Impact of climate change on the yields of strawberry fields on the Sunshine Coast

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Global climate change is expected to increase both temperature and the concentration of CO_2 (carbon dioxide) in the atmosphere. These changes will increase the rate of photosynthesis in the leaves of strawberries, however this increase will be off-set by decreases in flower and fruit development. Without better adapted cultivars or other mitigating strategies, the likely outcome is lower average productivity for farms in south-east Queensland in the future.

This article examines the impact of higher temperatures and CO_2 on photosynthesis, growth and the yield of strawberry plants growing on the Sunshine Coast.

Studies in several other crops suggests that yields will decrease under climate change in the absence of better cultivars or growing systems. For instance, research in hot pepper showed that higher temperatures (3.4°C above ambient) and a higher CO_2 concentration (540 ppm) increased plant growth, but decreased yield by up to 22% compared with standard conditions. Plant breeding can produce new more heat-tolerant cultivars and this can mitigate some of the negative impacts of climate change.

Effect of environmental conditions on photosynthesis in strawberry plants

Light, temperature and the concentration of CO_2 are the main environmental factors affecting the rate of photosynthesis in plants. Healthy strawberry leaves absorb 90% of the incoming solar radiation. Some of the incoming energy is lost in heating the plant and some is reflected back into the atmosphere. Overall, 75% of the energy is wasted and not used in photosynthesis. About 1.5% of the photosynthetically active radiation (PAR) is converted to dry matter through photosynthesis in strawberry plants. This is similar to many other crops.

In most plants, the rate of photosynthesis increases with increasing light levels up to a maximum value and then is stable, meaning higher light levels do not lead to further increases in photosynthesis. The reports for commercial strawberry suggest that photosynthesis is saturated at light levels equivalent to about 60% of full sunlight (Figure 1).

Several studies that have investigated the effect of temperature on the rate of photosynthesis in strawberry plants. The optimum temperature for photosynthesis per leaf area is about 27°C, although values do not differ greatly from 16o to 32°C (Figure 1).

The concentration of CO_2 in the atmosphere has a strong effect on photosynthesis in strawberries. The response to increasing concentrations of CO_2 depends on other factors, including light levels and temperature. In Korea, the rate of photosynthesis in commercial strawberry increased with increasing concentrations of CO_2 up to about 1400 ppm (Figure 1).

The natural concentration of CO_2 in the atmosphere at the moment is about 410 ppm. Plants can adjust to higher concentrations of CO_2 with the response by the leaves less dramatic after long-term exposure than after short-term exposure.

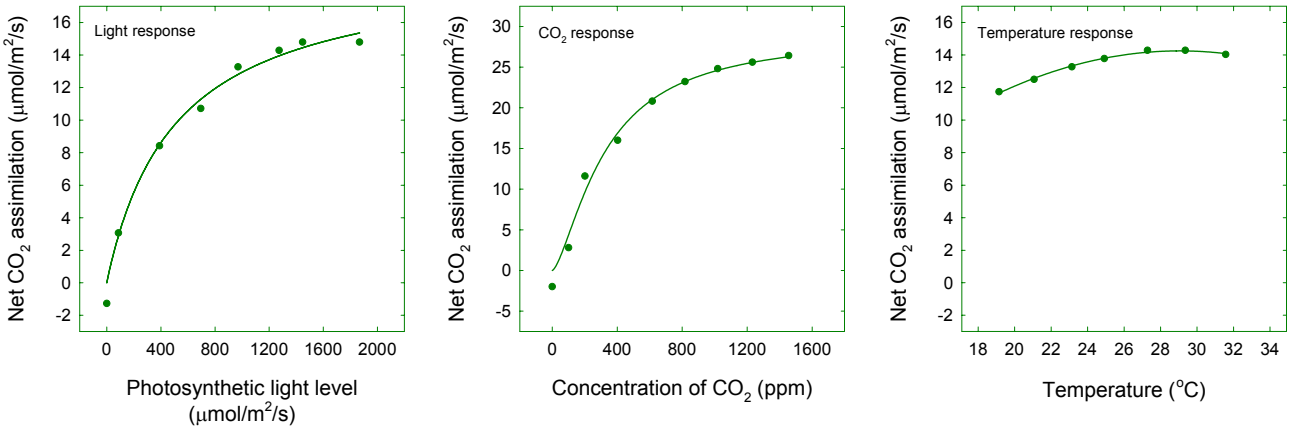

Figure 1.
Effect of light level, temperature and concentration of CO_2 on net CO_2 assimilation in strawberry plants in Korea. Photosynthesis was saturated at light levels equivalent to about 60% of full sunlight. The optimum temperature for photosynthesis was about 27°C, although values did not differ greatly from 18°C to 32°C. Photosynthesis increased with increasing concentrations of CO_2 up to about 1400 ppm. Overall, the responses to light and CO_2 are greater than the response to temperature. Data are from Jun et al. (2017).

