Project title:

Investigating drought tolerance and quality trade-offs in barley.

Project Summary:

Objectives and outcomes

- 1. Screen landrace material for malting quality
- 2. Validation of candidate genes
- 3. Investigate the effect of drought stress on malt quality
- 4. Field trials of pre-selected lines

Impact of COVID-19

The funding was initially awarded in July 2020 for a project start of September 2020 and end date of April 2021. Due to the COVID-19 pandemic, laboratories at Heriot-Watt University were closed for a substantial proportion of the original project timeline. An extension to September 2022 was requested to allow for the funds to be used as intended in support of student research projects. The extension allowed for the majority of planned activities to proceed although some planned collaborations (e.g. field trials) have been delayed due to the difficulties of coordinating cross-institution practical work during the pandemic and the project pivoted to focus on properties of existing experimental grain samples.

Student projects and research

The funding supported two student projects assessing the impact for use of drought tolerant and landrace barley for production of malted barley.

- Undergraduate student project. This project supported consumables and equipment budget for a summer studentship (stipend funding provided by IB3 research institute). The student was interested in pursing a PhD following their upcoming graduation and wished to gain experience within a research laboratory. The project allowed the student to develop their knowledge around malt production, malt analysis, and molecular biology, and concluded with a presentation of their research to academics and students of the International Centre for Brewing and Distilling. The experience gained during the project ultimately lead to the student successfully completing another project themed around malting science for their final year dissertation and contributed to their completion of the BSc Brewing and Distilling at First Class level.

- Postgraduate student research project. The project built upon the previous work validating nano-scale malting methodologies to expand the range of landrace and drought tolerant barley varieties screened for key markers of malt quality. The research conducted was written up as the student's MSc research project and was awarded the highest overall score across the postgraduate cohort (>70 students). The student was subsequently awarded the Allied Brewery Traders Association Prize for the best overall postgraduate student across on-campus and distance delivery modes
- Results obtained. Both students validated a 'nano'-scale malting regime (< 6 g samples) allowing for screening of low availability experimental barley samples. Provisional results indicated that malt produced using nano-scale methodology was of comparable quality to more typical micromalting analysis (sample sizes of approximately 400-500 g). Early results assessing a selection of landrace barley varieties identified some landraces achieving extract values like those of modern elite malting barleys. A selection of early results from this project were used in support of the presentation (Drought tolerant barley: could future proof the brewing and distilling industry?) delivered by Dr. Ross Alexander at the Worldwide Distilled Spirits Conference 2021. These landraces were also assessed for osmotic stress tolerance during germination, a crucial aspect of the malting process. From this screening many interesting lines were identified that were able to germinate in the presence of less water. The results of these screenings are currently being written up for publication in a suitable scientific journal. The proof-of-concept work carried out by the students funded by this BREF funding has shown that landraces can be used to promote a more sustainable and environmentally friendly form of grain to enter the malting barley economic chain. So much so, that work with a industry-scale farm-distillery has now been started, looking at improved (low water input) malting regimes. Preliminary data shows that landrace barley varieties have the potential to yield comparable extract, critical in the alcohol production process, to that of modern varieties and that the extract level was maintained under reduced-input malting regimes. In addition to pursuing further lab scale trials, discussion of these results are taking place with commercial maltsters to establish how these findings can be incorporated at a full production batch scale thus increasing the efficiency of the maltings process. Another interesting finding of the study related to the variable dormancy levels in several of the landrace varieties screened. These findings align nicely with other molecular work being carried out Heriot-Watt University, looking at how plants sense water. We have identified several key genes involved in the pathway that promotes both dormancy and germination in seeds. Recent publications suggest that

these genes may have implications for beer flavour and quality. A more comprehensive gene expression analysis is planned to assess this. This data also led to an exciting collaboration with Dr Hiroshi Hasano at the Institute of Plant Science and Resources, Okayama University, Japan. His group has a keen interest in dormancy and preharvest sprouting (PHS) and the damage this has to both grain quality and the production of cultivated barley.

Impact and conclusions

The project funding has already had a demonstrable impact on the undergraduate and postgraduate students supported and will continue to benefit the outcomes of future students through the impact on research-guided teaching practices and greater availability of modern research methodologies for use in student research projects. The funding will have lasting impact on current and future students working towards Brewing and Distilling BSc/MSc qualifications at Heriot-Watt University through the methodologies developed and validated during the project (e.g. 'nano'-scale malting). The funding will likewise have a lasting impact on HWU research expertise and reputation in the field of barley and malting sustainability. It is anticipated that the work generated will lead to at least one research publication in a suitable peer-reviewed journal and the funding and research theme will continue to be explored at HWU. The wider industry and research community will benefit from validation of 'nano'-scale malting methodologies and the screening of barley carried out here will help further research into malting barley resilience in a changing climate. In January 2023, a PhD student working in the field of heritage grain and malting will begin at the International Centre for Brewing and Distilling, the work will continue to build upon the knowledge generated in this BREF funded research, focusing on applications for heritage and landrace barleys within malt production. Raw materials sustainability is of increasing importance for malting, brewing, and distilling industries, and the BREF funding that has supported this project leaves HWU better equipped to provide graduates and research capable of addressing this challenge.