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Joseph Cogliano
202 Bay Road
Norton, MA 02766

Re: A Study Involving Cranberry Growth and Productivity under Solar Panels

Dear Mr. Cogliano:

I was contacted by you in January 2020 to review research information and policy documents concerning placing solar panels over cranberry plantings in Massachusetts. As for my background, I am currently a Professor of Horticulture at Utah State University. I hold BS and MS degrees in Botany from Brigham Young University and a PhD in Horticulture from Washington State University. I worked as a Professor for 20 years at the University of Wisconsin-Madison. During those 20 years I worked extensively with the cranberry industry both in Wisconsin and across the country. I have published numerous peer reviewed papers dealing with cranberry productivity, especially regarding the physiology of cranberry yield. I left Wisconsin because Utah is home and to be closer to family.

I have reviewed the study regarding the effects of solar panels over cranberry fields that was recently begun by the University of Massachusetts Cranberry Experiment Station. From what I read, the study is incomplete and some data remain to be analyzed, interpreted, and reported. Further, their letter did not provide any data tables with statistical analysis to give an idea of the variability of their data. Clearly, this was a preliminary report. However, rather than critique this study, below I have outlined an experiment that would better answer the questions of whether cranberries can still be both productive and profitable if covered by solar panels. Research of this type needs to include an environmental biophysicist on the team to ensure the data are collected and interpreted correctly.

1. In order to be successful, the research needs to have devoted funding. If done well, the study can be estimated to cost more than-$150,000. This would include installation of solar panels or surrogates, instrumentation, collection of field data, data interpretation, and publication. The study will require a substantial amount of staff and scientist labor. The solar company and the landowner have the burden of proof to show a solar installation would not adversely affect an underlying crop. It is not reasonable to require or to expect scientists at the Massachusetts Cranberry Experiment Station to do quality work without sufficient funding.

2. The solar company and landowner should be responsible for installing a portion of the proposed solar collection system. This would include the posts, piers, crossbeams, wiring, connections, and panels. The model should replicate as closely as possible what would eventually be installed, should commercial solar collectors over cranberries be shown to work effectively as planned. The mockup should be extensive, comprising perhaps an acre. Perhaps old non-functional panels could be used as this would be as close to 'real world' as possible. If the ultimate installation is to be solar tracking, it would be best if this feature could be installed in the trial. This would also demonstrate the construction that would need to take place during installation. The experiment should be done in at least three locations in southeastern Massachusetts. Replication is essential to data interpretation.

3. Instrumentation: Quantum sensors (measuring light between 400 and 700 nm) should be installed to measure light incident on the cranberry canopy. Point sensors would be acceptable, but line sensors would be preferred. Four to six sensors should be placed in a grid pattern under the solar panels with the top of the sensors at the top of the canopy. These should be near the middle of the installation to avoid 'leakage' of diffuse light from outside away from the panels. Thermocouples or thermistors should be placed near each light sensor. An identical array of light and temperature sensors should be placed well away from the solar panel installation where the panels would not provide shade, probably on an adjacent field. Data would be collected by a datalogger and could be transmitted via cell modem or through regular downloads to a laptop. The light incident on the sensors should be summed daily to determine the total solar radiation between 400 and 700 nm incident on the area under the solar panels and in the nearby unshaded area (daily light integral) through at least three complete growing seasons. This is reported as moles of photons m^{-2} d^{-1}. Then a regression is made comparing daily light integral with yield of shaded and unshaded areas.

4. Each year in the spring, eight individual square foot areas will be identified under the solar panels and not under the solar panels at each site. In the fall just before regular harvest, the uprights from within each square foot will be cut and taken to a laboratory for measurement. For each square foot sample, the following data will be collected: total number of uprights, number of fruiting uprights, number of fruit per fruiting upright, total fruit number, total fruit weight, and length of new growth per upright. A subsample of fruit will be analyzed for total anthocyanins. Data from this analysis will be subjected to analysis of variance to see if growth and fruiting vary between shaded and unshaded locations at each of the three sites. This is the most important part of the project.

5. Collection of the data in points three and four should continue for at least three years. We would not expect to see differences in year one. The year-one crop is produced as a result of buds that were produced the prior year. If differences are found, they would be found in years two or three and beyond.

6. The landowner will need to demonstrate, with video cameras recording the efforts, that farm implements can be operated under the panels. This would include fertilizer

applicators, pest control equipment, irrigation equipment, and harvest equipment. The time recorded to navigate posts should be noted compared to uncovered areas.

I would note a couple of concerns about how the data are interpreted. For the light measurements, the important information is not the light striking the canopy at a given point, it is the summation or integration of the total light incident over time (daily light integral). In every other temperate fruit crop with which I am familiar, yield per acre is nearly linearly related to light captured by the crop canopy. If light incident on the crop is reduced, reductions in yield will almost surely follow. Further, the time of shading is also important. The most critical time for shading to reduce yield is in the immediate post-bloom period. This is when fruit are set. Unfortunately, the 2019 Carver study did not impose shading until July. By that time fruit set had already occurred. Thus, no impact on yield by shading would have been expected for 2019.

Another question that could be asked is whether the newest hybrid cultivars from New Jersey respond the same to prolonged shading as older cultivars such as Ben Lear, Early Black, and Howes, or older hybrids like Stevens.

Based on my research and years of experience with the cranberry industry, I speculate shading from solar panels will cause three things to happen. First, the vines will become 'leggy'. The uprights will elongate trying to find light to capture. That was clearly obvious in my shading studies in the early 1990's in Wisconsin. Second, the percentage of uprights that become fruiting uprights will decline over time. Third, fruit color is going to be reduced. Fruit color in cranberries is a function of sunlight and cool temperatures, especially at night. It may well remain warmer under the panels both daytime and nighttime and this will delay or reduce fruit color. When fruit are delivered to a receiving station a subsample is taken and anthocyanin content is measured. Fruit that does not meet minimum color standards is rejected by handlers.

For the record, I don't have a vested interest in the Massachusetts cranberry industry. I have not worked with the industry for about 12 years. I receive no current financial support from the industry. My only reason for becoming involved in this matter is that I strongly believe that important decisions should be based on good science. I hope this research outline will lead to good science being done as a proper study will benefit the cranberry growers and the people of Massachusetts.

Cordially,

Teryl R. Roper

Teryl R. Roper, PhD

Relevant Literature:

DeVetter, L, J. Colquhoun, J. Zalapa, and R. Harbut. 2015. Yield estimation in commercial cranberry systems using physiological, environmental, and genetic variables. Scientia Horticulturae 190:83-93.

Eaton, G.W. and T.R. Kyte. 1978. Yield component analysis in the cranberry. J. Amer. Soc. Hort Sci. 103:578-583

Roper, T. R., J. Klueh, and M. Hagidimitriou. 1995. Shading timing and intensity influences fruit set and yield in cranberry. HortScience 30:525-527.

Roper, T. R. 1987. Physiology of Cranberry Yield. https://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1015&context=cranberry_factsheets