Expectations for Cranberry Growth and Productivity under Solar (Photovoltaic) Panels

This fact sheet is intended to summarize published research and share personal scientific observations regarding the impact of shading on cranberries and how those data might inform your decision regarding the installation of solar (photovoltaic, PV) panels on your farm. Whether it is profitable and/or realistic for you to proceed with installing panels on your bog will hinge upon many factors particular to your business and farm in addition to the biological considerations described here. As of Spring 2019, it is still early in the process and as projects move forward, we will gain experience that will help to guide future installations.

Background on the Dual-Use / SMART Program. The MA Department of Energy Resources (DOER) launched the Solar Massachusetts Renewable Target (SMART) program in 2018. It was created to support a long-term sustainable solar incentive program that promotes cost-effective solar development in the Commonwealth. Solar PV and farming are incentivized to work together. Systems designed to promote the continuation of productive agricultural activities under the array are eligible for additional financial incentives. These ag-solar systems are termed “dual use”. For more information: https://www.mass.gov/solar-massachusetts-renewable-target-smart and https://ag.umass.edu/clean-energy/current-initiatives/solar-pv-agriculture.

Can cranberries grow in shaded or low-light conditions? Since cranberry is an understory plant, it is reasonable to presume that it can be biologically successful in low light conditions. Cranberry Station scientists and growers have observed that cranberries can exist in very shady areas, but they usually have lower yield than other less-shaded areas. Observations from current solar projects show that cranberry vines can survive in shaded conditions under solar PV (Figure 1). At the moment, there are no available data on yield, fruit quality and fruit rot incidence under these systems.

Figure 1. Cranberry vines growing under solar PV system in Carver, MA.

What is light saturation and why is it important? As light increases, the rate of photosynthesis also increases, but only up to a point. At the light saturation point, having access to more light no longer causes an increase in photosynthesis. In fact, at high levels of solar radiation, oversaturation of the leaf photosynthetic apparatus may result in a decrease in photosynthetic light use efficiency in a process referred to as photoinhibition. The lower the light saturation point in cranberry may increase the likelihood that the vines will do well in shaded conditions due to reduced photoinhibition.

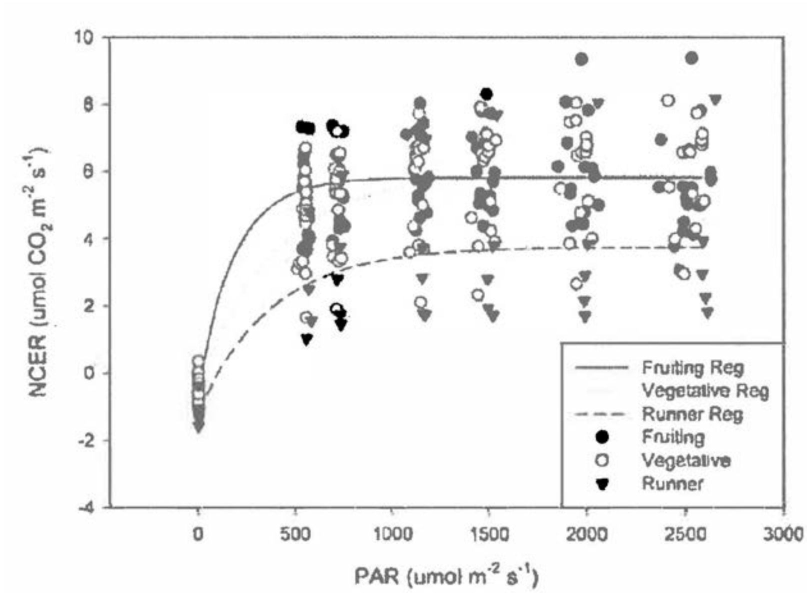

Figure 2. Influence of irradiation on net carbon exchange rate on potted cranberry uprights and runners. Light saturation for fruiting uprights was 700 $\mu mol \cdot m^{-2} \cdot s^{-1}$ *(97%; from Vanden Heuvel and Davenport, 2005).*

The light saturation point of cranberries varies based on cultivar and environmental conditions but has been shown to range from just under 500 to 800 $\mu mol \cdot m^{-2} \cdot s^{-1}$. If one assumes that the average light energy reaching the earth's surface on any given day is 1200 $\mu mol \cdot m^{-2} \cdot s^{-1}$, then cranberries could still reach their light saturation if shading reduced the light interception by 33% to 58%. These values assume sunny skies. Under cloudy conditions, the light levels may fall under the light saturation point. The amount of cranberries that can be grown under continuous year-round shading is not known. This requires replicable research to better answer this question. Even then, the sustainability of year-round shading of cranberries will vary by the particular economic position of each grower, as well as potentially many other variables, including variety, location, soil type, pest pressure, water use and individual grower management practices.

