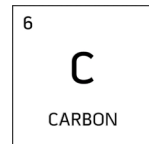
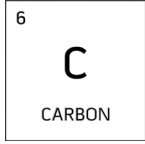


Biochar Sourcing & Usage in Vineyards

Charlie McIntosh
Pacific Biochar Benefit Co.







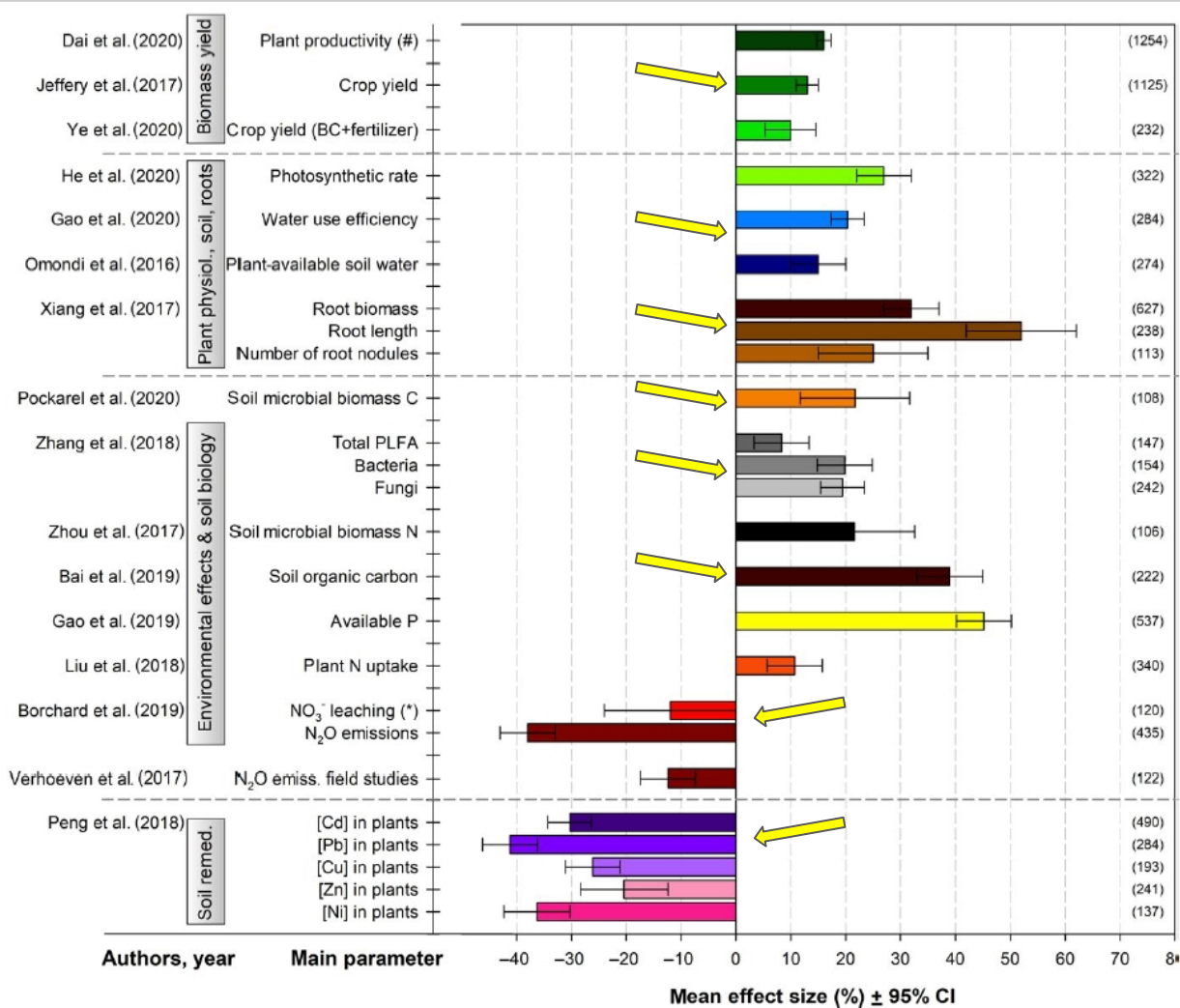




Biochar in agriculture – A systematic review of 26 global meta-analyses

Hans-Peter Schmidt¹ | Claudia Kammann² | Nikolas Hagemann^{3,4} | Jens Leifeld⁴ | Thomas D. Bucheli⁴ | Miguel Angel Sánchez Monedero⁵ | Maria Luz Cayuela⁵

