Studentship Project: Annual Progress Report 09/2023 to 09/2024

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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 plant propagation growing model to produce high-flowering strawberry plants (Twitchen, 2018). Twitchen (2018) found that the highest flowering plants were produced when propagated during the autumn in a heated glasshouse (20°C) for 9-weeks with 12 hours of supplementary lighting (220 $\mu molsm^{-2}\ s^{-1}$) provided by high-pressure sodium (HPS) lamps. 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°C 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 14°C with no supplementary lighting. This project will investigate how to overcome source limitation during fruit development of Junebearer strawberry cultivars through both environmental manipulation and crop management techniques. This project will also aim to further optimise the environmental conditions during plant propagation to maximise floral initiation and minimise early expression of inflorescences.

2. Key messages emerging from the project

- Plants propagated under supplementary light and heat initiated significantly more inflorescences than those under standard conditions and produced a significantly higher marketable yield.
- Starting the propagation treatment during or before flower initiation is necessary to maximise the number of inflorescences within the crown.

- Removing the primary flowers during fruiting has a positive effect on average berry weight of lower order fruits but an overall negative impact on marketable berry number and yield.

3. Summary of results from the reporting year

500cm^3 tray plants of Malling^{TM} Centenary were planted into 9cm pots and assigned to one of two propagation treatments, standard or elite, on the 16th September 2023. Standard plants were propagated in a heated glasshouse set at 14°C with 12 hours of low intensity lighting (3 µmols m^{-2} s^{-1}). Whilst elite plants were propagated in a glasshouse set at 20°C and received 12 hours of supplementary LED lighting (209 µmols m^{-2} s^{-1}).

After propagation, standard and elite plants were chilled in an un-heated glasshouse. After reaching the specific chill requirement for the cultivar, the plants were potted into 2L pots and transferred to polytunnel at the University of Reading's Sonning Farm. Elite and standard plants were split into two treatments, removal and control, where the yield and average berry weight at the end of the first flush and at the end of harvest was compared. Plants in the removal treatment had their primary flowers removed upon opening from all trusses which produced the first flush of fruit, whereas control plants had no flowers removed. The first flush of fruit ended on the 10th July 2024 but harvest continued until the end of the season with no further flowers removed. Fruit harvested from each plant was placed in groups according to the position it grew on the truss (primary, secondary, tertiary and quaternary). Fruit from each plant, at each position was weighed and classified into one of three groups: Class 1, Class 2 or waste. Class 1 fruit was high quality marketable fruit with a diameter at the shoulder of the berry ≥ 25mm, whilst Class 2 fruit was considered unmarketable only due due to their size (<25mm). Waste fruit varied in diameter but was unmarketable due to being mis-shaped or showing signs of powdery mildew or grey mould.

At the end of the first flush of fruit (10th July 2024), the total number of flowers produced, including flowers which were removed or failed to set fruit was calculated. Overall, the elite plants (45.79±1.88) produced significantly (p<0.001) more flowers per plant than the standard plants (32.1±1.34) and there was no significant difference in the number of flowers produced between the removal treatment and the control treatment prior to flower removal being carried out. The average number of primary flowers removed was 10.2±0.61 for the elite plants and 7.8±0.55 for the standard plants with the difference due to the higher number inflorescences produced per plant in the elite propagation group compared to the standard propagation group.

The total number of marketable fruits produced from the first flush was significantly (p<0.001) higher in the elite plants (35.45±1.37) compared to the standard plants (25.5±1.21) and significantly (p=0.009) higher in the control treatment (33.05±1.49) compared to the removal treatment (27.9±1.75) (Figure 1). Marketable yield showed the same result, with yield significantly (p<0.001) higher in elite plants compared to standard plants and significantly (p<0.001) higher in the control treatment compared to the removal treatment (Figure 2).

In the control treatment, the average number of primary flowers that produced a marketable fruit was 9.7±0.52 for the elite plants and 6.2±0.25 for the standard plants with the marketable yield of these 267.9g±14.2 and 182.2g±9.43 respectively. Removal of primary flowers reduced the total number of berries per plant by 5.1 for the elite plants and by 5.2 for the standard plants compared to the controls where no flowers were removed. Whilst the removal of primary berries did lead to an overall reduction in marketable berry number and yield, there was a positive impact on the number of berries of the lower order flowers which made it to the marketable standard as they were able to utilise more resources which would have been directed to the primary fruit leading to increase in berry diameter and weight and a higher proportion of fruit reaching the marketable standard. This reduced the impact on

marketable yield in the removal treatment to only being 107.2g lower in the elite plants and 112.5g for the standard plants when compared to the control treatments.

