Oasis Vineyard Trial

2020 Summer Report

California Department of Water Resources, Sonoma Ecology Center, University of California - Riverside, Monterey Pacific Inc., & Pacific Biochar Benefit Corporation

Image credit: Raymond Baltar

County: Monterey
Appellation: Monterey
Vine Type: Pinot Noir

Executive Summary: The Oasis Vineyard Trial was initiated in 2016 to study how biochar and compost treatments impact soil water potential, vine growth, and harvest yields in a newly planted vineyard. This vineyard, managed by Monterey Pacific, Inc., is located outside of King City, CA in the Salinas Valley. This field research project, funded by the California Department of Water Resources (DWR), was administered by Sonoma Ecology Center and included support from researchers from the University of California, Riverside.

In this vineyard trial, biochar and compost treatments were applied both separately and in combination during soil preparation activities prior to planting 'Pinot Noir' (*Vitis vinifera*) vines. Significant increases in harvest yield were observed for all treatments with the highest yield in the biochar treatment, resulting in a 45% increase over the control. Increased pruning weight was observed for both the compost and the compost + biochar treatments; and higher cluster counts were observed for both the biochar and the compost + biochar treatments. Though the treatments resulted in increased plant vigor and crop yield, all treatments received the same irrigation regime throughout the trial, demonstrating improved water use efficiency where soil had been amended. Results from this field research trial indicate that biochar and compost

treatments can improve water use efficiency, vine growth, and harvest yields for newly planted vineyards in sandy soils. While the results presented here show preliminary trends, ongoing monitoring is needed to validate these results over successive growing seasons.

Vineyard Description: Pinot Noir vines on 1103P rootstock. Planted with 9' by 5' spacing, resulting in 968 vines per acre. Vine rows are drip irrigated, with mechanically box-pruned sprawl on a high cordon trellis system.

Soil Description: Soil is variable throughout the plot. Soil type is primarily Oceano Sand with organic matter content of 0.7%, with other areas described as Garey Sandy Loam.

Pre-Planting Soil Preparations: In early 2017, soil amendments were applied before planting in a ripped delve down the vine row using GPS, then mixed with a winged plow to a depth of 30 inches in a 'bowl' approximately 2 feet wide by 2.5 ft deep. This resulted in approximately 25 cubic feet of cultivated and amended soil per vine (2' deep by 2' wide and 5' spacing per vine) (Image 1.1 in Images section.)

The applied biochar (10 tons/acre wet weight) is equivalent to a 0.42% SOM increase in the planting row. The applied compost (15 tons/acre wet weight) is equivalent to a 0.30% SOM increase in the planting row. (Fig. 1 below presents these calculations.)

The biochar and compost distribution was not completely uniform, varying somewhat higher and lower concentrations in this treated area.

Fig. 1

%OM Calculations for Vineyard Treatments						
Cultivated Area_ Soil Volume and Weight						
Cu ft / vine	vine / acre	cu ft / acre	cu yd / acre	soil density g/cm	soil density ton/cy	tons soil/acre
25	1089	27225	1008	1.3	1.10	1104.64
Biochar Application Rate_ Ton/acre Input, %OM Output						
	biochar applied (wet ton)	biochar moisture %	biochar applied (dry ton)	biochar OM content	tons OM applied	% SOM achieved
Biochar	10.00	38%	6.18	74.50%	4.60	0.42%
Compost Application Rate_ Ton/acre Input, %OM Output						
	compost applied (wet ton)	compost moisture %	compost applied (dry ton)	compost OM content	tons OM applied	% SOM achieved
Compost	15.00	49%	7.70	42.50%	3.27	0.30%

Amendment Descriptions:

- Biochar: Provided by Pacific Biochar. Softwood forestry residues, fired at 750C. Organic matter (dry) 74.5%, ash content (dry) 25.5%. NPK as delivered: 0.69, 0.6, 2.4. pH 10.5, carbonates (as $CaCO_3$ equivalent) 14.22%. Moisture content 38.2%. Bulk density (as delivered) 4.3 cubic yards per ton (17.1 lb/cu ft). Particle size ¼" minus. Biochar price ~ $240 per ton as delivered. (See images for more information.)

- Compost: Provided by Keith Day Company. Described as a blend of spent mushroom compost, green material, and grape pomace. C/N ratio 14. NPK as delivered: 0.79, 1.9, 4.1. Organic matter (dry) 42.5%, ash content (dry) 57.5%. pH 7.9, carbonates (as $CaCO_3$ equivalent) 6.5%. Moisture content 48.7%. Bulk density (as delivered) 1.8 cubic yards per ton (41 lb/cu ft). Particle size ⅜" minus. (See images for more information.)

Treatments:
All treatments applied at depth down each planting row (delved)

a. **Control:** 0 tons/acre compost, 0 tons/acre biochar
b. **Biochar 10:** 0 tons/acre compost, 10 tons/acre biochar
c. **Compost 15:** 15 tons/acre compost, 0 tons/acre biochar
d. **Compost + Biochar:** 15 tons/acre compost, 10 tons/acre biochar

