Studentship Project: Annual Progress Report
October 2022 to October 2023

Student Name:	Ece Moustafa	**AHDB Project Number:**	SF/TF 170a
Project Title:	Improving cane crop resilience by overcoming the legacy effects on photosynthesis from short-term stresses.		
Lead Partner:	NIAB East Malling & University of Essex		
Supervisor:	Dr Mark Else Professor Tracy Lawson, Dr Amanda Cavanagh, Dr Andrew Simkin, Harriet Duncalfe		
Start Date:	October 2020	**End Date:**	October 2024

1. Project aims and objectives

Water is essential for plant growth and development, and due to their sessile nature, plants must regulate water uptake and losses to maintain key metabolic processes such as photosynthesis. Photosynthesis is the process by which plants use water, carbon dioxide and sunlight to create oxygen and energy in the form of sugars. In cane crops such as raspberries, the legacy effects on photosynthesis from short-term stresses, such as a temporary rootzone water deficit stress, could limit marketable yields and berry quality due to a disruption in supply at critical stages of crop development. With the changing UK climate, abiotic stresses are becoming more prevalent and so it is important to better understand the effects of these abiotic stresses on cropping potential and fresh produce quality.

This project aims to better understand how to improve raspberry resilience to climate change by overcoming or ameliorating the legacy effects on photosynthesis from short-term stresses. The objectives of this project include understanding: 1) leaf physiological responses to coir drying episodes and associated water deficit stress, 2) the persistence of leaf adaptive responses following re-wetting, 3) the impact of legacy stress effects on berry yield and quality, 4) the signalling process(es) that regulate recovery from a rootzone water deficit stress and 5) whether it is possible to overcome the legacy effects on photosynthesis to reduce losses in Class 1 yield and berry quality.

2. Key messages emerging from the project

A transient rootzone water deficit stress imposed to raspberry canes caused a legacy effect on photosynthesis and leaf gas exchange. The temporary root zone water deficit stresses were imposed at different growth stages and durations to better understand the relationship between water deficit stress and the observed legacy effects on photosynthesis. This information could help to inform growers' decision-making and be used to develop effective strategies to mitigate the negative effects of abiotic stresses on cropping potential.

The legacy effects of transient water deficits on photosynthesis may be more persistent than initially thought. Even a four-day-long rootzone water deficit stress caused a legacy reduction in photosynthesis following rewetting. The re-wetting of the coir was decided once significant differences in photosynthesis values recorded between the well-watered and the dried-down plants were evident. Once re-wetting began, following the four-day temporary rootzone water deficit stress, shoot-water balance recovered within one day. In contrast, it took four days for photosynthesis values to recover to those recorded in well-watered plants. This suggests that a signalling cascade regulates the slow recovery from a temporary rootzone water deficit stress.

3. Summary of results from the reporting year

One of the main aims of the reporting year was to understand the duration and severity of a water deficit stress needed to induce a legacy depression of photosynthesis following rewetting. Previously, the effects of a ten-day water deficit stress were reported (see 2022 Annual Report).

In one experiment, the duration of the root water deficit stress was reduced to seven days. Changes in midday stem water potential values were observed 3 days after coir drying was initiated. On day 5, photosynthesis was significantly reduced, and this difference from well-watered values continued for the next two days. After rewetting the coir, midday stem water potential returned to pre-stress values within five hours, but photosynthesis and leaf gas exchange were suppressed for a further 6 days.

In a further experiment, a shorter duration rootzone water deficit was imposed. By day 4, the average coir volumetric water content was 0.312 m^3 m^{-3} for the dried-down plants and 0.611 m^3 m^{-3} for the well-watered plants. At this point, there were significant differences in all measured parameters, including photosynthesis, stomatal conductance, midday stem water potential, and volumetric water content, and so coir was re-wetted on day 5. Photosynthesis and stomatal conductance values recovered to well-watered values on day 8.

Both experiments were conducted in a glasshouse compartment at NIAB East Malling, where the environmental conditions were controlled and maintained; therefore, physiological responses to the water deficit stress and subsequent recovery in both experiments were similar. Xylem sap and leaf samples were collected from both experiments for analysis of hormone concentrations in the laboratory.

4. Key issues to be addressed in the next year

A focus next year will be to better understand the nature of the chemical signalling that is triggered by the stress, and which persists during recovery following a rootzone water deficit stress. Xylem sap and leaf samples were collected from the experiments described in Section 3 and will be analysed for key plant hormones in due course. Understanding the causal signalling that occurs may help us to develop practical advice for growers wishing to avoid these stress legacy effects on photosynthesis and, perhaps, on cropping potential.

In the reporting year, the effects of a temporary rootzone water deficit stress on photosynthesis were investigated to better understand the legacy effects. Other experiments, such as partial rootzone drying, are planned for the coming year, and these will help to improve our understanding of how recovery of leaf gas exchange following a short-term water deficit stress is regulated.

The final year of the project is 2023-2024, and so the focus will be on finishing planned experiments, completing analysis of data sets, and writing up and submitting the thesis.

5. Outputs relating to the project

(events, press articles, conference posters or presentations, scientific papers):

Output	**Detail**
East Malling Rubus Breeding Consortium	A PowerPoint presentation was presented at the EM Rubus Breeding Consortium on the 7th December 2022, where I discussed my project findings.
CTP Student Winter Event	A PowerPoint presentation was presented at the CTP Winter Student Event on the 17th January, 2023, where I gave an update on the work completed.

NIAB Poster Day	A poster was presented at the NIAB Poster Day on the 7th February, 2023 where I shared my results so far and discussed future experiments.
CTP Student Summer Event	A PowerPoint presentation was presented at the CTP Summer Student Event on the 4th July, 2023, where I gave an update on the work completed.
Society for Experimental Biology (SEB) Centenary Conference	A poster was presented at the SEB Centenary Conference held in Edinburgh, UK, on the 5th July, 2023.
David Miller Awards	As an awardee of the David Miller Travel Bursary 2023, I gave a PowerPoint presentation at the David Miller Awards, attended by the SCI Horticulture Group, in London, UK, on the 10th October, 2023.

6. Partners (if applicable)

Scientific partners	NIAB East Malling & University of Essex
Industry partners	Berry Gardens Growers
Government sponsor	CTP-FCR