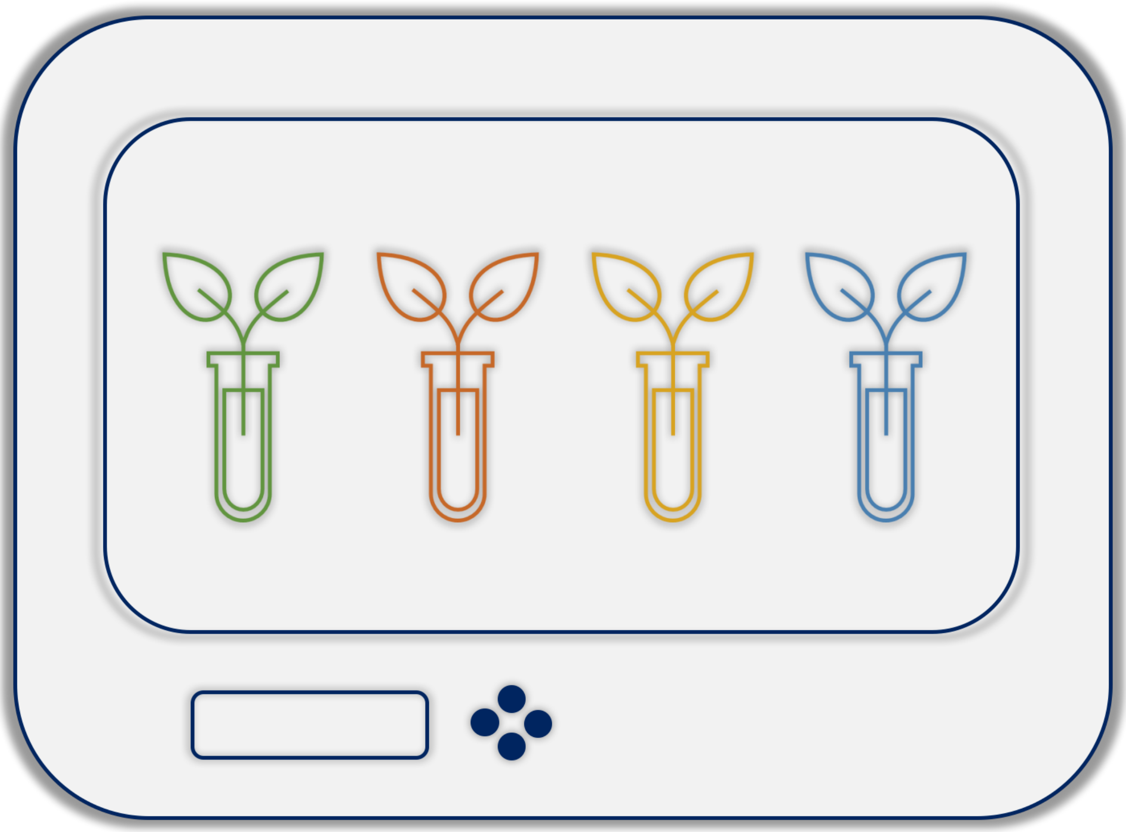


BENCH-TOP CONTROLLED ENVIRONMENT GROWTH CHAMBER FOR SPEED-BREEDING AND CROP TRANSFORMATION

6 MONTH REPORT

OpenPlant

sharing tools for a sustainable future

SUMMARY

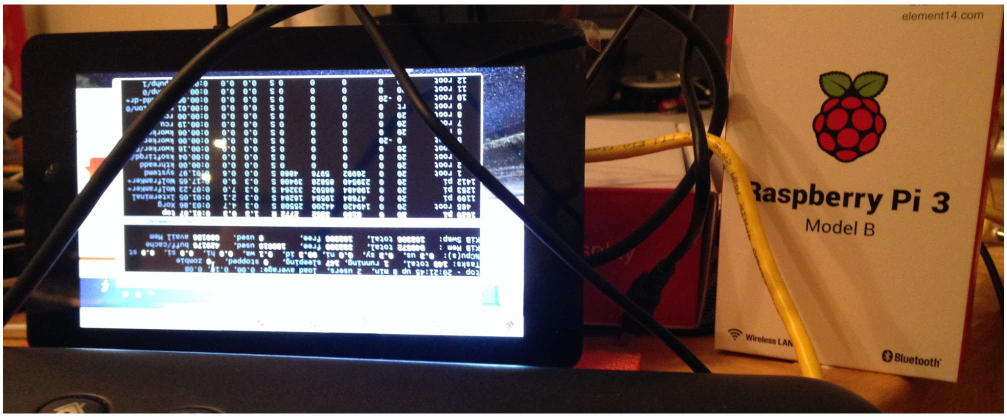
Our project consists of the development of an open-hardware low-cost bench-top controlled environment chamber. A device with these characteristics can potentially benefit plant synthetic biology research worldwide. The main feature is a Speed Breeding capability, i.e. a protocol of prolonged photoperiod that accelerates plant development, therefore allowing an increased number of cycles per year compared to traditional glasshouse trials. The controlled environment chamber is controlled by a Raspberry Pi, to provide