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Re: UMass Extension - Carver, MA Experiment – Cranberry Production Under Solar Photovoltaic Installation & Fairland Farms, Norton MA – ASTGU Eligibility

I have reviewed the following documents:

- October 17, 2019 UMass Extension letter to Mr. Gerard Kennedy of the Mass Dept. of Agricultural Resources regarding the Carver data and cranberry production under a solar photovoltaic installation.

- October 21, 2019 Mass Dept. of Agricultural Resources letter from Gerry Palano to Kaitlin Kelly of the Mass Dept. of Energy Resources regarding Fairland Farms, Norton MA – ASTGU Eligibility Application.

- November 13, 2019 Dept. of Energy Resources letter from Eric Steltzer to Adam Schumaker of NextSun Energy regarding pre-determination of the Fairland Farms site as an ASTGU.

Background

The American cranberry is an evergreen woody perennial, having a trailing stoloniferous vine. Flowers are typically borne on indeterminate ascending vertical stems referred to colloquially as "uprights," which arise from stolons, and are referred to as "runners." The requirement of an acidic media or soil (maximum pH 5.5) limits the American cranberry's adaptation. Having a fine root system lacking root hairs, it is best suited to soils such as sands, loamy sands, and organic soils consisting of coarse peat or muck. Cranberry, being a temperate woody perennial with normal growth and flowering in spring, requires a minimum of 800–1000 hours of winter-chilling (~0–10 °C) to fulfill the winter dormancy requirement. Inflorescence buds, having 5–7 florets, are formed in late summer and fall, mostly at the apex of the vertical stems with upward facing adaxial leaf surfaces. For the subsequent year's crop, in regions having moderate to severe winter freezes, e.g., Wisconsin, New Jersey, and Massachusetts, inflorescence buds and leaf tissues are typically protected with a "winter flood," which can span from December to April. Spring growth typically initiates in mid to late April, with flowering initiating in mid to late June and terminating by mid-July. Vertical shoots, i.e. uprights, can be defined as fruiting (having a floral inflorescence bud or 'non-fruiting' with vegetative bud only. Depending on both cultivar and environment, the proportion of uprights fruiting in a given area of subsequent years varies. Non-fruiting uprights of a given year are expected to form floral buds for the subsequent year's crop. For fruit set, cranberry requires insect pollination, which occurs with mostly hymenopteran insects. Growers typically supply honeybee colonies to supplant pollination. Commercial cultivars are highly self-fertile and do not require nor appear to benefit from cross-pollination for seed set nor fruit set (Sarracino and Vorsa 1991). In the northern hemisphere the majority of fruit development occurs during August, with seed maturation occurring in September. Early maturing varieties, e.g., 'Ben Lear', 'HyRed', 'Crimson Queen', typically begin to ripen in early September, and later maturing varieties, e.g., 'Stevens', in October.

<u>Multiple year assessment of cranberry's response to environmental factors</u>

Cranberry is a woody perennial setting fruit typically in mid-June to mid-July, with fruit sizing and development through August, and has concurrent primordial inflorescence bud set developing during late-summer early fall for subsequent season's cropping. Thus, it has been noted that management, e,g., plant nutrition, and crop load, as well as climatic conditions, etc. of a given year, likely impact the following season's, 'next years', productivity. Like with many woody perennials biennial fruit bearing is a well noted phenomenon in cranberry. In fact, environmental effects such as plant nutrition, climatic stresses and cropping of a given year, can influence plant parameters well into the future (3-5 years). Effects of a nitrogen fertilization experiment (Davenport and Vorsa 1999) were noted in high nitrogen treatment plots exhibiting 'second bloom' three years following treatment years (Vorsa, unpublished data). In contrast to annual crop species, e.g., corn, where one year's conditions do not impact future cropping, multiple years are needed to assess plant habit and productivity in cranberry following management treatments. It might be suspected that shading cranberry over time will result in reduced fruit bud set and encourage transition to greater stolon production, and thus lower productivity. For example, shading during a given year may affect the formation of floral bud set on fruiting and non-fruiting uprights that will be realized, predictably reduced, the following year. Note: uniformity is required for agronomic efficiency.

<u>Effect of shading and saturating radiation level</u>

Few studies regarding the effects of shading in cranberry have been published. A study published by Roper et al. (1995), studied shading at various time points (1-month spans) during the growth phase of cranberry through pre-bloom to harvest of current season's response, using shade cloth. The effect of shading treatments were found to reduce non-structural carbohydrate concentrations but did not always reduce fruit set or yield the treatment year. No data was presented for effects in subsequent years. Kumudini (2004) reported that depending on temperature, maximum photosynthesis (P max) was ≈10 or 12 μmol CO 2/m 2/s (net photosynthesis) and the saturating radiation level was estimated to be 600 to 800 μmol·m-2·s-1. Note: the UMass Extension report used 500 μmol·m-2·s-1 as the threshold. Based on the referenced publication by Kumudini, (2004), the 500 μmol·m-2·s-1 threshold may underestimate the maximum saturating radiation level that cranberry can utilize, thus the value underestimates cranberry's photosynthetic full potential. Thus, one would need long term empirical data to determine if the 500 μmol·m-2·s-1 threshold is valid.

Farm management issues anticipated with solar structures

1) Structures will impede fertilization, fungicide, insecticide application/uniformity.
2) Structures will impede irrigation uniformity.
3) Not apparent efficient method on how the fruit harvest will be carried out.
4) Insect IPM sweeping impeded?
5) An efficient method of sand application, 'sanding', a standard cultural management technique in cranberry, is not obvious.
6) Fertilization distribution will likely be impacted by rain distribution by structures. Drip edge will elute fertilizer whereas little if no elution under the solar structures.

