Agrivoltaic poly tunnels with semi-transparent organic PV modules

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1. Introduction

Greenhouse roofs represent areas of untapped potential ready for PV integration. This application is of particular interest, as the PV energy produced can be directly used for the agricultural purposes inside the greenhouse, allowing net positive commercial activities. As greenhouse energy usage profiles can be highest during the daytime, PV production fit well to self-usage in irrigation for example. Furthermore, agricultural trends have shown the need for crop protection systems to mitigate effects of extreme weather conditions like storm, hail, or drought, which have been occurring at tremendously higher frequencies as a result of climate change. As crop protection measures spread in the agricultural domain, so too will the available area for integrated PV infrastructure. Tapping this potential could address societal problems such as land-use conflict, the decarbonization of the agricultural sector and result in increased food security. The key limitation of this technology is that PV-integrated greenhouses present a complex light management challenge whereby sunlight that is utilized for energy production does not reach plants to support photosynthesis. Systems must be designed around light-sharing concepts to achieve maximal synergistic usage, and this work presents semi-transparent PV use cases to find solutions to this fundamental problem.

2. Content

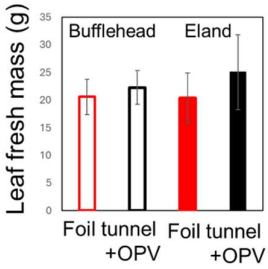
2.1. Plant response in OPV foil tunnel systems

We demonstrate the integration of semi-transparent photovoltaic modules with organic absorber layers (OPV) in foil tunnel greenhouse facilities to combine efficient crop growth and renewable electricity generation in parallel. Figure 1 shows two application possibilities, where OPV modules are integrated in foil tunnel systems. One research system (top) and one commercial system (bottom), wherein we perform our plant growth studies. Figure 2 shows results of spinach and raspberries grown in these OPV poly tunnels. In our contribution we present different integration methods of OPV modules in various poly tunnel systems (e.g. on our research campus, in commercial farms in Germany and in hot climate conditions in Portugal). In addition, we present plant measurements data of crops grown in the OPV poly tunnels compared with reference systems without OPV, like the example in figure 2.





Figure 1 – Integration of OPV modules in experimental poly tunnel with spinach (top) and in a commercial raspberry farm (bottom)



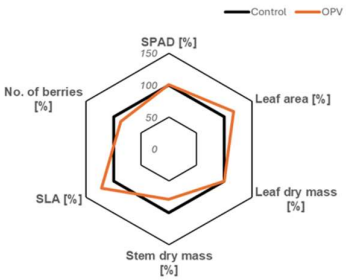


Figure 2 – **Top**: leaf fresh mass of two spinach varieties (Bufflehead and Eland) grown in poly tunnels with OPV (black) and without OPV (red).
Bottom: plant parameters measured in polytunnel systems with OPV (orange) and without OPV (black): chlorophyll content (SPAD), leaf area, leaf dry mass, stem dry mass, specific leaf area (SLA) and number of berries.

2.2. Energy Generation and Agricultural Productivity

A considerable number of poly tunnel greenhouses can be found in Spain and Italy [1], where the levels of irradiation are notably high. This aspect renders the region a compelling subject for a case study. As an emerging PV technology, OPV possesses the potential to compete with conventional silicon flexible modules in terms of commercial viability. This is attributable to its ease of deployment and its projected low costs and increased efficiency. Nevertheless, the issue of long-term stability remains a crucial problem to be addressed. Crops cultivated in polytunnels are of significant importance regarding overall profitability, due to their relatively high market value. It is evident that yield changes induced by shading have a considerable impact on the economic performance of the PV concept. The profitability of Poly tunnels is contingent on a number of factors, as they are primarily utilized to satisfy low levels of self-consumption [2]. The self-consumption level and the projected economic shading effect are the most significant drivers of profitability, which will be demonstrated in our presentation in detail.

4.2. References

1. Kierdorf, C., Lubjuhn, S., Meier-Grüll, M., & Venghaus, S. (2025). Organic Photovoltaics in European Greenhouses – Advancing self-sufficiency and the energy transition. (Preprint). https://doi.org/10.2139/ssrn.5705202

2. Aroca-Delgado, R., Pérez-Alonso, J., Callejón-Ferre, Á.-J., & Díaz-Pérez, M. (2019). Morphology, yield and quality of greenhouse tomato cultivation with flexible photovoltaic rooftop panels (Almería-Spain). *Scientia Horticulturae*, *257*, 108768. https://doi.org/https://doi.org/10.1016/j.scienta.2019.108768