FIGURE 2 Selected parameters with highest agronomic relevance that were investigated in the 26 reviewed meta-analyses. The mean overall effect size (% change) and 95% confidence intervals are given as reported in the original studies. The numbers in parentheses indicate the number of pairwise comparisons used for that specific parameter





Oasis Vineyard Biochar Trial

California Dept. of Water Resources, University of California Riverside,
Sonoma Ecology Center, Monterey Pacific Inc, & Pacific Biochar

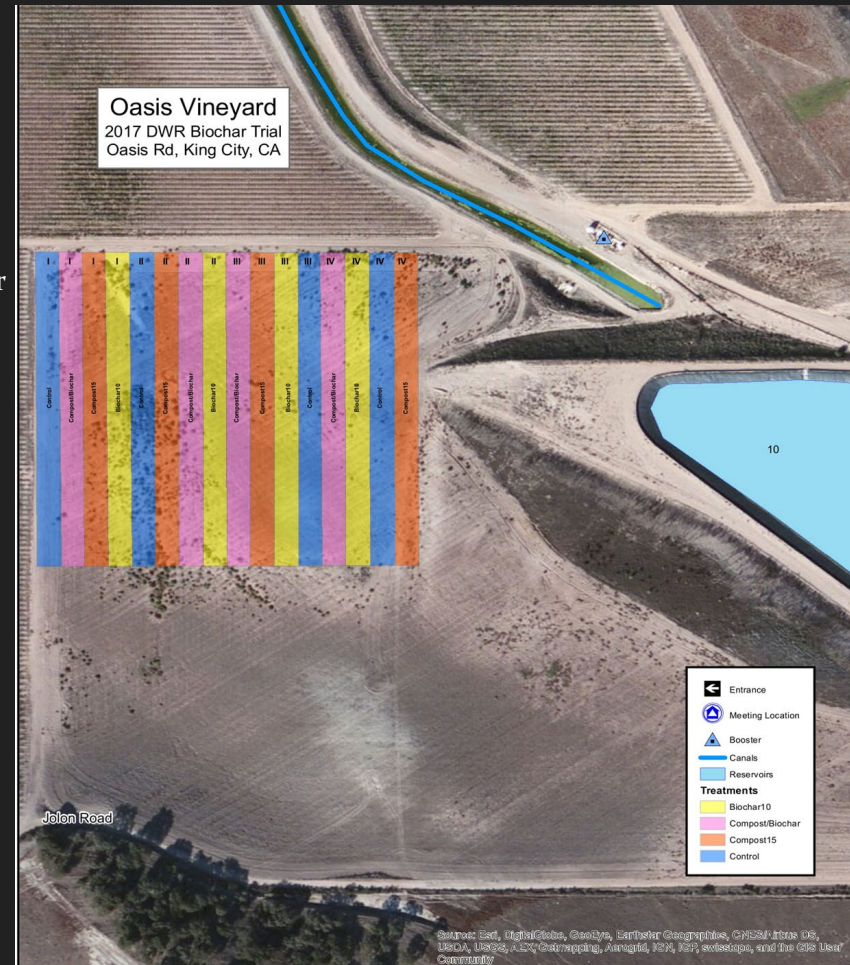


Oasis Vineyard Trial 2017-2020

Treatments:

All treatments applied at depth down planting row (delved) in random pattern (4 replicates) across 8 acre trial area with standard annual fertilizer applications across all blocks