Relationship between growth, yield & photosynthesis in strawberry plants

Researchers have examined the relationship between in plant growth, yield and photosynthesis in different strawberry species and cultivars.

In a study from northern America, clones of the local wild species had higher values of photosynthesis than clones of commercial strawberry. In a similar study in Canada, photosynthesis was up to 30% higher in strawberry species and hybrids than in commercial cultivars. Only a few authors have examined whether higher rates of photosynthesis can contribute to better growth or higher yields.

Korean researchers investigated the performance of strawberries under different light and temperature conditions in a greenhouse. They found that there was a strong correlation between yield and the rate of photosynthesis in the different treatments. The high-yielding plants tended to have higher rates of photosynthesis per leaf area.

In another study with seven cultivars of commercial strawberry in Maryland, United States, there was a moderate relationship between yield and the stability of net CO_2 assimilation. High-yielding cultivars had more stable photosynthesis than low-yielding cultivars across different growing conditions. Yield was not related to the absolute rate of photosynthesis.

Workers in Canada examined the relationship between plant growth and photosynthesis in different species, hybrids and commercial cultivars in growth chambers set at different temperatures. Overall, temperature had a greater effect on growth than on the rate of photosynthesis.

The results of this analysis suggests that in some cases, better growth or yield are related to higher rates of photosynthesis. However, in other cases better growth or yield are related to the stability of photosynthesis across different growing environments.

Response of strawberry plants to elevated CO_2

Numerous scientists have investigated the effect of elevated CO_2 concentrations on photosynthesis and yield in strawberry and other plants. There was a large variation in the response of strawberry to elevated CO_2. On average, higher concentrations of CO_2 increased photosynthesis by 100% and yield by 25%.

In one experiment in Belgium, increasing CO_2 from 250 or 350 ppm to 600 ppm increased photosynthesis by 9.9% and yield by 6.7%. These results reflect the response of plants to short-term increases in the concentrations of CO_2 and plants growing at optimum temperatures. The plants eventually adjust to the higher concentrations of CO_2, with a less dramatic response over longer periods. Temperature conditions outside the optimum for growth can also affect the response.

Response of strawberry plants to elevated temperatures

Temperature has a strong effect on the development of new leaves, flowers and fruit in strawberry plants. Higher temperatures will increase leaf area expansion initially, and then decrease leaf area expansion. Higher temperatures will reduce flower and fruit development. The overall response will be a decrease in yields.

The effect of temperature on the development of strawberry in subtropical environments has not been well explored. The available information suggests that the optimum temperature for leaf growth is about 25°C, while the optimum temperature for flower initiation is about 18°C. Experiments conducted in south-east Queensland indicated that average fruit fresh weight decreased from 24 g to 8 g as the average daily mean temperature in the seven weeks before harvest increased from 18°C to 20°C. The results of this analysis suggests that small increases in temperature will decrease the yield of strawberry plants on the Sunshine Coast.

Researchers in Korea provided some information on the response of strawberries to elevated temperatures and CO_2. Higher concentrations of CO_2 increased yields compared with control plants, but only under standard temperatures (Table 1).

Table 1.
Effect of elevated temperature and CO_2 (carbon dioxide) on the yield of strawberry plants growing in Korea. Data are from Sun et al. (2012).

Treatment	Control	Elevated CO_2	Elevated Temperature	Elevated CO_2 & Temperature
Temperatures	20°/15°C	20°/15°C	25°/20°C	25°/20°C
CO_2 concentration	360 ppm	720 ppm	360 ppm	720 ppm
Fruit d. wt. (g/plant)	10.8	24.8	13.1	11.7

The plants under higher temperatures or under higher temperatures and concentrations of CO_2 had similar yields as the controls. The plants growing under higher temperatures had fewer flowers than those under standard temperatures.

Scientists in Mexico examined the effect of higher temperatures on the performance of strawberries. The plants were grown at both ambient temperatures and 5°C above ambient. The plants under the higher temperatures had higher CO_2 assimilation and greater shoot growth than the plants under ambient temperatures. In contrast, the plants under higher temperatures had about half the flowers and fruit than those under ambient temperatures.

Similar work conducted in southern Australia indicated that elevated CO_2 (650 or 900 ppm versus 400 ppm) could not overcome the negative effect of elevated temperatures (30°C versus 25°C) on the yields of strawberry plants.

Implications for commercial strawberry production

Increases in temperature and the concentration of CO_2 will increase the rate of photosynthesis in the leaves of strawberry plants. However, the higher rates of CO_2 assimilation will be off-set by less flowering and smaller fruit. These changes in plant development will contribute to lower yields in the absence of better adapted cultivars or other mitigation strategies. The development of heat tolerant cultivars could mitigate some of the negative impacts of climate change on the productivity of strawberry fields on the Sunshine Coast.

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