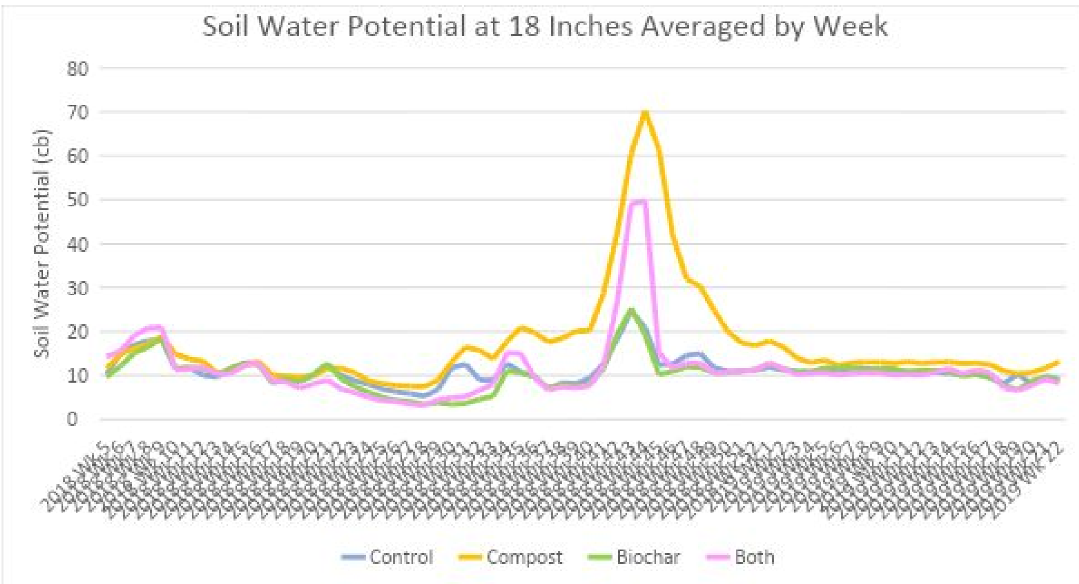
Plot Design: Shown in map below, image 2 in Images section.

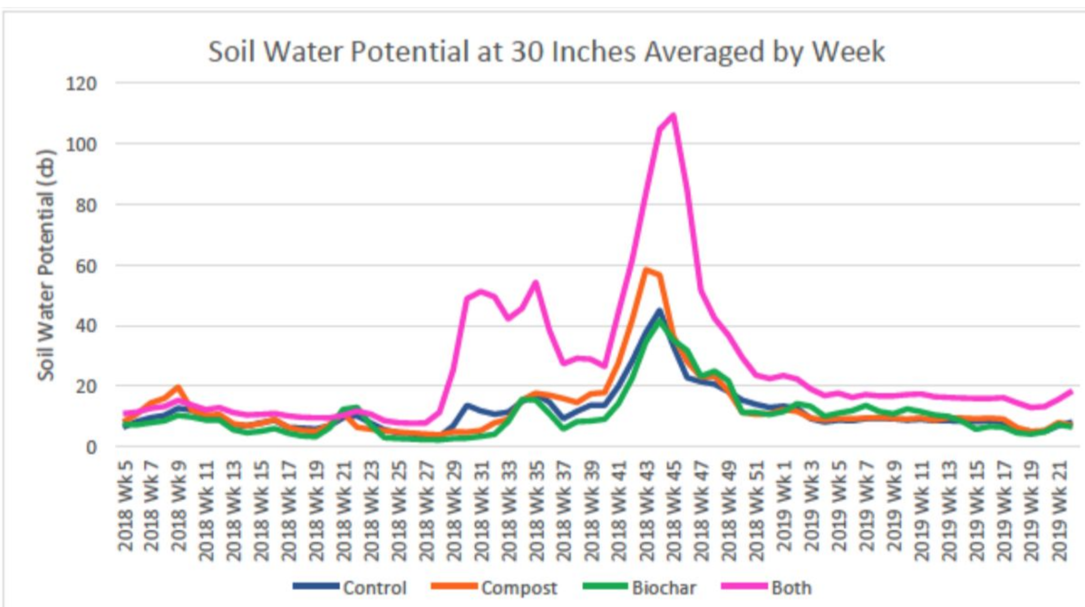
Methods:
Cluster counts: Data on the number of inflorescences were obtained from every 10th vine, with a total of 10 vines per plot counted.
Pruning weight: During dormancy, data on the weight of pruned vines were obtained from every 10th vine, with a total of 10 vines per plot counted.
Fruit weight: At harvest in 2019, data on the weight of fruit per vine was obtained from every 5th vine, with a total of 10 vines per plot counted.
NDVI: Normalized Difference Vegetation Index reading (NDVI) of the entire field was measured on June 18, 2019 by VineView and is represented as Enhanced Vegetation Index (EVI). EVI by VineView described as "Our Calibrated Vine Vigor data products are created using the Enhanced Vegetation Index, a ratio of how much sunlight is reflected off the plants in different colour bands, including infrared...Using additional wavelengths of light, we are able to correct the errors associated with NDVI."
Moisture sensors: Two Watermark sensors were installed on February 1, 2018 in each plot, one at 18-inch depth and the second at 30-inch depth. These sensors were installed with the wires running through PVC pipes buried 2 ft. deep. Soil moisture data was logged with a Watermark 9000 logger.

Results: The results reported below are averaged over 4 replicates. All treatments received identical irrigation and fertilizer inputs. Water sensors, installed at 18 and 30 inches to monitor soil water potential, showed soil moisture remained fairly consistent across all treatments and depths, with the exception of: compost + biochar treatment showed increased soil water potential (i.e. it was drier) at the 30-inch depth.

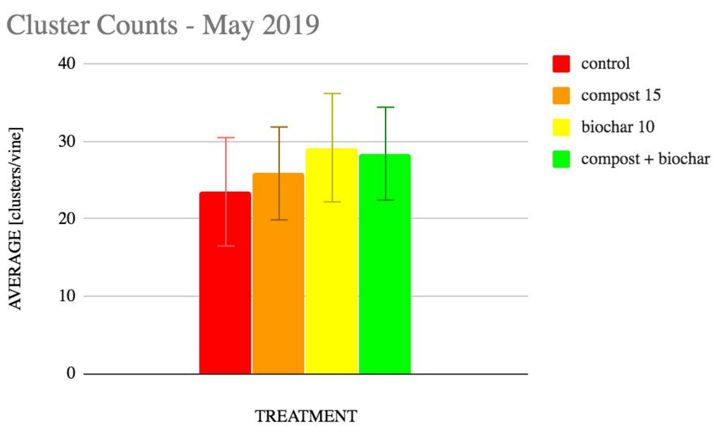
In the biochar-only treatment rows, data from the first harvest season in third leaf show a 45% increase in yield over the control (+1.3 ton/acre), a significant increase in grape clusters (+6 clusters/vine), and improved vine balance (i.e. Ravaz Index). The compost + biochar treatment produced the largest pruning weight measurements as well as a significant increase in yield (+¾ tons/acre) over control.