a graphic user interface (GUI) for easy manipulation, and an Arduino microcontroller, that adjusts the environment with the feedback of an array of sensors inside the bench-top chamber. All the information and knowledge acquired is being deposited in a GitHub repository (see: https://github.com/PhenoTIPI/SpeedSeed3/wiki)

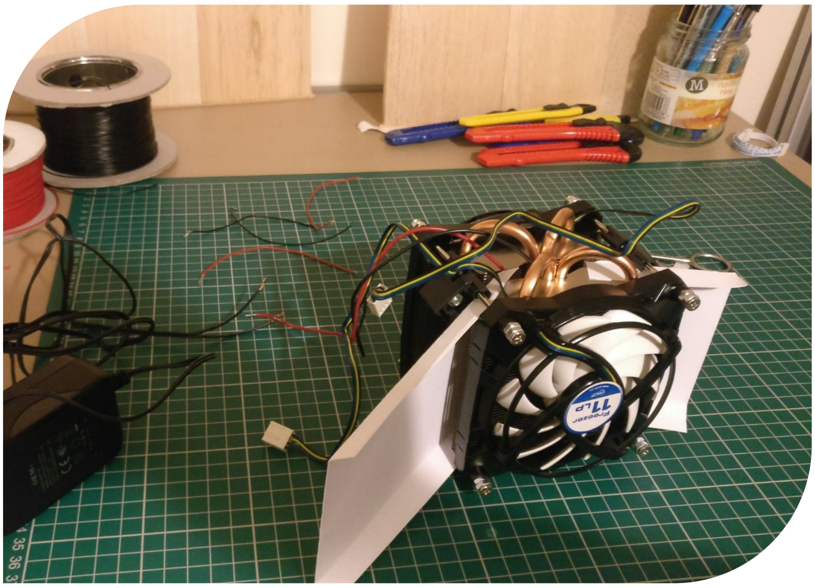
REPORT AND OUTCOMES

The project kicked-off with a meeting in the Chris Lamb Training Suite at the John Innes Centre on 30 September 2017. On that day, we visited the controlled environment facilities and of the Speed Breeding setup onsite. In this meeting the workload was divided in four teams:

- Structural design
- Software and human interface
- Environmental controls
- Integration and follow on plans