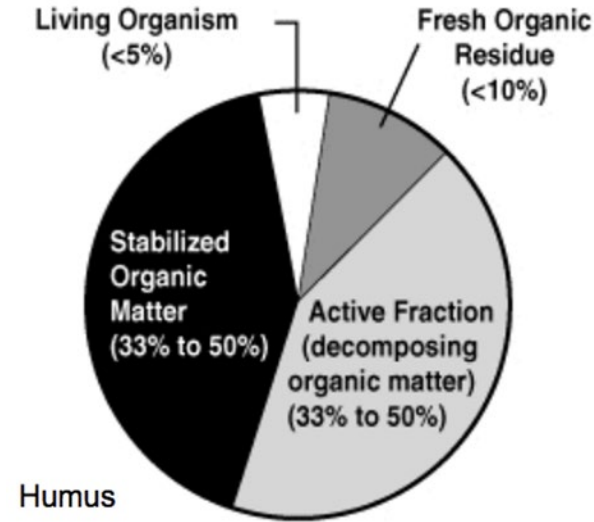
- Control - 0 tons/acre compost, 0 tons/acre biochar
- Compost 15 - 15 tons/acre compost
- Biochar 10 - 10 tons/acre biochar
- Compost + Biochar - 15 tons/acre compost, 10 tons/acre biochar



Treatments + soil prep work done in late 2016



Soil Organic Matter (SOM) Calculations for Biochar and Compost Treatments



%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%

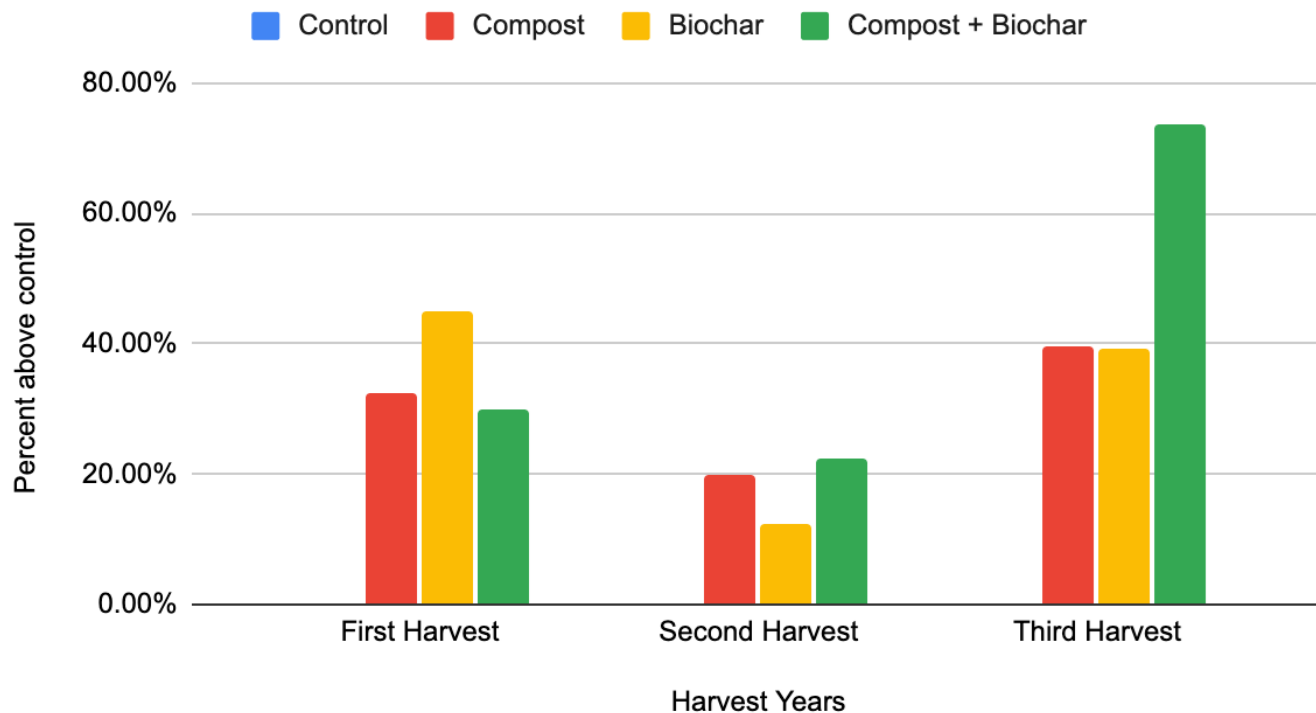
Tables show data from the first 3 harvests: 2019 - 2021

