Using thermography to investigate the effect of drought on two crop plants

Overview Climate change puts rising pressure on agriculture to find suitable crops to feed a growing human population. Different plants use alternative types of photosynthesis (C3 or C4), potentially allowing some crops to cope better than others with stresses, such as drought. Thermography is a novel technique to measure leaf temperature, which can be linked to drought responses. Our investigation utilised this methodology to compare French bean (*Phaseolus vulgaris*, C3) and maize plants (*Zea mays*, C4) to determine which crop can best withstand drought stress.

Aims

- To evaluate two crop species' ability to cope with drought stress, possible impacts on yield and their suitability to grow in the different environmental conditions created by climate change
- To achieve this we utilised thermography to measure the leaf temperature of French bean and maize plants that were grown under **well-watered** and ***drought*** conditions

Background information

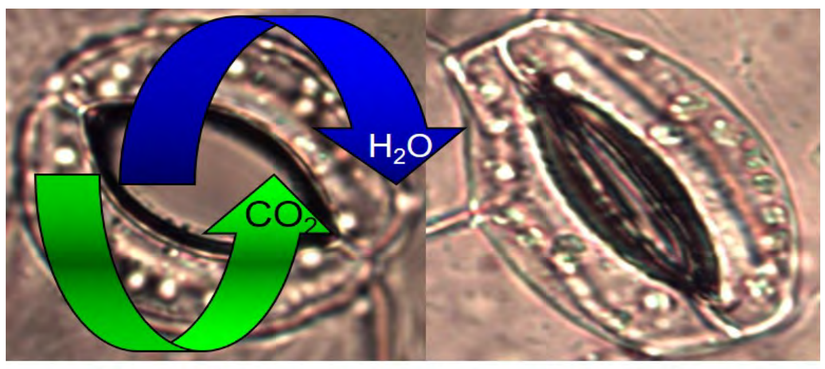

Fig. 1 Micrograph of open and closed stoma

On the epidermis of leaves, plants have pores called stomata which control gas exchange and transpiration (Fig.1). Under drought conditions, stomata close to limit water loss, however this also reduces CO_2 uptake. In crops, this is likely to affect yield, as both water and CO_2 are required for photosynthesis. Additionally, transpiration of water is also needed to cool leaves, as high leaf temperatures could also adversely affect photosynthetic rates by denaturing enzymes. C4 photosynthesis involves a carbon concentrating mechanism which allows C4 plants, such as maize, to cope with lower atmospheric CO_2 concentrations, enabling stomata to open less compared to C3 plants, such as beans. We therefore hypothesised that stomata of C4 plants will be less affected by drought, showing less difference in leaf temperature.