The NDVI data shown in the images section illustrate trends that were also observed on the ground. That is, vines in the biochar + compost treatment area had the greatest vigor, with all different treatment areas showing increased vigor when compared to the control.





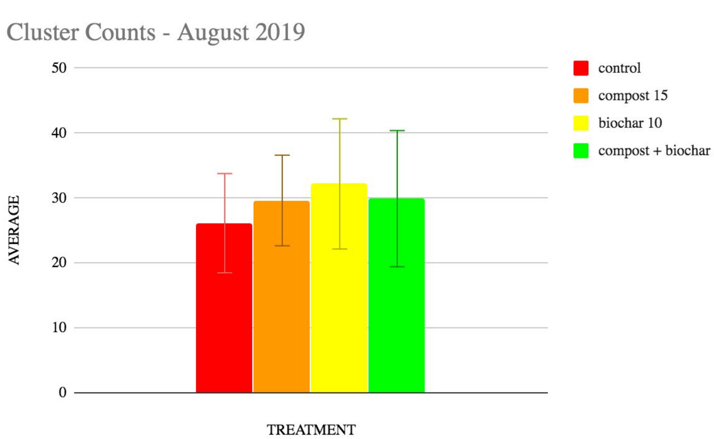
Each line represents the average soil water potential for each treatment over the course of a week in centibar values. These data were collected from the Watermark sensors from February 1, 2018 to June 4, 2019 at the Monterey Pacific vineyard. Higher measurements indicate drier conditions in the soil. Measurements were taken at both 18 in (1a) and 30 in (1b). Blue lines indicate the unamended control plots, orange indicate the compost-amended plots, green indicate the biochar-amended plots, and pink indicate the plots amended with both biochar and compost. (Figure and description courtesy of Elizabeth Crutchfield and Milton E. McGiffen, UC-R.)



Average Cluster Count Data (clusters/vine) MAY 2019

TREATMENT	AVERAGE*	% over control	ST. DEV.*
control	23	0%	7
compost 15	26	10%	6
biochar 10	29	24%	7
compost + biochar	28	21%	6

*using data from all four replications



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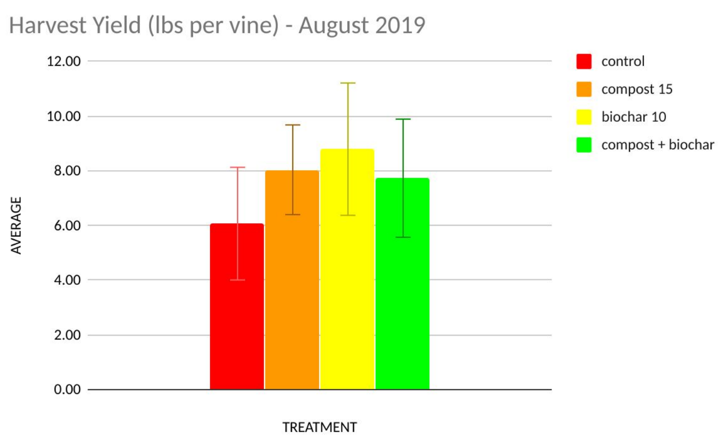
Average Cluster Count Data (clusters/vine) AUGUST 2019

TREATMENT	AVERAGE*	% over control	ST. DEV.*
control	26	0%	8
compost 15	30	13%	7
biochar 10	32	23%	10
compost + biochar	30	14%	10

*using data from all four replications



Average Harvest Yield Data (lbs/vine) 2019

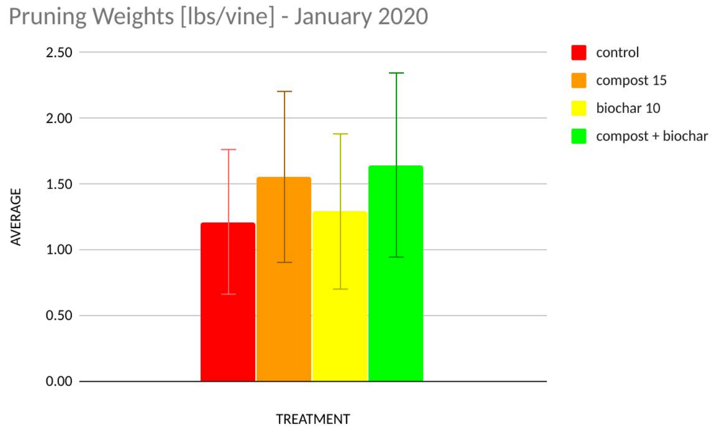
TREATMENT	AVERAGE*	% over control	ST. DEV.*
control	6.07	0%	2.1
compost 15	8.04	32%	1.6
biochar 10	8.79	45%	2.4
compost + biochar	7.73	27%	2.2

*using data from all four replications

Average Harvest Yield Data (tons/acre) 2019

TREATMENT	AVERAGE*	% over control	ST. DEV.*
control	2.94	0%	1.0
compost 15	3.89	32%	0.8
biochar 10	4.26	45%	1.2
compost + biochar	3.74	27%	1.0