Harvest 2019 3rd Leaf	Yield	Cluster #	Cluster lb
R1	2.78	26.40	0.31
R2 Control	3.73	28.70	0.27
R3	2.82	23.10	0.25
R4	2.42	26.30	0.31
Control Average	2.94	26.13	0.29
R1	4.04	30.60	0.27
R2 Compost	3.30	27.10	0.25
R3	4.20	33.20	0.26
R4	4.02	27.60	0.30
Compost Average	3.89	29.63	0.27
R1	3.94	28.50	0.29
R2 Biochar	4.90	39.60	0.26
R3	3.63	27.30	0.28
R4	4.55	33.30	0.28
Biochar Average	4.26	32.18	0.28
R1	3.78	26.80	0.29
R2 Compost + Biochar	3.58	24.40	0.30
R3	3.83	36.90	0.21
R4	4.08	31.50	0.27
Compost-Bio Average	3.82	29.90	0.27

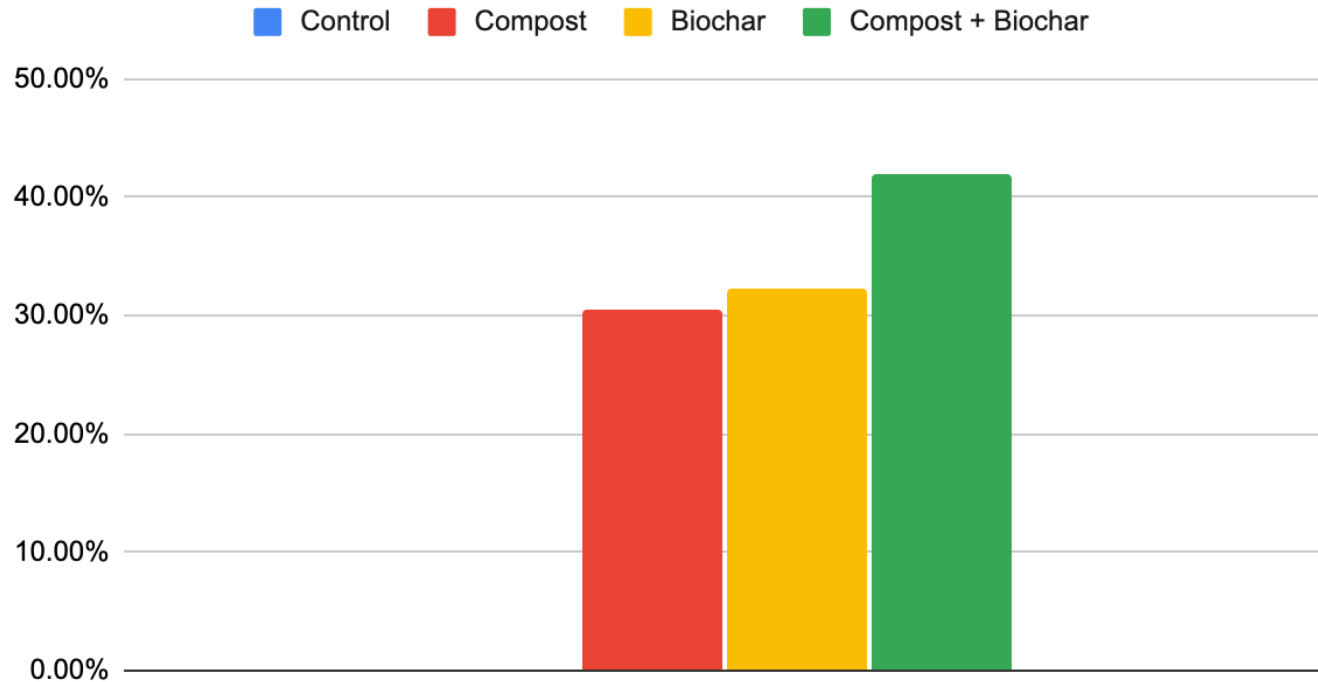
Harvest 2020 4th Leaf	Yield	Cluster #	Cluster lb
R1	9.22	54.60	0.31
R2 Control	10.12	53.95	0.34
R3	8.66	46.60	0.34
R4	8.00	41.85	0.35
Control Average	9.00	49.25	0.34
R1	10.37	55.25	0.34
R2 Compost	10.72	54.30	0.36
R3	11.39	62.60	0.33
R4	10.68	54.45	0.36
Compost Average	10.79	56.65	0.35
R1	10.71	57.00	0.34
R2 Biochar	10.79	57.40	0.35
R3	10.72	58.50	0.34
R4	8.27	45.55	0.33
Biochar Average	10.12	54.61	0.34
R1	11.21	58.80	0.35
R2 Compost + Biochar	10.23	55.15	0.34
R3	13.09	65.10	0.37
R4	9.57	49.85	0.35
Compost-Bio Average	11.02	57.23	0.35

