How Much Light Is Too Much?

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Light is essential for growth in berry crops. As light increases, so does growth and yields. There comes a point, though, where increases in light levels have the opposite effect, where they decrease or stop growth and reduce yields and fruit size. This turning point is influenced by genetics and environmental conditions such as air temperature, CO_2 concentrations, and water and nutrient availability.

Higher CO_2 concentrations, cooler air temperatures, and optimal water and nutrient availability increase the amount of light that plants can utilise and tolerate. Berry crops typically have low light saturation points compared to other commercial horticultural crops.

Light saturation point

Plants are good at adapting to changing light levels. Berry crops respond to light in a way that is typical of 'C3-type' plants (Figure 1). As days become sunnier in spring, they make changes in their leaves to utilise the increasingly available light. As light levels increase, a point is reached where it stops being the limiting factor for growth. This is called light saturation point. At this point, plants reach maximum photosynthetic capacity. Increases in light intensity beyond this can lead to more energy being absorbed by the leaves than can be used and this leads to stress.

Plants avoid stress by shedding excess light energy captured in their cells as heat. When light stress becomes unavoidable, as temperatures increase and leaves can no longer shed excess energy as heat, they tolerate stress by concentrating damage in leaf proteins. Damaged proteins can be replaced, however, when light intensity is extremely high, damage becomes irreversible.

Light saturation points for berry crops are generally low (less than 1000 µmol.m^2.s) compared to other commercial horticultural crops. This means that berries are more prone to stress, damage and yield penalties at higher light intensities. Figure 2 shows radiation intensity over a typical day in February on a Victorian berry farm. Light levels recorded that day exceeded 1000 µmol.m^2.s (which equates to around 500 W/m^2) from 9am to 6pm. Shade screening for at least part of this period will have been beneficial to the crop, particularly where temperatures were above 25-30^{o}C.

- Light saturation point is measured in micro moles per metre squared per second (µmol.m2.s) and is a measure of radiation intensity over the Photosynthetically Active Range (PAR 400 – 700nm)
- PAR light makes up approximately 45% of the total light spectrum
- The PRIVA light sensor used in Figure 2 measures radiation intensity over the entire light spectrum (300 – 3000nm) in Watts/m2, so the 1,300 W/m^2 peak seen in at 1.30pm equates to approximately 585 Watts/m^2 PAR
- 1 Watt/m^2 equals approximately 4.57 µmol.m^2.s (Thimijan & Heins, 1983)
- The peak light intensity at 1.30pm is therefore approximately 2,673 µmol.m^2.s (585 x 4.57), much higher than the expected light saturation point of berries. Temperatures at this time of day are also often outside the optimum range which limits the plant's ability to shed excess light as heat

