Annual Report January 2021

Saffron and Solar Farms: A Win/Win for Environment and Agriculture

Arash Ghalehgolabbehbahani, Bruce L. Parker and Margaret Skinner

North American Center for Saffron Research and Development
https://www.uvm.edu/~saffron/
Contact: aghalego@uvm.edu Tel: 802-656-5434

Executive Summary

Saffron (*Crocus sativus* L.) is an emerging high-value crop, valued at $19-55/g retail, which could contribute to revenues of Northeastern farmers. Scientists at the Univ. of Vermont initiated research in 2015 to investigate the potential of saffron as a specialty crop to support Northeastern farms. Ground-mounted solar arrays are displacing crop production, which has resulted in vocal opposition among some lawmakers and agriculturalists. Saffron had never been cultivated within solar fields before, but we projected that it could be grown either between the rows of panels, around the perimeter of the solar arrays, or under the panels. This would demonstrate that the agricultural potential of land within solar arrays could be maximized. An experiment was designed to test this hypothesis which is being carried out at a Peck Electric solar field in Burlington, VT. Plots of saffron were established in three locations within the solar field: 1) in the aisles, 2) under the solar panels and 3) around the perimeter of the arrays. In addition, two planting methods, in raised beds and directly in the ground were tested.

Our results over the past 2 years confirmed the potential of producing saffron in solar fields. As expected, saffron yield was low in Year 1 because corms were newly planted. Harvest averaged 0.93-2.1 lb/acre. More flowers were collected from plots in the perimeter (edges) than in the aisles or under the panels. In addition, yield was higher in the raised beds than in the direct ground plots. Corm production was also better in the raised beds compared to in-ground beds. **In Year 2, over 17 lb of saffron/acre (equal to $192,775/acre at $25/g) was obtained in some of the plots. This is three times greater than the average yield from other saffron-producing regions.** Yield was greater in plots located in the aisles and around the perimeter than under the solar panels. These results clearly show that saffron can be grown successfully within solar fields, and it can provide significant agricultural revenues in addition to solar power. Saffron is a perennial crop and yields usually increase annually for at least 3 years. Therefore, greater revenues from saffron solar fields are anticipated in future years. The full economic benefits over time of growing saffron in solar arrays will be demonstrated with the continuation of this project.

Fig. 1. Saffron flowers in Peck's solar field.

Introduction. According to the American Farmland Trust, the best land to support crop production has dropped to <17% of our total land area. The number of farms and amount of tillable farmland are being lost to development at an alarming rate. Over 24 million acres of agricultural land have been lost to development since 1982. A 4.3% drop in the number of farms in the US was observed from 2007 to 2012 and this decline continues. Crop diversification is key to their viability and to the economic stability of small family farms. Ground-mounted solar arrays are displacing crop production, which has resulted in vocal opposition in some regions. Farmers of all types across the US are supporting their existing agricultural production through generation of renewable energy, in particular solar power. The concern is that farmers will take advantage of the lower-risk, higher-reward opportunities of energy generation and discontinue farming, which can be high-risk as weather conditions become more extreme and unpredictable. UVM scientists started research in 2015 to investigate the potential of saffron as a specialty crop to support Northeastern farms. Saffron is an emerging high-value crop, valued $19-55/g retail, which could contribute to revenues of Northeastern farmers. Saffron is commonly used as a culinary flavoring and coloring agent in Asian and European cuisine, and is reported to have valuable medical properties. Saffron is adapted to arid and semi-arid regions and is somewhat resistant to cold. Saffron had never been cultivated within solar fields before, but we project that it could be grown either between the rows of panels, around the perimeter of the solar arrays, or under the panels. An experiment was designed to test this hypothesis which is being carried out at a Peck Electric solar field in Burlington, VT.