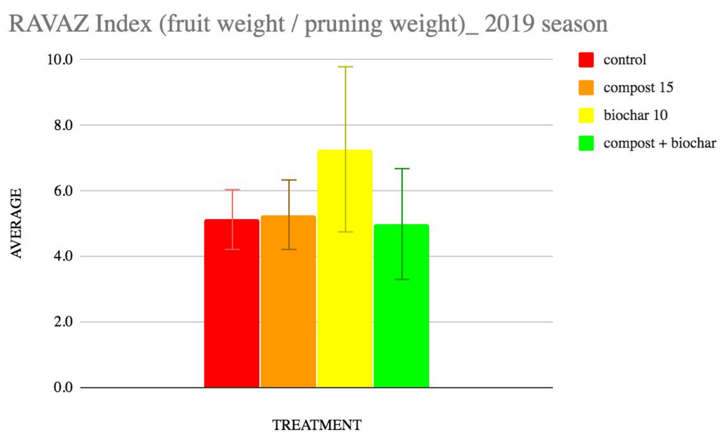
*using data from all four replications



Average Pruning Weight Data (lbs/vine) January, 2020

TREATMENT	AVERAGE*	% over control	ST. DEV.*
control	1.21	0%	0.55
compost 15	1.55	28%	0.65
biochar 10	1.29	6%	0.59
compost + biochar	1.65	36%	0.70

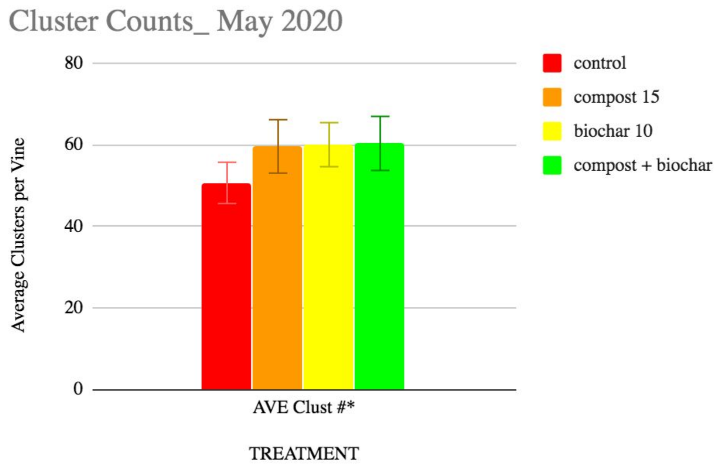
*using data from all four replications



Average RAVAZ Index Data [lb/lb]

TREATMENT	AVERAGE*	% over control	ST. DEV*
control	5.1	0%	0.9
compost 15	5.3	3%	1.1
biochar 10	7.3	42%	2.5
compost + biochar	5.0	-3%	1.7

*using data from all four replications



Cluster Count (clusters/vine)_ May 2020

TREATMENT	AVE Clust #*	% over control	ST. DEV.*
control	51	0%	10
compost 15	60	18%	11
biochar 10	60	19%	9
compost + biochar	60	19%	11

*using data from all four replications

Discussion: Global research has demonstrated that both biochar and compost are valuable sources of soil organic matter. When applied as soil amendments, both biochar and compost have been used to improve soil health, improve water conservation, and enhance crop productivity in agricultural soils. Of particular interest in this trial is the synergistic relationship between compost and biochar and its impact on water use efficiency. Because all treatments received identical irrigation the observed increases in yield, pruning weight, and clusters were achieved without any additional water usage. In fact, our soil water potential data shows that soil moisture was relatively unchanged between treatments with the exception of the compost + biochar treatment at the 30 inch depth. This is consistent with growth data because vigorous vines, as observed in the compost + biochar treatment, tend to pull more water from the surrounding soil.

Harvest yield data taken during the 2019 season showed a 45% yield increase -- from 6.07 lbs/vine in the control to 8.79 lbs/vine in the biochar-only treatment. With 968 vines per acre, this represents approximately a 1.3 ton/acre increase over the control. At the current grape price of about $1 per lb. of fruit, the value of this yield increase would be $2,600/acre. The cost of biochar in this trial was approximately $2,400/acre (10 tons biochar/acre * $240 per ton biochar), indicating that the biochar has already paid for itself in the first harvest. There is, of course, great interest now to see what second year harvest will show.

Wine grape quality metrics were not collected in this first harvest. Industry professionals have suggested that in addition to soil health and yield volume metrics, data on grape quality will be critical in supporting widespread adoption.

Pruning weight data collected in the dormant season further corroborated the beneficial impact of biochar based on the Ravaz Index (RI), a ratio of fruit weight to pruning weight indicating vine balance with the ideal range 5-10 for *Vitis vinifera*. From this perspective the biochar treatment stands out with a vine balance of 7.3 (lb/lb) compared with the control and compost treatments ranging between 5.0-5.3 (lb/lb). The results represent a dramatic increase in RI over the control while still under RI < 10 (lb/lb), indicating a good balance between fruit yield and vine vigor. Increases observed in yield and plant growth characteristics reflect improved water use efficiency, with the same amount of water resulting in increased vigor and crop production.

May 2020 cluster counts show a similar trend to that of 2019, where more clusters were found in all treatments when compared to the control. While in 2019 the greatest increase in both cluster counts and fruit yield was found in the biochar-only treatment, the cluster counts of May 2020 show an essentially dead-even increase above control among all the different treatment approaches. It is speculated that the compost-fueled vigor observed in 2019, which represented itself more as increased foliage than as increased yield, likely supported development of root system and vine girth, and may be able to better translate into yield this year.

The vine vigor imagery attached shows the very large range of variability in this field experiment. High weed and rodent pressure, as well as highly variable soil composition provided tough trial conditions. For this reason, standard deviations for measured parameters were high and so differences were not all significant, but were large enough to indicate real effects.

It appears clear that adding organic matter, whether through using compost or biochar or both, has been beneficial in this vineyard in which sandy soil and low organic matter were defining characteristics. This finding is consistent with many other research results.

