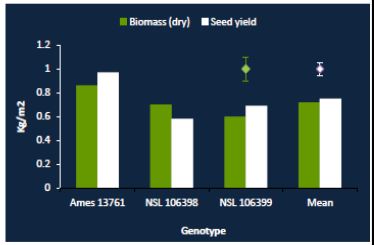
## On-station trials…

- 5 top-ranking accessions selected from field trials of 120 accessions received from the USDA (2006-07)
- Mass selection performed to improve seed yield (2008)
- Replicated yield trial conducted to assess grain and biomass yield potential during 2009-10
- Irrigation water salinity was 2-3 dS/m
- Mean grain (0.46 kg/m$^2$) and dry matter (1.5 kg/m$^2$) yields obtained were much higher than the average yields (2 and 8.8 t/ha, respectively) reported from the Andes (Rao & Shahid, 2012)



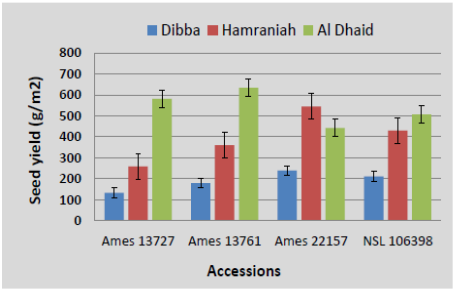

## On-farm trials (2012-13)

- Three genotypes were evaluated during winter (Nov 2012-Mar 2013)
- Plot size was 5 x 25 m, distance between rows and between plants was 50 and 25 cm, respectively
- Good germination, plant establishment and growth despite the poor quality of soil and water
- Seed yields ranged between 0.58 and 0.97 kg/m$^2$ with an average of 0.75 kg/m$^2$
- Dry biomass yields ranged between 0.60 and 0.86 kg/m$^2$ with an average of 0.72 kg/m$^2$




## Trails at MOEW Research Stations 2013-14

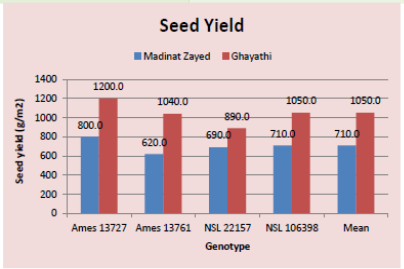
- No. of locations: Three locations
- Water Salinity: 2-6 dS/m
- No. of genotypes: 4
- Design: RCBD
- Mean seed yields ranged between 0.32 kg/m$^2$ to 0.41 kg/m$^2$ with an overall mean of 0.38 kg/m$^2$.

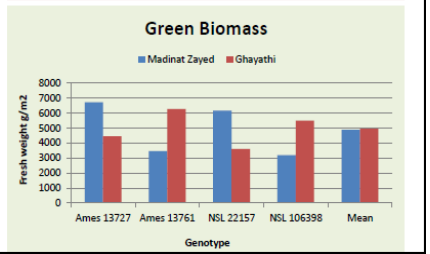



| Location | Water Salinity (dS/m) | Soil | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Texture Class | pH | ECe (dS/m) | $CaCO_3$ eq. | P (ppm) | K (ppm) | Clay | Silt | Sand |
| Dibba | 6.1 | Sand | 7.55 | 35.86 | 22.00 | 84.59 | 54.33 | 2.83 | 4.87 | 92.30 |
| Hamraniah | 4.5 | Sandy loam | 7.49 | 48.50 | 38.97 | 88.83 | 161.67 | 8.53 | 18.83 | 72.63 |
| Al Dhaid | 2.3 | Loamy sand | 8.34 | 2.49 | 34.60 | 115.80 | 149.67 | 4.20 | 9.30 | 86.50 |

## On-farm trials (2013-14)

- Two locations: Madinat Zayed and Ghayathi
- Water salinity: 16-19 dS/m
- Four genotypes
- Plot size: 5 x 30 m
- Seed yields ranged between 0.62 and 0.80 kg/m$^2$ with an average of 0.71 kg/m$^2$ in Madinat Zayed and between 0.89 and 1.2 kg/m$^2$ with an average of 1.1 kg/m$^2$ at Ghayathi
- Fresh biomass yields ranged between 3.2 and 6.7 kg/m$^2$ with an average of 4.9 kg/m$^2$ at Madinat Zayed and between 3.6 and 5.5 kg/m$^2$ with an average of 4.9 kg/m$^2$ in Ghayathi



# Materials and Methods

## Heat Stress

### Germination test under growth chamber controlled conditions

Objective

Evaluate the effect of temperature on germination on 5 quinoa accessions

Tested temperatures:

2, 10, 22, 30, 42 °C

Quinoa accessions

- Q3
- AMES 13749
- NSL 106399
- AMES 13757
- Q5

5 replications

### Post experiment under greenhouse conditions

Objective

Phenotype 5 quinoa accessions grown under 4 different environments and two irrigation levels