Methods. Saffron plots were established at the Peck Electric solar array in Burlington, VT (USDA plant hardiness zone 5a). Plots were situated in three locations: 1) in the aisles, 2) under the solar panels and 3) around the perimeter of the arrays. In addition, two planting methods, in raised beds and directly in the ground were tested. This was set up as a factorial (3×2) experiment using a randomized complete block design (RCBD) with three replications. In total, 18 planting beds were planted. The existing soil on site was supplemented with perennial potting soil, containing compost and topsoil, to create fertile planting beds. Saffron corms (9/10 cm circumference) were planted in September 2019 at a depth of 6 inches with a density of 9 corms/sq. ft. To prevent rodent damage, hardware cloth (0.5 x 0.5 inch) was installed under each raised bed and over the top of in-ground plots. Wood chips were spread around the edges of each plot to control weeds (Fig. 2). During the blooming seasons (October-November 2019 and 2020), flowers were harvested every other day and the number of flowers was recorded to estimate yield. Stigmas were separated from the flowers and dehydrated at 100 °C for 10-15 minutes. The average weight of dry stigmas/plot for each treatment was determined. To assess plant health and survival, random samples of the secondary corms produced by the original corm were taken in June 2020. The mean number and size of the corms per plot were determined. Data on saffron yield, and the number and size of corms were analyzed by ANOVA in SPSS to compare results by treatment. The statistical significance among treatments was evaluated with Duncan's multiple ranges.

Fig. 2. Raised bed and in-ground plot at Peck's solar saffron research site.

Year 1 (2019). Significantly more saffron flowers were collected from plots located around the perimeter (edges) than those under the solar panels and in the aisles (Fig. 3). In addition, there were significantly more flowers in the raised beds than in the in-ground plots. Saffron yield as estimated based on the number of flowers observed and the average weight of an individual stigma ranged from 0.93 to 2.1 lb/acre among treatments. Based on a retail price of $25/g, this is equivalent to a gross revenue of $10,546-23,813/acre. Saffron yield usually increases exponentially 1-2 years after initial planting.

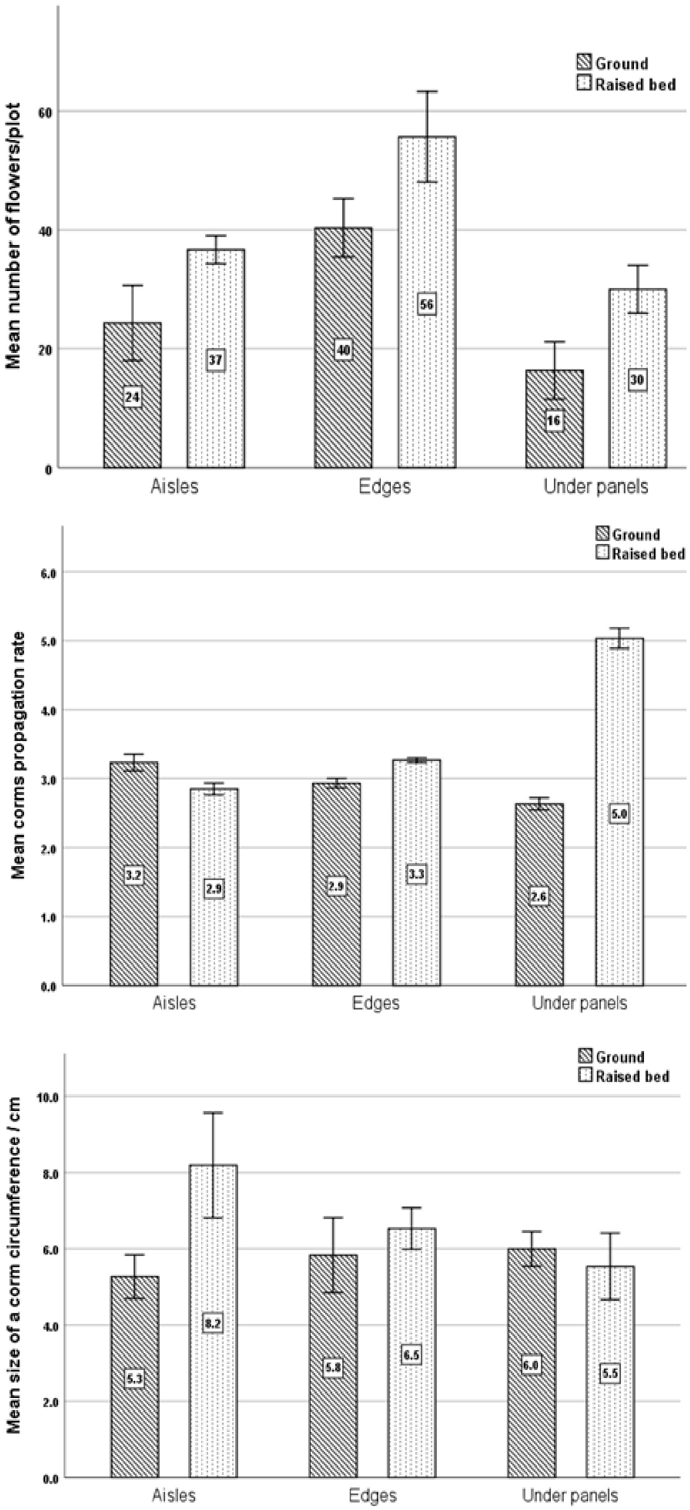

Fig 3. Mean number of flowers, corm propagation rate and size of secondary corms Year 1.

Saffron yield in Year 2 is strongly related to the number and size of secondary corms formed by the original corm. An average of 3.36 secondary coms/original corm was recorded among saffron plots. Significantly more secondary corms were produced in raised beds under the solar panels (over 5 secondary corms/mother corm) than for the other treatments. The largest corms were observed in raised beds located in the aisles (average of 8.2 cm in circumference).

Year 2 (2020). Data on flowers and saffron yield were collected in Oct.-Nov. 2020 from plots established in 2019. The greatest saffron yield was from raised beds located around the perimeter (mean: 473 flowers/plot) (Fig. 4). In general, more saffron was produced in raised beds than in the in-ground plots. Statistical analysis illustrated that differences in yield from plots in the aisles vs along the edges were significant. Surprisingly, the number of 2020 flowers harvested from in-ground beds under the panels was 30% less than in 2019. This suggests that the microclimate under the panels was not ideal for flower production. It is possible that the droughty conditions of 2020 affected yield. Planting method and plot location did not have a significant effect on average weight of stigmas produced. An average weight of 0.006 grams/stigma was observed among all treatments.

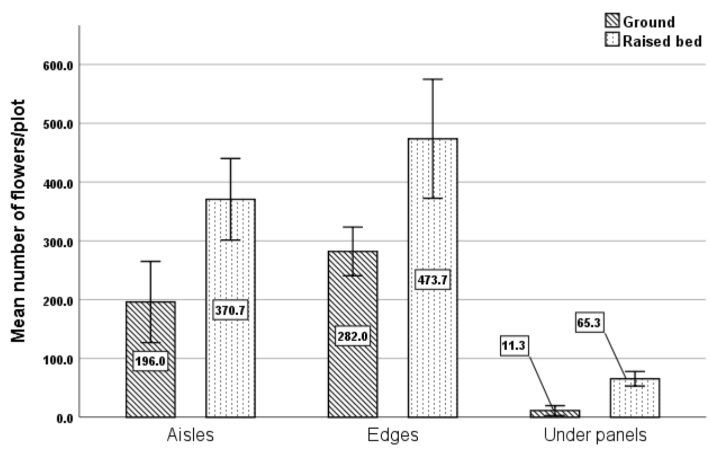

Fig. 4. Average number of flowers by treatment in Year 2.

Yield per acre. It was expected that that saffron yield would increase in the second year of production (Fig. 5). We have observed this in our previous research in Vermont, and it is reported worldwide. In some treatments, a 2-3-fold increase in saffron yield was observed from Year 1 to 2, which is particularly high. Yield was significantly higher in plots located along the edges or in the aisles than under the panels. The average saffron yield per acre in traditional saffron producing regions is around 5-6 lb/acre. **We obtained yields of >17 lb/acre, which is three times more than the average of saffron yield in other saffron producing countries.** This amounts to a gross revenue of **$192,775/acre** at $25/g, the average retail price for US grown saffron. Cold winters and wet springs seasons can affect saffron production negatively in Vermont. In addition, droughty conditions in the summer can impact flower production. Soil texture and structure play an important role in flower production and corm survival. These results confirmed the potential of solar farms to serve as a multifunctional ecosystem and being used as actual agricultural production systems.