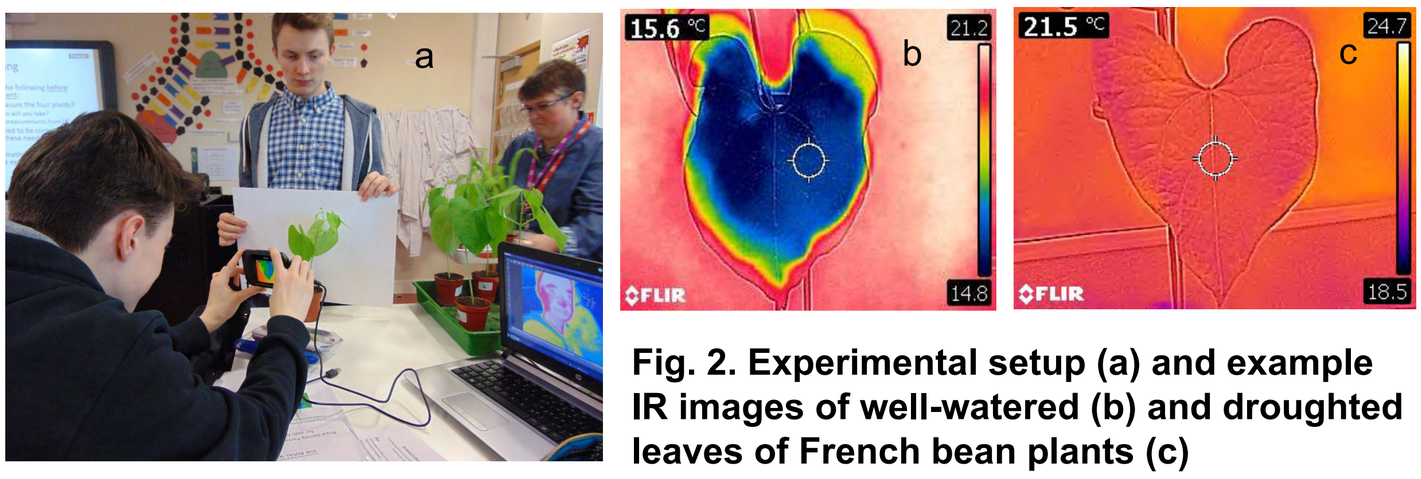

Fig. 2. Experimental setup (a) and example IR images of well-watered (b) and droughted leaves of French bean plants (c)

Methodology

1. Using a FLIR C2 thermal camera, each group took photographs of the first leaf of five well-watered and five droughted maize and French bean plants.
2. FLIRtools was used to view the images (Fig. 2) and record the leaf temperature from five positions of the leaf, to establish the mean for each species and growth condition.

Results

Droughted plants of both species had higher mean leaf temperatures than well-watered plants; however the difference was minimal in maize (Fig. 3). In contrast, the mean leaf temperature of French bean plants was 4.45°C higher in droughted than well-watered plants.

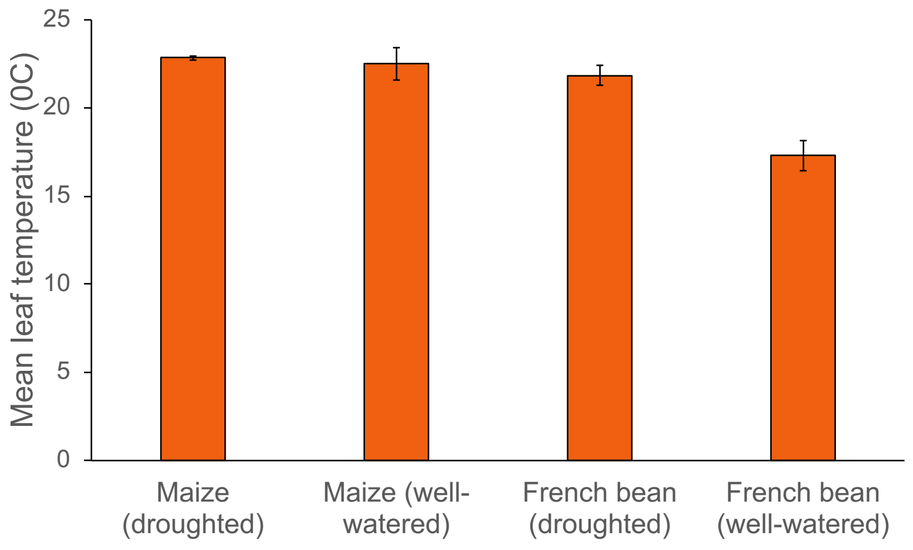

Fig. 3. Mean leaf temperature of two crops grown in different conditions (n = 20, +/- SD)

Conclusion

Our results suggest that drought conditions have no impact on the leaf temperature of maize, which is generally high even under well-watered conditions. These plants' capability to tolerate high leaf temperatures may be in some way linked to their ability to carry out C4 photosynthesis. French bean plants, on the other hand, closed their stomata in response to drought, potentially impacting on CO_2 uptake for C3 photosynthesis and yield, making them less suitable for the drier conditions created in some areas by global warming. Our results are similar to a number of other studies investigating the effect of drought stress on maize and bean species[1,2,3].

Evaluation

Our investigation could have been improved by utilising a higher quality thermal imaging camera (e.g. FLIRT660), with a better resolution and reduced background radiation; controlled environmental conditions; a greater number of repeat measurements; and statistical analysis to improve accuracy, reliability and validity of our conclusions. Additionally, measurements of photosynthetic rates are needed to assess the effect of leaf temperature on yield further.

References: 1. Aslam et. al. (2013). Cercetari Agronomice in Moldova, 2 (154), 99-114.; 2. Gourdji et al. (2015). Agricultural and Forest Meteorology, 200, 270-281.; 3. Martynenko et al. (2016;) Springerplus, 5(1), 1393.

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