Crop Response to Agrivoltaics in Soft Fruit Production

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1. Introduction

Modern soft fruit production systems have several characteristics that make them potentially suitable for integration into agrivoltaics (APV). Cultivation takes place in rows that are in a fixed position over multiple years and the machines used are small, allowing APV constructions to be relatively low and rows to be close together. The crops are often protected from rain, hail or excessive solar radiation by plastic covers or nets, and water and fertilizer are supplied via drip irrigation. In addition, many fruit cultivations systems have some sort of crop support system. If the solar panels provide a protective function comparable to the one offered by plastic or netting, and/or if the support structure can support the crop as well, this makes a dual use that reduces overall costs [1, 2].

Here we report on the effects of APV on raspberry and strawberry crops in the Netherlands. For raspberry, we compared a conventional commercial production system under plastic rain cover with a commercial-scale system with solar panels as rain protection [3]. Strawberries were grown under small-scale experimental APV systems with two different transparencies, as compared to an uncovered reference crop.

2. Material and methods

The studies were conducted at two commercial soft fruit farms in Babberich (51°54' N, raspberry) and Boekel (51°36' N, strawberry), the Netherlands, in 2021 (Figure 1).

Raspberry. Cool stored long canes cv. Lagorai (grown in a conventional system in the previous year) were planted in the week of 14 June 2021 for berry production (two canes per pot, two pots per running meter) in each of the two systems.

- The 3.2-hectare APV system had rows of interconnected panels 2 m wide above each plant row; 60% of the glass-glass panel surface consisted of solar cells. Rows of panels were alternately tilted to the east or west, distance between panel rows was 0.64 m.
- The reference system had a plastic cover suspended above the individual rows on a wooden support system, with shade netting suspended above the grass alleyway.

In both systems, the rainwater drained into the alleyway. Harvest period was from the end of August to the end of September.

Strawberry. Cool stored plants cv. Elsanta were planted at three moments in April and May in an elevated gutter system, creating a continuous harvesting period from the beginning of June to mid-September. Three treatments were created at each of the three planting times. The APV plots (of 168 m^2 each) had rows of interconnected glass panels 1 m wide above each plant row. The glass panels had 60% (APV1) or 75% (APV2) of the surface consisting of solar cells. Panels were tilted towards the south and distance between panel rows was 0.42 m. The reference system had no cover.

Observations were done on microclimate, light availability (measured at various points along transects perpendicular to rows), crop development, evapotranspiration, leaf characteristics, final crop dry weight, fruit production and quality, and presence of pest and diseases.

Fig. 1: Large-scale cultivation of raspberry under APV in Babberich, the Netherlands (left) and experimental APV installations in a commercial strawberry farm in Boekel, the Netherlands (right).

3. Results

Preliminary measurements showed that for raspberry the PAR light availability was circa 42% of full daylight in the APV system and 58% in the reference system, although spatial and temporal variation was large. For strawberry, PAR light was circa 50% (APV1) and 37% (APV2) of full daylight.

In raspberry, less light in the APV system led to a 57% increase of the specific leaf area and ultimately to a 35% increase of total leaf area per plant compared to the reference. Total aboveground and belowground vegetative dry matter after harvest was 12% lower in APV, and total (fresh weight) fruit production was 5% lower. Fruits from APV had less sugar, with differences up to 1.5 °Brix at some sample dates, and a slightly lower dry matter content, but commercial quality was satisfactory.

The strawberry crops reacted differently to the reduction of light. Even though the specific leaf area increased with decreasing PAR, the total leaf area per plant was 19% (APV1) and 39% (APV2) smaller than in the reference. This sharp reduction in leaf area resulted in a 41% (APV1) to 57% (APV2) reduction in total vegetative dry matter for plants planted in May. Fruit production (fresh weight) for the different plantings was reduced with 23-25% (APV1) to 27-40% (APV2).

4. Conclusion and outlook

Our measurements on raspberry cultivation under APV show that the use of solar panels instead of a conventional plastic cover had only a minor effect on yield (5%) even at middle latitude (~51°N) regions. Further optimization seems possible through an earlier planting time, so that the crop grows in the most light-rich period of the season. Strawberries need more light than was provided in the current setup. Adjustment of the system by either increasing the transparency of the panels or by increasing the distance between the rows is necessary.

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References

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