Potential impacts of global warming on fruit size in strawberries in south-east Queensland

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Global warming is likely to have a large impact on the growth and yield of strawberries. Experiments were conducted to investigate the relationship between fruit development and temperature in plants growing in south-east Queensland.

The percentage of fruit smaller than 12 grams was higher when the average daily mean temperature in the seven weeks before harvest was 18°C to 21°C and lower when the temperature was 16°C to 18°C. None of the cultivars produced large berries at the end of the growing season. The effect of higher temperatures on fruit growth will contribute to lower yields under global warming. There is an urgent need to develop heat-tolerant cultivars or other mitigating strategies to reduce the impact of these changes on commercial strawberry production.

Global climate change will increase both the temperature and the concentration of CO_2 (carbon dioxide) in the atmosphere. These changes will increase the rate of photosynthesis in the leaves of many crops, however this increase will be off-set by excessive leaf production and decreases in flower and fruit development. Overall, higher temperatures will have a greater effect on productivity than higher concentrations of CO_2.

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 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 for sustainable production than global warming to within 2.0°C.

There is limited information on the impact of climate change on strawberries. Higher temperatures will alter the production season and the pattern of plant development. This article reports on the relationship between fruit growth and temperature in strawberries growing in south-east Queensland. Four cultivars were grown under tunnels or in the open field and information collected on yield, fruit size and temperature. The relationship between the incidence of small fruit and temperature was determined.

What we did

We planted transplants of 'Festival' and 'Fortuna' and two breeding lines in late March at Nambour. Half the plants were grown under plastic high tunnels, while the other half of the plants were grown in open field plots. We harvested fruit every week for an assessment of marketable yield (fresh weight). Mature fruit were harvested and were classified as those that were at least three-quartered coloured. Fruit that were smaller than 12 g or affected by rain or grey mould or misshapen, or that had other defects (mainly other disease, surface bronzing or bird damage) were considered non-marketable.

We also collected temperature data at the site under the tunnels and in the open field plots. The relationship between the percentage of small fruit (less than 12 g fresh weight) and average daily mean temperature in the seven weeks before the fruit was harvested was determined in the different growing areas. This period covered both flower and fruit development in the berries.

What we found

There were only small differences in average mean daily temperatures between the tunnels and the open field plots (Table 1). Mean monthly maximum temperature ranged from 22.9°C to 30.2°C, while mean monthly minimum temperature ranged from 7.2°C to 15.5°C. The lower temperatures were adequate for strawberry production. However, the higher temperatures were probably excessive for strawberry production. Plants under the tunnels had higher marketable yields than the plants in the open (Table 2). In contrast, there was no effect of growing system on average fruit fresh weight or on the percentage of small fruit. 'Festival' had the highest yield followed by 'Breeding Line No. 1' and 'Rubygem', and then 'Breeding Line No. 2'. Average fruit weight was higher in the two breeding lines than in the other cultivars, while the reverse was true for the incidence of small fruit (Table 2).

There were linear relationships between the percentage of small fruit and the average mean daily temperature in the seven weeks before harvest in 'Festival', 'Breeding Line No. 1' and 'Breeding Line No. 2'. In contrast, in 'Rubygem', there was a linear-linear relationship between the percentage of small fruit and temperature. A linear relationship indicates that the percentage of small fruit continued to increase as temperatures increased over the season. A linear-linear relationship indicates that the percentage of small fruit increased as the temperature increased, but there were different rates of increase in the early and late harvests. Overall, the percentage of small fruit was higher when the average daily mean temperature in the seven weeks before harvest was 18°C to 21°C and lower when the temperature was 16°C to 18°C (see Figure 1). This response is not likely to be associated with the small changes in day length and solar radiation recorded over the period.

Table 1. Average mean daily temperatures and ranges in monthly averages during this study on strawberries in south-east Queensland. Data are the means of four replicates per treatment and are the averages from mid-May to mid-October.

Growing system	Mean daily maximum temperature (°C)	Range in mean daily maximum temperature (°C)	Mean daily minimum temperature (°C)	Range in mean daily minimum temperature (°C)
Open	26.5	23.9-30.2	10.5	7.2-14.2
Open	26.0	22.9-29.9	11.9	9.0-15.5

Table 2. Effect of growing system and cultivar on marketable yield, mean seasonal average fruit fresh weight, mean percentage of small fruit over the season and maximum percentage of small fruit at the end of the season in strawberries in south-east Queensland. Data are the means of four replicates per treatment.