Environments

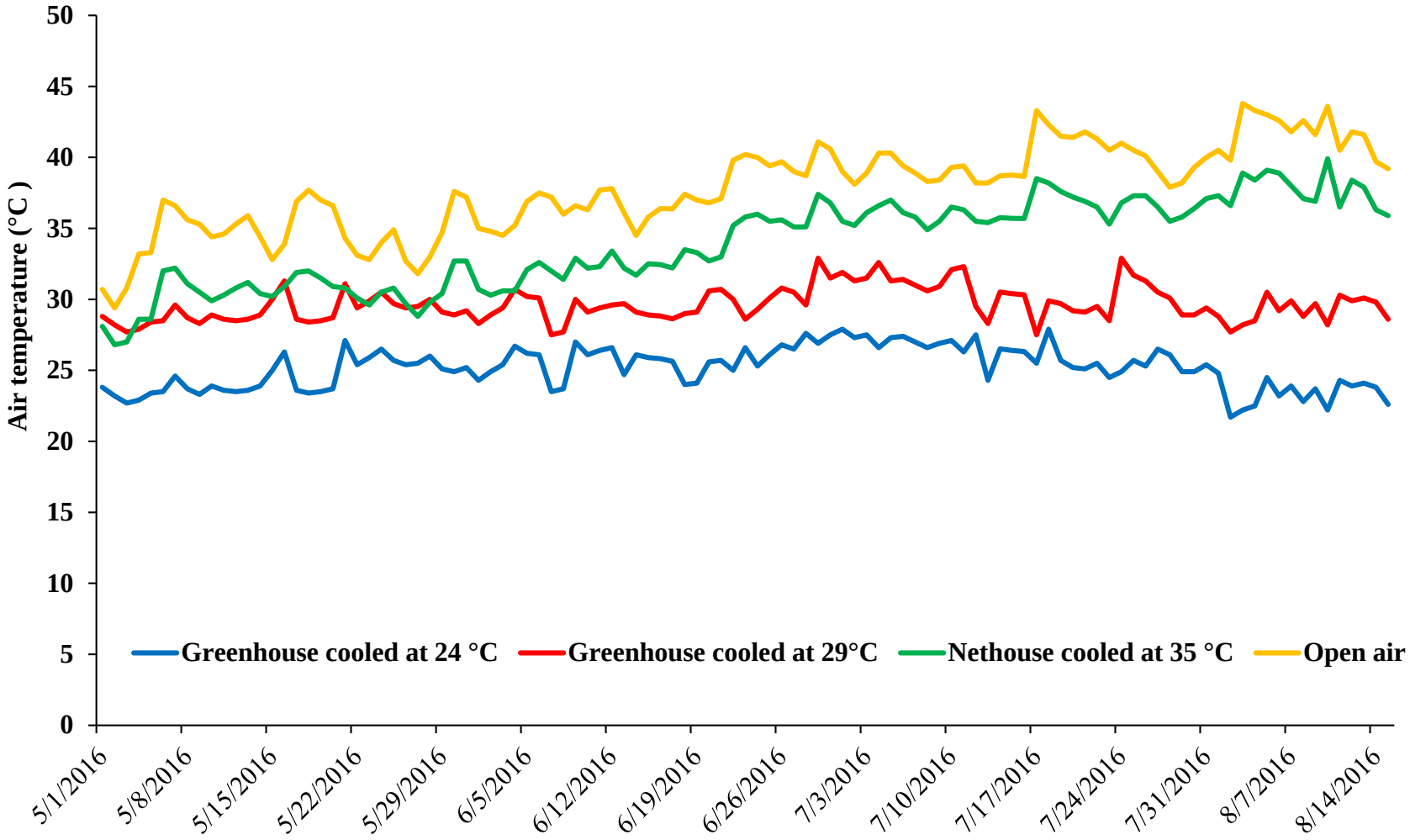
- Greenhouse cooled at 24 °C
- Greenhouse cooled at 29 °C
- Net house cooled at 35 °C
- Open air

