A new class of plant growth chamber and a proposed open source plant growth protocol.

Grobotic Systems®

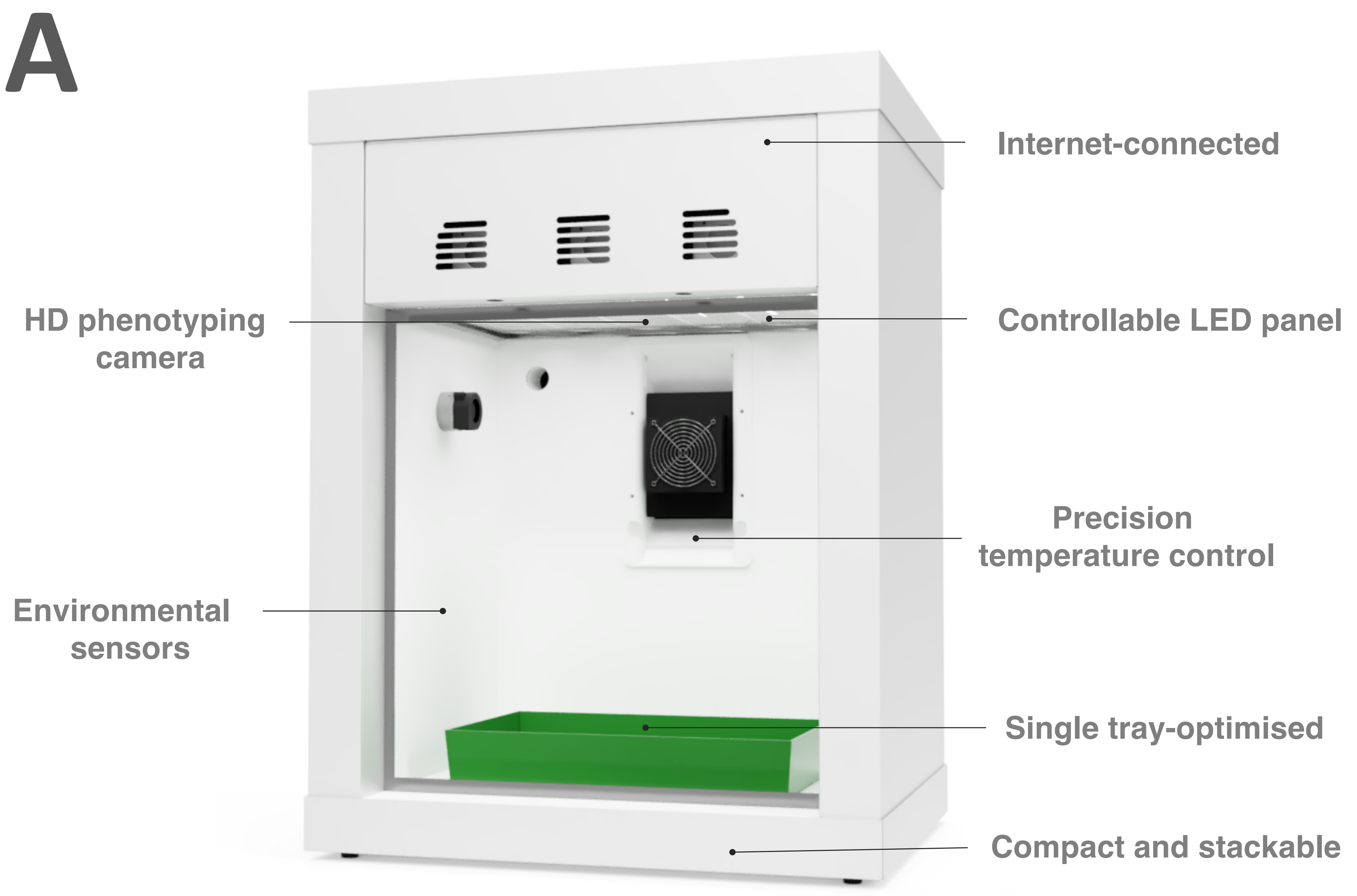
Alexis Moschopoulos*, Richard Banks, Gareth Coleman, Andrew Merson | Grobotic Systems Limited | *alexis@groboticsystems.com