The average berry weight of secondary fruit was significantly (p<0.001) higher in standard plants compared to elite plants by 3 g/berry and in the removal treatment compared to the control treatment by 2.9 g/berry (p=0.001) (Figure 3). Tertiary fruit has the same result, with average berry weight significantly (p<0.001) higher in standard plants compared to elite plants by 3 g/berry and in the removal treatment compared to the control treatment by 2.8 g/berry (p<0.001) (Figure 4).

Final marketable yield was calculated at the end of the season, and the yield of the elite plants remained significantly (p<0.001) higher than standard plants and in the control treatment compared to the removal treatment (p=0.002) (Figure 5).

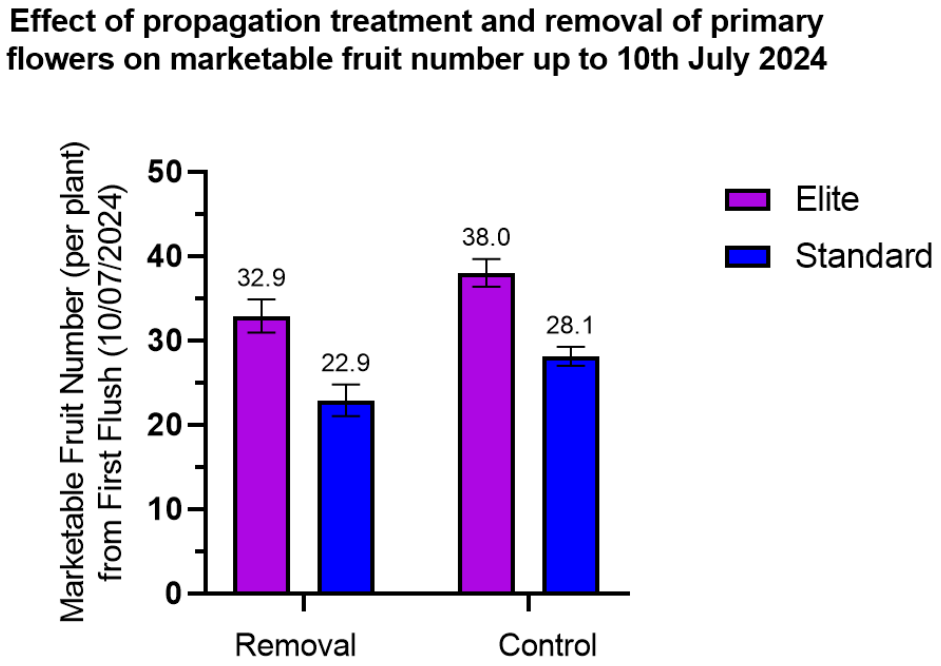

Figure 1. Effect of removal of primary flowers and propagation treatment (elite and standard) on marketable fruit number (marketable fruit considered 25mm and above) from the first flush of fruit which ended on the 10th July 2024.

