Studentship Project: Annual Progress Report 09/2021 to 09/2022

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Project Title:	Overcoming the limitations to yield in strawberry		
Lead Partner:	BBRSC		
Supervisor:	Dr Carrie-Anne Twitchen, Professor Paul Hadley and Dr Mark Else		
Start Date:	19/09/2021	End Date:	19/09/2025

1. **Project aims and objectives**

Previous research at the University of Reading developed an optimal growing model for use during propagation to produce high-flowering strawberry plants (Twitchen, 2018). Twitchen (2018) found that the highest flowering plants were produced when propagated in a heated glasshouse (20℃) for 9-weeksduring the autumn with 12 hours of supplementary high-pressure sodium (HPS) lighting. Under these conditions the transplants produced larger crowns offering an increased number of sites for floral initiation. However, the marketable yield of these plants was limited as a large proportion of the berries were below marketable size. Therefore, the aim of this research is to investigate how to overcome source limitation during fruit development of these high-flowering plants, to increase the proportion of berries which make it to marketable fruit size.

The present research will continue to propagate plants in a heated glasshouse at 20℃ for 9 weeks, but instead of utilising HPS lighting as a form of supplementary lighting, light emitting diodes (LEDs) will be used. The industry is in the process of transitioning towards the use of LEDs as they are consistently proving to be a more economical alternative (Katzin, Marcelis and Mourik, 2021; Pattison, Hansen and Tsao, 2018; Yoomak, Jettansen, Ngaopitakkul, Bunjongjit and Leelajindakrairerk 2018). When investigating how to overcome source limitation during fruit development these elite plants will be compared to plants propagated under standard conditions in a heated glasshouse at 12℃ with no supplementary lighting.

2. **Key messages emerging from the project**

Broadly this project will investigate overcoming source limitation during fruit development of June bearer strawberry cultivars through both environmental manipulation and crop management techniques.

Year one tested the hypothesis that providing supplementary nitrogen, which has previously been shown to increase yield of strawberry by increasing the canopy size, light interception, and photosynthesis (Deng and Woodward 1998; Biscaro, Riffle and Geisseler 2022), will increase the proportion of fruit which meet the marketable size standard in the elite plants. One of three feed regimes was supplied to each of the five cultivars. All regimes contained baseline feed recipe with either 188mg/l, 218mg/l or 248mg/l of nitrogen being supplied at the drip line.

3. Summary of results from the reporting year

The elite propagation treatment used in the first year, caused an undesirable amount of early flower expression during the propagation phase (Table 1.). This may have been caused by the storage of the transplants prior to their delivery. Propagators will strike daughter plants produced on stolons (runners) for the next season in July, they will then mist the daughter plant and allow them to establish a root system for transplanting, they will then cold store the transplants to accumulate enough chill to break dormancy. Therefore, as it was likely the plants were cold stored prior to delivery when transferred to the warm, long photoperiod and well-lit glasshouse the plants began to express their flowers. Alternatively, the early flower expression may have been caused using LED instead of HPS lights. Both lights produce similar proportions of far red and blue light, but they differed substantially in their proportion of red to green light. Murohashi, Uchida and Hasegawa (2018) studied the photosynthetic activity produced by cultivars of strawberry using an LED panel and for the cultivar ‘Elan’ the highest bioelectric potential was seen under a red:green ratio of 70:30. In this experiment the spectrum provided by the HPS gave 40:60 (red:green ratio) compared to the 80:20 for the LEDs red:green it is, therefore, possible that the plants under the LEDs were photosynthesising more and began to express flowers sooner than when previously propagated under HPS lights. However, despite the undesirable amount of early flower expression seen in the propagation treatment meristem dissections of plants prior to planting indicated that plants produced under the elite propagation treatment had still initiated more inflorescences within the crown than plants which under the standard propagation treatment (Figure 1.).

Cultivar	**Flowers expressed in standard propagation treatment**	**Flowers expressed in elite propagation treatment**
A	**0.13**	**10.52**
B	**0.11**	**11.09**
C	**0.21**	**13.47**
D	**0.29**	**12.88**
E	**0.14**	**14.47**

Table 1. *Mean number of flowers expressed per plant during the propagation treatment.*

Analysis after fruiting found that plants from the elite propagation treatment produced higher marketable and unmarketable fruit yields compared to plants produced in the standard propagation treatment for five cultivars (Figure 2.). Whilst an increase in marketable fruit yield is positive only an increase in unmarketable fruit yield was expected from the elite propagation treatment. This increase in marketable yield was likely caused by the early flower expression seen in the propagation treatment allowing the plants to focus more resources on the remaining fruits allowing them to reach their maximum potential size.

