The impact of water limitation on the leaf metabolite profiles of red raspberry (*Rubus idaeus*)

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Introduction

Climate change scenarios for the British Isles indicate an increase in basal annual temperature with increases in weather extremes, possibly resulting in a higher frequency of floods and droughts. However, the biochemical response of red raspberry to drought is not well characterized, therefore this study aims to provide insight into the associated chronological biochemical adaptations within the primary metabolism of red raspberry leaf tissue.

Methods

Two biennal raspberry cultivars were selected (Glen Ample and Octavia) and grown in 4L pots in a protected cropping system with a drip irrigation system (twice daily; 330mL). Initially plants were cut to the same height at the end of March and allowed to establish under these conditions. This allowed for primocane growth and in June, water was withheld for different periods of time (control, 1, 3, 7 and 14days; see Figure 1), with 6 plants per treatment divided in 3 blocks (Figure 2). Plants were sampled at the same time point (3 replicates, with one from each block). GC-MS analysis was performed on the polar and non-polar extracts of the youngest fully developed leaf of the 7th terminal node in a method adapted from Foito *et al*. (2009).

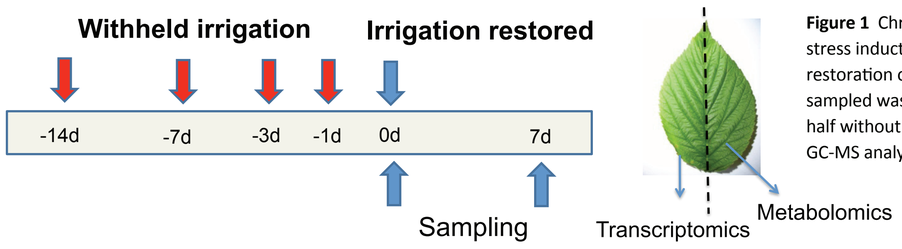

Figure 1 Chronological order of stress induction, sampling and restoration of irrigation. Each leaf sampled was divided in 2, and the half without midrib was used for GC-MS analysis.

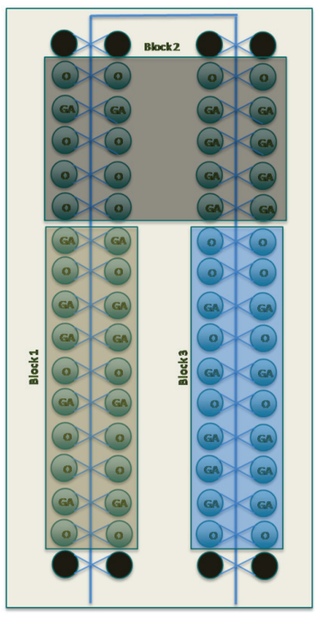

Figure 2 Experiment layout and block randomization

Results

With increasing periods of drought, the water content of the soil decreases gradually, particularly after periods longer than 3 days (Figure 3). This decrease is not accompanied by decreases in the relative water content of leaves, neither by decreases in chlorophyll content (data not showed). In most cases metabolites did not display a clear pattern of response to drought but a trend was found with some sugars such as glucose, fructose and galactose, which show that increased periods of stress result in increases (particularly after 14 days of exposure to stress) and that these metabolites decrease to basal levels once water supply is re-established (Figure 4). Some N-containing metabolites such as putrescine, allantoin, allantoic acid (data not shown) do have a similar pattern of response to stress which indicates that drought is inducing remobilization of carbon and nitrogen (Figure 4).

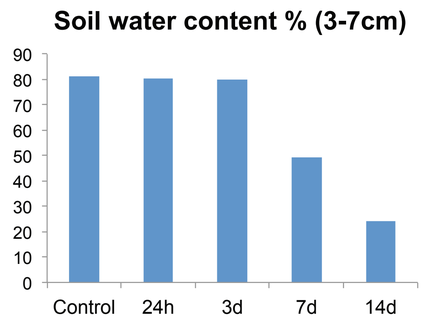

Figure 3 Soil water content at 3-7 cm depth in pots of plants exposed to different periods of water limitation

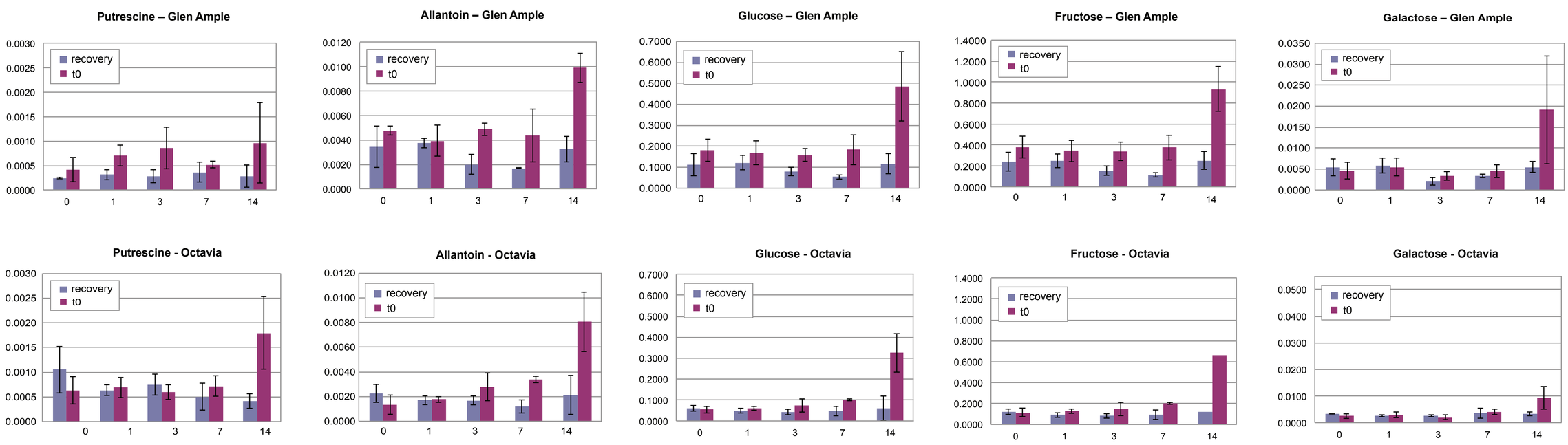

Figure 4 Plots representing the levels of putrescine, allantoin, glucose, fructose and galactose relative to an internal standard and how these respond to different periods of exposure to drought in two different varieties. y axis - Levels of metabolites relative to an internal standard. X-axis - Number of days that plants have been exposed to water limitation. A second series is represented which shows the metabolite levels after 1 week of recovery at control irrigation.

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Conclusions

- There were no differences in tolerance between the different cultivars
- The stress treatments did not elicit a reduction in relative water content and chlorophyll content
- The stress treatments produced a reduction in soil water content
- The levels of glucose, fructose and galactose increase in response to stress
- The levels of putrescine, allantoin and allantoic acid also increase in response to stress
- The responsive metabolite levels returned to control levels after 1 week of recovery
- Drought is inducing remobilization of carbon and nitrogen

Foito A., Byrne S., Shepherd T., Stewart D., Barth S. (2009) Transcriptional and metabolic profiles of *Lolium perenne* L. genotypes in response to a PEG-induced water stress. Plant Biotechnol J. (7(8):719-32