PhD Project Advertisement

Project title: Unpicking the causes of infertility in wheat triggered by temperature stress
Project No: FBS2023-45-Phillips-ar

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Project description:

Wheat is the world most cultivated crop, and 219 million hectares of land was used to generate 760 million tonnes of grain in 2020. Elevated heat stress, particularly sudden spikes, caused by climate change has already been shown to reduce yield and poses a major threat to global food security. Global yield of wheat could drop by 6% for each 1°C increase in average global temperatures, with the associated increase temperature extremes having a key role. Current adaptations to high temperature, via changes in technology and on-farm management are insufficient to sustain yield, and further innovation is required to develop heat-tolerant crops.

Previous studies have identified that a high temperature spike during meiosis is one of the most vulnerable periods in the crops lifecycle and drastically reduces yield. Exposure to high temperature at the onset of meiosis can lead to damaging effects on plant fertility and therefore reduced grain yield. Evidence suggests that temperature stress disrupts the cytoskeleton, chromosome pairing, and recombination, resulting in the mis-segregation of chromosomes, leading to a genetic imbalance, and uneven cell division (De Storme & Geelen 2020; doi.org/10.1038/s42003-020-0897-1).
This project seeks to refine past research where a simplistic approach has been adopted to determine the effect temperature has on meiosis, for example, by exposing plants to an unrealistically high temperatures for several days which does not mimic natural climatic conditions. This project aims to rectify this by building on work carried out at the University of Reading to generate a set of climate projections to predict the frequency and magnitude of adverse weather events for UK wheat crops (Harkness et al., 2020; doi.org/10.1016/j.agrformet.2019.107862). These climate projections will be replicated in Controlled Environment Rooms, and their effect on meiosis in wheat assayed. This work will serve to establish the extent to which future yield can be affected by the forecasted climatic events.
Not all wheat varieties respond in the same way to heat stress, and previous work at Rothamsted Research identified varieties tolerance to heat stress applied while the plants went through meiosis (Xu et al 2022; doi: 10.3389/fpls.2022.886541). The differences in cellular response between susceptible and tolerant cultivars has not been determined. The project will use modern cytological methods to survey the major cellular events of both rounds of division in these varieties to explore how tolerant varieties manage to successfully undergo meiosis under stress conditions.

Heat stress elevates the concentration of damaging reactive oxygen species (ROS), and plants generate antioxidants as a protective measure. Any change in this balance can cause damage. It's been shown that the harmful effects of elevated temperature can be significantly reduced if antioxidants are introduced to the cells. During a placement at Rothamsted Research the redox status of tolerant and susceptible wheat will be assayed to determine if tolerant cultivars have evolved mechanisms to deal with the excess of damaging ROS. In addition, the protective effects antioxidants will be evaluated in wheat.

This project aims to i) better understand how meiosis is impacted by plausible temperature extremes, ii) to determine the nature of the cellular defects that cause heat induced infertility, iii) to examine heat tolerant wheat varieties, and iv) test whether the application of antioxidants protect against the harmful effects of heat stress.

Training opportunities:

This project offers multidisciplinary training in climate modelling, cell biology, and biochemical analysis, equipping the student with skills that can be utilised in a range of scientific disciplines either at a university or in industry. The project offers advanced training in climate modelling from the University of Reading, cell biology and microscopy at Aberystwyth University, and biochemical analysis during a year-long research placement at Rothamsted Research. The funding attached to the project will allow the student to showcase their research to the scientific community in the UK, and at an international conference. During the project the student would complete several postgraduate courses at Aberystwyth, attend summer schools run by the DTP, and have the opportunity to gain a teaching qualification.

Student profile:

This project would be ideal for a student with an interest in plant biology and climate change, with degree in biology or a related area. Prior laboratory experience in cell biology, molecular biology, or other relevant subject area is desirable, though not essential. We are looking for an individual with a genuine interest in understanding fundamental science and translating this understanding into crop development.

Stipend (Salary):

FoodBioSystems DTP students receive an annual tax free stipend (salary) that is paid in instalments throughout the year. For 2022/23 this will be £17,668 and this will increase slightly each year at rate set by UKRI.

Equality Diversity and Inclusion:

The FoodBioSystems DTP is committed to equality, diversity and inclusion (EDI), to building a doctoral researcher(DR) and staff body that reflects the diversity of society, and to encourage applications from under-represented and disadvantaged groups. Our actions to promote diversity and inclusion are detailed on the FoodBioSystems DTP website.

In accordance with UKRI guidelines, our studentships are offered on a part time basis in addition to full time registration. The minimum registration is 50% FT and the studentship end date will be extended to reflect the part-time registration.

For up to date information on funding eligibility, studentship rates and part time registration, please visit the FoodBioSystems website.