Plant growth chamber

Plant growth chambers are key enabling technologies for plant science research. However, problems with current chambers - including poor uniformity of environmental conditions, lack of remote monitoring, and very high cost - reduce experimental reproducibility and limit access to high-quality growing environments for many groups. To address these and other problems we have developed a new class of plant growth chamber for plant science research. Our chambers are designed to be affordable, reliable, easy to use, and to offer high experimental reproducibility. These features are achieved through integrated controllable LED lighting, multiple environmental sensors, thermoelectric coolers for temperature control and an integrated phenotyping camera system. Chamber protocol control, phenotyping, and sensor data collection is carried out using a browser-based platform, and open APIs will allow researchers to develop hardware and software add-ons to suit their specific needs.

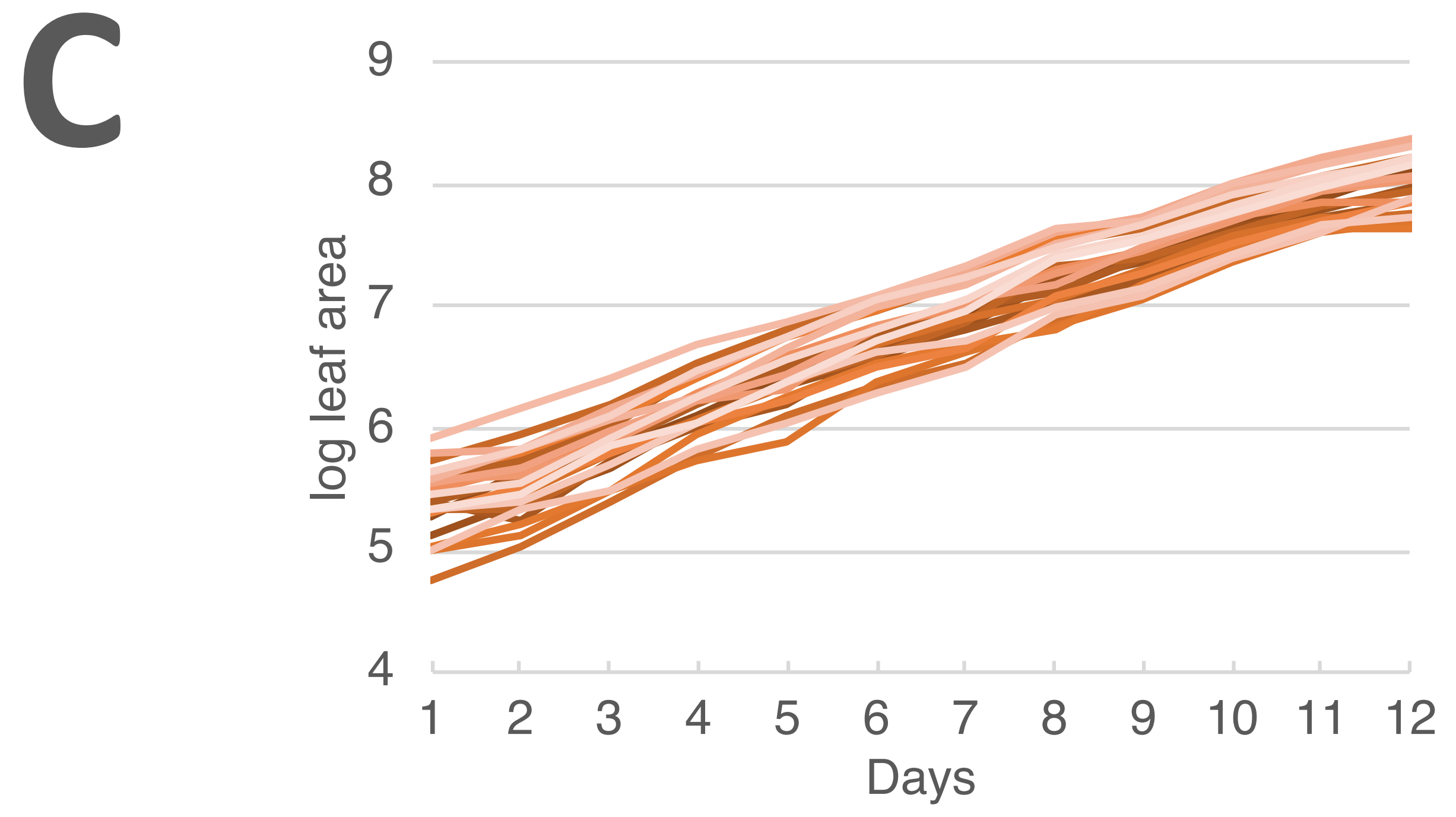
Open source plant growth protocol

Alongside our novel growth chamber, we propose a human- and machine-readable plant growth protocol document format to improve experimental replicability and reproducibility in plant science. The protocol builds on the guidelines for measuring and reporting parameters in growth chambers[1] and tissue culture[2] and allows for more complex growth protocols including dynamic set points over the course of a plant life cycle, radiation information in the form of spectral plots, and a DOI to share protocol set points and actual recorded experimental data through a repository (e.g. fairsharing.org). This protocol can be used for routine plant growth, more formal phenotyping experiments, and in controlled environment agriculture as a "plant growth recipe." The protocol will be open source to allow community development, and extensible, to allow for the evolution of the protocol as technologies and user preferences change over time.