Harvest 2021 5th Leaf	Yield	Cluster #	Cluster lb
R1	2.897	25.40	0.21
R2 Control	3.376	30.25	0.20
R3	4.438	56.15	0.15
R4	4.62	48.60	0.17
Control Average	3.833	40.10	0.18
R1	4.397	33.40	0.24
R2 Compost	3.762	37.20	0.19
R3	6.044	49.65	0.22
R4	7.193	65.85	0.20
Compost Average	5.349	46.53	0.21
R1	4.108	32.30	0.23
R2 Biochar	5.418	45.40	0.22
R3	6.161	52.95	0.21
R4	5.685	50.05	0.21
Biochar Average	5.343	45.18	0.22
R1	4.775	36.50	0.24
R2 Compost + Biochar	6.382	41.00	0.29
R3	7.914	63.80	0.23
R4	7.533	68.30	0.20
Compost-Bio Average	6.651	52.40	0.24

Yield, Percent Above Control, 3 Harvests



Yield, Percent Above Control, 3 yr Average



Compost Analysis

Nutrients	Dry wt.	As Rcvd.	units	Stability Indicator:		
Total Nitrogen:	1.5	0.79	%	CO2 Evolution	Respirometry	Biologically Available C
Ammonia (NH ₄ -N):	18	9.1	mg/kg	mg CO ₂ -C/g OM/day	0.73	1.0
Nitrate (NO ₃ -N):	450	230	mg/kg	mg CO ₂ -C/g TS/day	0.31	0.44
Org. Nitrogen (Org.-N):	1.5	0.77	%	Stability Rating	very stable	very stable
Phosphorus (as P ₂ O ₅):	3.7	1.9	%	Maturity Indicator: Cucumber Bioassay		
Phosphorus (P):	16000	8300	mg/kg	Compost:Vermiculite(v:v)	1:2	
Potassium (as K ₂ O):	7.9	4.1	%	Emergence (%)	93	
Potassium (K):	66000	34000	mg/kg	Seedling Vigor (%)	109	
Calcium (Ca):	27	14	%	Description of Plants	healthy	
Magnesium (Mg):	2.7	1.4	%	Pathogens		
Sulfate (SO ₄ -S):	4000	2000	mg/kg	Results	Units	Rating
Boron (Total B):	110	58	mg/kg	Fecal Coliform	8.5	MPN/g
Moisture:	0	48.7	%	Salmonella	< 3	MPN/4g
Sodium (Na):	1.6	0.83	%	Date Tested: 20 Apr. 16		
Chloride (Cl):	0.83	0.43	%	Inerts	% by weight	
pH Value:	NA	7.59	unit	Plastic	< 0.5	
Bulk Density :	21	41	lb/cu ft	Glass	< 0.5	
Carbonates (CaCO ₃):	130	66	lb/ton	Metal	< 0.5	
Conductivity (EC5):	13	NA	mmhos/cm	Sharps	ND	
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			