California has been appropriately ambitious in its efforts to improve drought resiliency, to build and maintain healthy soils throughout the state, and to support effective climate-smart agricultural practices. This is important since there are many clear and ominous signs that ignoring such challenges would be greatly detrimental. Healthy soils high in organic matter can help the state meet its goals of drought resiliency, crop productivity, and carbon drawdown, as recognized in the Healthy Soils Program. Biochar is a naturally occuring and stable form of organic matter that holds great potential for long-term benefit when adopted with broader use throughout modern agriculture. This is particularly true in this western region where woody biomass waste management can be measured in tens of millions of tons per year and soils low in organic matter are quite abundant.

In sum, the observations provided in this Oasis Vineyard field trial identify application of biochar that is certainly worthy of being repeated. As shown, further research and development are recommended to demonstrate increasingly the advantages in soil health and agricultural success feasible from this approach.

Images:

Image 1: Preplant soil preparation

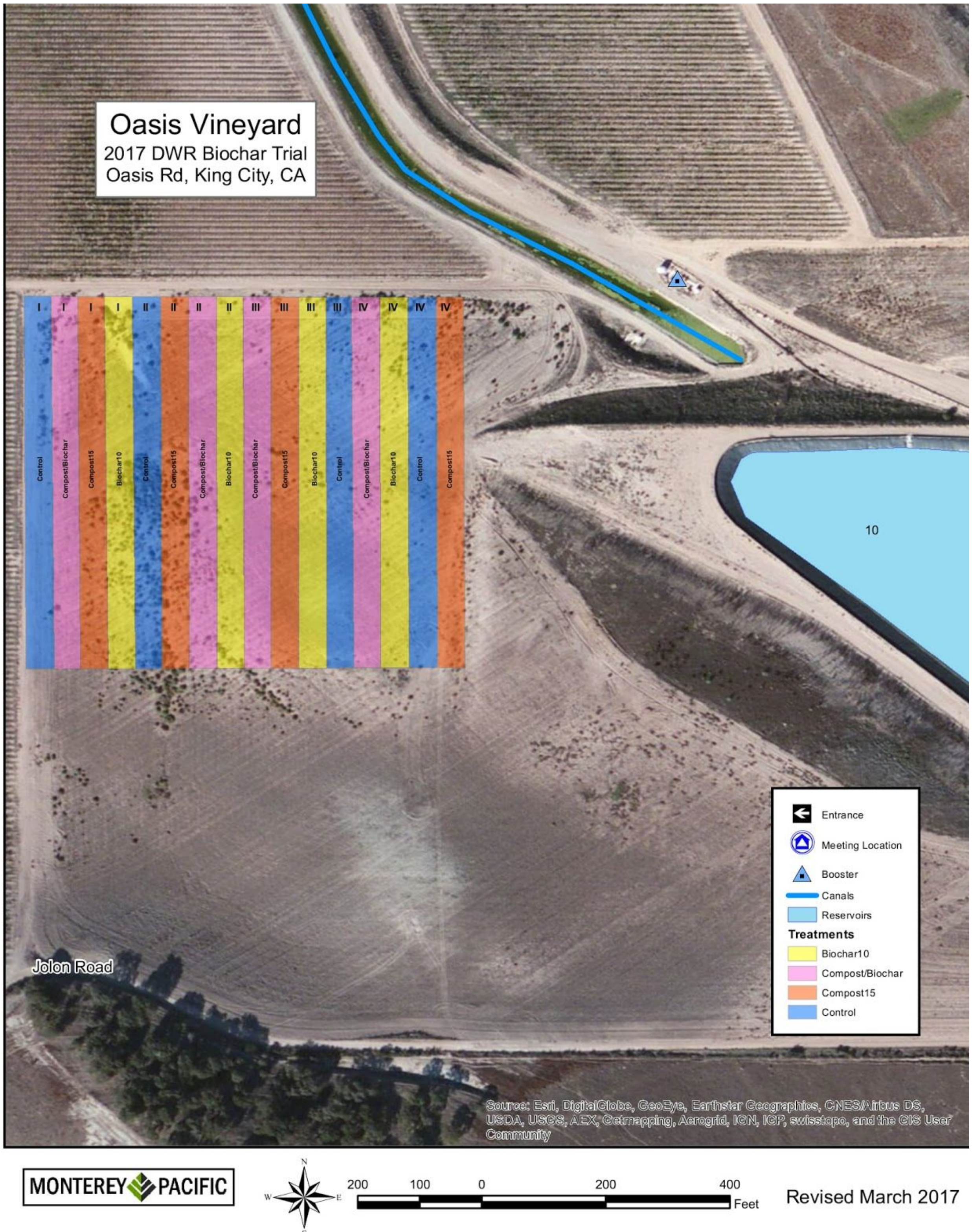
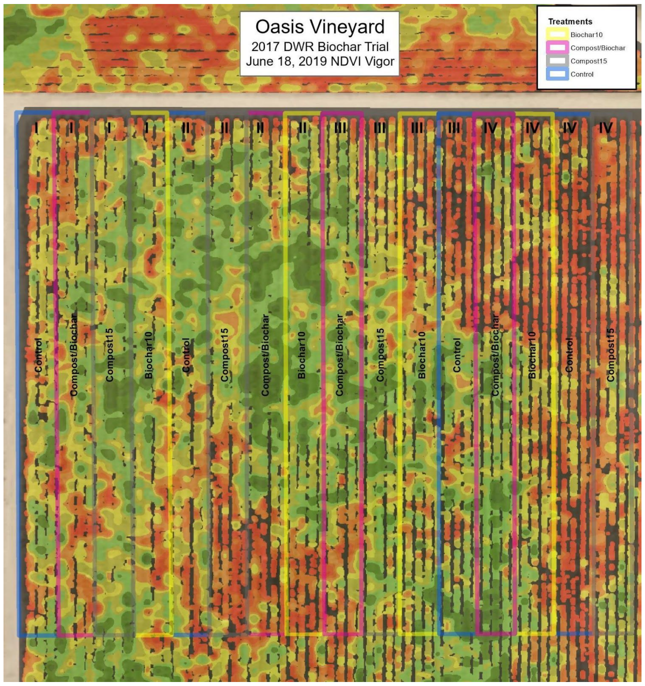
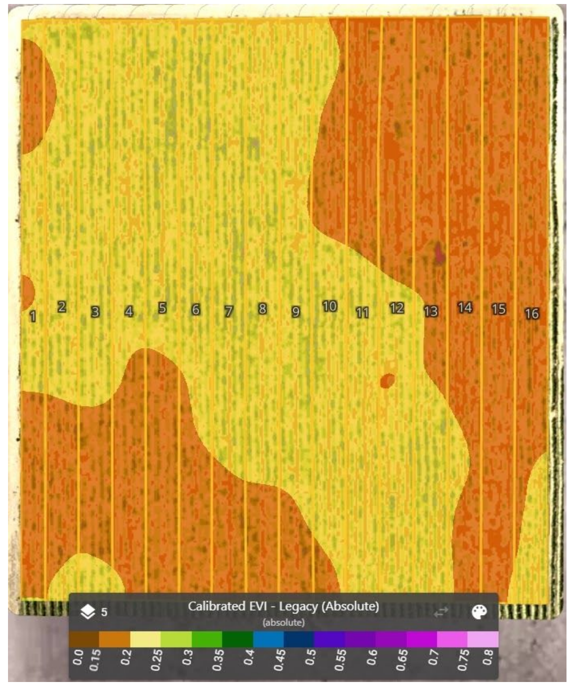
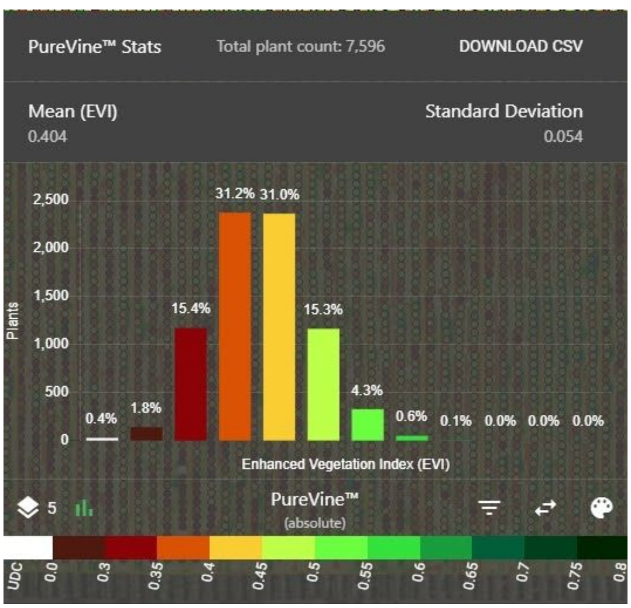