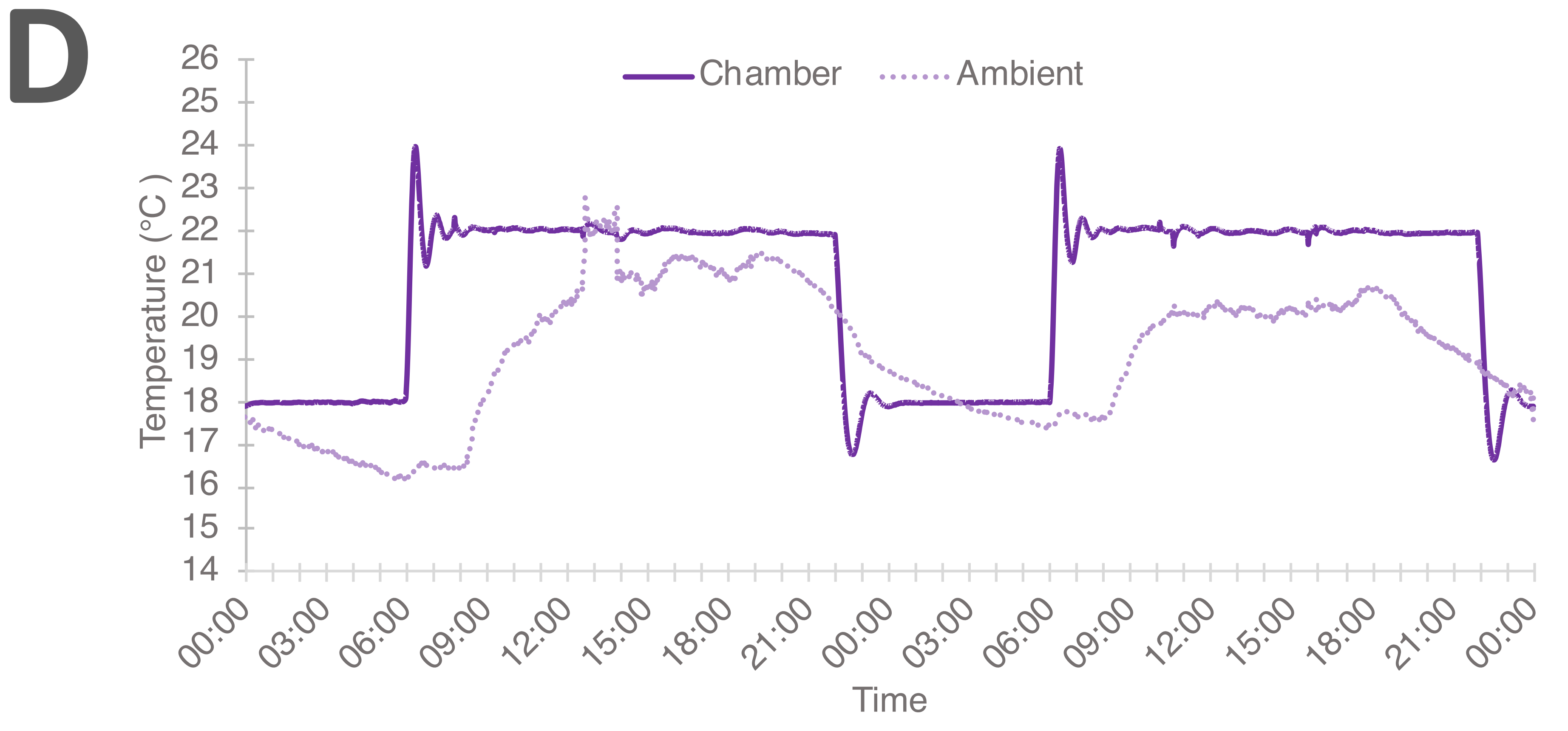


Alpha 4 prototype plant growth chamber. Technical and operational features.

