Yield is strongly related to leaf area expansion in strawberries – implications for cropping under climate change

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This article examines the relationship between productivity and leaf area expansion in strawberry plants growing on the Sunshine Coast. In some crops, increasing leaf area under climate change (higher concentrations of CO_2 and temperatures) are associated with lower yields. Higher yields are found with decreasing, rather than increasing leaf areas. Plant breeding can produce new heat-tolerant cultivars with lower leaf areas and higher yields to mitigate some of the negative impacts of climate change.

Higher concentrations of CO_2 (carbon dioxide) and temperatures under climate change are likely to change the relationship between productivity and leaf area expansion in strawberries. Plant breeders can develop new heat-tolerant cultivars with a better balance between leaf and fruit growth.

Cultivars with excessive leaf areas will have lower yields than those with lower leaf areas under climate change. When there is too many leaves produced by a plant, the leaves at the top of the canopy shade the leaves and the bottom of the canopy. This reduces the amount of photosynthesis by the canopy. The extra leaves also compete with the fruit for the plant's resources.

Relationship between yield and leaf area in strawberries in south-east Queensland

An experiment was conducted to investigate the relationship between yield and leaf area expansion in strawberries in south-east Queensland. Leaf area expansion was assessed by measuring leaf area per plant and leaf area index (LAI).

Leaf area index is the one-sided area of the photosynthetic tissue or green leaf area per unit of ground surface area. It can be estimated manually by measuring the area of all the leaves on a plant and dividing this value by the area of the ground covered by the plant. A plant with a leaf area of 2.0 has a leaf area that can cover a given ground surface area two times.

For many crops, maximum light interception and yields occur with LAIs of 3.0 to 4.0, with lower light interception and yields with lower or high LAIs.

High LAIs are associated with dense canopies and low light levels at the base of the plants. Leaves at the top of the canopy have higher rates of photosynthesis than leaves at the bottom of the canopy.

Optimum LAIs are available for several important crops, and range from 1.5 to 5.0 for soybean, tomato, apple and mango and up to 7.0 to 11.0 for peach and orange. In soybean and maize (corn), average yields were best with a LAI of 4.0 and 10% lower with a LAI of 5.0 or greater. There is usually a closer relationship between yield and LAI than between yield and leaf area per plant. There is little information on the relationship between dry matter production or yield and LAI in strawberries.

What we did

Transplants of 'Festival' and 'Fortuna' strawberries were grown in the field at Nambour. One group of plants had half of their leaves removed in June (defoliated treatment), while the other group of plants was left intact (control treatment).

Data were collected on the changes in leaf area expansion, plant dry weight and marketable yield over the growing season. Fruit smaller than 12 g or misshaped, or affected by rain, disease or other defects were rejected as non-marketable.

What we found

The marketable yields of the defoliated plants were 28% lower (256 ± 9 g per plant) than the yields of the control plants (357 ± 12 g per plant). All aspects of leaf production and dry matter accumulation were also lower in the defoliated plants (Table 1).

There was a moderate linear relationship between cumulative yield and leaf area per plant over the growing season (R^2 = 0.50, $P < 0.001$) (Figure 1). Yield increased with increasing leaf area per plant.

In contrast, there was a weak linear relationship between cumulative yield and LAI (R2 = 0.09, $P < 0.001$) (Figure 1). Yield increased with increasing LAI, but the data were highly variable. This was possibly due to variations in the shape of the canopy in the different plants contributing to variations in LAI.

Figure 1. The Certification label on a box of strawberry runners

Table 1. Effect of defoliation on average seasonal plant growth in 'Festival' and 'Fortuna' strawberries.
The plants had zero or half of the mature leaves removed in mid-June. Data are the means of four replicates per treatment, pooled over six harvests. LAI is leaf area index.

TREATMENT	NO. OF LEAVES per plant	LEAF AREA (cm² per plant)	LAI	DRY WEIGHT (g per plant)		
				Leaves	Crowns	Roots
FESTIVAL						
Control	16.9	1,745	3.1	13.1	3.1	1.5
Moderate defoliation	12.6	1,161	2.6	8.6	2.3	1.2
FORTUNA						
Control	19.0	1,475	3.0	10.0	2.4	0.9
Moderate defoliation	14.6	1,000	2.5	6.9	1.9	0.7

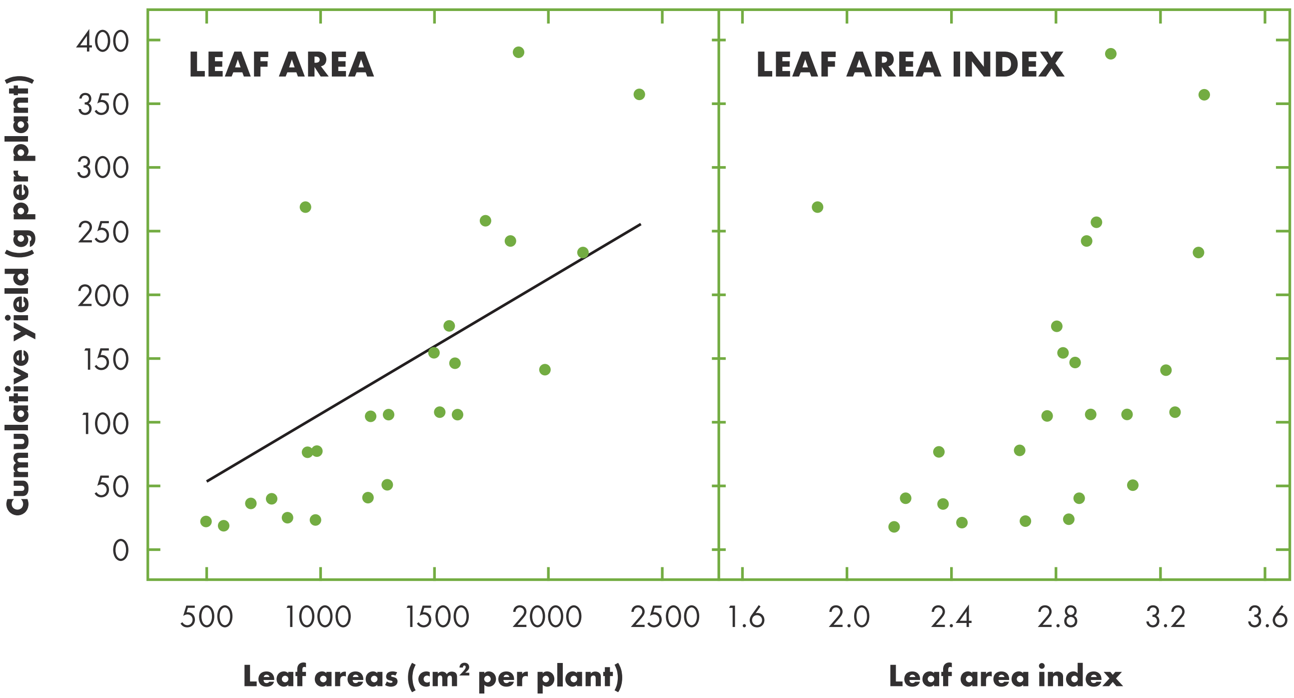

Figure 1. Relationship between cumulative marketable yield and leaf production in 'Festival' and 'Fortuna' strawberries in Nambour. The plants had zero or half of the mature leaves removed in mid-June. Data are the means of four replicates per treatment. Yield was more closely related to leaf area per plant than to LAI (leaf area index).

Implications for commercial strawberry producers

The results of this experiment indicate that yield was related to leaf area production. Yield continued to increase with increasing leaf area expansion.

There was no evidence of excessive leaf production for cropping. This may change in the long-term, with higher concentrations of CO2 and temperatures expected to increase leaf production in strawberries.

In the short-term, the main effect of climate change will be to decrease flower production and fruit size. Both these responses will result in lower yields in the absence of heat-tolerant cultivars or other mitigating strategies.

Plant breeders producing new cultivars should ensure that excessive leaf growth does not come at the expense of flower and fruit development. Overall, there was a closer relationship between yield and leaf area per plant than between yield and leaf area index (LAI). LAI was highly variable within a treatment.

Dr Christopher Menzel is a Principal Horticulturist for DAF and has conducted research for the strawberry industry in Australia for the past 15 years. He has more than 35 years of experience in tropical horticulture, including strawberries.

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