Plum Response to Partial Shading by Simulated Agro-Voltaic Panels

Moshe Meron[1], Uri Marchaim[2], Joseph Tsipris[2], Niva Shaked[2] and Valerie Levin-Orlov[2],

[1]Head, Crop Ecology Laboratory, MIGAL Galilee Research Institute, P.O.Box 831, Kiryat Shmona 1101600, Israel.
Phone +972-50-5764086, mail: meron@migal.org.il

[2]MIGAL Galilee Research Institute, P.O.Box 831, Kiryat Shmona 1101600, Israel

Introduction:

Turning wasted sun-radiating energy not assimilated by photosynthesis to electric power by photovoltaic panels (PV) creates steady additional income for the grower and releases land area for the investor close to the end user. The partial sky cover may provide additional benefits, like crop protection and reduced energy input for evapotranspiration (ET). A basic condition for the success of the new method is minimal or at least bearable damage to yields and incomes from the crop. The aim of the study was to evaluate the main factors effecting the crop under partial shading of the PV panels and the outcomes.

Materials and methods

At the Ayelet Hashahar plum orchard (33.021N, 35.605E) in a small experimental plot 2.1 meter wide PV were installed above the midrow of 4.25 m width, between 0.5-0.7 m wide and 2.5 m tall trees, along a 30 m section of the row. For bureaucratic reasons, the panels were dismounted but subsequently replaced with tarps, to enable monitoring the shading effects of PV implementation. The crop was Japanese plums cv. *Silver-red*, 4th season from planting, irrigated with single line, 0.5 m spaced Naan “Adi” 2.2 l/h drippers, common to both sections, applying the same timing and amounts of water to the fully sunlit (“**Sunlit**”) or partiallt shaded (“**Paneled**”) row sections. (Figure 1.) A complete meteorological station was placed in the plot to follw climatic conditis, and additional instrumentation was deployed along the season to monitor 3 stations in each section, 3 trees in each, 18 trees in total:

- Fruit growth rate ; * Stem water potential; * Soil water conent at 0.3 m and 0.7 m depths; * End season wetted soil volume; * Prune weight; * Yield and quality.

Results and discussion:

Water use of the **Paneled** sections was considerably lower than the **Sunlit** as is documented in soil water content: (Figure 2.) and end season wetted volume measurements. Excessive watering resulted also significantly higher water potential in the paneled section (Figure 3.) and intensive vegetative growth as demonstrated in visual observations, aerial mapping and prune weight.

Fruit set was delayed by two weeks, but fruit growth catch up along the season (Figure 4.). Nightly obstruction of skies by the PV simulation to outgoing radiation, and restriction of cold air to settle down through the midrow cover might cause reduced chilling units and late fruit set.

Yield loss of 38% was observed, however it is inconclusive, as fruit size was similar between the treatments, and the difference was in fruit numbers, dating back to the fruit set period. Fruit quality, even the fruit was protected from direct sun, did not compensate for yield loss.

Analysis of the sun angles relative to the setup of PV midrow between thin “wall” type rows brings up the question whether the straightforward logic of utilizing the clear sky part of the field is the right setup after all. (Figures 5. and 6.)

Conclusions:

First conclusion is the obvious: To separate irrigation of PV partially covered crop from the crop in full sun, and schedule each by the real water requirement, to be determined in future research. Secondarily we have to find ways to reach adequate chilling units in marginally cold winters. Optimization of the PV setup and crop shape designs need revision and in depth analysis. It must take chilling units in consideration.

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Figure 1. Partially covered section (front) and sunlit section (back) of simulated PV effects monitoring, Ayelet Hashahar 2021.