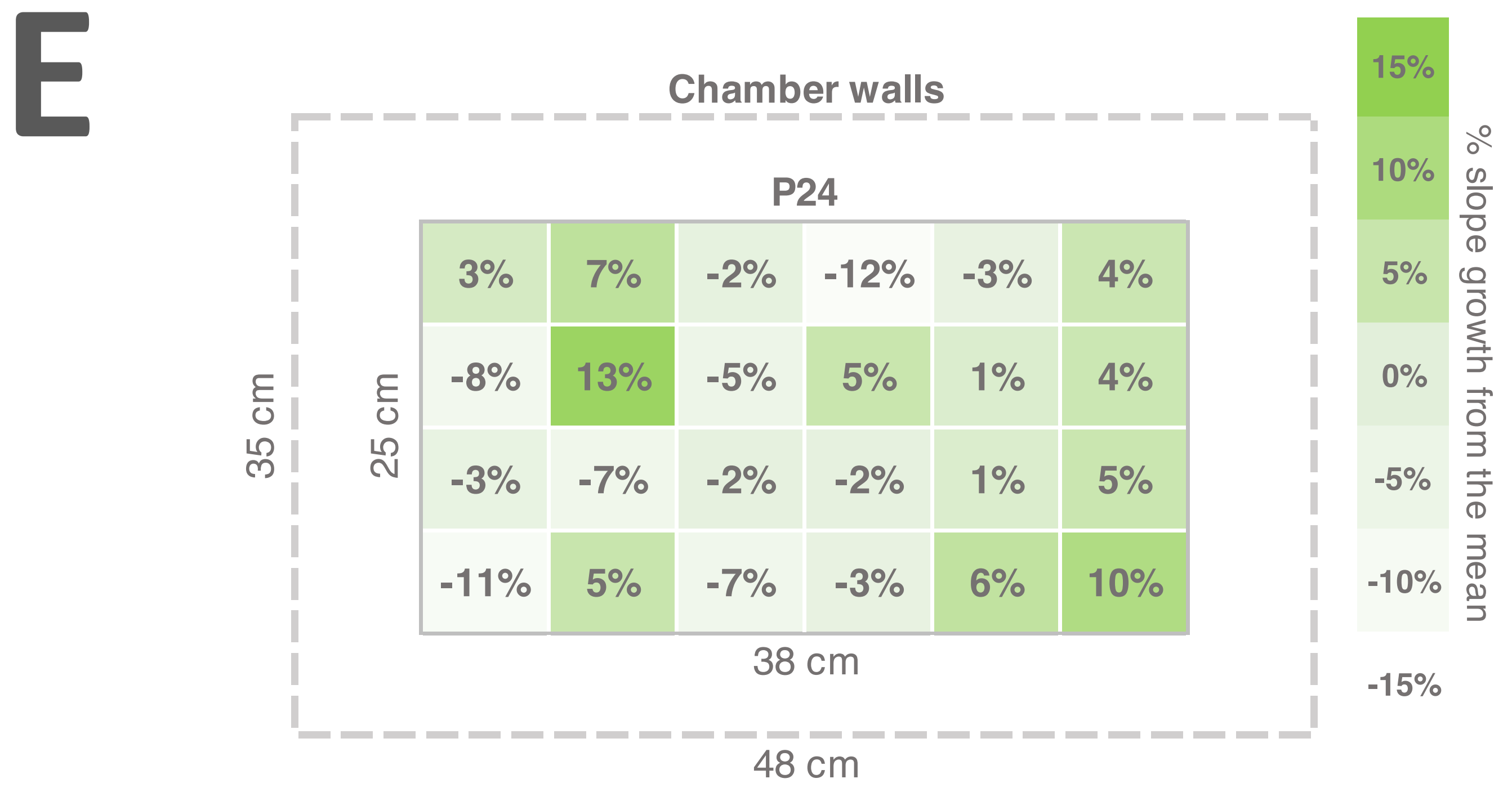
Image quality. Representative image of Arabidopsis (Col) used to calculate leaf area and subsequent growth rate analysis. Scale 5 cm.



Uniformity of Arabidopsis growth over 12 days. Leaf-GP[3] was used to measure leaf area over a period of 12 days.

