School of Agriculture, Policy and Development

University of Reading

Apples in a Warmer World ®: Productivity, Fruit Quality and Climate Change

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Introduction

IPCC climate change temperature rise scenarios of +2.1 to +3.5°C will alter the growth, physiology and production of apple trees (Figure 1)[1]. The effects of a warming climate on phenological events over the past 50 years are already apparent (Figure 2)[2]. The value of UK dessert apples in 2020 was £158m[3], with the majority of produce sold directly to supermarkets. Strong market competition from imported fruit has raised fruit quality standards over recent years. The industry requires research on climate change impacts on fruit quality attributes to ensure UK produce can remain competitive in a warming world.

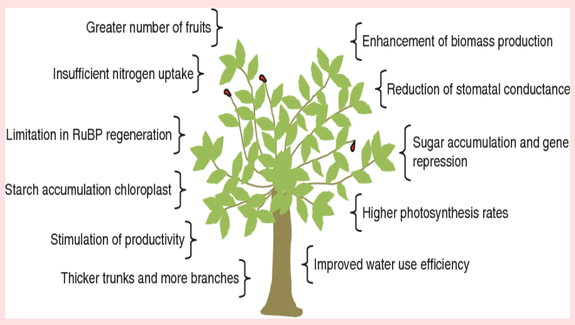

Figure 1 – Responses of fruit trees to global climate change[1].

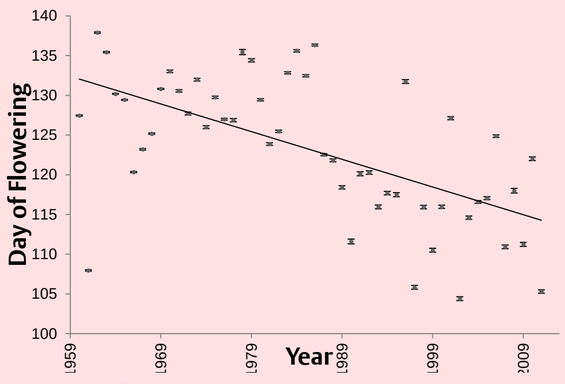

Figure 2 – Average 'full flowering' date of apple varieties (1959 – 2011) at the National Fruit Collection, Brogdale, Kent (1st Jan = Day 1)[2].

The Experimental Facility

Completed in 2017, a 0.6 ha modified environment orchard based in Brogdale, Kent, was established to evaluate the effect of varied climate regimes on apple production: three separate triple-span polythene tunnels house 20 unique varieties under nine different climate regimes that reflect uncertainty amongst climate change scenarios (**Figure 3**). These consist of three temperature (ambient, +2°C, and +4°C [nominal values]) and three rainfall (ambient, +20%, and -20%) regimes. The 20 varieties (**Figure 4**) grown differ in commercial importance (e.g. Gala), seasonality (early to late), or specific phenotypic traits (e.g. low chill requirements).

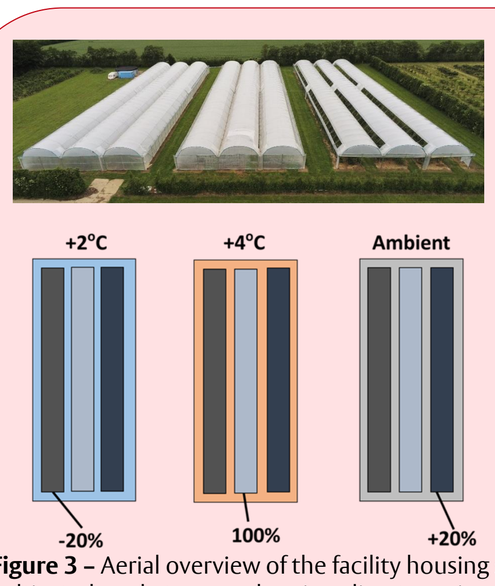

Figure 3 – Aerial overview of the facility housing soil-cultivated apple trees under nine climate regimes

Varietal name	Trait	Seasonality
Beverly Hills	Low chill	Early
Braeburn	Commercial	Late
Bramley's Seedling (LA)(3n)	Commercial	Late
Cox's Orange Pippin (LA)	Fruiting mid	Late
Discovery (EMLA 1)*	Fruiting early	Early
Edward VII	Flowering late	Late
Fuji	Standards	Late
Gala (LA 69A)	Stand./Comm.	Late
George Cave (LA 70A)	Diversity	Early
Golden Delicious (LA 65A)	Fruiting late	Late
Granny Smith (LA 73A)	Fruiting late	Late
Jolyne	Growth Habit	Mid
Jonathan (EMLA 1)	Growth Habit	Late
King of the Pippins	Standards	Mid
Lappio	Growth Habit	Late
Stark's Earliest (LA 68A)	Flowering early	Early
Tropical Beauty	Low chill	Late
Winter Banana	Low chill	Late
Winter Pearmain	Growth Habit	Late
Yellow Bellflower	Low chill	Late

Figure 4– The 20 dessert and culinary cultivars assessed for production performance within the trial

Long-Term Data Collection

The trial aims to collect data over 10+ years to analyse the effects of varied climate regimes across an orchard's lifespan. In each production season, data is assessed on phenology, yield, and growth. In the current trial phase, there is greater emphasis on fruit quality (FQ) analysis. In line with commercial practice, the following parameters are determined: fruit maturity (% starch /index), weight (g), firmness (kg), soluble solids content (SSC, % Brix) and dry matter content (%).