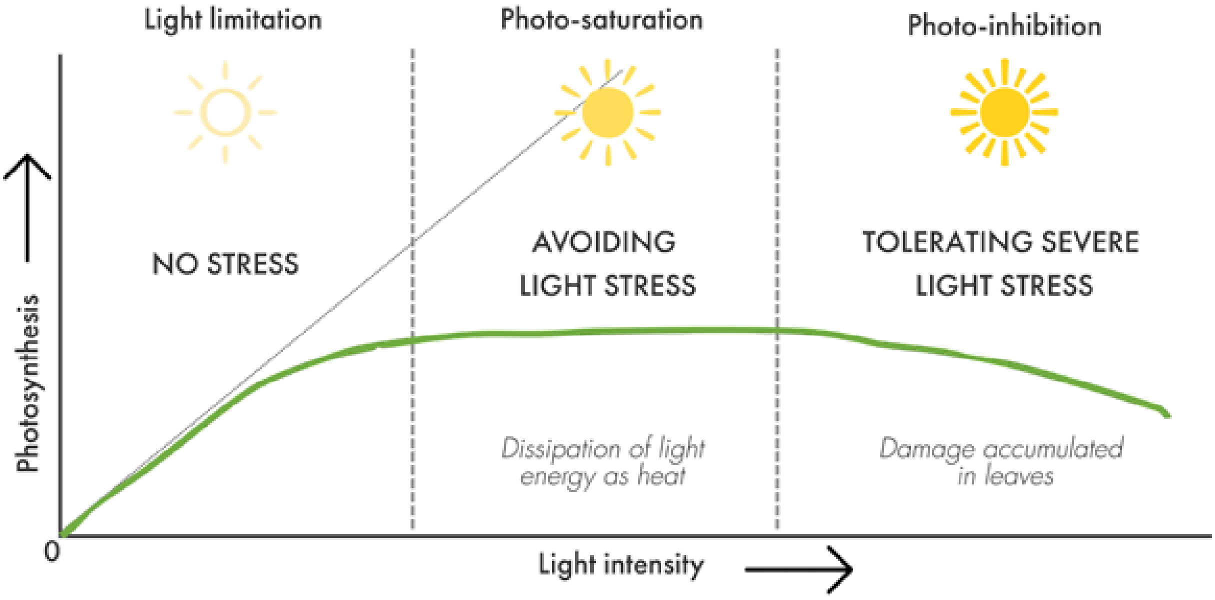


Figure 1. Light response curve and how typical C3-type plants avoid and tolerate light stress
Adapted from Yamamoto (2016)

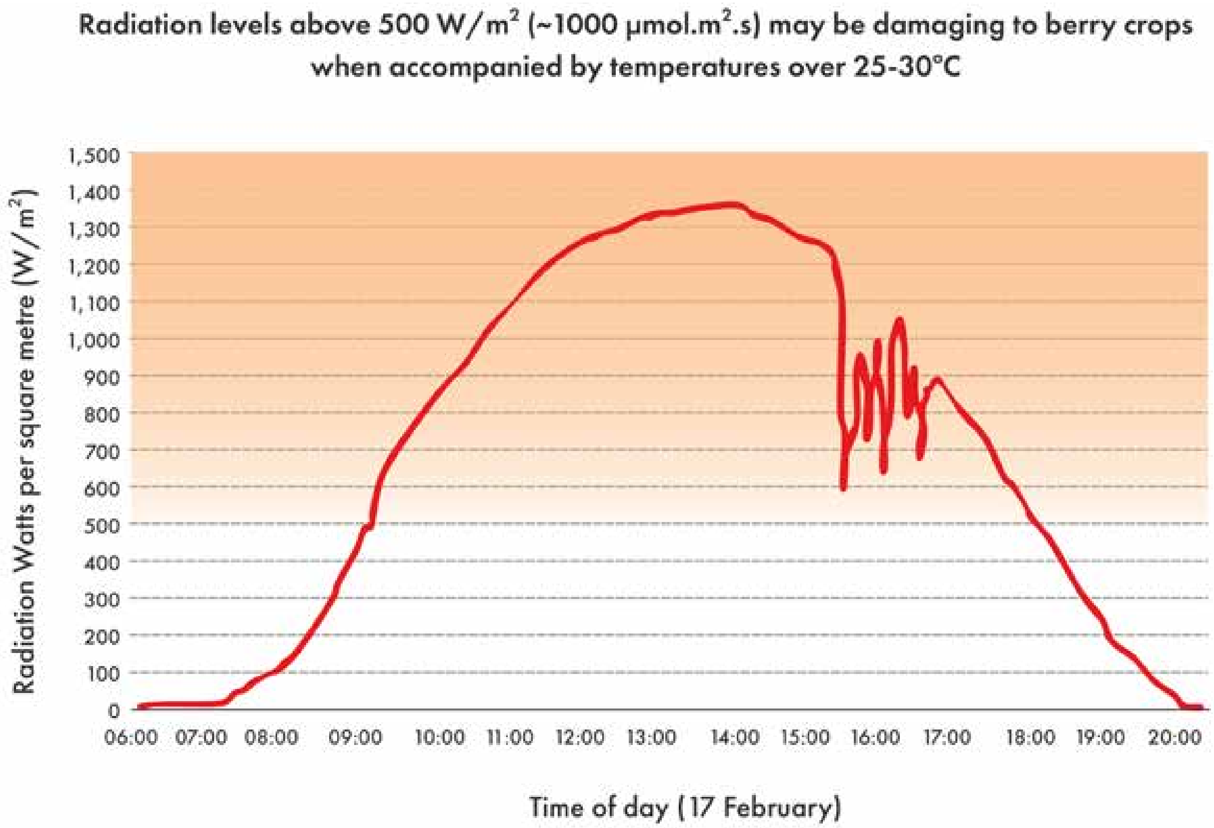


Figure 2. Outdoor radiation levels recorded by a PRIVA light sensor on a sunny February day in Victoria. Readings are in Watts per square metre (W/m2). Passing clouds created the sharp dips seen in the afternoon.