Potential physiological issues

1) Fruit ripening/coloring will likely be affected, i.e. reduced.
2) Yield, flower bud set, flowering, fruit set will be reduced, particularly in subsequent years.
3) Stolon biomass will increase, requiring increased pruning.

Carver, MA Experiment

The data and methods of the Carver experiment are wholly inadequate to assess the impact of PV structures on the physiology of the cranberry plant, and how the structures will impact farming operations, i.e., management such as uniformity of irrigation, fertilization, pesticide application, sanding, and harvest efficiency. The preliminary 'experiment' was flawed to assess effect on the plant through the entire growing season, being it appears the reading was taken at only a one time point.

The 'solar photovoltaic (PV) units' as described, and being deployed July 3, 2019 in the 'Stevens' cranberry bed and where sensors monitoring environmental impacts were deployed August 27, 2019 to assess putative impact of the structures on cranberry operation: The assumption is that the installation of a PV and readings was to make a determination on the impact on photosynthesis. However, the report states that "…photosynthetic measurements were only taken on one day". One issue is that since the sun angle continuously changes through the growing season (April – September), the estimate of total season's photosynthesis output with this experiment's shading would be an unreliable estimate. There are two issues to consider: 1) one is the impact on the physiology of the plant, and 2) the impact of the structures on cranberry management (operations). Briefly, the design of this experiment is wholly inadequate as to assess the physiological impact on the plant, either the year (2019) the data were taken or the longer impact of cranberry agriculture (for reasons discussed previously). The 'experiment' is inadequate from a number of aspects including: the structures were installed too late (July 3rd) towards the end of 'fruit set' season. Note: The UMass report acknowledges this "…We do not have data for spring…". The cranberry plant would have initiated growth in April/May synthesizing carbohydrates which would impact fruit set (crop productivity) for that season. Furthermore, the impact of the shading is likely to have a profound effect on the subsequent year's (2020) crop. As stated in the UMass report that "…is critical to understand that the analysis presented…and our interpretation of data presented…is based was preliminary in nature…on this limited review". The physiological impacts of these structures on commercial cranberry production cannot be determined from this data. Moreover, the methods used were severely flawed to assess this.

In addition, the 'experiment' utilized only 3 panels, whereas it is assumed the entire bed would be utilized. It would seem there would be more shading as one moves away from the summer solstice and from the effects of multiple rows of panels. Although it is stated in the UMass report that the" …commercial PV panels will transmit a portion of light…" there is no determination on the effect of impact on the light spectrum. The limitations of the presented data expressed on page 3 of the October 17, 2019 letter to MDAR are significant.

<u>Assessment of "In order to qualify for an Agricultural Solar Tariff Generation Unit adder under 225 CMR 20.00, the Project must satisfy all five components of the special provisions for Agricultural Solar Tariff Generation Units detailed in 225 CMR 20.06(1)(d) …."</u>

1. *the Solar Tariff Generation Unit will not interfere with the continued use of the land beneath the canopy for agricultural purposes;*

    As presented the structures will interfere with continued use of the land. The structures will interfere with irrigation, fertilization, pesticide application, sanding, and harvest efficiency.

2. *the Solar Tariff Generation Unit is designed to optimize a balance between the generation of electricity and the agricultural productive capacity of the soils beneath*;

    As presented the structures will interfere with the agricultural productive capacity (e.g. nutrition and water distribution) of the soils beneath by affecting the physiology of the plant since farming operations (uniformity) will be impacted. Therefore, agricultural productive capacity is likely to be severely reduced.

3. *the Solar Tariff Generation Unit is a raised structure allowing for continuous growth of crops underneath the solar photovoltaic modules, with height enough for labor and/or machinery as it relates to tilling, cultivating, soil amendments, harvesting, etc. and grazing animals*;

    As presented the structures will interfere with continued use of the land. The structures will interfere with irrigation, fertilization, pesticide application, sanding, and harvest efficiency.

4. *crop(s) to be grown to be provided by the farmer or farm agronomist in conjunction with UMass Amherst agricultural extension services, including compatibility with the design of the agricultural solar system for such factors as crop selection, sunlight percentage, etc.*;

    Inadequate assessment although crop productivity will degrade over time (current season as well as subsequent years).

5. *annual reporting to the Department and MDAR of the productivity of the crop(s) and herd, including pounds harvested and/or grazed, herd size growth, success of the crop, potential changes, etc., shall be provided after project implementation and throughout the SMART incentive period; and*

    N/A

Conclusion

The UMass Extension Carver, MA 'experiment' does not provide the necessary data to make a reasonable 'Assessment' of whether cranberry culture with these PV structures "…*will not interfere with the continued use of the land beneath the canopy for agricultural purposes".* Moreover, it is impossible to make a determination due to the limitations, e.g. lack of necessary scale of the 'experiment' and the insufficient duration regarding the long-term viability of cranberry crops under solar photovoltaic installations. Based on the expectations of the SMART program, the data from the Carver 'experiment' is inadequate to support eligibility or qualification for a project involving solar installation over cranberry crops under the SMART program. A minimum 4 to 5-year study is required, as well as increased scale, to determine the impacts to cranberry crops from solar photovoltaic installations. The bed management issues also need to be addressed.

Very truly yours,

Nicholi Vorsa

Enclosures: Self and Cross Fertility in Cranberry (Sarracino and Vorsa 1991), Shading Timing and Intensity Influences Fruit Set and Yield in Cranberry (Roper et al 1995), Effects of Radiation and Temperature on Cranberry Photosynthesis (Kumudini 2004)