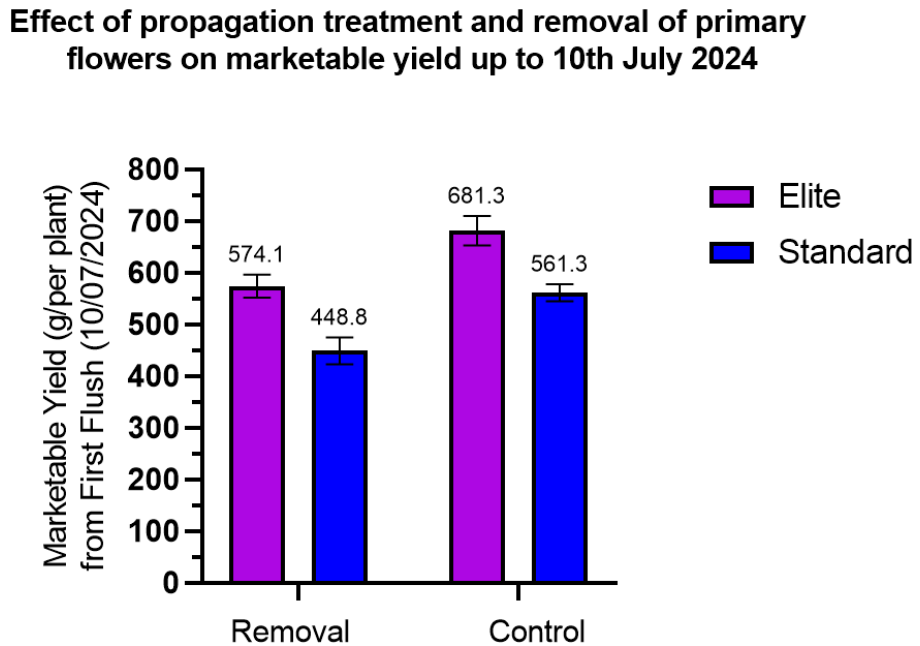

Figure 2. Effect of removal of primary flowers and propagation treatment (elite and standard) on marketable yield (high quality marketable fruit where the shoulder of the berry measures 25mm or above) after the first flush of fruit (10th July 2024).

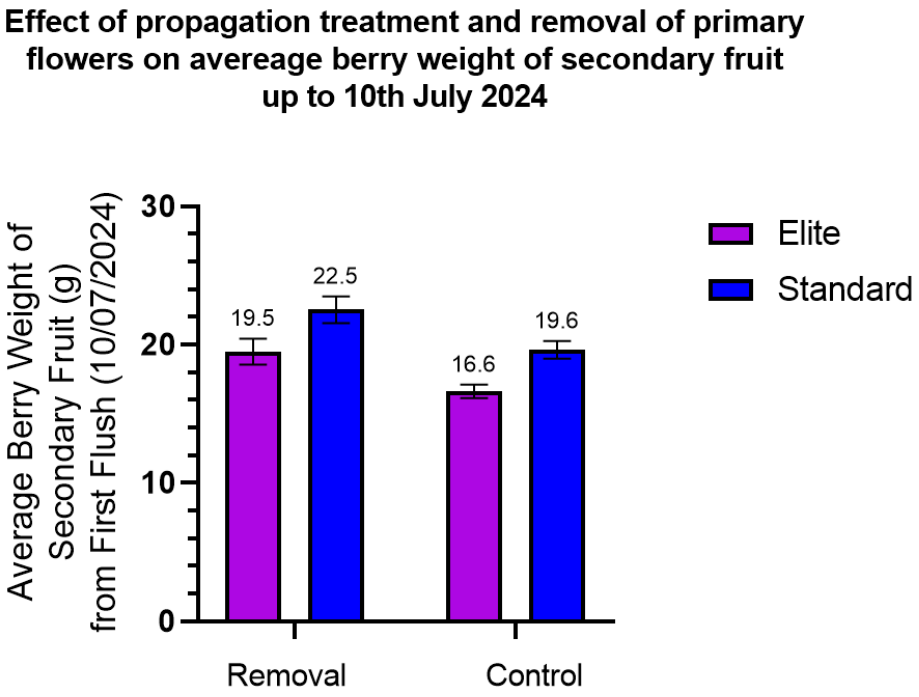

Figure 3. Effect of removal of primary flowers and propagation treatment (elite and standard) on average berry weight of secondary fruit. Average berry weight was calculated from all secondary fruit from the first flush of fruit (up until 10th July 2024) which was not classified as waste regardless of whether it reached the marketable standard of 25mm and above or not.