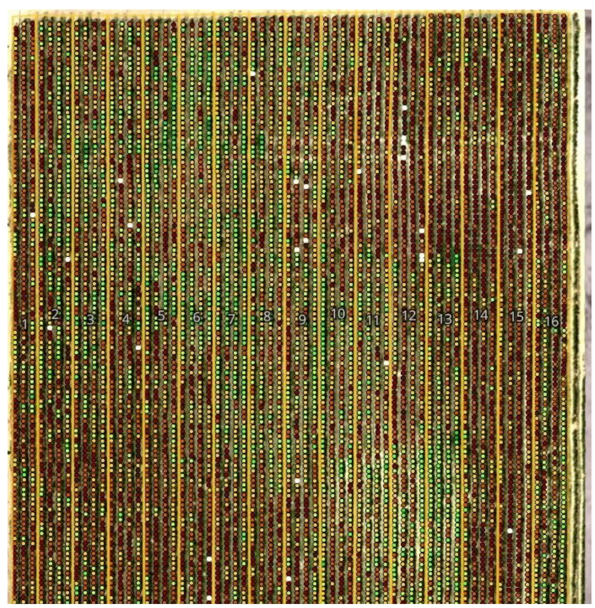
Image 2, Plot design and treatment information. (image credit: Doug Beck)