Although light has a clear link to photosynthesis, other factors such as CO_2 levels, temperature, and nutrition also affect photosynthesis and influence the light saturation point. Higher light saturation points can be achieved in CO_2-enriched environments and/or in controlled environments where cooler temperatures are maintained. Like light response, berry plant responses to these factors vary depending on the crop growth stage.

Temperature response is interesting to consider alongside light response, as they are closely related and can both be manipulated (to some extent) by shading. Figure 3a shows the general temperature response curve for C3-type plants. Figure 3b shows an example of how optimum temperatures for photosynthesis shift with the crop cycle. In this example, optimum growing temperatures for northern highbush blueberry '*Duke*' varied between 25 and 28°C. Studies on strawberries suggest that the optimum temperatures for most Australian-grown cultivars vary between 20 to 25°C (Menzel, 2023; Menzel, 2024ab).

Berry light response curves

Light response curves found in research papers from around the world are presented here. Results from studies that tested light response under ambient CO_2 concentrations (~350-400 umol.mol-1) or close to ambient are shown as they better reflect outdoor growing conditions. Care must be taken when interpreting these curves as temperature and humidity conditions during the testing may not reflect your growing situation.

Strawberries

Studies in the 1980s suggested that light saturation points for strawberries ranged from 800-1000 µmol.m^2.s. More recent studies in controlled environments have seen light saturation points as high as 2000 µmol.m^2.s under ambient CO_2 levels and maximum temperatures up to or less than 25°C. Figure 4 shows examples of light response curves recorded in a range of these studies.

NOTE: In the field, where it is difficult to maintain optimum temperatures (particularly in warmer climates), lower, more pronounced light saturation points would be expected as plants are less able to dissipate excess light as heat.

Blueberries

Light response curves in most of the studies of blueberries I was able to find suggest that light saturation is reached somewhere between 400 to 600 µmol.m^2.s. These studies were conducted in a variety of growing conditions but tested light response at maximum temperatures of 25ºC or less. Figure 5 shows examples of blueberry light response curves recorded in a range of these studies.

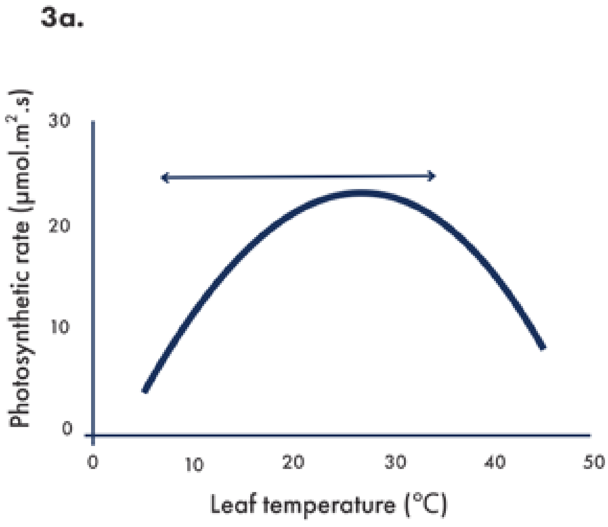
Figure 6 shows results from a study yet to be published that was conducted on northern highbush blueberries by Michigan State University. This study measured light response at different growth stages and found that there was very little difference (not statistically significant) between light response during flowering and fruiting. Interestingly, light saturation points closer to 1000 µmol.m^2.s were recorded in this study. More details on this study can be found in this webinar presented by Dr Josh Vander Weide: https://youtu.be/8xcM96HMq7k?si=X32WgbnM6FGvMjKQ

Blackberries

Light response studies in Rubus were a little tricky to locate. Figure 7 presents the results of research undertaken in a 5-year-old variety trial of blackberry plants located at the Musser Fruit Research Center in South Carolina. Plants were ground-grown with in-row white plastic mulch. Average humidity during the trial period ranged from 53 to 96%, and maximum temperatures ranged from 27.5 to 28.9°C. The study found that the photosynthetic response of the floricane leaves varied between varieties and growth stages, with light saturation points ranging from 661 to 1613 µmol.m^2.s.

Closing Comments

While there is quite a bit of variation in light saturation points between studies, it can be said that light levels received by berry crops across Australia frequently exceed saturation point. Solar radiation peaks in late December each year (around the summer solstice) and at midday each day, however ambient temperatures do not follow the same pattern. A *link to examples of this are provided at the end of this article*. When planning, it is useful to look at the interaction between solar radiation and temperature patterns to identify when plants are unable to shed excess light as heat (i.e when radiation levels are above saturation point and temperatures are higher than optimal (25-30°C)). This can help you to determine the optimal timing and placement (e.g. at what sun angle) of shade treatments for your crop.



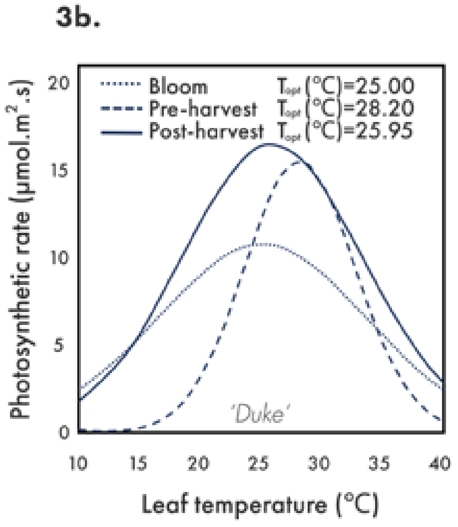


Figure 3a. Temperature response curve of typical C3-type plants (Yamori et al., 2014)
Figure 3b. Temperature response curves of Duke blueberries growing in Michigan (USA) during flowering, pre-harvest and post-harvest (Rett-Cadman & Weide, unpublished)