Irrigation treatments

- 100% of full irrigation
- 50% of full irrigation

# Results

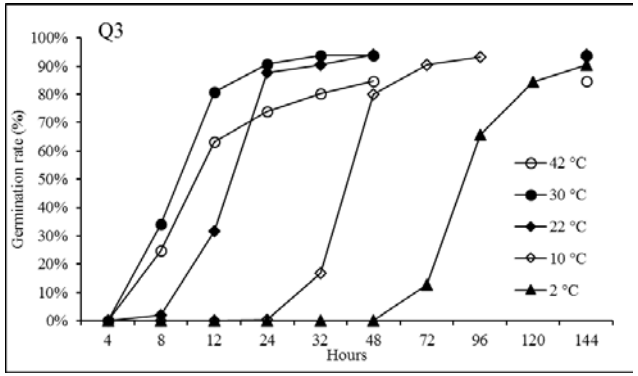
## Air temperature

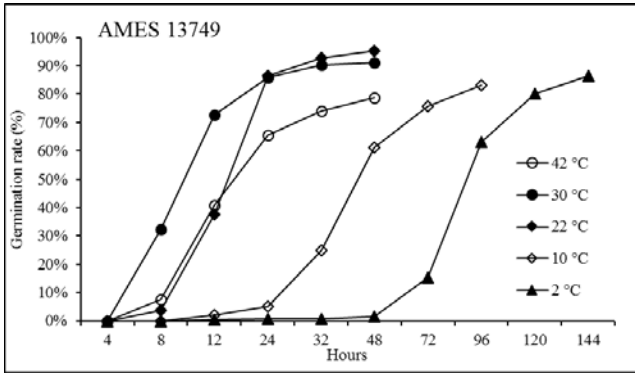


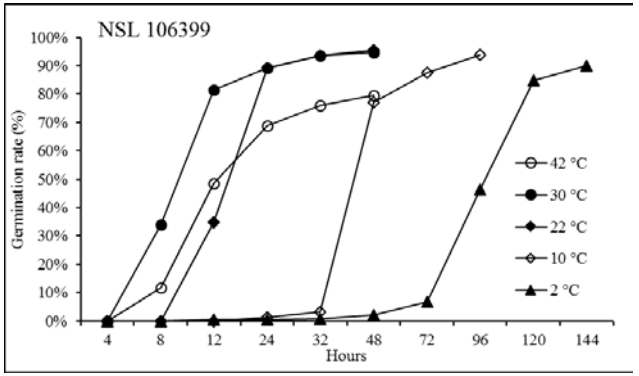
# Results

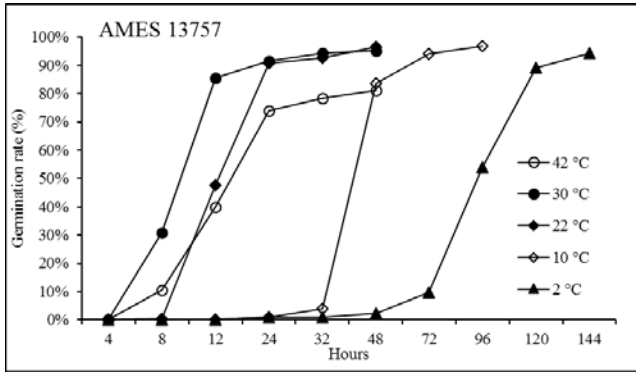
