Grower Summary

Realising Increased Photosynthetic Efficiency to Increase Strawberry Yields

CTP-FCR-2018-2

Final report

Final Report

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Title: Realising Increased Photosynthetic Efficiency to Increase Strawberry Yields

Short title for the website: Increasing Strawberry Photosynthesis

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This is the final report of a PhD project that ran from 10/2018 to 10/2022. The work was funded by AHDB as part of the CTP FCR (BBSRC and industry consortium headed by Berry Gardens).

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

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Industry Summary

This project aims to improve strawberry fruit yield per hectare and strawberry fruit quality by increasing leaf photosynthetic performance through genetic manipulation of relevant enzymes.

As the global population continues to rise and climate change threatens current crop yields, new solutions are required to increase agricultural and horticultural productivity. Early studies have suggested that photosynthetic efficiency is a limiting factor on maximised crop growth and thus represents a target for improving yield. Previous work has demonstrated that genetically manipulating a key process of photosynthesis (the Calvin-Bensom Cycle, CBC) results in an increase in biomass yield and grain yield in tobacco and wheat respectively. Enhancing photosynthesis through genetic manipulation of this process is therefore demonstrative of a viable and effective method for improving photosynthetic efficiency across species. My work continues this line of research.

This work is being carried out in cultivated strawberry (*Fragaria x ananassa Duch.*), as current research in this area aims to understand how fundamental research in model plants, such as Tobacco and Arabidopsis, can be applied to crops. I will aim to determine if improvement of the CBC, through genetically manipulating one or multiple enzymes, results in changes to total biomass, harvestable yield, and developmental characteristics. Another key area of my research is to ascertain if enhanced photosynthesis, increased total biomass and increased fruit yield affect strawberry fruit quality. I will investigate this using a range of analytical chemistry techniques to study if or how key flavour and nutritional compounds differ between genetically modified and unmodified lines.

In the first year of this project, plasmids (loops of DNA) containing the CBC enzyme SBPase (sedoheptulose-1,7-bisphosphatase) and the starch synthesis enzyme AGPase (adenosine diphosphate glucose pyrophosphorylase) were constructed. Insertion of these plasmids (transformation) into strawberry leaves and subsequent regeneration of transformed plants from this tissue were tested in a range of cultivars. Regeneration was shown to be successful for the cultivar Calypso and the experimental line EMR 773. Successfully transformed and fully regenerated plants of Calypso were generated after extensive troubleshooting of the transformation method. EMR 773 was found to be recalcitrant to regeneration, though transformation of the tissue is achievable. Greater than 50 rooting transgenic Calypso lines were successfully generated with the double expressing construct and were weened onto soil for phenotyping. Analysis through chlorophyll fluorescence imaging revealed enhanced photosynthetic properties of transgenic lines.

Methods for extracting and analysing flavour components of strawberry fruit have also been developed in preparation for understanding how manipulating primary carbon metabolism in the leaf influences secondary carbon metabolism of strawberry fruit flavour. Results identified the high sensitivity of flavour compounds to different extraction methods, fruit age and cultivar type, highlighting the need for strict controls in this field of analysis.

Extensive field work has been carried out examining the influence of polytunnel row position on photosynthesis and yield of strawberry. Plants grown in the easternmost of the centre two rows (Row 4) displayed approximately 10 % - 20 % greater photosynthesis; this is in line with a historical 10 % - 15 % greater yield of Row 4 strawberries. Yield data has shown that, in the centre of the polytunnel, rows 3 and 4 yield approximately 17 % greater than rows 1 and 6. While row 4 was found to be the highest yielding row, row 3 had a similar yield (a difference of ~1.5 %). This segregation of yield between inner and outer rows may be indicative of marginally warmer temperatures generating more favourable growth conditions in the centre of a polytunnel. Historical yield differences between row 4 and all other polytunnel rows may derive from yield differences at polytunnel ends.

While it is difficult to ascertain exact financial payoffs at this stage of the project, it is reasonable to hypothesise that the project will have similar benefits on fruit growth and quality of carbon dioxide enrichment, as this also improves atmospheric carbon assimilation. This method, employed extensively by the Dutch horticultural industry, has been shown to increase strawberry fruit soluble sugar by up to 20 % (Wang and Bunce, 2004) and roughly double fruit dry weight production per plant (Sun et al., 2012). These data imply that genetic manipulation may also be capable of improving both fruit yield and quality, which could result in large monetary returns for growers.