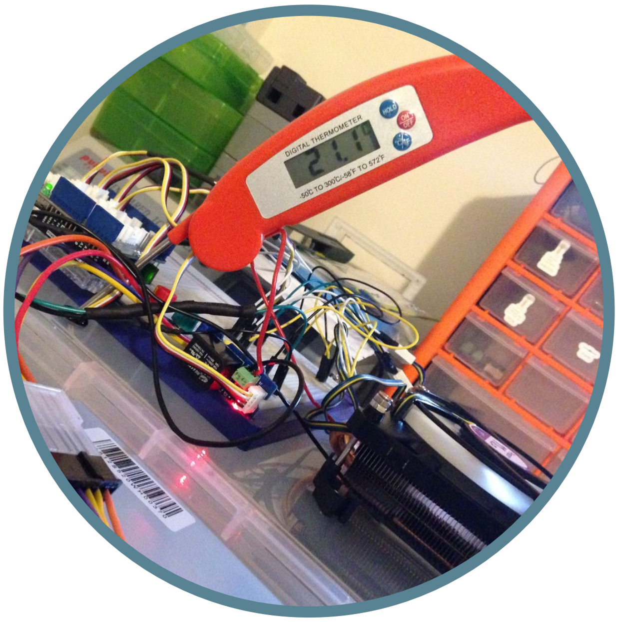
Each team designed and tested each subsystem. One of the of the things that didn't go to plan was the temperature control. While the thermoelectric cooling element is the right choice of hardware for controlling precisely the temperature, the chosen heat sink didn't perform as expected.