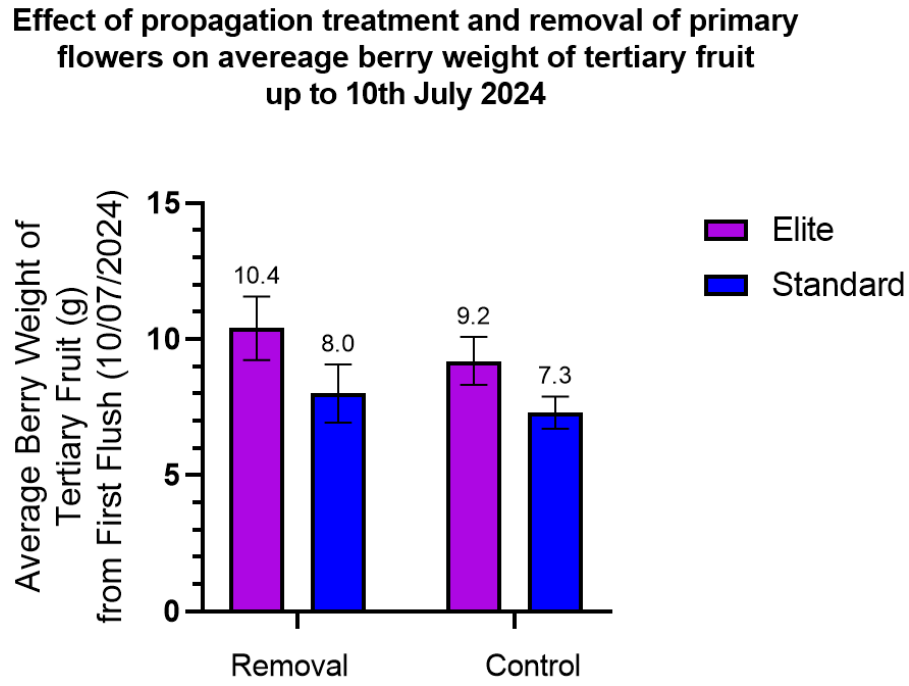

Figure 4. Effect of removal of primary flowers and propagation treatment (elite and standard) on average berry weight of tertiary fruit. Average berry weight was calculated from all secondary fruit from the first flush of fruit (up until 10th July 2024) which was not classified as waste regardless of whether it reached the marketable standard of 25mm and above or not.

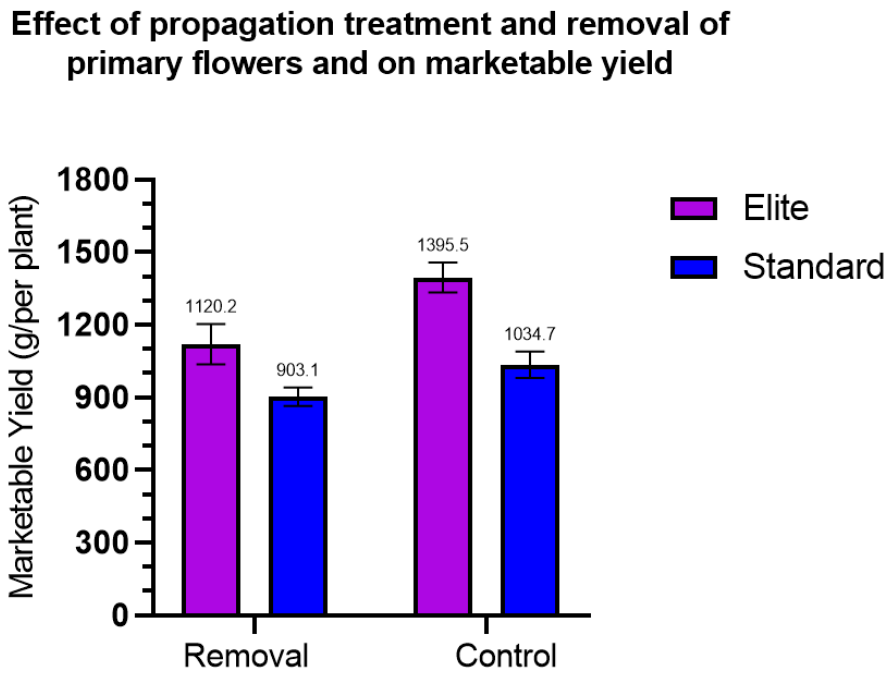

Figure 5. Effect of removal of primary flowers and propagation treatment (elite and standard) on total marketable yield (high quality marketable fruit where the shoulder of the berry measures 25mm or above)

4. Key issues to be addressed in the next year

- Whether tipping date has an impact on floral initiation during propagation and marketable yield.
- Whether plants propagated under elite and standard conditions have different chill requirements and how different levels of chill could impact the cropping profile.

5. Outputs relating to the project

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

Output	**Detail**
Presentation	CTP Winter Event (23/01/2024-24/01/2024)
Presentation	CTP Summer Event (09/07/2024)

6. Partners (if applicable)

Scientific partners	
Industry partners	
Government sponsor	