P per ton Compost at 8,300 ppm is about 17 lb/ton
=255 lb P per 15 tons compost or **0.26 lb/vine**

K per ton Compost at 34,000 ppm is about 68 lb/ton or
=1,020 lb K per 15 tons compost or **1 lb/vine**

Biochar Analysis



International BioChar Initiative (IBI) Laboratory Tests for Certification Program

	Dry Basis Unless Stated: Range	Units	Method
Moisture (time of analysis)	38.2	% wet wt.	ASTM D1762-84 (105c)
Bulk Density	10.6	lb/cu ft	
Organic Carbon	68.0	% of total dry mass	Dry Combust-ASTM D 4373
Hydrogen/Carbon (H:C)	0.30 0.7 Max	Molar Ratio	H dry combustion/C(above)
Total Ash	25.5	% of total dry mass	ASTM D-1762-84
Total Nitrogen	0.69	% of total dry mass	Dry Combustion

Basic Soil Enhancement Properties

Total (K)	19554 mg/kg	E
Total (P)	2738 mg/kg	E
Ammonia (NH4-N)	13.4 mg/kg	A
Nitrate (NO3-N)	10.2 mg/kg	A
Organic (Org-N)	6856 mg/kg	Calc.

P per ton Biochar at 2,738 ppm dry weight is about 3 lbs per ton as delivered

=33 lb P per 10 tons biochar or **0.03 lb/vine**

K per ton Biochar at 19,554 ppm dry weight is about 23 lb/ton as delivered

=230 lb K per 10 tons biochar or **0.24 lb/vine**

4th Leaf Grape Quality

Titratable Acidity			
AVERAGES	mg/L	% difference	ST DEV
Control	6.425	0.00%	0.26
Compost	6.375	-0.78%	0.29
Biochar	6.375	-0.78%	0.33
Com+Biochar	6.25	-2.72%	0.24
pH			
AVERAGES	pH	% difference	ST DEV
Control	3.3925	0.00%	0.08
Compost	3.4125	0.59%	0.09
Biochar	3.4275	1.03%	0.12
Com+Biochar	3.4575	1.92%	0.09
Brix			
AVERAGES	brix	% difference	ST DEV
Control	23.875	0.00%	1.01
Compost	23.35	-2.20%	0.47
Biochar	24.25	1.57%	0.99
Com+Biochar	23.75	-0.52%	0.87

Harvest 2020 4th Leaf	Yield	Cluster #	Cluster lb
R1	9.22	54.60	0.31
R2 Control	10.12	53.95	0.34
R3	8.66	46.60	0.34
R4	8.00	41.85	0.35
Control Average	9.00	49.25	0.34
R1	10.37	55.25	0.34
R2 Compost	10.72	54.30	0.36
R3	11.39	62.60	0.33
R4	10.68	54.45	0.36
Compost Average	10.79	56.65	0.35
R1	10.71	57.00	0.34
R2 Biochar	10.79	57.40	0.35
R3	10.72	58.50	0.34
R4	8.27	45.55	0.33
Biochar Average	10.12	54.61	0.34
R1	11.21	58.80	0.35
R2 Compost + Biochar	10.23	55.15	0.34
R3	13.09	65.10	0.37
R4	9.57	49.85	0.35
Compost-Bio Average	11.02	57.23	0.35

4th Leaf Berry Size

Berry Weight			
AVERAGES	g/berry	% difference	ST DEV
Control	1.3675	0.00%	0.02
Compost	1.33	-2.74%	0.05
Biochar	1.3925	1.83%	0.05
Com+Biochar	1.3575	-0.73%	0.02