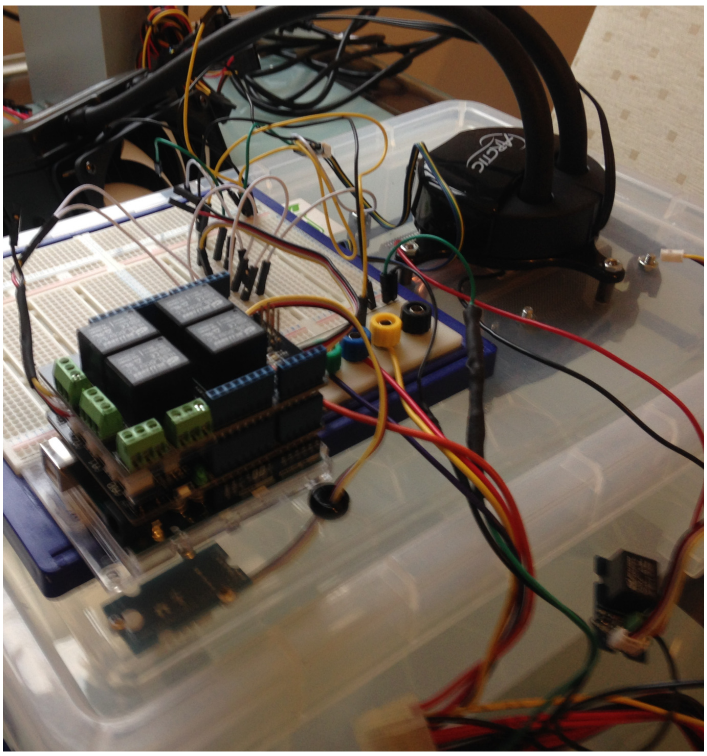


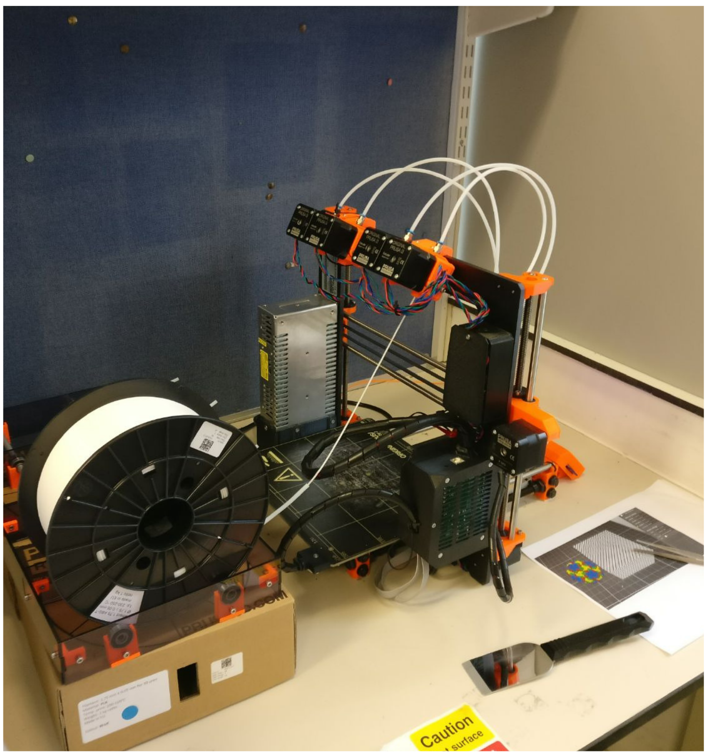


The layout we used involved two CPU heatsink fans, one on each side of the thermoelectric cooling element, the initial assumption for the insufficient cooling was that we were not transferring enough heat out from “the hot side” of the plate. The arrangement of the fans pushed air to the thermoelectric element, which resulted in transferring the hot air towards the cooled source.

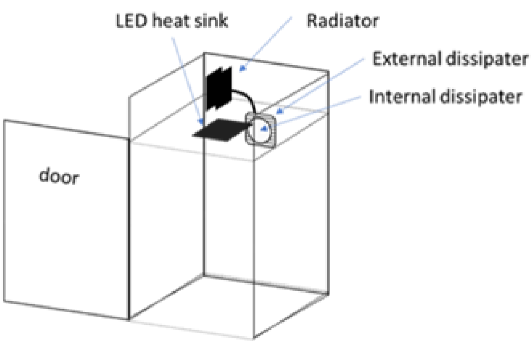
We decide to use instead a high-performance CPU liquid cooler to ensure that the heat was removed away of the chamber, but this only solved the problem partially. We did however manage to lower the air temperature to 17.2˚C inside the test box (i.e. a plastic container). The solution to this problem, after doing some research and talking with other engineers, is to keep the high-performance CPU liquid cooler on the hot side of the element, and use a larger aluminium heatsink and a fan on the cold side, to increase the cooling area.