Example strawberry light response curves

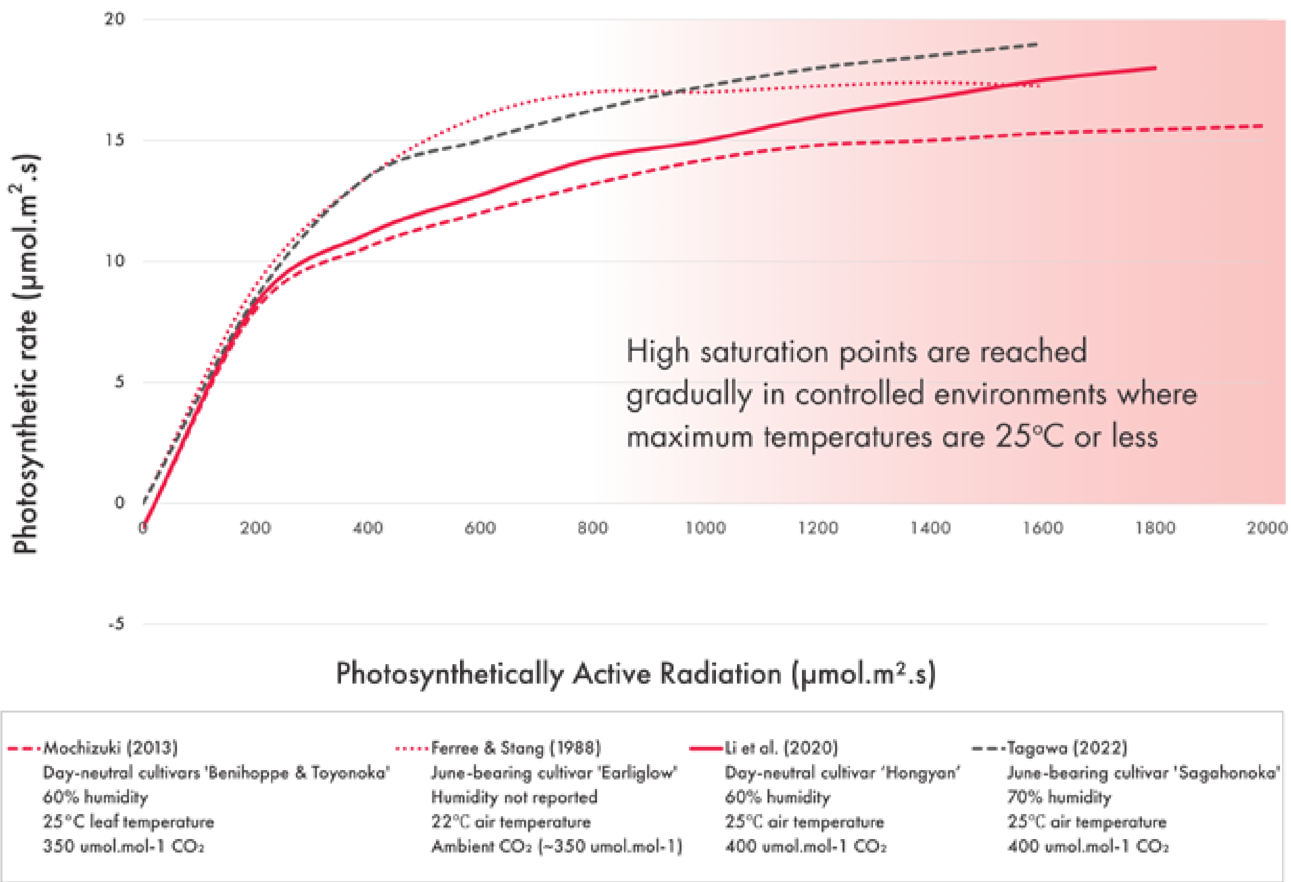


Figure 4. Strawberry light response curve examples

Example blueberry light response curves

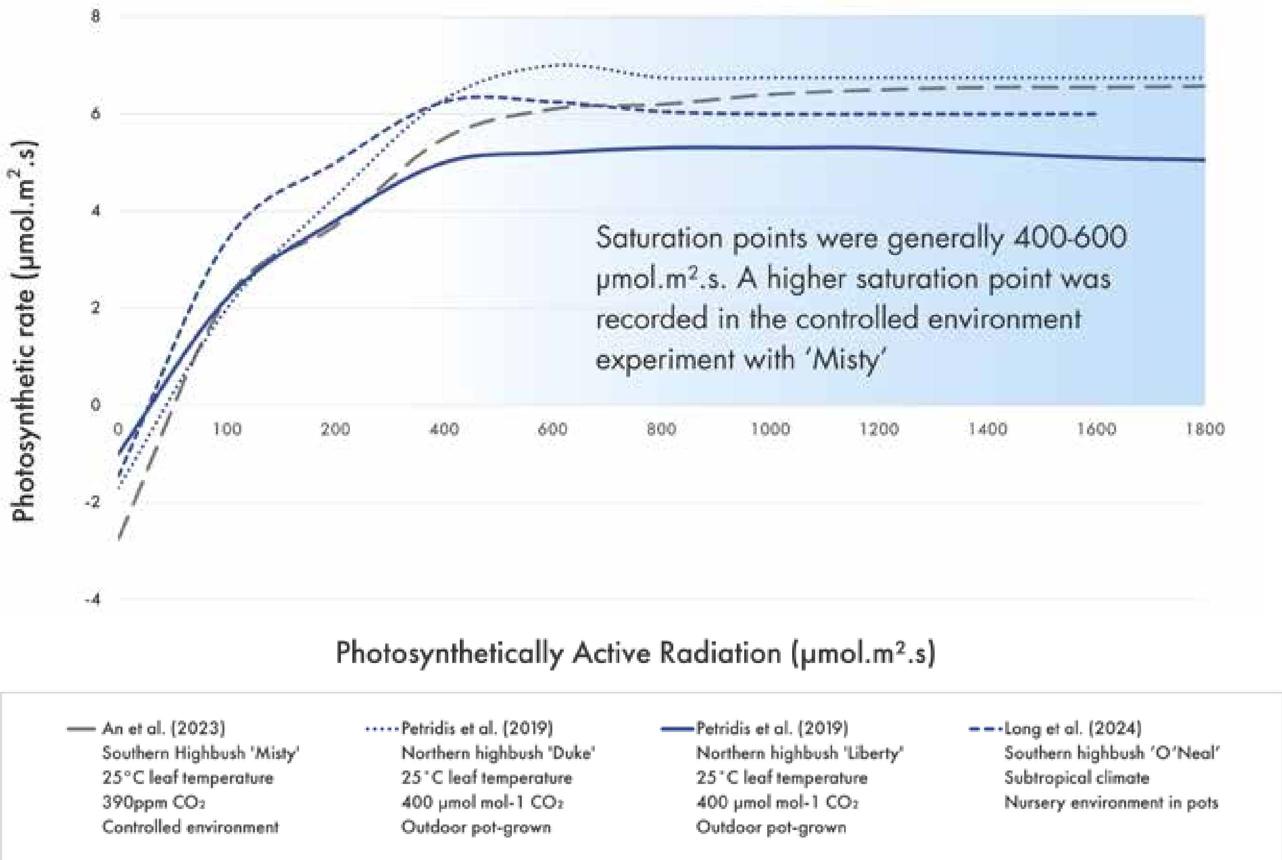


Figure 5. Blueberry light response curve examples

Light response curves of field-grown 'Bluecrop' northern-highbush