Berry Volume			
AVERAGES	ml/berry	% difference	ST DEV
Control	1.1475	0.00%	0.04
Compost	1.185	3.27%	0.07
Biochar	1.24*	8.06%	0.08
Com+Biochar	1.15	0.22%	0.03

Sugar per Berry			
AVERAGES	mg/berry	% difference	ST DEV
Control	271.5	0.00%	12.48
Compost	273	0.55%	16.15
Biochar	298.5*	9.94%	12.79
Com+Biochar	270.5	-0.37%	16.82

Harvest 2020 4th Leaf				
Yield		Cluster #	Cluster lb	
R1	Control	9.22	54.60	0.31
R2		10.12	53.95	0.34
R3		8.66	46.60	0.34
R4		8.00	41.85	0.35
Control Average		9.00	49.25	0.34
R1	Compost	10.37	55.25	0.34
R2		10.72	54.30	0.36
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R4		8.27	45.55	0.33
Biochar Average		10.12	54.61	0.34
R1	Compost + Biochar	11.21	58.80	0.35
R2		10.23	55.15	0.34
R3		13.09	65.10	0.37
R4		9.57	49.85	0.35
Compost-Bio Average		11.02	57.23	0.35

4th Leaf Grape Color?

Polymeric Anthocyanins

AVERAGES	mg/L	% difference	ST DEV
Control	6.25	0.00%	0.9574
Compost	6.00	-4.00%	0.0000
Biochar	6.50	4.00%	0.5774
Com+Biochar	5.75	-8.00%	0.5000

Tannin

AVERAGES	mg/L	% difference	ST DEV
Control	207.50	0.00%	18.9473
Compost	200.25	-3.49%	18.9978
Biochar	211.75	2.05%	22.3961
Com+Biochar	201.00	-3.13%	20.4124

Total Anthocyanins

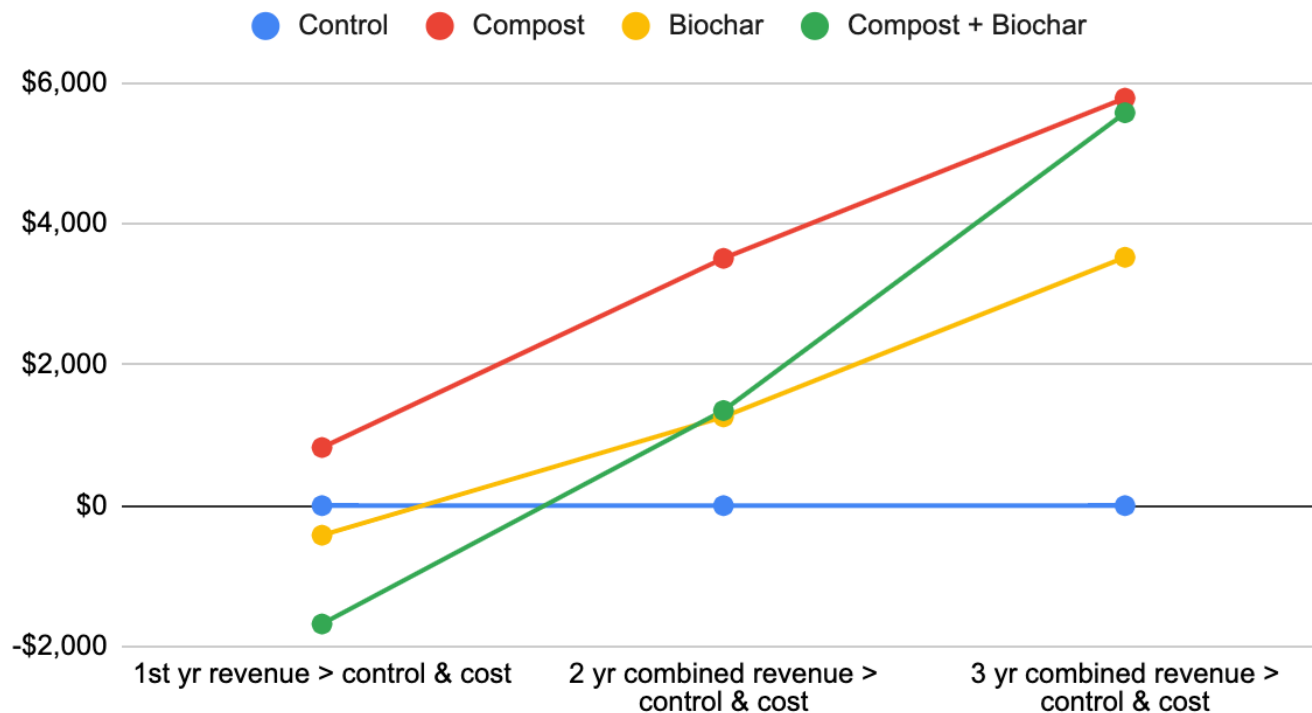
AVERAGES	mg/L	% difference	ST DEV
Control	627.50	0.00%	63.1057
Compost	628.50	0.16%	15.3514
Biochar	659.75	5.14%	49.5202
Com+Biochar	642.50	2.39%	60.7317

