Results of Biochar Application at Oak Hill Farm

Oak Hill Farm, located on State Highway # 12 just north of the city of Sonoma, was fortunate in avoiding the water availability problems associated with California's severe drought that so impacted the other two farms in our project. As a result, we achieved a rather successful trial here — with encouraging results. Between May and November 2015, a green manure cover crop using biochar and compost was grown on the designated 1/4-acre test plot, and also grown on the equal-sized adjacent control plot. After this cover crop was plowed in, winter squash was planted on these two plots. These plots were in an existing field that has received quality care in the past; so their soils were already in very good condition.

Plot preparation for the biochar trial began in April 2015. Previous crop residues growing here were tilled in, followed by our soil amendments applied by a manure spreader. The test plot received about 6 cu. yd. of a biochar/compost mix in a 67%/33% ratio. The control plot received 2 cu. yd. of unadulterated compost. These amendments were then tilled in and the cover crop was planted. The farm manager reported having observed that the green manure crop in the test plot was shorter and less dense than in the control plot. Fig. 7 confirms this observation, showing the cover crop at our OHF field trial site in mid-May 2015. The biochar test plot is to the right of the center sprinkler row; the control plot is to the left. In late May the cover crop was tilled in and nearly a month elapsed to allow crop residues to break down.

Figure 7 - Oak Hill Farm Field Trial Site (May 2015)

On June 20, 2015, OHF planted a winter squash crop here. Preparation simply involved tilling before seeding rows and setting out drip tape for irrigation. An equal number of rows of two squash varieties (Delicato and Butternut) were planted in each plot. Irrigation came from centerlines of the squash rows. Irrigation duration, and thus total water applied, was identical for both test and control plots. Irrigation frequency and duration were adjusted by

the farm manager to meet moisture requirements of the drier of the two plots, rather than differentially from one plot to the other. The farm manager reported that on extremely hot days, the test plot with its biochar was under visibly less stress than was the control plot. Irrigation ceased about September 1, after which the crop began about a month of drying and curing. The greater soil moisture retained in the test plot due to biochar impacts actually became a concern for the farm manager at this point as it forced him to delay harvest to allow more curing time for the squash there.

Fig. 8 shows the growing season moisture retention results at our OHF field trial site. Note the wilted squash vines in the row to the left of center (in the control plot) in contrast to the larger squash vines with no wilting on the right (in the biochar test plot). Fig. 9 shows the OHF field trial plots in mid-September, halfway through the curing period (again, control on left, test on right of center pumpkin row). Note smaller biomass and greater wilting in the control plot (left) as compared to the test plot.

Figure 8 - Oak Hill Farm Field Trial Site (July 2015)

Figure 9 - Oak Hill Farm Field Trial Site (September 2015)

On September 29, 2015, SEC collected end-of-growing-season soil moisture and soil health samples. On September 30, crop sampling was performed. A couple of days later, all crops were harvested by the Oak Hill farmer and placed in storage for later sale.

Due to the busy nature of harvest in the fall months, the farm manager delayed completing our year-end farm manager's questionnaire until late November. His completed questionnaire is included in Appendix D to this report; a summary of his core observations and concerns appears below.

Summary of Oak Hill Farm Manager's Observations

The following are the farm manager's primary observations and comments as taken from his completed questionnaire:

1. After the green manure cover crop was tilled in to the test and control plots, the crop residue took longer to break down in the test plot than in the adjacent control plot. This kind of delay for future farm uses of biochar might pose a concern for use of certain types of primary cover crops.

2. Initially more weeds were observed in the biochar test plot, requiring greater labor for hand hoeing.

3. The test plot grew larger plants and fruit than were grown in the compost-only control plot.

4. The biochar/compost test plot withstood high temperatures better than did the compost-only control plot.

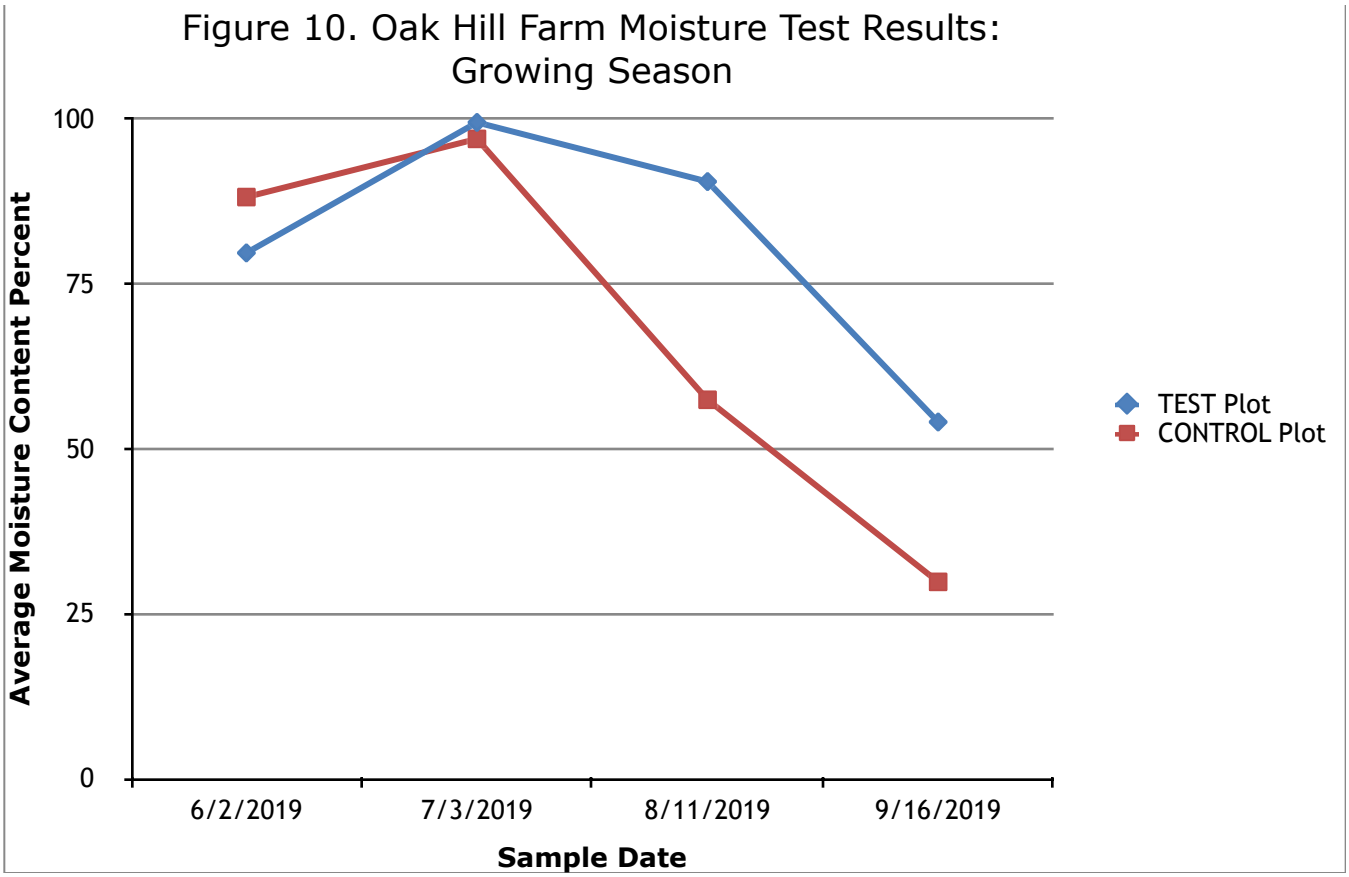
5. The test plot lost its retained soil moisture much more slowly than did the control plot during the curing stage. This behavior was a basis for the farm manager's concern about completion of winter squash curing before fall rains were to begin.

6. Biochar as a soil amendment was viewed as fully compatible with typical OHF farming practices. The farm manager's primary concern was it likely cost (purchase price). A farm such as Oak Hill that uses its own well water has less motivation to conserve water than would another farm where water is in short supply or is being purchased from an outside supplier. From this perspective, biochar's purchase price was viewed as the primary constraint against its further use.

Summary of Results in Terms of Soil Moisture Retention Levels

Soil moisture retention data was collected monthly over a 4-month period between June and September 2015. Moisture sampling was done in each plot on 5 transects distributed roughly evenly along the lengthy axes of these rectangular-shaped plots. We inserted a moisture probe in alternate longitudinal crop rows within about 4 inches of the drip tape, to a depth of 6 inches.

Fig. 10 shows the varying soil moisture test results. Initially, SEC had not been notified of the exact timing of irrigation cycles in use here, so we did not at first measure soil moisture levels at the appropriate times. Once we synchronized our sampling visits with the proper times in the OHF irrigation cycle, moisture readings recorded showed obvious differences between the test and control plots. Analysis of the properly-timed data collected during both the squash growth and curing phases showed that the biochar test plot on average retained soil moisture at significantly higher levels than did the control plot.



NOTES:

6/1/2015 testing was done after the green manure crop was tilled in.

7/2/2015 testing was incorrectly done shortly AFTER irrigation cycle at both plots

8/10/2015 testing was correctly done shortly BEFORE irrigation of the two plots

9/15/2015 testing was again correctly done shortly BEFORE the irrigation cycle

The soil moisture sampling done in mid-August captured the squash crops at their high-growth period. Fruits were rapidly gaining size and weight and plant foliage was still increasing. Moisture readings from the test plot averaged 90.6 as compared to an average of 57.5 from the control plot. That is, the biochar-treated test plot achieved average retained soil moisture readings 57% higher than in the control plot).

The soil moisture sampling done in mid-September captured conditions after irrigation had ceased in both plots, halfway through the squash curing stage. The vines at this point were drying out and the fruits were losing some of their moisture content (giving them longer post-harvest storage life). In this moisture sampling, readings from the test plot averaged 54.1 compared to average readings from the control plot of 29.8. In sum, at this time the biochar-treated test plot achieved average retained soil moisture readings that were fully 81% higher.

This data corroborates our core test hypothesis that biochar-treated soils would show increased soil moisture retention. However, an additional lesson learned here is that this anticipated result needs to be factored in to formulation of crop planning. The farm manager became concerned about the growing risk of significant fall precipitation arriving before adequate crop curing occurred for squash in the test plot; these rains would have halted curing and compromised storage life of the crop.

Summary of Crop Sampling Results

The squash crop was counted and weighed at a total of 16 random locations: 8 in the test plot and an equal number in the control plot. Within each plot, 4 locations were in the Delicato plantings and 4 in the Butternut plantings. A 6-foot diameter circle was drawn, centered on each random location. All squash within and touched by the outline of this circle were counted and weighed. Fig. 11 shows this process underway.

Figure 11 - Sampling, Counting and Weighing of Squash at Oak Hill Farm Field Trial Site (September 2015)

The results of this sampling showed, for both varieties, that the test plot yielded significantly higher numbers of squash and had a significantly higher total weight of squash as compared to the control plot. Table 4 presents the data, depicted in Fig. 12.

Table 4. Crop Weight and Number Comparisons, Oak Hill Farm

OHF Crop Sampling	Control Plot	Test Plot	Difference	Pct. Difference
Delicato Squash - Count	35	68	33	194%
Delicato Squash - Weight in lbs.	30	74	44	247%

Butternut Squash-Count	22	37	15	168%
Butternut Squash-Weight lbs	56	107	51	191%