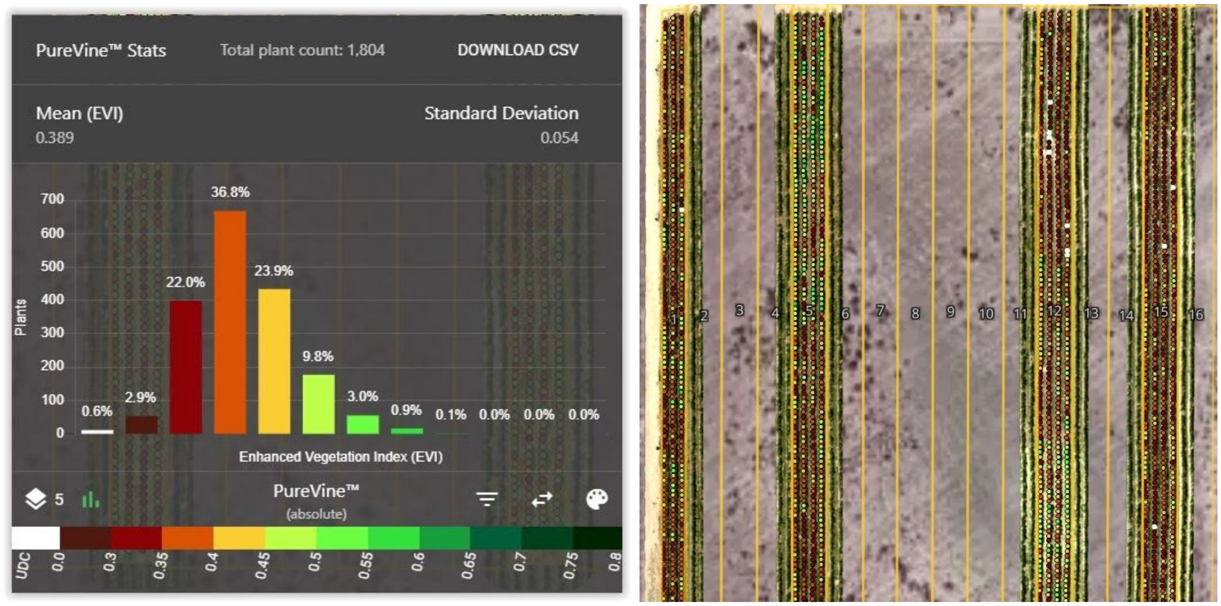


Normalized Difference Vegetation Index (NDVI - left) & Enhanced Vegetation Index (EVI - right)

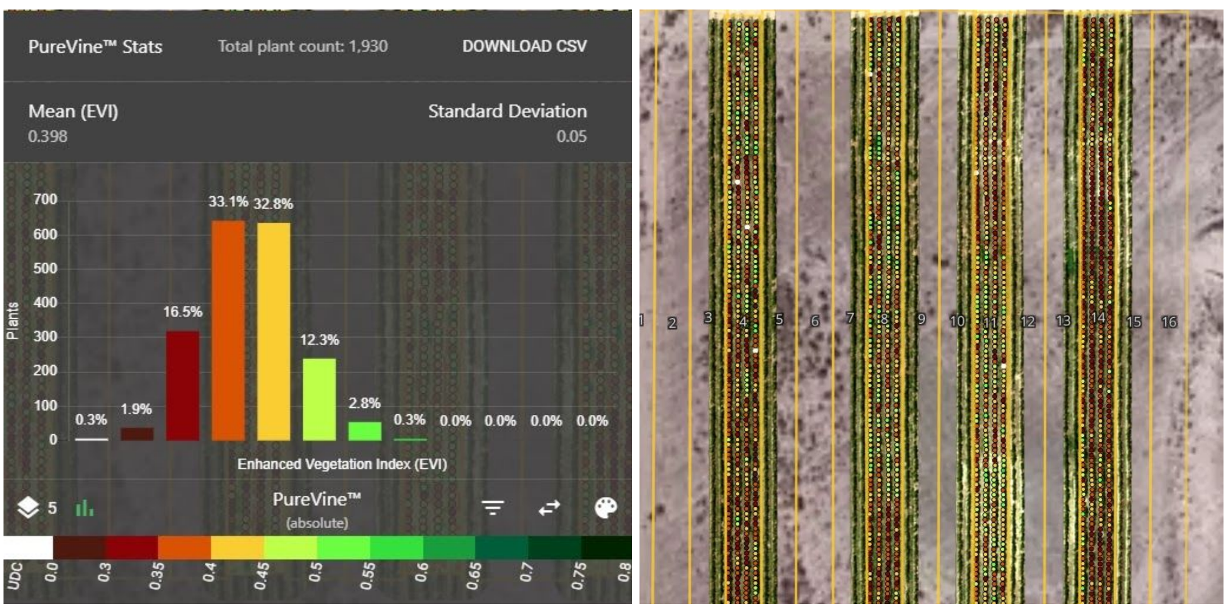




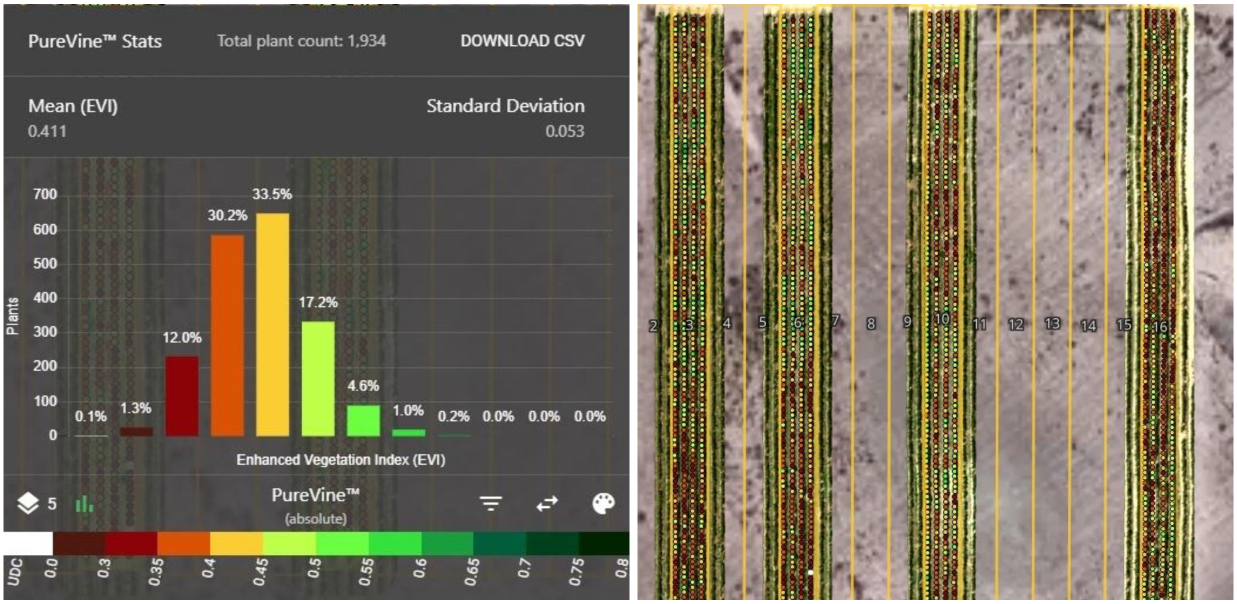
VineView PureVine Stats - All Blocks - Mean EVI 0.404



