Global warming decreases fruit size in strawberries and increases the costs of harvesting on the Sunshine Coast

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- Higher temperatures decrease fruit size in strawberries
- Plants with small fruit are more expensive to harvest than plants with large fruit
- Global warming will reduce the profitability of growing berries in Queensland in the absence of heat-tolerant cultivars or other strategies

Strawberry plants were grown on the Sunshine Coast in 2020 to determine whether global warming is affecting production. Minimum temperatures were 2°C to 4°C higher than the long-term averages from 1965 to 1990. The plants continued to produce a marketable crop towards the end of the season in October, but the fruit were small and more expensive to harvest. These results suggest that the economics of production in this area is already affected by rises in temperature. Global warming will reduce the profitability of strawberries in Queensland in the absence of heat-tolerant cultivars or other mitigating strategies.

Introduction

Some crop models predict higher yields in the short-term with climate change and lower yields in the long-term, while other models predict lower yields across both periods or even under current conditions.

There can be difficulties in predicting yields under climate change because the changes in CO_2 (carbon dioxide) and temperature, etc. vary across different regions.

There are also uncertainties in how individual crops respond to growing conditions. Keeping global warming to within 1.5°C is less problematic than global warming to within 2.0°C.

There is some information on the impact of climate change on strawberries. Several reviews suggest that increases in the concentration of CO_2 and temperature will alter the production season and the pattern of plant development in different growing areas. Two analyses in California suggested that yields would decline by 10% by 2050 and by 43% by 2070 to 2099. High temperatures and low rainfall in November were associated with low yields in this area from 1980 to 2003. Two analyses in China and Chile indicated that global warming will decrease the distribution or productivity of wild strawberry species in their native habitats.

An experiment was conducted in 2020 to examine the performance of five strawberry cultivars on the Sunshine Coast. Information was collected on marketable yield, fruit size, fruit soluble solids content (SSC) and fruit titratable acidity (TA). Changes in the performance of the plants over the season were used to evaluate the sensitivity of the plants to higher temperatures. The main objective of the study was to determine whether global warming is already affecting production in this area.

What we did

Containerised transplants of 'Festival', 'Brilliance', 'Red Rhapsody' 'Scarlet Rose' and 'Sundrench' were planted on 29 April 2020 at Nambour. Fruit were harvested every week for an assessment of marketable yield (fresh weight) and average fruit fresh weight from 8 July to 28 October. Mature fruit were classified as

those that were at least three-quartered coloured. A record was kept of the number of fruit that were small (less than 12 g fresh weight). Fruit that were affected by rain and/or grey mould or misshapen, or that had other defects (mainly other disease, surface bronzing or bird damage) were considered non-marketable. Fruit that were small and misshapen were rated as misshapen. Data were also collected on fruit total soluble solids content (SSC) and titratable acidity (TA) weekly from 16 September to 28 October.

What we found

Average daily maximum temperatures ranged from 21.3°C to 26.6°C and average daily minimum temperatures ranged from 10.1°C to 15.7°C. The average daily mean temperature in the eight days before fruit harvest increased from 15°C to 21°C from 8 July to 28 October (Linear model, $P < 0.001$, $R2 = 0.78$, $N = 14$). Maximum temperatures were close to the long-term averages from 1965 to 1990, while minimum temperatures were 2°C to 4°C higher.

Marketable yield was lower in 'Brilliance' than in the other cultivars (Table 1). Mean seasonal average fruit fresh weight was lower in 'Festival' and 'Brilliance' and higher in 'Red Rhapsody', 'Scarlet Rose' and 'Sundrench'. The reverse was true for the mean incidence of small fruit (higher in 'Festival' and 'Brilliance') (Table 1).

There were only small differences in mean soluble solids content (SSC) and mean titratable acidity (TA) across the five cultivars (Table 1).

There was a strong negative relationship between average fruit weight (marketable) and the average daily mean temperature eight days before harvest from 29 July to 28 October (Figure 1).

In contrast, there was a strong positive relationship between the incidence of small fruit and temperature over the same period (Figure 1). Average fruit size decreased as temperature increased, whereas the reverse occurred for the incidence of small, non-marketable fruit. There were no relationships between SSC and TA, and average mean temperature from 16 September to 28 October. The average daily mean temperature 8 days before harvest over this period ranged from 18.2°C to 22.2°C. Average SSC was lower on 28 October (6.7 ± 0.3%) than from 16 September to 21 October (7.4 ± 0.3% to 8.5 ± 0.4%).

Implications for commercial strawberry production

There were large changes in marketable yield and fruit size in the strawberries as the temperatures increased in Queensland. Higher temperatures generally had a negative effect on the performance of the plants.

Table 1. Variations in marketable yield and mean seasonal average fruit fresh weight (marketable), percentage of small fruit (< 12 g fresh weight), fruit soluble solids content (SSC) and fruit titratable acidity (TA) in five strawberry cultivars in Queensland in 2020. Soluble solids content and titratable acidity were measured over seven harvests from 16 September to 28 July.