## Germination parameters

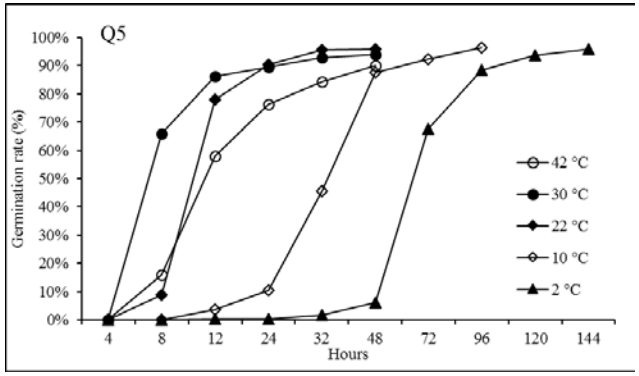
### Germination rate



# Results

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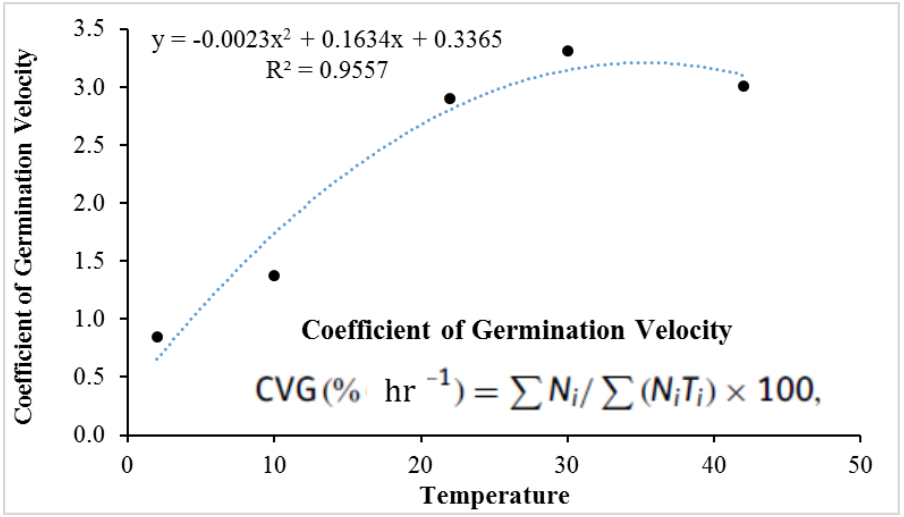
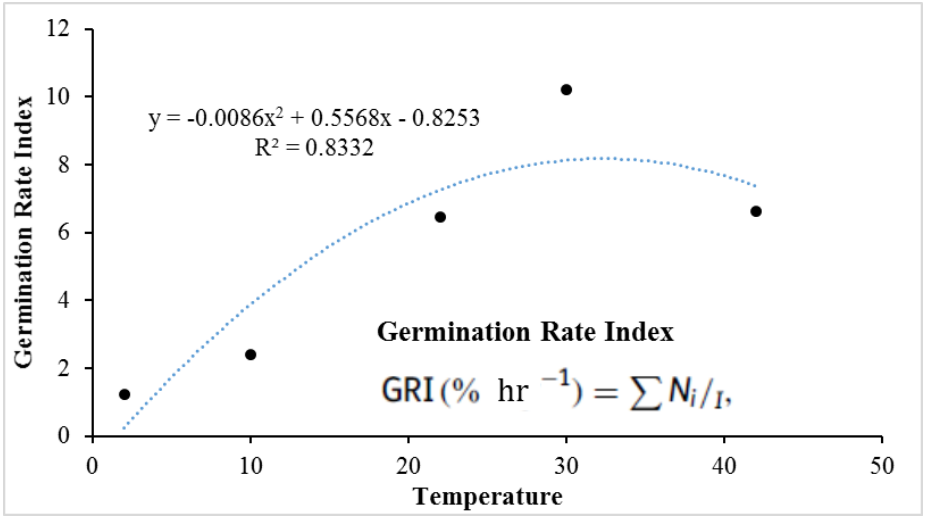
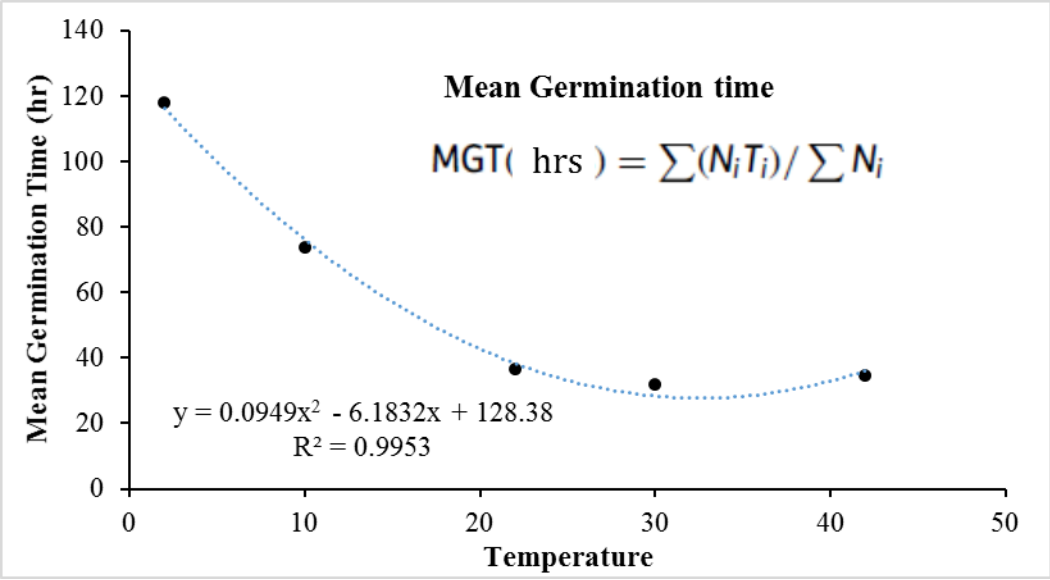
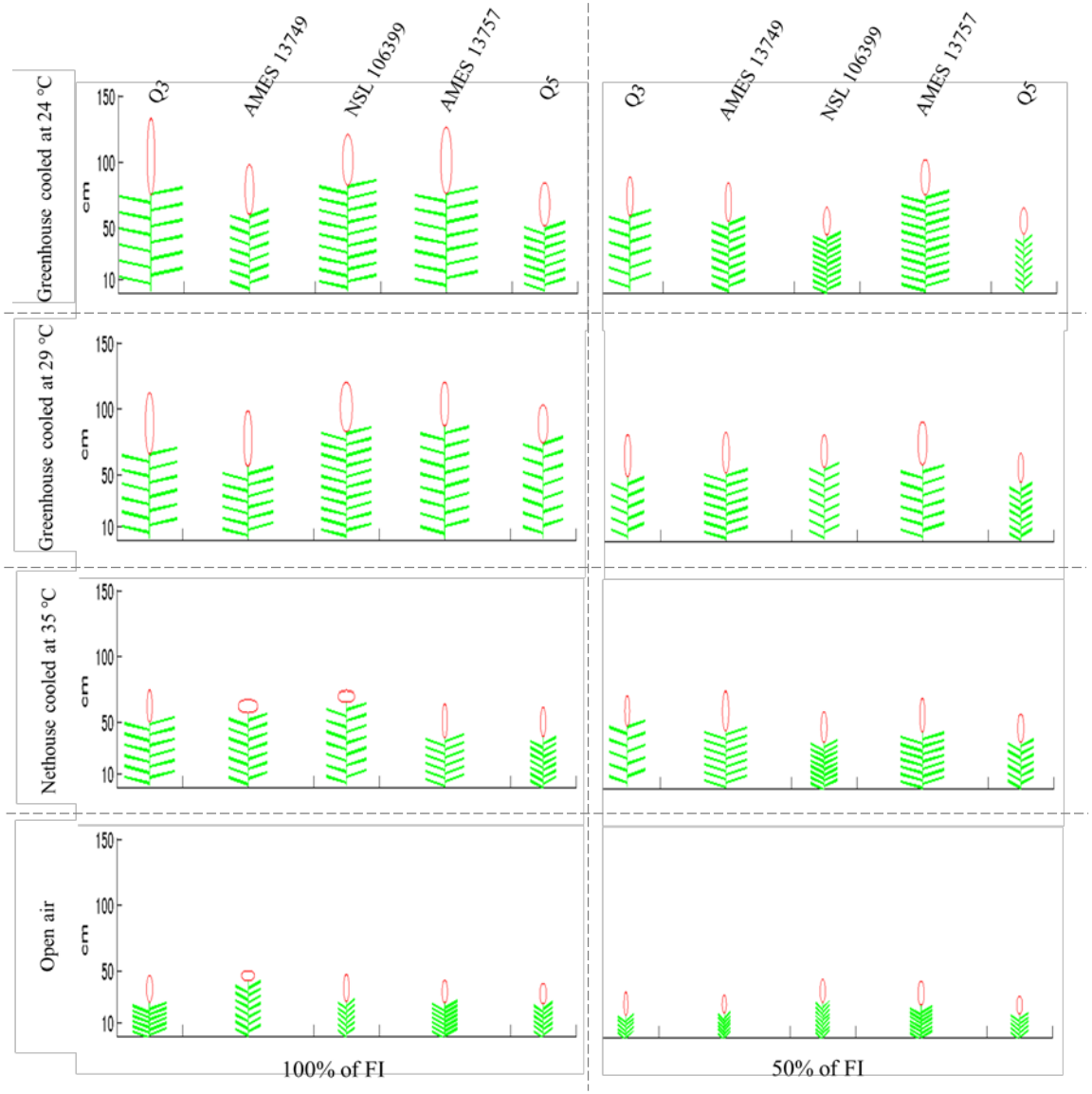