How do cranberries respond to growing in shade? No long-term shading studies have been conducted on cranberry and as such, we do not know the impact of continual year-round shading on this perennial fruit crop. In one study, cranberry vines were covered with 72% or 93% shading for 30 days at three different growth stages (pre-bloom, post-bloom, and pre-harvest) for 3 consecutive years (Roper et al. 1995). Vines shaded pre-bloom yielded no differently than unshaded vines. However, yield was reduced with post-bloom and pre-harvest shading in all years (except 72% in Year 1) and 2 of 3 years, respectively. Other work has shown that cranberries become less photosynthetically efficient when temperatures exceed 85°F and when these conditions arise, the vines would likely benefit from shading (Taiz and Zeiger, 2010). Another study used 35% shading on vines exhibiting a condition known as yellow vine syndrome (YVS) (Jeranyama and Sack 2004); the hope was that shading during the summer months would reverse the negative effects of YVS. Normal green vines, however, were not shaded as part of the study as the objective was to see if shading would improve the photosynthetic capacity of the affected YVS vines. Previous work indicates that when self-shading (thick dense canopies) occur, yields decline but the vines survive.

What is known about growing other crops under solar panels? UMass-Amherst conducted studies evaluating the growth and productivity of vegetables under solar arrays. The study was conducted by Stephen Herbert at the South Deerfield farm in 2016-2017. Panels were 7.5 feet off the ground and the space between panels clusters varied from 2 to 5 feet. They found that the solar panels helped to mitigate heat stress of 2016 for broccoli, Swiss chard, kale, peppers, and common green beans. Leaf temperatures were 15°F cooler under the shade of the PV panels on clear days, which contributed to higher yields compared to the unshaded crops. Shade did decrease yield in some crops, but not all as green beans had higher yield with more shade (lower heat stress) in 2016. In 2017 when the summer was cool, the unshaded plants produced higher yields than the shaded plants.

Adaptation of cultural practices: The change in the microclimate that will occur when growing cranberry vines under solar panels might necessitate changes in some cultural practices. Irrigation schedules may need to be adapted to reflect the reduced transpiration and soil evaporation losses. Growers might need to be more careful when spraying phytotoxic chemicals dues to the increased drying times as solar panels will create a barrier that will reduce wind speed underneath. Growing plants in shady conditions induces more vegetative growth through elongation towards the light. This may result in excess vigor that needs to be controlled by pruning or adjusting nitrogen fertilization.

Summary. If (and when) dual-use solar projects are constructed on cranberry farms, much benefit would be derived from research that evaluates the productivity of cranberry vines growing under solar panels. Growers may wish to try solar panels on a small area or on a small parcel to see how it works in their particular situation before engaging in a large project.

(Summary, continued)

• It is reasonable to expect that cranberry vines should be able to survive, bloom, and produce fruit in shaded conditions. Whether the fruit yield will be comparable to unshaded conditions is not known and will likely vary by variety, site, and array configuration.
• We do know that cranberry vines have a low light saturation point, indicating they should be able to produce carbohydrates (e.g., fruit) in shaded conditions.
• We do know that light saturation can vary by variety, locale, and environmental conditions.
• The photosynthetic capacity of cranberry does not only depend on the amount of solar radiation but also on the prevailing air temperature. The cranberry enzyme responsible for facilitating photosynthesis can be hampered at temperatures above 85°F.
• Shading, at levels higher than permitted in the SMART program, reduced yield when vines were shaded at specific growth stages (flowering and fruit development) for a 30-day period.
• We do NOT know how much light will actually be intercepted by vines under or near the panel, year-round, with an articulating solar panel system.
• We do NOT know how year-round shading will allow the production of fruit at a level that can be sustained at a commercially viable level.
• We do NOT know how shading will affect fruit quality in cranberry. Fruit color is the most important fruit quality parameter in cranberry production and light is needed for the formation of anthocyanin which give fruit their red color. This could be negatively affected under solar panels. On the other hand, solar panels may improve fruit quality by reducing sunscald and consequently fruit rot.

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Photos by G. Mupambi.