Biennial Fruit Bearing

Some apple varieties exhibit a biennial cycle of a heavy fruiting crop year followed by a lighter cropping year. Preliminary data suggests higher temperature regimes may be enhancing biennial effects in some varieties, leading to lower crop yields in comparison to the ambient treatment (**Figure 5**). Future analysis of historic yield and climatic data will help identify the relationships between these variables.

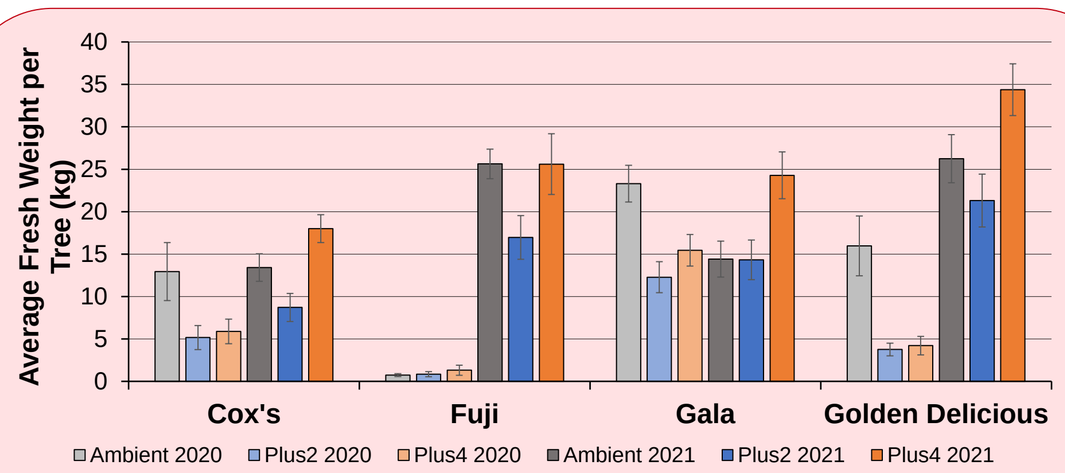

Figure 5 – Average fresh weight of apples harvested from trees cultivated in three temperature regimes (ambient, +2°C, +4°C) for four selected trial dessert varieties in years 2020 and 2021.

Production Temperature and Apple Storability

Controlled atmosphere (CA) storage enables growers to extend produce shelf life (dependent on variety). One trial experiment is assessing the impact of varied temperature regimes on the storability of the UK's most widely-grown variety Gala. At regular intervals fruit is removed from CA storage (maintained at 0.7°C, 1% O_2, 5% CO_2) and FQ attributes assessed over a 6-7 month period. The first year of results have produced statistical differences ($P < 0.05$) between treatments for several FQ attributes. In the warmest treatment, firmness and SSC appear to change at an accelerated rate compared to the ambient treatment (**Figure 6**). This may present challenges to industry, as accelerated ripening may reduce Gala storability. Further years of data will be collected to confirm these relationships.

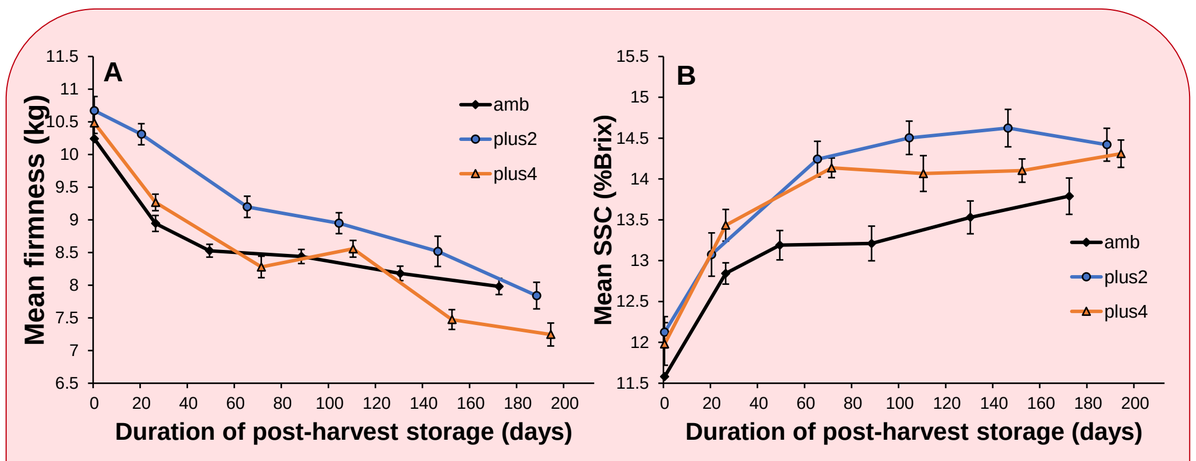

Figure 6 – Change in mean (±SE, n=30 fruit) firmness (**A**) and SSC (**B**) with duration of storage for apples (Gala from 3 field temperature treatments: ambient, +2°C, and +4°C)

References

1. Ramirez, F. and Kallarackal, J., 2015. '*Responses of fruit trees to global climate change*'. Springer.
2. Hadley, P. (*personal communication*).
3. DEFRA, 2021. Horticulture Statistics 2021 Report, Office for National Statistics.

Acknowledgements

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