# Results

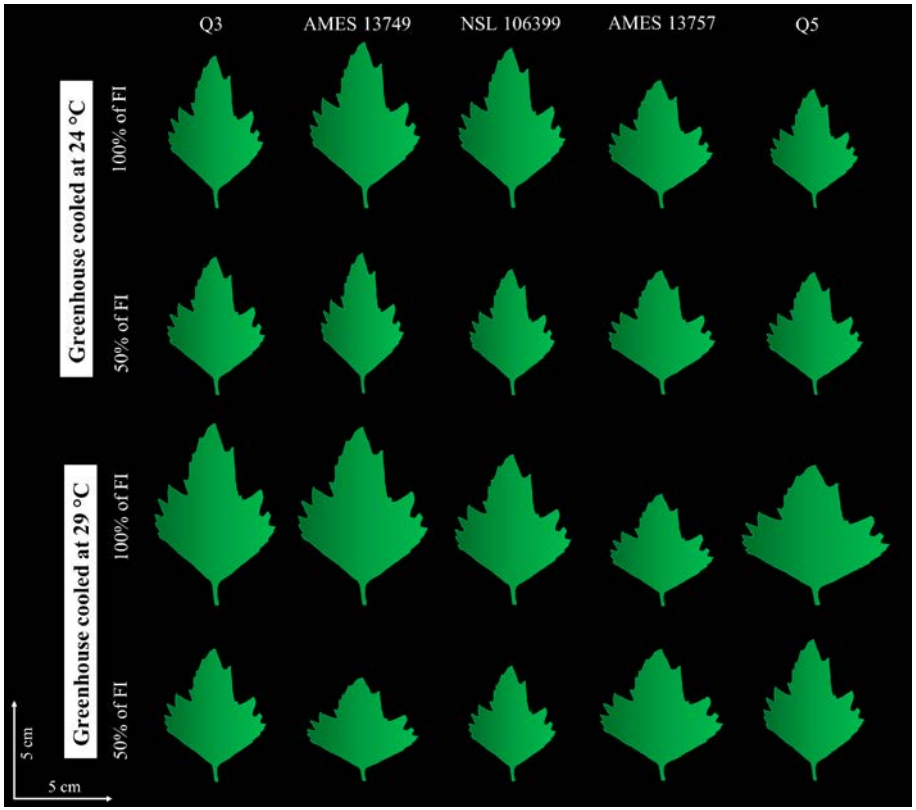
## Plant architecture

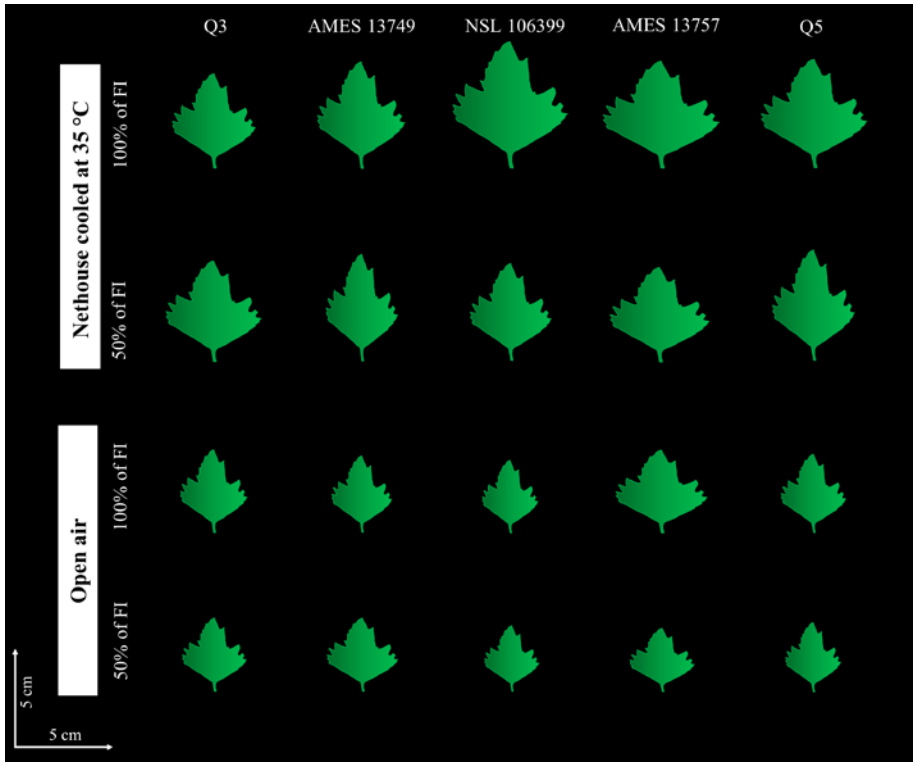



- Plant height
- Number of primary branches
- Average length of primary branches
- Main panicle length
- Main panicle width