Growing system or cultivar	Marketable yield (g/plant)	Average fruit fresh weight (g)	Average percentage of small fruit over the season	Maximum percentage of small fruit at the end of the season
Open	720	23.2	16.0	64.0
Tunnel	991	23.5	16.6	65.8
Festival	1064	19.8	18.3	75.7
Breeding Line No. 1	868	28.1	11.4	59.3
Breeding Line No. 2	657	24.2	12.2	58.5
Rubygem	834	21.3	23.2	66.2

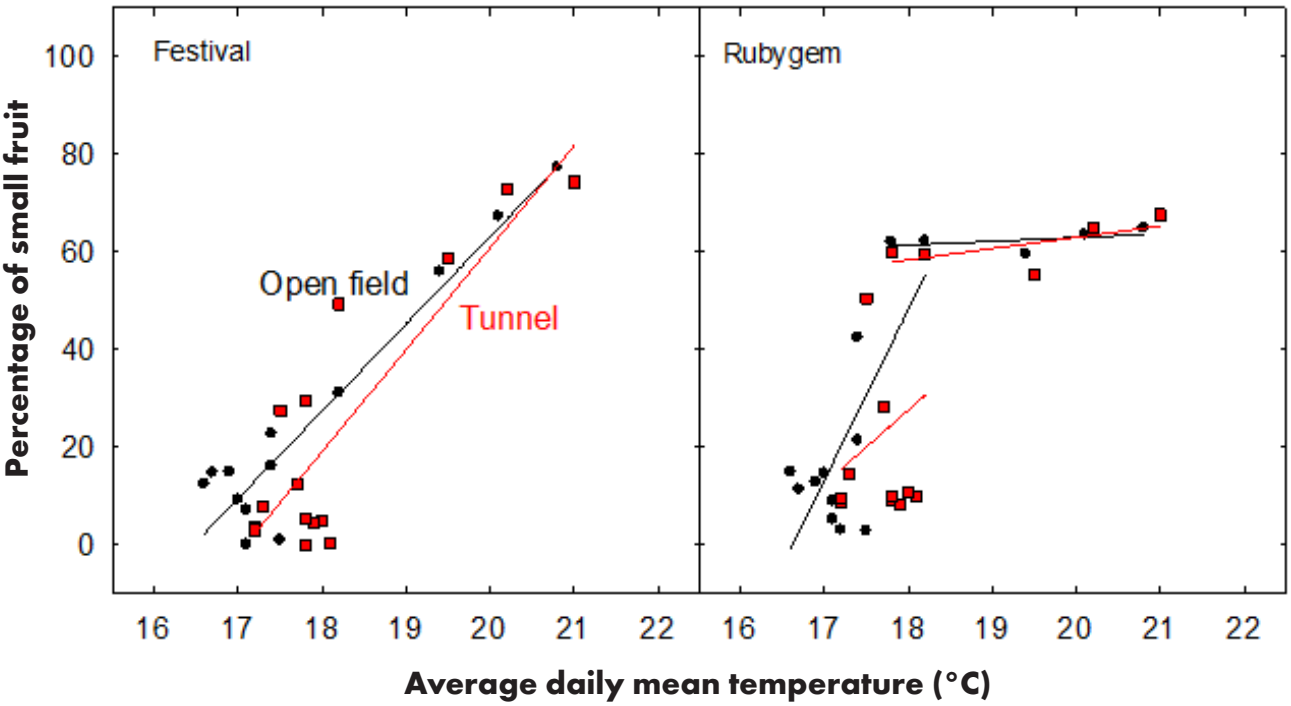

Figure 1. Relationship between the incidence of small fruit and the average daily mean temperature in the seven weeks before harvest in 'Festival' and 'Rubygem' strawberries in south-east Queensland. This period covered both flower and fruit development in the berries. The plants were grown in the open or under tunnels. Data are the means of four replicates per treatment.

Implications for commercial strawberry production

Temperatures before, during and after flowering affect fruit growth in strawberries. The results of the current study show that the incidence of small fruit in south-east Queensland was lower at 16°C to 18°C and higher at 18°C to 21°C. These findings are consistent with the results of the earlier study with 'Festival', where average fruit weight decreased by more than 50% as the temperature increased from 16°C to 20°C.

The plants under the tunnels had a similar incidence of small fruit as the plants in the open. This was because temperatures were similar in the two growing systems, with the sides of the tunnels raised to improve ventilation around the plants. In contrast, there were differences in the incidence of small fruit across the four cultivars. 'Festival' and 'Rubygem' had a higher percentage of small fruit than the two breeding lines.

Higher temperatures affect many aspects of plant development in strawberries. In most cultivars, there is a broad temperature optimum for flowering and a narrow optimum for average fruit weight. These results suggest that the changes in fruit size are likely to be larger than the changes in flowering under global warming.

Conclusions

The incidence of small fruit in strawberries increased over the season in south-east Queensland, and was higher in 'Festival' and 'Rubygem' than in the two breeding lines. The percentage of small fruit was higher when the average daily mean temperature in the seven weeks before harvest was 18°C to 21°C and lower when the temperature was 16°C to 18°C. None of the cultivars produced large berries at the end of the growing season. The effect of higher temperatures on fruit growth will contribute to lower yields under global warming. There is an urgent need to develop heat-tolerant cultivars or other mitigating strategies to reduce the impact of these changes on commercial strawberry production.

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