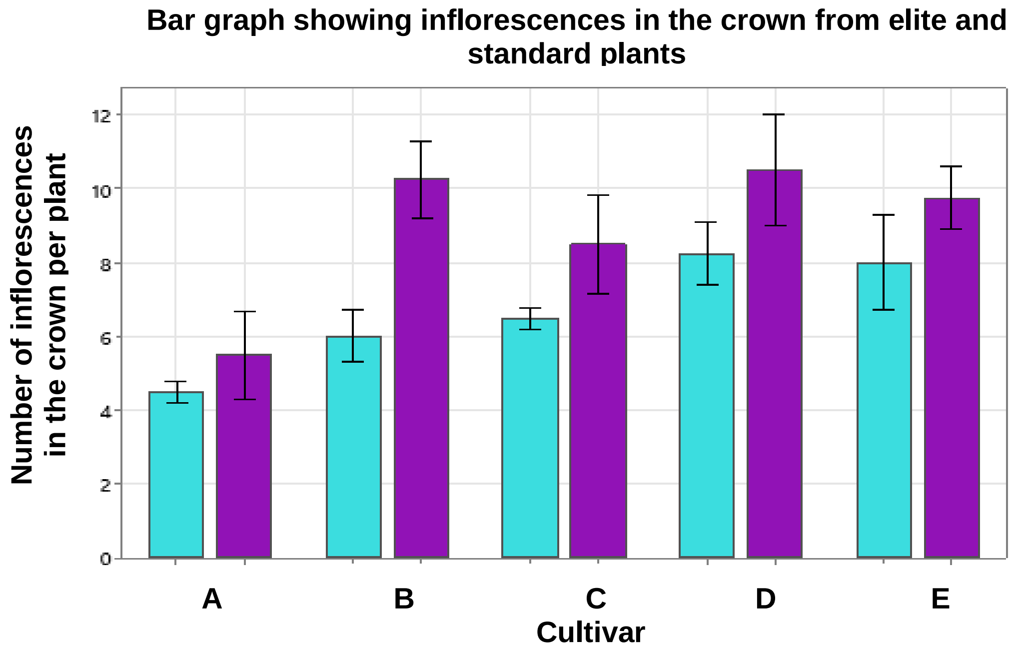

Figure 1. *Bar graph showing elite (purple) and standard (blue) inflorescences remaining in the crown at the end of propagation.*