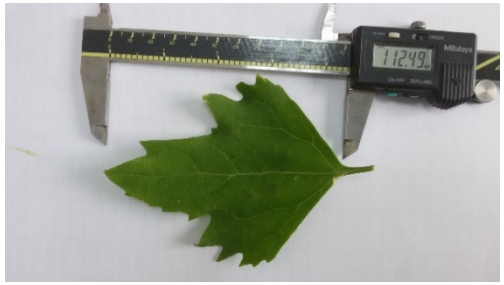
# Results

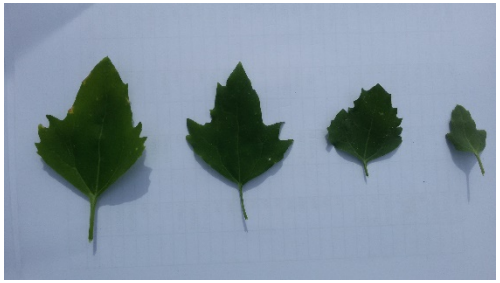
## Leaf architecture



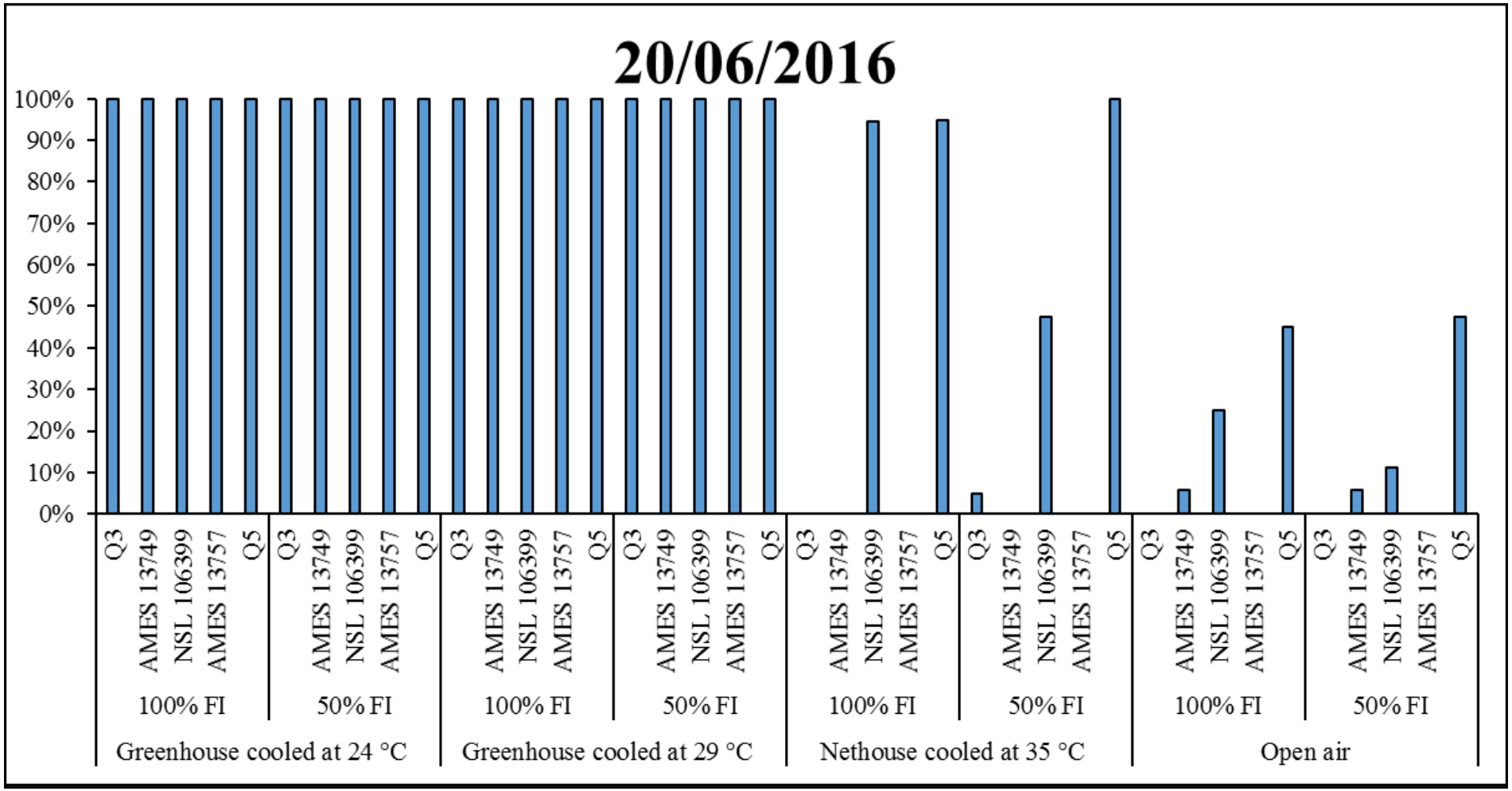

9 leaves per plant were taken from different parts (bottom, middle and top of the plant). Leaf length and width were measured.