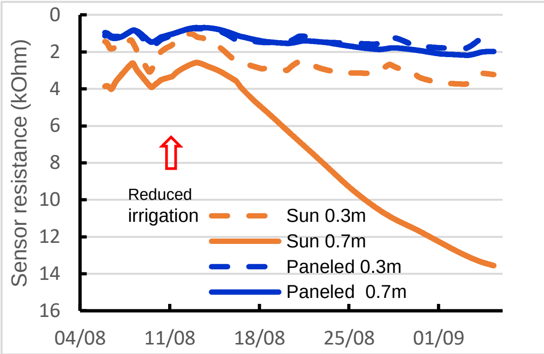

Figure 2. Soil water content of sunlit and paneled sections in 0.3 and 0.7 m depths in simulated PV effects monitoring, Ayelet Hashahar 2021

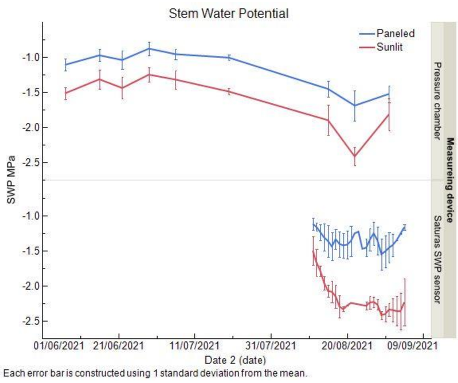

Figure 3. Stem water potential of sunlit and paneled sections measured with pressure chamber (top) and embedded electronic (Saturas) sensors (bottom).

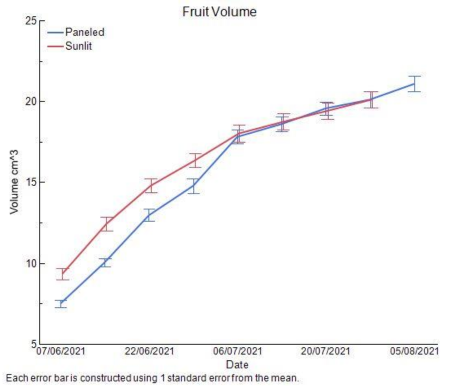

Figure 4. Fruit growth progress with time in sunlit and paneled sections, in simulated PV effects monitoring, Ayelet Hashahar 2021

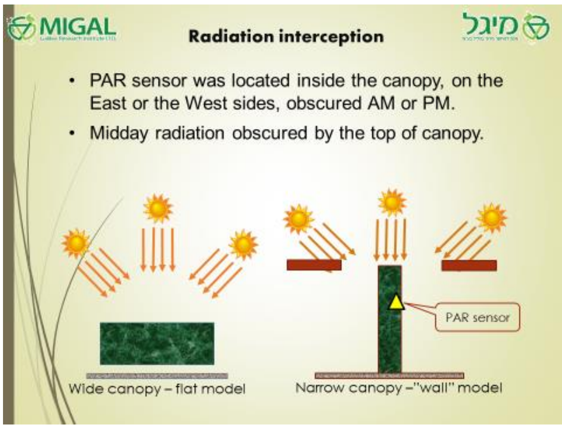

Figure 5. Schematic representation of PV setup in midrow - narrow canopy configuration.

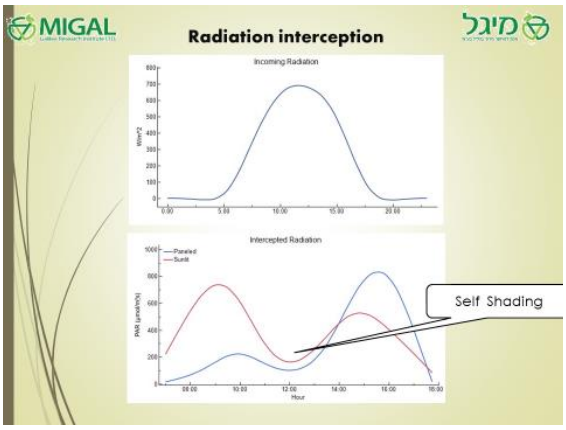

Figure 6. Incoming radiation (top) and intercepted radiation by within canopy located PAR sensor (bottom)) in simulated PV effects monitoring, Ayelet Hashahar 2021.