Cultivar	Marketable yield (g per plant)	Av. fruit fresh weight (g)	Percentage of small fruit	Soluble solids content (%)	Titratable acidity (%)
Festival	616	20.3	29.0	8.3	0.64
Brilliance	457	22.7	28.2	7.3	0.57
Red Rhapsody	617	23.9	16.2	7.3	0.64
Scarlet Rose	592	24.4	21.7	8.9	0.83
Sundrench	656	25.5	16.0	6.8	0.57

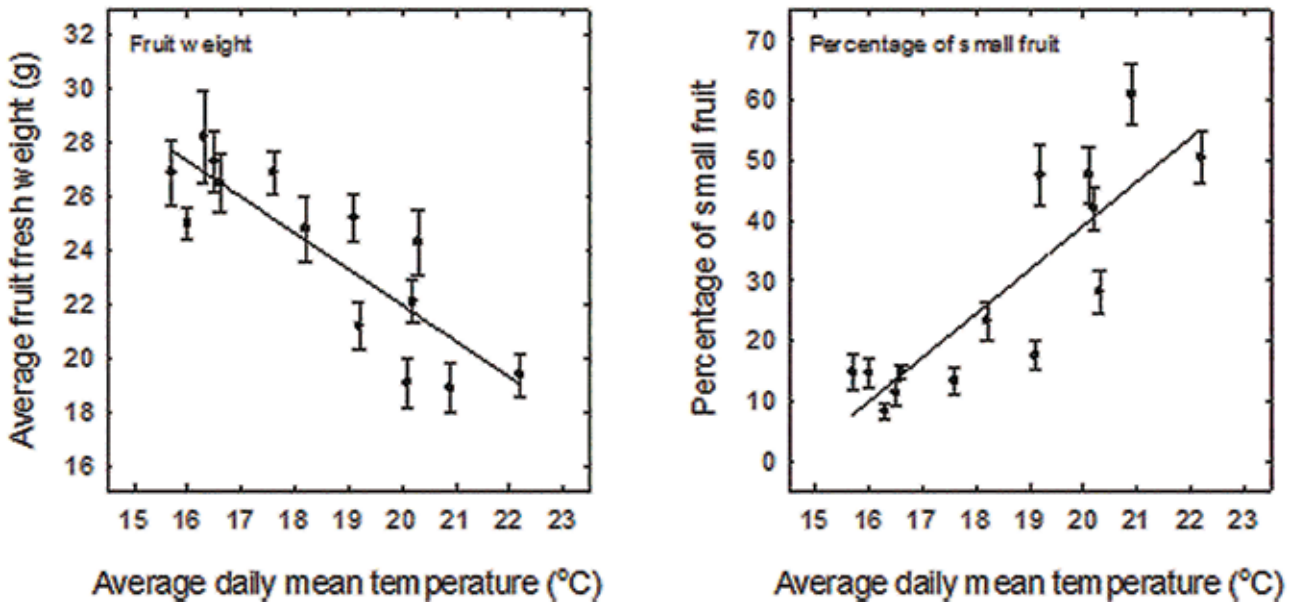

Figure 1. Relationship between average fruit fresh weight (marketable fruit weighing at least 12 g) (AFWT) and the incidence of small fruit (Small (%)), and average daily mean temperature (Temperature) in the eight days before harvest from 29 July to 28 October in strawberries in Queensland. Data are the means (± SE or standard error) of five cultivars with six replicates for each cultivar. AFWT (g) = Intercept – 1.33 × Temperature (P < 0.001, R2 = 0.70, N = 14). Small (%) = Intercept + 7.3 × Temperature (P < 0.001, R2 = 0.71, N = 14).

The plants continued to produce a marketable crop towards the end of the season. However, the fruit were small and more expensive to harvest. These results suggest that the economics of production in this area is already affected by rises in temperature.

Commercial fruit production continued to the end of the season on the Sunshine Coast. However, average fruit weight decreased and the incidence of small fruit increased. A high incidence of small fruit, even including those that are marketable reduces profitability. Harvesting accounts for up to 60% of variable costs for growing strawberries in Japan, California, Florida and Queensland. Plants with small fruit cost more to harvest than plants with large fruit.

Studies in the United Kingdom demonstrated that 'Malling Centenary' has larger fruit than many earlier cultivars and lower harvesting costs. Pickers could harvest 30 to 40 kg per hour of fruit of the new cultivar under table-top production compared with 25 to 30 kg per hour in the earlier cultivars.

A study in Italy showed that for each 1 g decrease in average fruit fresh weight, the cost of harvesting was increased by €500 per ha. Other investigations in Australia, indicated the cost of harvesting increased by $600 per ha for each one gram decrease in fruit weight from 30 g to 17 g.

Conclusions

Temperature affected the growth and development of the strawberries in Queensland. Minimum temperatures were 2°C to 4°C higher than the long-term averages from 1965 to 1990.

The plants continued to produce a marketable crop towards the end of the season in October. However, the fruit were small and more expensive to harvest. These results suggest that the economics of strawberry production in this area is already affected by rises in temperature. Global warming will reduce the profitability of strawberries in the absence of heat-tolerant cultivars or other mitigating strategies.

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Queensland Government