Harvest 2020 4th Leaf	Yield	Cluster #	Cluster lb
R1	9.22	54.60	0.31
R2 Control	10.12	53.95	0.34
R3	8.66	46.60	0.34
R4	8.00	41.85	0.35
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Compost-Bio Average	11.02	57.23	0.35

Economic Return Assessment on Biochar-Only Application

- Yield Increase 3rd Leaf
 - 2019 +biochar=1.3 ton/acre increase
Grape price \$1500/ton
 - Additional revenue/acre = **\$1,950**
- Yield Increase 4th Leaf
 - 2020 +biochar = 1.1 ton/acre increase
 - Grape price \$1500/ton
 - Additional revenue/acre = **\$1,650**
 - No further amendments cost
- Yield Increase 5th Leaf
 - 2021 +biochar = 1.5 ton/acre increase
 - Grape price \$1500/ton
 - Additional Revenue = **\$2,250**
- Biochar cost
 - 10 ton/acre
 - Biochar cost \$240 per ton
 - Cost/acre = **\$2,400**
- Return on Investment
 - Additional revenue
\$5,850/ac first 3 producing
years, **\$3450 above cost**

Additional revenue above cost for inputs



Biochar + Compost

CO-COMPOSTING, BLENDING, & AGING

- Compost is improved
 - Odor control (i.e. ammonia)
 - GHG emission reduction (i.e. CH_4 , N_2O , etc.)
 - Reduced nutrient loss, especially N
 - Increased microbial activity & diversity
 - Maturity and stability superior
- Biochar is improved
 - Complexed surface becomes more functional
 - Microbial colonization
 - Nutrient loading
 - Better plant growth response



Compost and biochar blend, side-dressed in existing vineyard





Microsoft carbon removal

Supplier	Project(s)	Location	Type	Description	Newly contracted volume (mtCO ₂)	Certification	Contracted durability (years)
Carbonfuture GmbH	Pacific Biochar	California	Biochar	Biochar produced from feedstock to directly lower water consumption of drought-stricken agricultural areas or as soil enrichment with compost additives	1,500	European Biochar Certificate	>100



United States
Department of
Agriculture



Natural Resources Conservation Service

Environmental Quality Incentives Program



The Environmental Quality Incentives Program (EQIP) provides financial and technical assistance to agricultural producers and non-industrial forest managers to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, increased soil health and reduced soil erosion and sedimentation, improved or created wildlife habitat, and mitigation against drought and increasing weather volatility.

Code	Practice	Component	Units	Unit Cost
808	Soil Carbon Amendment	100% Biochar	Ac	\$806.94
808	Soil Carbon Amendment	HU-100% Biochar	Ac	\$968.33



Thank you

Questions?