blueberries at different growth stages

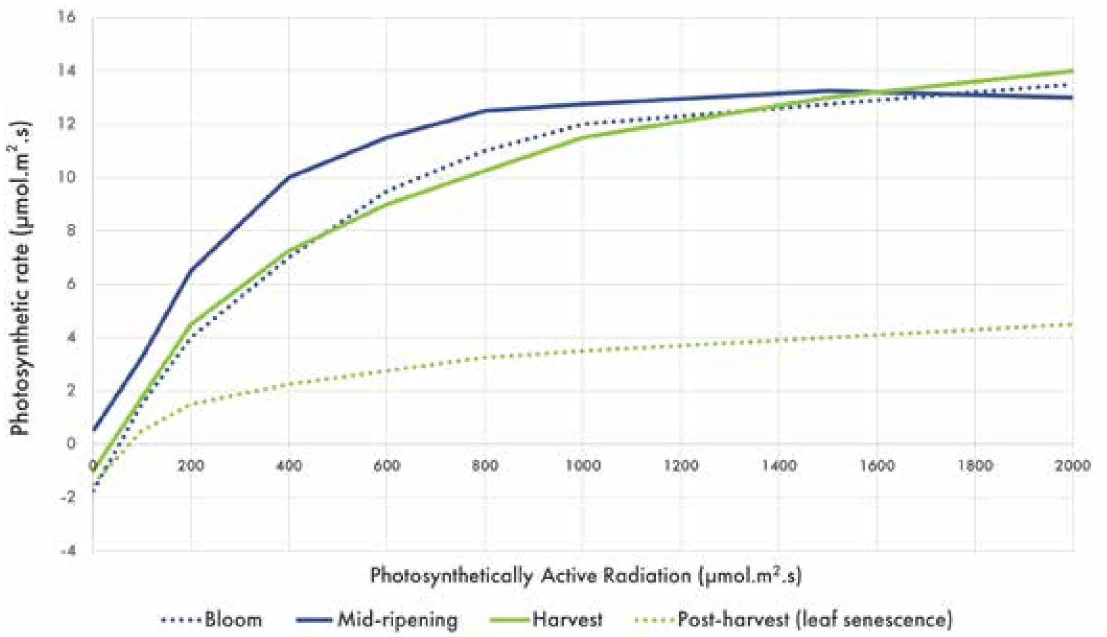


Figure 6. Light response of northern highbush 'Bluecrop' blueberries grown in an open field (2023 & 2024) with black weed mat ground cover in Fennville, Michigan, USA (cool climate with winter snow)
Source: Li & Weide, unpublished

