Measurement of Light Interception by Crops under Solar Panels using PARbars

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1. Introduction

In agrivoltaics systems, sunlight is used both by solar panels for electricity production and by crops for production of plant products. There can be synergy in the combination of crops with solar panels, e.g. when adverse conditions are relieved by the presence of the panels, but often there will be a trade-off between electricity yield and crop yield. To explore these synergies and trade-offs and to design best fitted agrivoltaics systems for specified conditions, two types of models can be combined that 1) describe radiation interception and electricity production by the solar panels and 2) describe crop production under the remaining light [1].

Crop growth and crop yield are determined by the amount of light that is intercepted by the canopy and used for photosynthesis. Light interception is therefore an important part of crop growth models [2]. Crops may adapt to shading by increasing stem elongation and reducing leaf thickness in order to intercept a larger fraction of incoming radiation. Knowledge of these crop responses to shading is needed and can be gained by actual measurements on crops growing at different light levels. In addition to (non) destructive measurements such as stem length, specific leaf area (cm^2/g dry matter), total leaf area and biomass of various plant organs, light interception by the crop can be measured. This paper describes a system that is applied in the Sunbiose project [www.sunbiose.nl] for continuous measurement of light interception by row crops under solar panels. This system uses long bars containing multiple light sensors to measure light over the entire width of the agrivoltaics system, both above the crop (but below the solar panels) and below the crop. Continuous measurement allows analysis of variation over time.

2. Materials and methods

Linear arrays of light sensors were built according to instructions by [3]. Light sensors measuring photo-synthetically active radiation (PAR; 390-700 nm) were placed 5 cm apart in 1.5 m long aluminum bars (PARbars). The sensors were connected in serial, giving one signal per PARbar that was recorded by a data logger.

A carrying construction was designed to install the PARbars at two heights: 1) above the crop, below the solar panels, and 2) below the crop (Fig. 1). The lower PARbar construction allowed for turning away the PARbar from the alley when machinery needed to pass (Fig. 2).

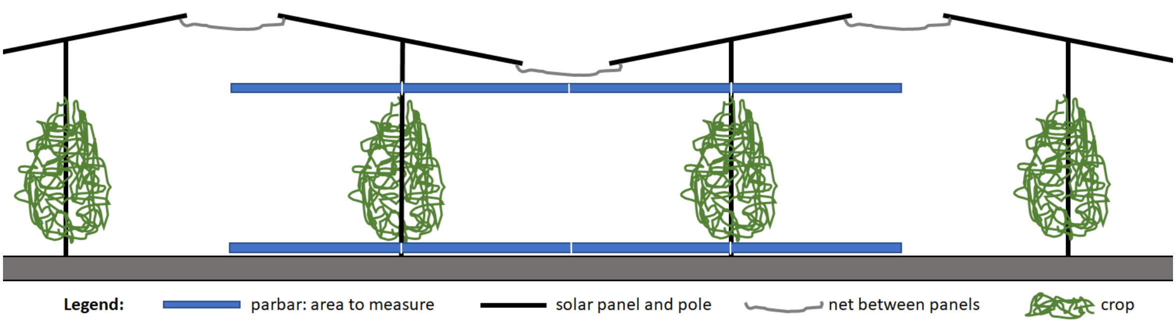

Fig. 1. Schematic representation of PARbar locations in raspberry agrivoltaics

3. Results

PARbars were installed in spring 2022 in the agrivoltaics systems with raspberries and strawberries (Fig. 2). Results for a single fully sunny day for raspberry under plastic foil are given in Fig. 3. The foil absorbed almost 40% of incoming light and the strongest light interception by the crop could be observed at the west side of the row in the morning, and the east side in the afternoon.

Light interception as measured with the PARbars will be compared with measurements of leaf area, and the integral of light interception over the season will be compared with crop biomass production and yield.

Fig. 2. Left: PARbars above and below raspberry in agrivoltaics. Middle: raspberry control under plastic. The lower PARbar is in temporal position parallel to the row for traffic to pass. Right: strawberry.

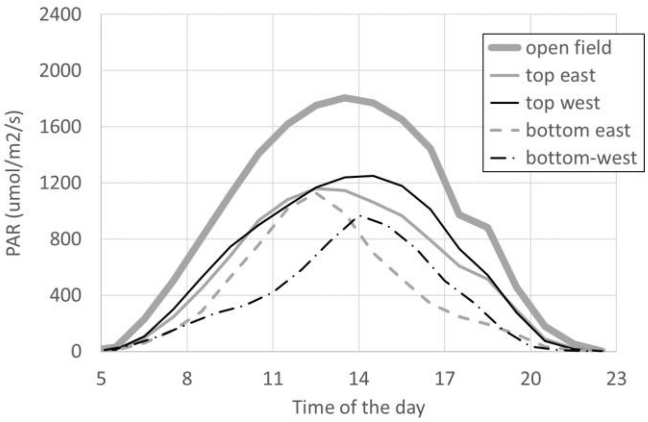

Fig. 3: PAR measured on a fully sunny day (June 15) in the raspberry control under plastic with four PARbars: above and below the crop, both east and west of the plant row.

Acknowledgement

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References

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