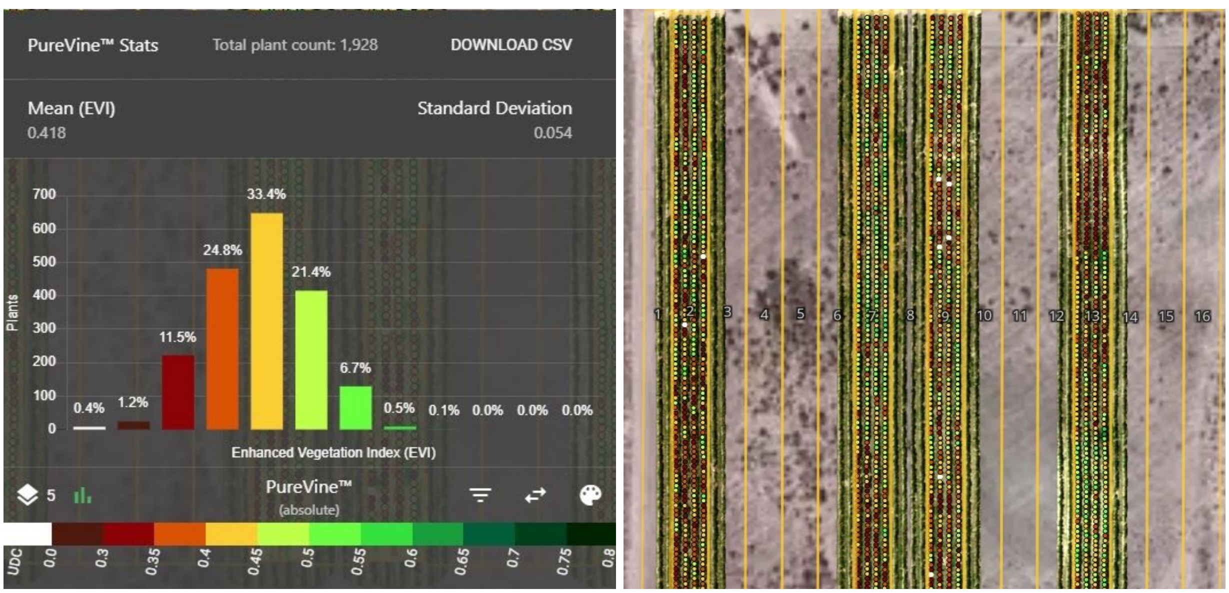
VineView PureVine Stats - Control - Mean EVI 0.389



VineView PureVine Stats - Biochar Treatment - Mean EVI 0.398



VineView PureVine Stats - Compost Treatment - Mean EVI 0.411



VineView PureVine Stats - Compost + Biochar Treatment - Mean EVI 0.418

	As-Received	Dry Weight Basis
Moisture	38.2 %	0.0 %
Bulk Density	0.27 g/cc	0.17 g/cc
	17.1 lb/cu ft	10.6 lb/cu ft
Carbon (C)	43.0 %	69.7 %
Hydrogen (H)	1.1 %	1.7 %
Nitrogen (N)	0.4 %	0.7 %
Oxygen (O -calc.)	1.5 %	2.5 %
Ash	15.7 %	25.5 %
	100.0 Sum	100.0 Sum
Volatile Matter	12.3 %	19.9 %
Butane Activity	3.6 g/100 g	5.8 g/100 g
Surface Area Correlation	196.5 m^2/g	318.0 m^2/g
Organic Carbon	42.0 %	68.0 %
H/Corg.	0.30	0.30
Carbonates (as $CaCO_3$)	8.78 %	14.22 %

Biochar analysis representative of material delivered by Pacific Biochar

Nutrients	Dry wt.	As Rcvd.	units
Total Nitrogen:	1.5	0.79	%
Ammonia (NH_4-N):	18	9.1	mg/kg
Nitrate (NO_3-N):	450	230	mg/kg
Org. Nitrogen (Org.-N):	1.5	0.77	%
Phosphorus (as P_2O_5):	3.7	1.9	%
Phosphorus (P):	16000	8300	mg/kg
Potassium (as K_2O):	7.9	4.1	%
Potassium (K):	66000	34000	mg/kg
Calcium (Ca):	27	14	%
Magnesium (Mg):	2.7	1.4	%
Sulfate (SO_4-S):	4000	2000	mg/kg
Boron (Total B):	110	58	mg/kg
Moisture:	0	48.7	%
Sodium (Na):	1.6	0.83	%
Chloride (Cl):	0.83	0.43	%
pH Value:	NA	7.59	unit
Bulk Density :	21	41	lb/cu ft
Carbonates ($CaCO_3$):	130	66	lb/ton
Conductivity (EC5):	13	NA	mmhos/cm
Organic Matter:	42.5	21.8	%
Organic Carbon:	22.0	11.0	%
Ash:	57.5	29.5	%
C/N Ratio	14	14	ratio
AgIndex	5	5	ratio

Stability Indicator:		Biologically
CO2 Evolution	Respirometery	Available C
mg CO_2-C/g OM/day	0.73	1.0
mg CO_2-C/g TS/day	0.31	0.44
Stability Rating	*very stable*	*very stable*

Maturity Indicator: Cucumber Bioassay	
Compost:Vermiculite(v:v)	1:2
Emergence (%)	93
Seedling Vigor (%)	109
Description of Plants	*healthy*

Pathogens	Results	Units	Rating
Fecal Coliform	8.5	MPN/g	*pass*
Salmonella	< 3	MPN/4g	*pass*

Date Tested: 20 Apr. 16

Inerts	% by weight
Plastic	< 0.5
Glass	< 0.5
Metal	< 0.5
Sharps	ND

Compost analysis representative of material delivered by Keith Day Company

Many thanks to all that contributed, particularly: