Studentship Project: Annual Progress Report 10/2021 to 11/2022

Student Name:	Sophie Read	**AHDB Project Number:**	CTP_FCR_2019_8
Project Title:	Towards year-round production of UK strawberries		
Lead Partner:	NIAB EMR		
Supervisor:	Mark Else (NIAB EMR), Carrie Twitchen (University of Reading) and Paul Hadley (University of Reading)		
Start Date:	01/10/2019	**End Date:**	22/09/2024

1. Project aims and objectives

- To investigate the use of specialist low-chill strawberry cultivars for winter glasshouse production to produce out-of-season UK strawberries.
- To explore different environmental and cultural growing conditions to develop optimal growing models for winter glasshouse production.
- To develop chilling models for major Junebearer (JB) and Everbearer (EB) cultivars.
- To carry out an economic study to balance the costs of delivering environmental conditions including lighting, heating and CO_2 enrichment with the financial returns from out-of-season strawberry production.

2. Key messages emerging from the project

- JB and EB cultivars can be successfully combined in one growing system to extend the strawberry production season with the focus on the low chill JB for maximising yields.
- A starting temperature of 22°C which is then lowered to 16°C prior to fruiting seems optimal for promoting earlier flowering and fruiting without compromising berry size and yield. Compromised berry size and yield is seen with a higher temperature in the latter fruiting growth stages.
- A light duration of 12hrs LED lighting (+4hrs photoperiod extension lighting) over the winter season with a continuation of +4hrs photoperiod extension in the spring, seems beneficial for balancing economic and environmental inputs and outputs for a sustainable growing model. This will be confirmed by the full cost analysis planned to be carried out for this upcoming year's experiment.
- Night-break lighting (NBL) has the potential to be incorporated into an economical and environmental beneficial growing system to bring flowering and fruiting forwards to enable earlier planting and hence earlier fruiting whilst also supplementing some of the higher energy LED lighting.

3. Summary of results from the reporting year

In the third year of this PhD project, a winter glasshouse experiment was planned to incorporate the results from the second year experiment showing NBL to be beneficial in helping reducing the strawberry chill

requirements of a specialist low-chill JB and an EB, with CO_2 enrichment to improve strawberry quality. However, due to technical difficulties, the CO_2 enrichment was post-poned to the final year so the design for this experiment, was changed to look at the effect of NBL or no NBL combined with either 13 weeks or 17 weeks of LED lighting. This aimed to address the last objective of looking at the economic and environmental costs of producing out-of-season strawberries in terms of whether an additional 4 weeks of LED lighting has significant benefits on yield and quality or whether energy and money can be saved with a slightly shorter duration of LED lighting. Incorporated into this experiment due to another technical difficulty with the automatic photoperiod control facilities, was the added factor of 12hrs LED (+4hrs photoperiod extension) versus 16hrs of LED lighting alongside the control of 12hrs natural light (+4hrs photoperiod extension). Analysis of the complete experimental results are still being carried out but the initial analysis shows some interesting findings:

- The use of NBL reduced the time to flowering and fruiting for both the JB and EB confirming the results from the year 2 experiment.
- LED lighting combined with the NBL reduced the time to flowering and fruiting further than without the LED, but further analysis is required to look at whether there was a significant difference between the 12 and 16hrs.
- There was a slight increase in Class 1 yield of both the JB and EB with the 1 month shorter LED lighting duration.
- The overall yield produced was greater under the 16hrs LED lighting compared to the 12hrs LED (+4hrs photoperiod extension).

Also, this year an experiment was conducted looking specifically at the specialist low-chill JB cultivar used in the previous experiments to find the maximum photoperiod for short-day flower initiation. This experiment was conducted in a vertical tier growing system with 8 hours LED lighting as the control and the photoperiod extension treatments of +2, +4, +6 and +10hrs. The results collected from this were crown dissections carried out every three weeks with expressed and un-expressed vegetative and floral growth being recorded. These results are currently being analysed and will be reported in due course.