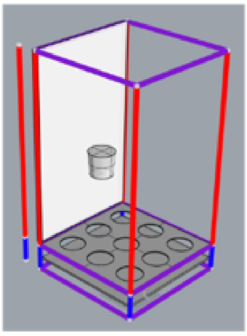


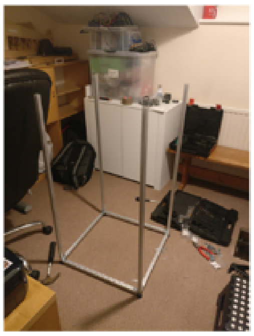


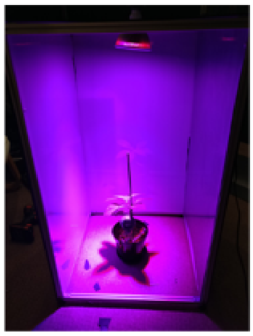


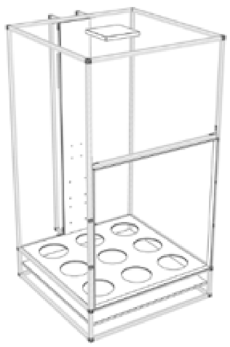
The next problem to solve was the construction of the prototype structure. We tried to use some 3D-printed connectors that we design, and that Roger Castells kindly printed out. The pieces were sturdy for compressing force. However, they failed under the tension and torsion forces produced by the torque of the screw. Instead, we used metal braces and rivets as connectors which provided sufficient support. Although this is not an ideal or easy way to assemble, it allowed us to test the electronic components in a more realistic prototype. For the final product the team in charge of the structural design has come up with a cleverer design that allows for modular components to be attached in an allocated column at the back of the chamber. For this next design we will use MakerBeam components (see https://www.makerbeam.com/).