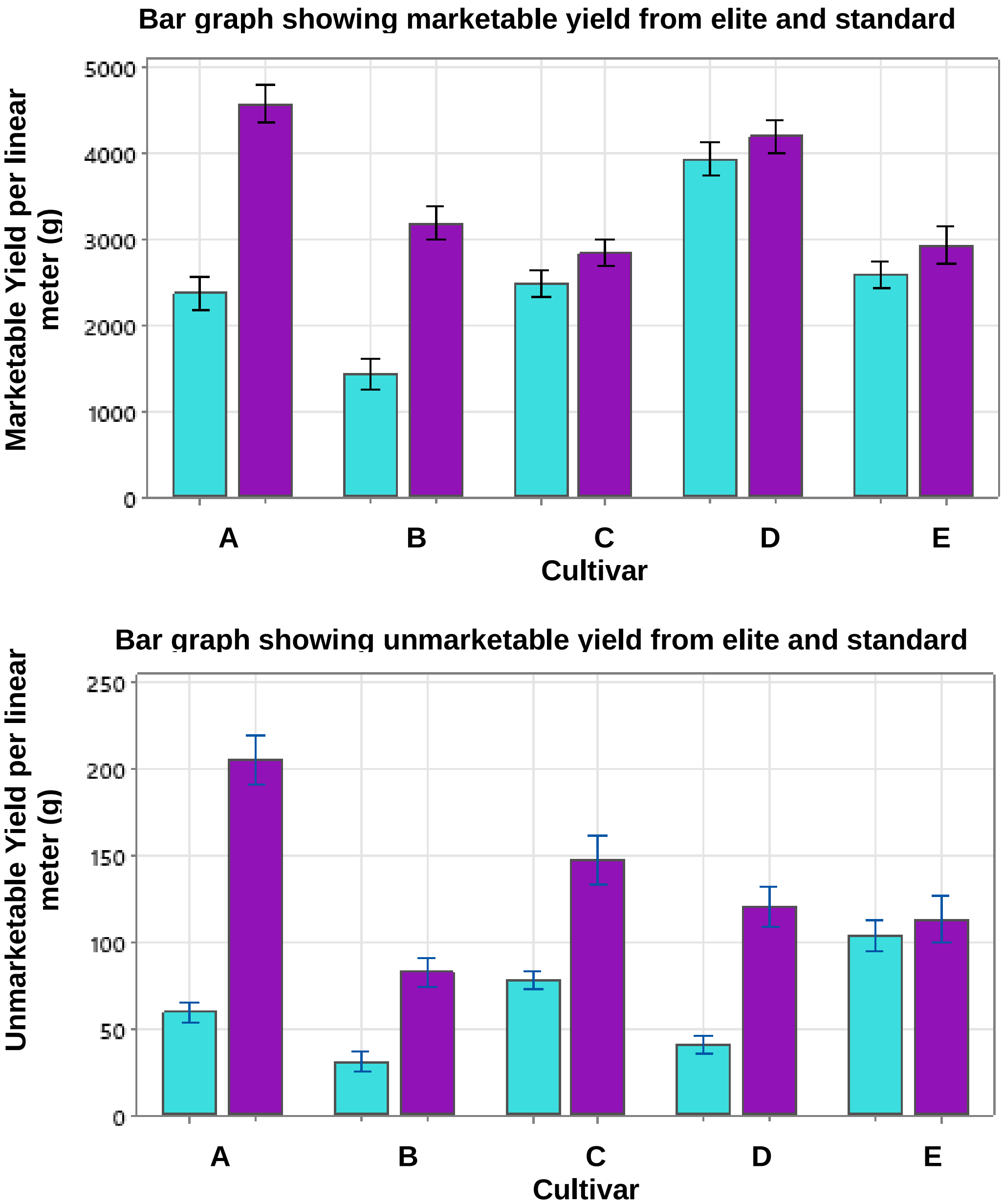

Figure 2. *Bar graph showing elite (purple) and standard (blue) marketable yield (top) and unmarketable yield (bottom) for each cultivar.*

Nitrogen had no significant effect on yield across the elite or the standard propagation treatments, but the effect on vegetive growth and photosynthesis is still being analysed. Nitrogen may have had no effect on yield because the plants may not have needed the additional nitrogen due the early expression in propagation. However, it could be that supplementing nitrogen through drip irrigation in a hydroponic growing system may not be an effective method to maximise uptake within the plant.

4. Key issues to be addressed in the next year

Given the undesirable amount of flower expression seen in the propagation treatment in the first-year plant material has been sourced earlier and has not been cold stored. Additionally, the elite propagation treatment will be reduced to 7 weeks to reduce flower expression during propagation. An additional set of plants will be grown for the same period at the same temperature but under HPS lighting to provide a comparison to propagation under the LEDs. The number of expressed inflorescences for each plant will also be recorded.

To overcome source limitation during fruit development next year two experiments will be carried out. One will investigate using different levels of CO2 in a controlled environment maintained at two different temperatures whilst the second will explore the effect of plant density and the use of reflective material used within a polytunnel to increase light interception and maximise photosynthesis.

5. Outputs relating to the project

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

Output	**Detail**
Presentation	University of Reading Crop Science Student Symposium (02/11/2021)
Presentation	CTP Autumn Event (03/11/2021)
Presentation	CTP Summer Event (18/07/2022 – 19/07/2022)
Presentation	University of Reading Crop Science Student Symposium (01/11/2022)
Co-authorship on a conference paper	Relationship between temperature and PAR on rate of strawberry fruit ripening. Twitchen, C., Johnstone, E., Else, M., and Hadley, P. *31st International Horticultural Congress 2022.*

6. Partners (if applicable)

Scientific partners	
Industry partners	
Government sponsor	