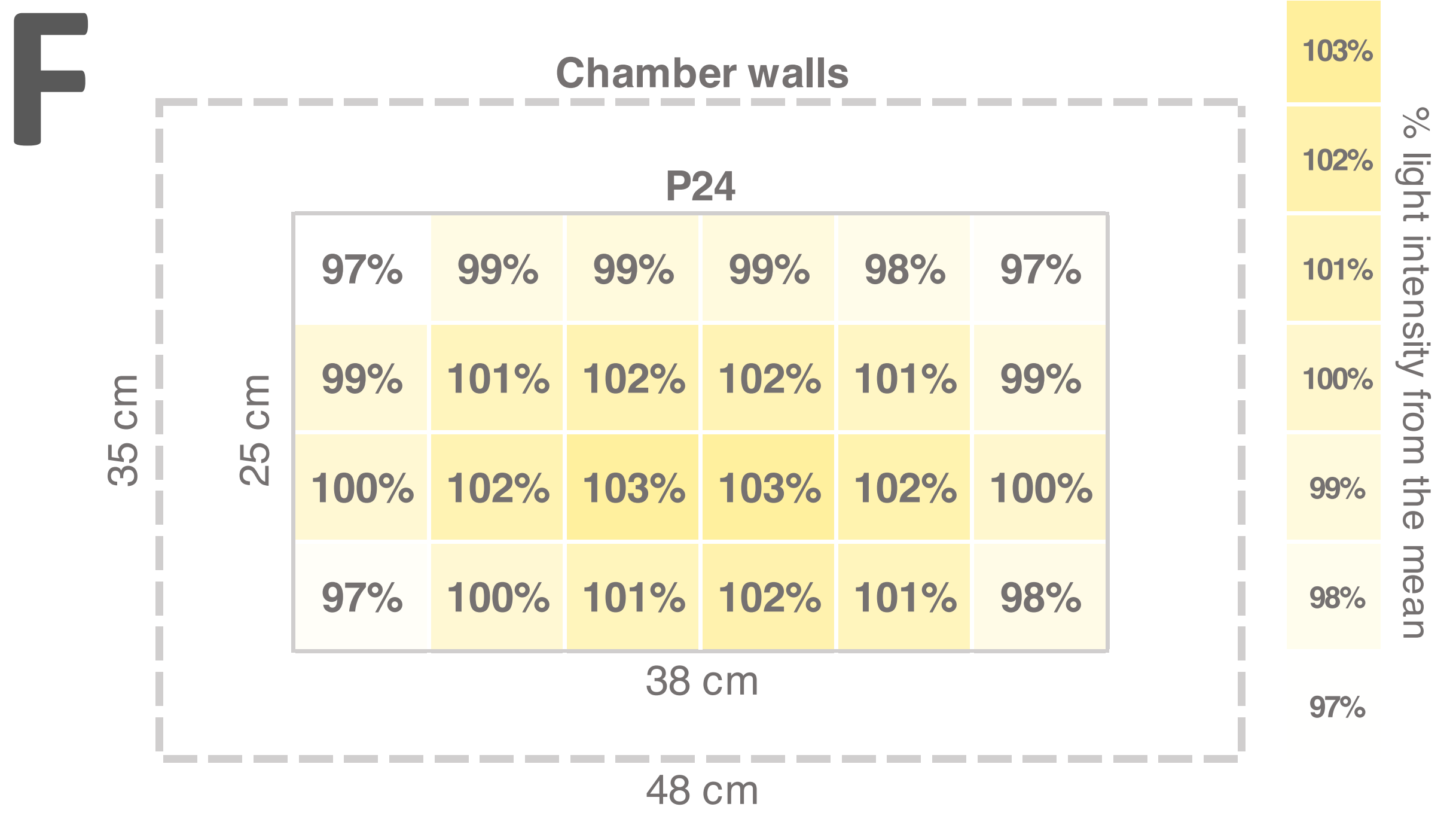


Temperature stability. Forty eight hours of representative temperature data, running an Arabidopsis protocol of 22°C lights on at 150 µmol m^{-2} s^{-1} for 16 hrs and 18°C lights off for 8 hrs.