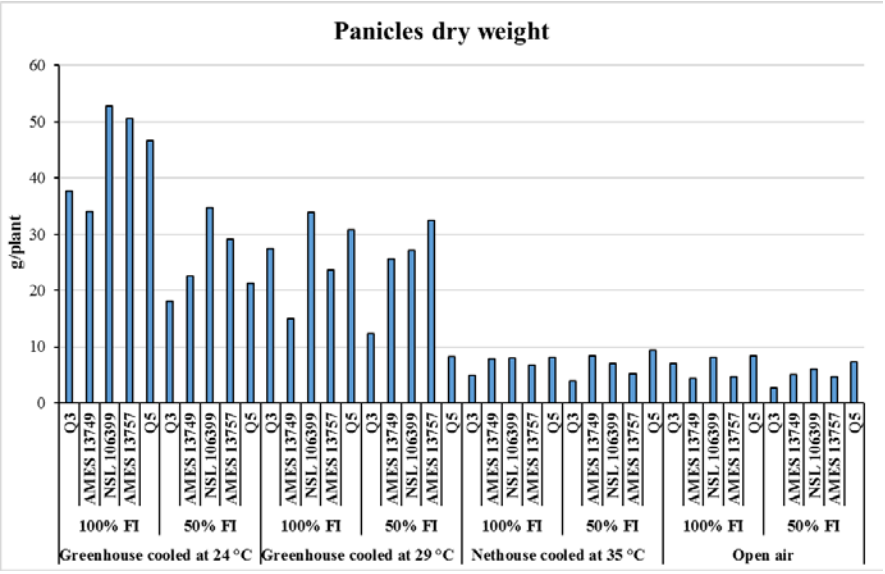
# Results

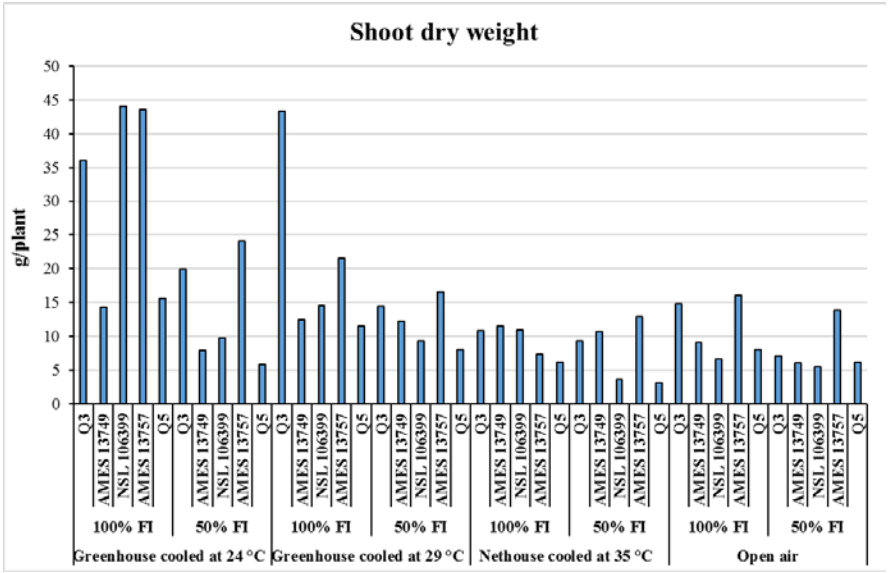
## Flowering

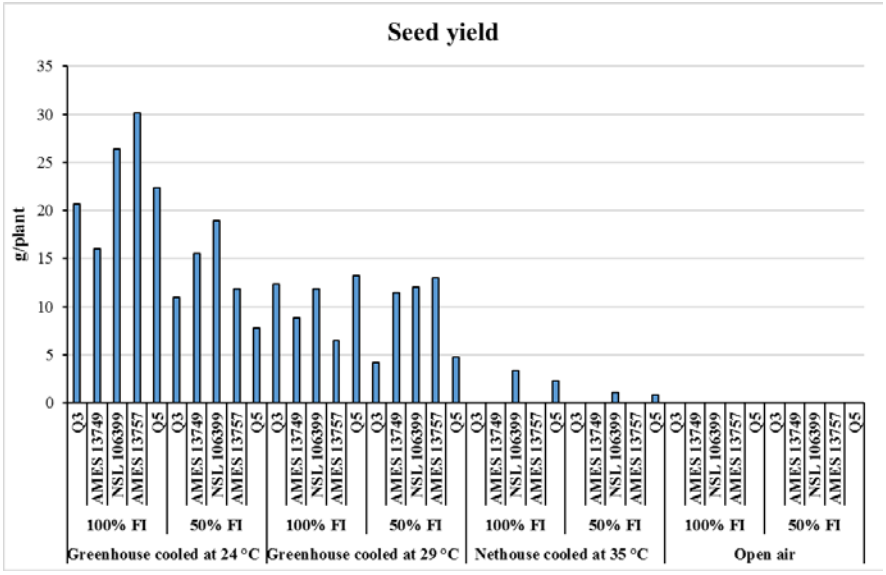


# Results

## Biomass and yield productivity

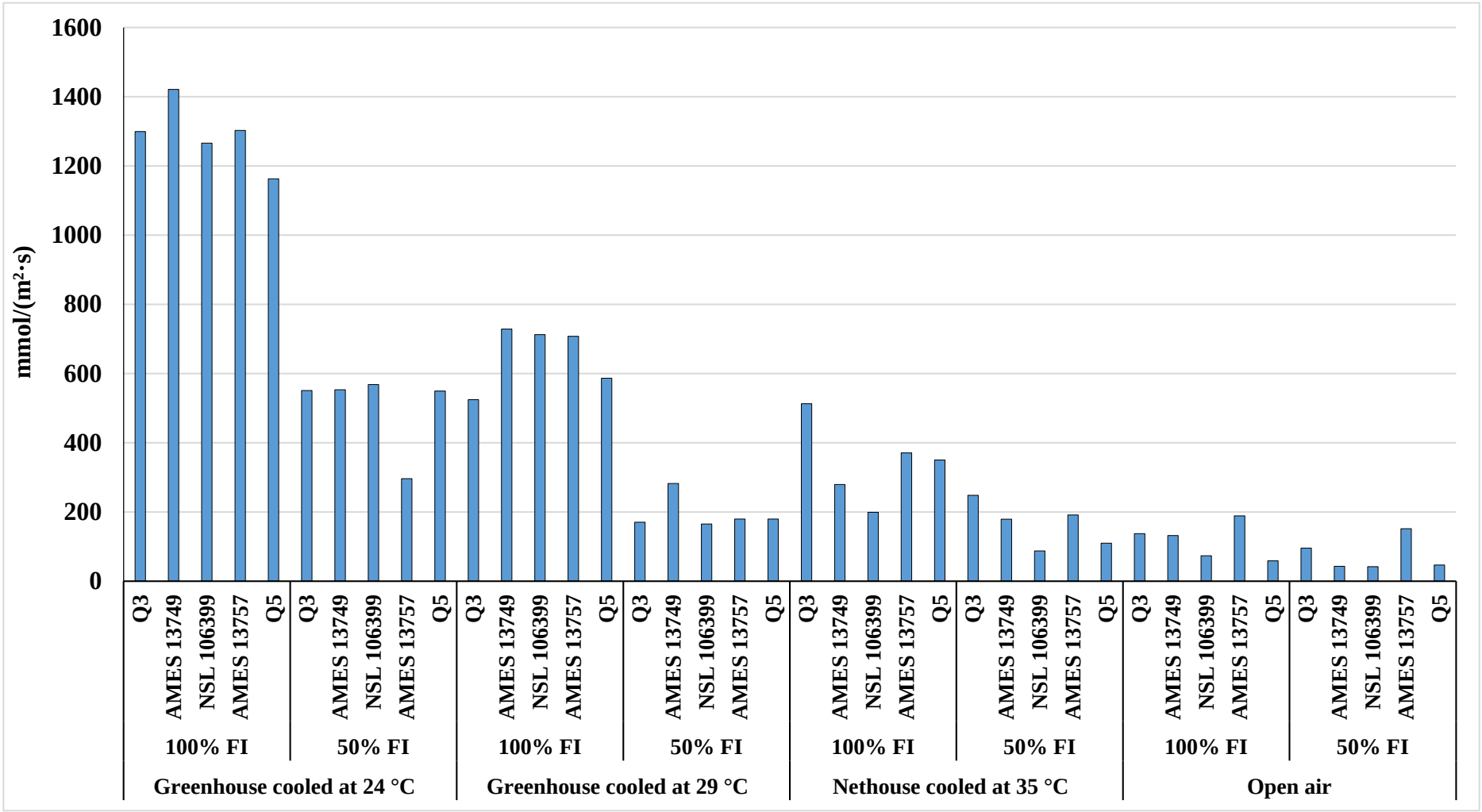


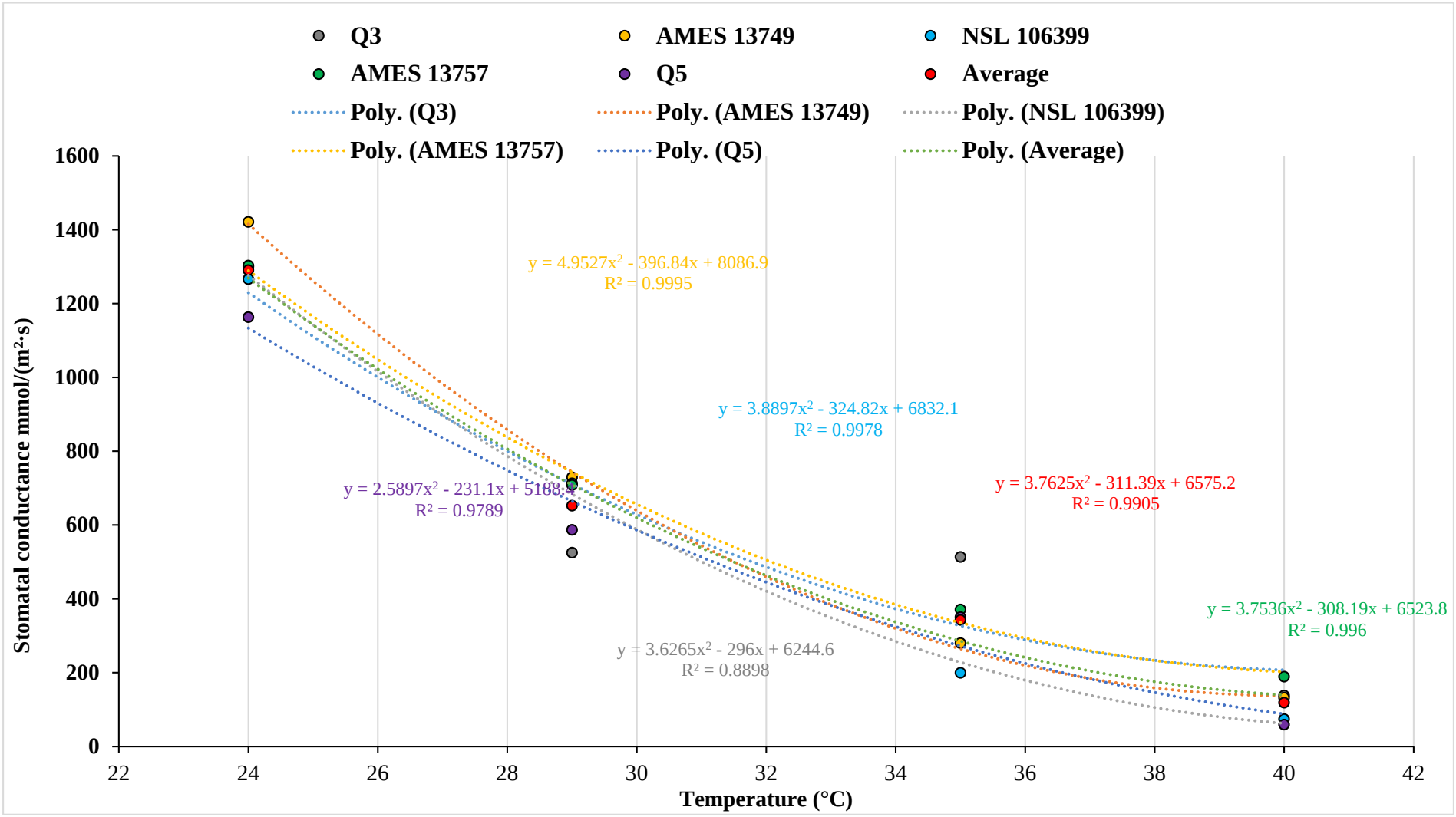
# Results

## Stomatal conductance



# Results

## Stomatal conductance



# Conclusions

- The optimal temperature for quinoa germination was 30 °C where germination rate and velocity were the highest and the mean germination time was the lowest.
- Increased temperature and water deficit affected plant and leaf architecture and reduced yield. Which is a adaptation strategy in order to survive under heat and water stress,
- Q5 and NSL 106399 were the only accessions flowering and producing seeds under net house cooled at 35 °C. while under open air hot conditions all accessions were not able to produce seeds.
- Stomatal conductance was affected negatively both by increased temperature and reduced irrigation with more pronounced effect under increased temperature. In order to survive under heat stress, quinoa closed its stomata and reduce transpiration.

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## Thank you

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