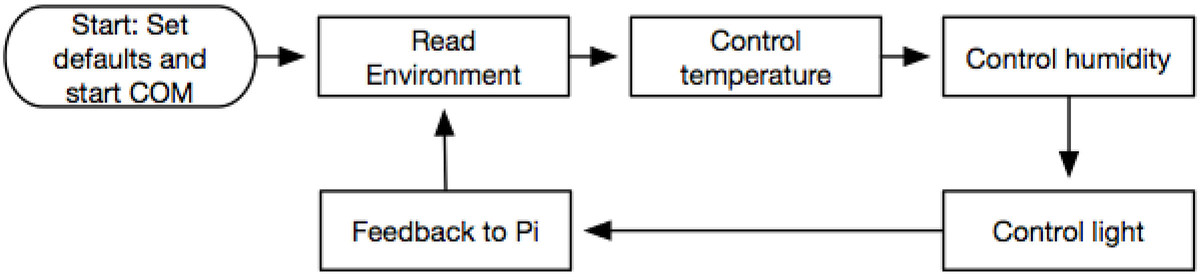


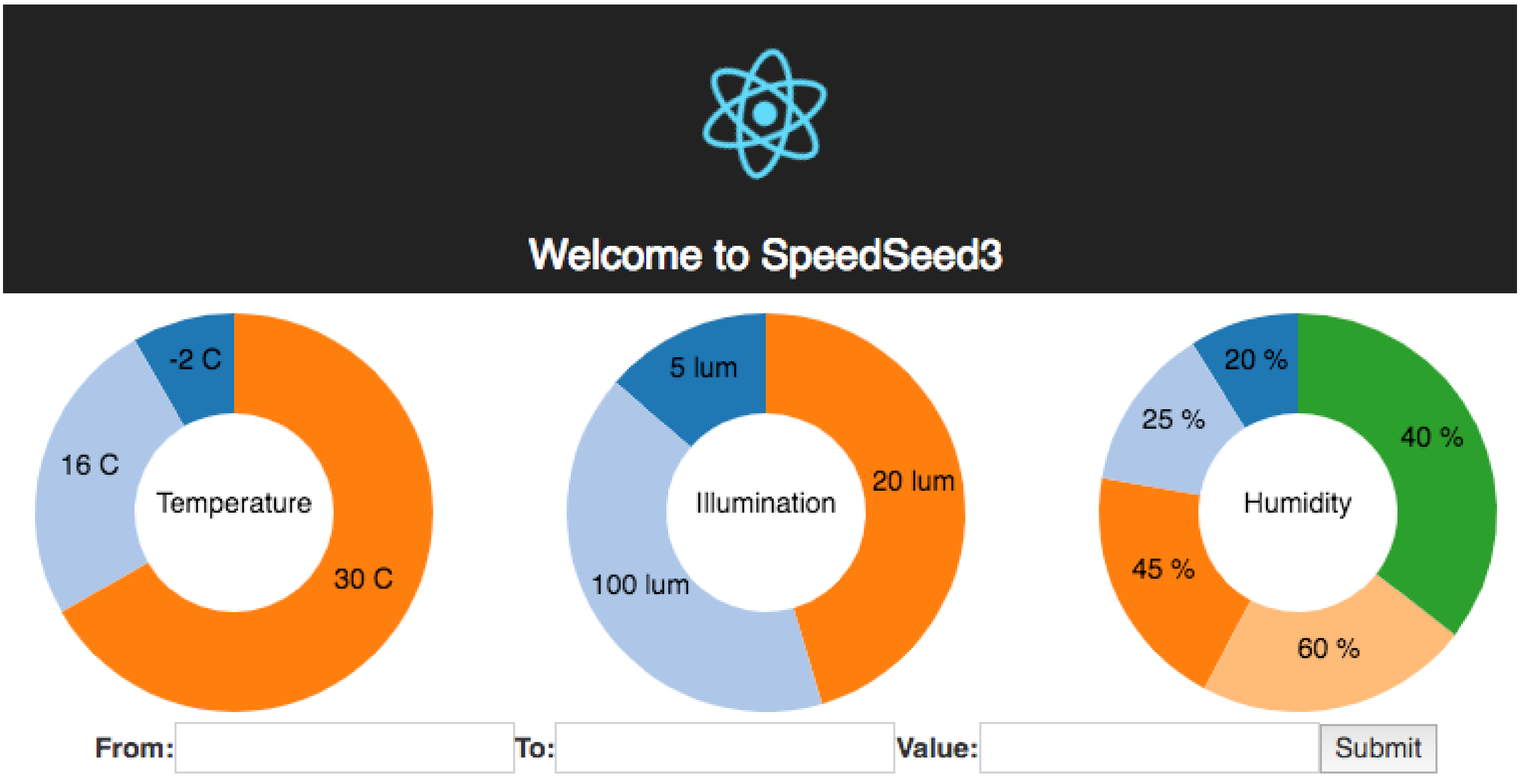






The hardware controller and graphical user interface component of the project had gone through several iterations, as we solved the different challenges of the project. Briefly, the chamber is controlled by an Arduino microcontroller, that interfaces with the sensors. A Raspberry Pi is used to provide a graphical interface with a touch screen. The full description and technical documentation are found in the wiki of the project: https://github.com/PhenoTIPI/SpeedSeed3/wiki.
The code is in a github repository: https://github.com/PhenoTIPI/SpeedSeed3.





EXPENDITURE

So far, we have spent 44% of the budget in hardware, sensors, tools, and travel expenses for a strategic team meeting. We have deliberately underspent in the prototyping and testing of the different components. This is with the aim to be able to fabricate during the second part of the project, at least, three of the final versions of the bench-top controlled environment chamber. We intend to allocate them in three different laboratories within the Norwich Research Park for usability and performance tests.

Financial Summary for CY293H11C
Bench-top Controlled Environment Growth Chamber for Speed-Breeding and Crop Transformation

Project Leader	Brittany Hazard
Status	Active
Start Date	01 Aug 2017
End Date	31 Jul 2018
Award Value	£4,000.00

Colour Key:

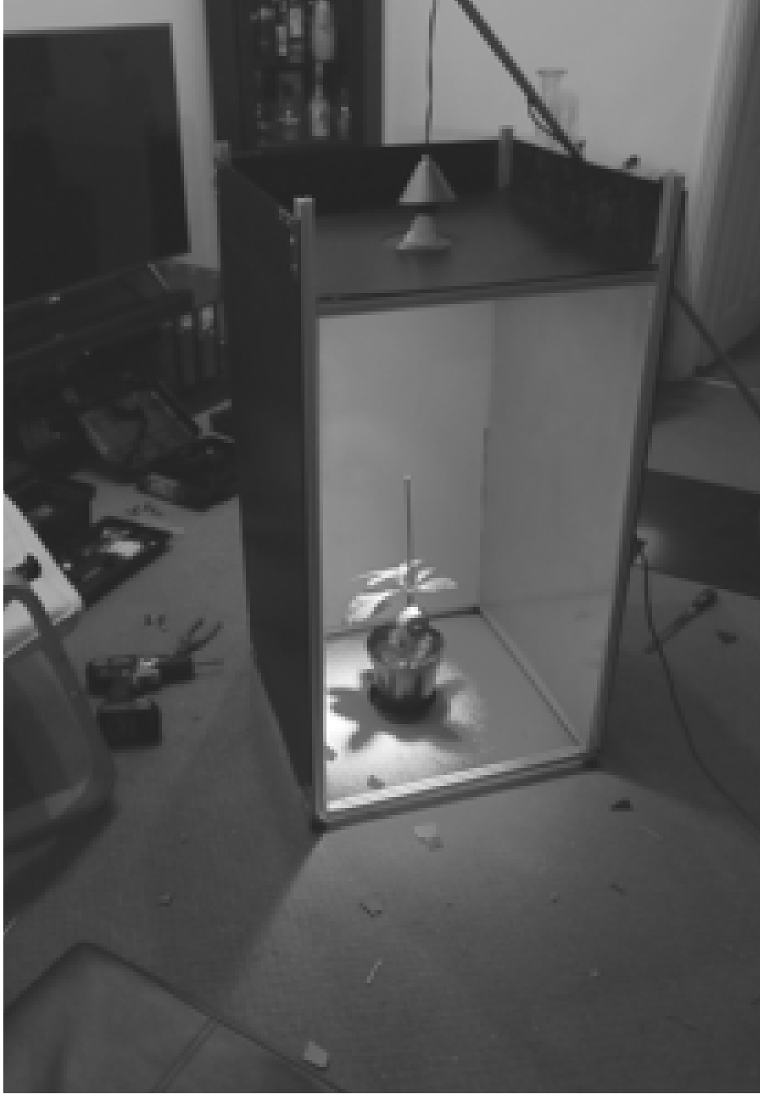
Red	Overspent	
Blue	Underspent by less than 50% of budget to date	
Amber	Spend:	Continued spend at this level will result in budget being exhausted before the end of the project
	Income:	Unless income levels are increased, targets will not be met by the end of the project
Green	Income	Income greater than budgeted

	Reporting Period: Full Project Life			
	Budget	**Actual**	**Commitment**	**Balance**
Computing		£219	£0	-£219
Consumables	£3,500	£984	£0	£2,516
Hospitality & Catering		£133	£0	-£133
Minor Equipment <10k		£183	£0	-£183
Travel and Subsistence	£500	£247	£0	£253
Totals for Other Costs	£4,000	£1,765	£0	£2,235
TOTALS:	£4,000	£1,765	£0	£2,235

Data as at: 26/01/2018 20:47:39 Reporting Years: All Years Advanced Options: False Year / Period: 2017/2018 Jan (Period 10)

FOLLOW ON PLANS

The next step in the development of the project is to finalize the prototyping within the next three to four weeks and to focus on the completion of the final version, especially since the whole Speed Breeding protocol is starting to be implemented in several laboratories.



The Speed Breeding protocol has caught the attention of a high impact journal. We are aiming to include the benchtop chamber as part of the protocol. We also got the opportunity to have the chamber potentially included in a paper on Speed Breeding. So, the additional £1000 and the unspent budget will be used to deliver a working product on time to be included in this paper.

We will also develop a Business Plan following the strategy of an Open Hardware Business Model. The Open Hardware Business Model has all of its products and designs released to the public in a way that anyone can make, modify, distribute and use such products, allowing for the developed product to not only be a simple DIY product in a hardware repository, but also a commercially viable product for a market that prefers buying instead of building it.

Pathways to Impact

We will implement a marketing plan for scientific entrepreneurship to ensure the process of starting our own business is easier.

ATTRACT, ENGAGE & CONVERT

One of the main actions will be to apply for Startup accelerator programs and make contact with industry mentors who will share their expertise in commercialising products. Via such programs, we can design the Product/Market fit to have a sustainable and replicable product. An accelerator program will give us access to a network of young and successful entrepreneurs, and opportunities for funding through grants and Angel investors.

THE TEAM

Oscar Gonzalez
John Innes Centre

Ricardo Ramirez
John Innes Centre

Luis Yanes
Earlham Institute

Carolina Ramirez
Newcastle University

Sreya Ghosh
John Innes Centre

Marcela Mendoza
Oxford University

Luis Hernan
Newcastle University