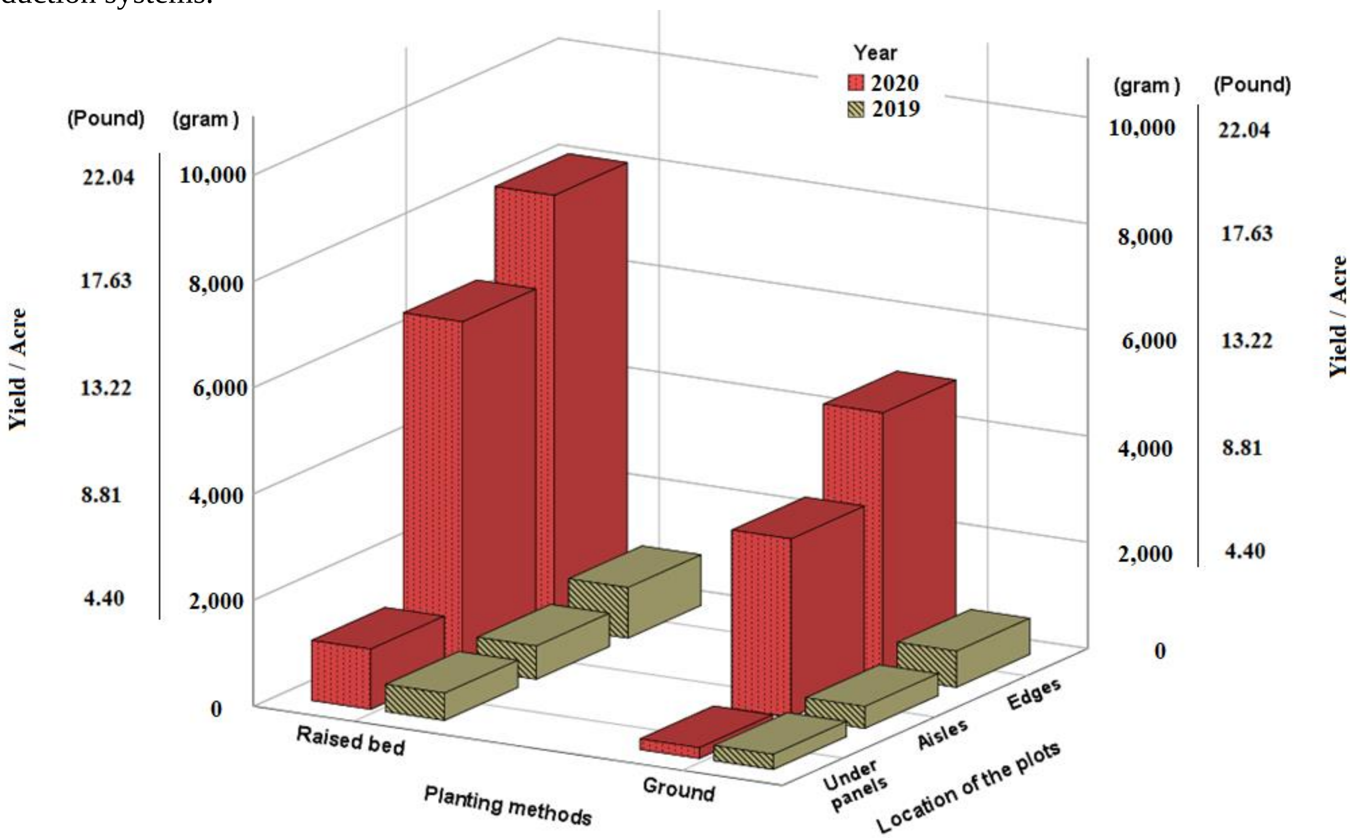

Fig. 5. Average yield of harvested saffron/acre among the treatments in 2019 and 2020.

Media coverage. Local and national media sources continue to show interest in saffron production in general. An article featuring a large saffron operation in California appeared in Martha Stewart's "Living" magazine (Oct. 2020). VT Digger did a story in November which resulted in considerable interest from prospective growers. We have also been interviewed by several online publications. These articles help to increase grower interest in saffron, which over time will lead to expanded implementation of saffron cultivation in solar arrays. We will contact solar-related journals for a follow up on our progress.

Acknowledgements: Saffron corms for this study were supplied by Roco Saffron, NL https://rocosaffron.com/