Alongside the above two main experiments, two smaller experiments were carried out to follow up on a couple of individual factors affecting strawberry production. One of these was following on from the second year experiment looking at the potential for GA_3 to be used to reduce chill requirements and to see whether the timing of application affected its ability to bring flowering and fruiting forwards without compromising fruit shape and quality. Despite this data still being analysed, observations throughout, showed that the timing of the application did not improve the negative effects seen on fruit shape in the previous experiment and hence, it can be concluded that GA_3 is not a favourable option for reducing chilling requirements to allow for earlier planting. The second experiment was purely observational looking at the potential for continuing an EB into a second year of winter production as opposed to re-planting. The purpose of this was to see whether it could be economoically advantageous to continue a crop for a second year after a period of chilling to allow for dormancy. However, regular observations clearly suggest that this is not a viable option with the second year plants producing a high quantity of mis-shapen and viviparous strawberries.

4. Key issues to be addressed in the next year

The plan for the final year of this PhD project is to repeat the NBL experiment with the 13 weeks of 12hrs LED lighting (+4hrs photoperiod extension lighting) with and without CO_2 enrichment. The CO_2 enrichment facilities have now been installed and will enrich one glasshouse compartment to 700ppm with JB and EB strawberry plants grown with and without NBL. There will be a second glasshouse compartment which will be kept at ambient CO_2 levels, again with both the JB and EB strawberry plants grown with and without NBL. In both compartments there will be plants under natural lighting with and without NBL and with and without chill to allow for comparisons to be made. An economic and carbon footprint analysis will be conducted for this experiment, taking into account all of the monetary inputs including lighting, heating, CO_2 and venting and the monetary outputs in terms of strawberry yields. For the carbon footprint analysis, all carbon emissions will be accounted for from these inputs. The costs calculated from this experiment will then be scaled up to give an idea of what a growing system based on these growth factors would cost on a commercial scale.

5. Outputs relating to the project

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

Output	Detail
Oral Presentation at the RHS PHD Symposium	- Held on-line (6th January 2022) - Result of winning the Marsh Charitable Trust Award for Horticultural Science (2021)
Poster Presentation at the STEM for Britain Finals 2022	- Held at the House of Commons, London (7th March 2022) - Poster presentation given as a finalist in the Biological and Biomedical Sciences category of the STEM Award with MPs attending
Oral Presentation at the 'Bridging Worlds Conference'	- Hybrid conference – held on-line and at the UoR - Sponsored by Corteva and the UoR - Presentation given as part of the 'Sustainable Development' section of the conference
Poster Presentation at the Graduate School Conference at the UoR	- Selected to display entries for three competitions at the Graduate School Research Conference (15th June 2022) – 'Research Life in Pictures', 'Research Image' and 'Research Poster'
Oral Presentation given as part of the Crops Group Seminar Series at the UoR	- On-line presentation giving an update from year 3 experimental results (5th July 2022)
Oral Presentation at the Summer CTP Conference	- On-line presentation giving an update of year 3 experimental results (18th July 2022)
Oral Presentation at the 31st International Horticultural Congress	- Held in Angers, France (14th-22nd August 2022) - Presentation given as part of Symposium 6: 'International Symposium on Innovative Technologies and Production Strategies for Sustainable Controlled Environment Horticulture' - Paper currently under review to be published in the conference proceedings
Poster Presentation at the 4th International Strawberry Congress	- Held in Antwerp, Belgium (21st-23rd September 2022)
Oral Presentation at the David Miller Awards	- Held at the SCI Headquarters, London (7th October 2022)
Oral presentation for the Crops Group Symposium at the UoR	- Recorded presentation presented at the symposium (2nd November 2022) summarising second and third year experimental results

6. Partners (if applicable)

Scientific partners	
Industry partners	Richard Harnden and Harriet Duncalfe - Berry Garden Growers Ltd
Government sponsor	AHDB