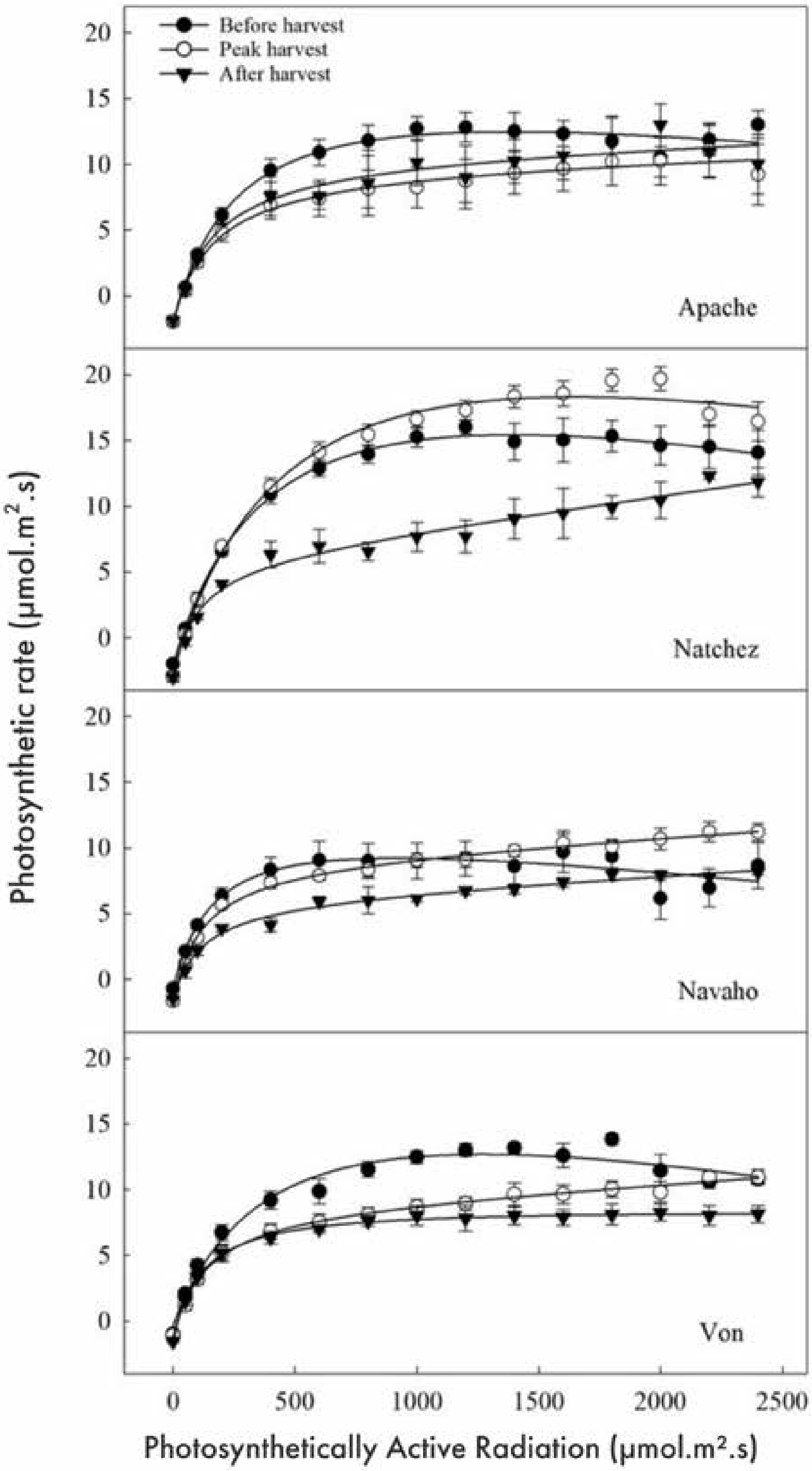


Figure 7. Light response of four commercial blackberry cultivars (Apache, Natchez, Navaho, and Von) before harvest (solid circles), at peak harvest (open circles), and after harvest (solid triangles) Source: Lykins et al., 2021.

Read about berry shading options in the Autumn 2025 edition on PAGES 42–50 'Strategies to keep plants comfortable when it's hot' at bit.ly/ABJ-Hot-Plants or scan the QR Code

To see more example daily radiation patterns recorded in Muchea in WA, download this PDF from the Resource Library at bit.ly/ABJ-Radiation-WA or scan the QR Code

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