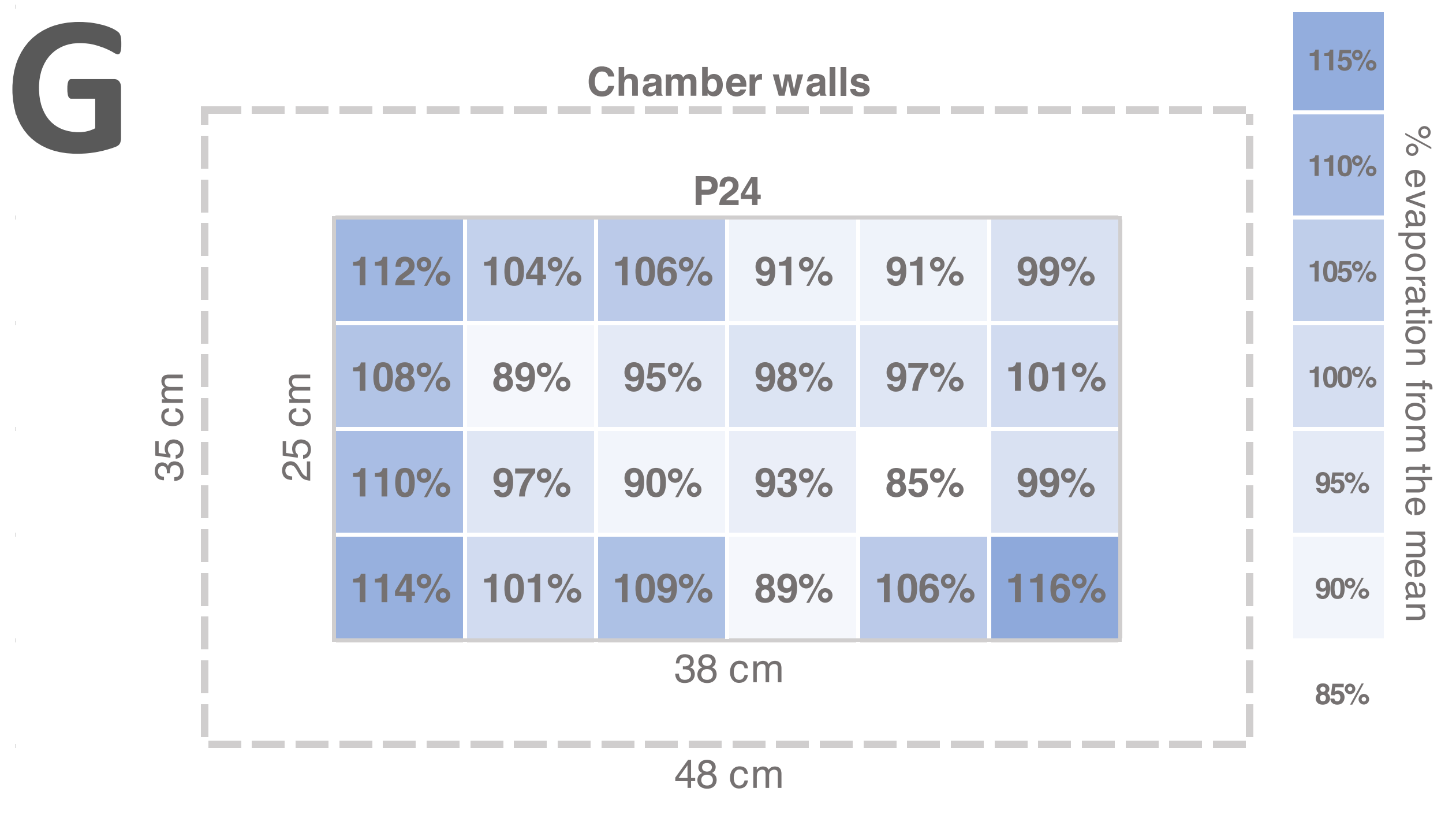
3%	7%	-2%	-12%	-3%	4%
-8%	13%	-5%	5%	1%	4%
-3%	-7%	-2%	-2%	1%	5%
-11%	5%	-7%	-3%	6%	10%

Uniformity of Arabidopsis growth over 12 days. Percentage variation in the slope of growth from the mean.



97%	99%	99%	99%	98%	97%
99%	101%	102%	102%	101%	99%
100%	102%	103%	103%	102%	100%
97%	100%	101%	102%	101%	98%

Uniformity of light intensity. Measured light intensity at P24 grid positions, percent variation from the mean. Set point 150 µmol m^{-2} s^{-1}.



112%	104%	106%	91%	91%	99%
108%	89%	95%	98%	97%	101%
110%	97%	90%	93%	85%	99%
114%	101%	109%	89%	106%	116%

Uniformity of air flow. Measured water evaporation at P24 grid positions as a proxy for air flow, percent evaporation variation from the mean.

Acknowledgements

Stephen Rolfe (University of Sheffield); Henry Bookey, John Macarthur, Vasili Savitski (Fraunhofer Centre for Applied Photonics); Adam Ormerod (Stockbridge Technology Centre)

Funded by
Innovate UK

References

1. ICCEG 2004.
2. ICCEG 2008.
3. Zhou et al 2017 *Plant Methods.*