AGRICULTURAL RESEARCH FOUNDATION
FINAL REPORT
FUNDING CYCLE 2020 – 2022

TITLE:
Impact of Temperature, Ozone and Feedstock on Biochar Produced to Improve Soil Characteristics for Blueberry Systems in Eastern Oregon.

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COOPERATORS:
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SUMMARY/ABSTRACT:
Biochar is a highly porous, carbon-rich residue produced by thermochemical conversion (pyrolysis) of plant biomass and carbonaceous organic materials under oxygen-controlled conditions. Chars produced by this process tend to have high ion-exchange capacities and, when added to soil, increase retention of water and nutrients and improve soil aggregation, porosity, and aeration. Productivity has been shown to respond positively to biochar addition in several crops, including northern highbush blueberry; however, the cost is high, and benefits vary depending on the source, pyrolysis conditions, and feedstock of the biochar. A controlled experiment was conducted in a greenhouse to evaluate potential feedstocks for producing suitable and cost-effective biochar for blueberry. Biochars were individually produced from three locally available feedstocks (apple, blueberry, and grape prunings) at different pyrolysis temperatures (350 and 700 °C) and a control (non-pyrolyzed), and were either used "as is" or were co-composted for 6 weeks with grape pomace. Each treatment was mixed at 20%, by volume, with Atkins sandy loam soil and planted in 4-L pots with 'Duke' northern highbush blueberry. Additional treatments included soil with no amendments or 20% compost only. The plants were watered as needed, and fertilized weekly using a dilute solution of organic nitrogen, phosphorous, and boron fertilizers. Data of liquid drainage from plant containers (leachate) indicated the pH averaged 4.5–5.5 in each treatment, which is within the recommended range for northern highbush blueberry; however, the electrical conductivity of the leachate was 15-45% higher than recommended (< 2 dS/m) when the soil was amended with biochar only. Consequently, plants grew better with co-composted biochar than with biochar alone. Overall, plants grown with apple biochar produced at 350 °C co-composted with grape pomace had greater leaf area and approximately 30% greater total dry weight compared to the controls with no amendment or compost only. Plant response with other treatments showed an average of 30–80% reduced total dry weight compared to the apple biochar produced at 350 °C co-composted with grape pomace.

OBJECTIVES:
The objectives of this study were to identify a suitable and cost-effective soil amendment for northern highbush blueberry produced in calcareous soils by evaluating: 1) three locally available feedstocks for producing biochar, including woody prunings from apple, blueberry, and

wine grape; 2) optimal pyrolysis temperatures (350 and 700˚C) for biochar production; and 3) the impact of biochar co-composted with grape pomace (Table 1).
This project is focused on providing research-based solutions to ensure growers have access to data-driven, regionally specific recommendations. This research aims to provide management strategies to facilitate soil and plant relationships which optimize blueberry production. Although this proposal is focused on blueberries, the data will likely be transferrable to other important specialty crops produced in Oregon.

Table 1: A 3 × 3 × 2 experiment with 18 biochar treatments, including a combination of three pyrolysis temperatures [0 (control), 350, and 700°C], three feedstocks (prunings of 'Duke' blueberry, 'Fuji' apple, and 'Cabernet sauvignon' wine grape), and two levels of composting (no compost and co-composted with grape pomace).

Pyrolysis temperature	**No compost (C_0)**			**Co-composted with grape pomace (C_1)**		
	Apple (F_1)	**Blueberry (F_2)**	**Grape (F_3)**	**Apple (F_1)**	**Blueberry (F_2)**	**Grape (F_3)**
Control (T_0)	$T_0F_1C_0$	$T_0F_2C_0$	$T_0F_3C_0$	$T_0F_1C_1$	$T_0F_2C_1$	$T_0F_3C_1$
350°C (T_1)	$T_1F_1C_0$	$T_1F_2C_0$	$T_1F_3C_0$	$T_1F_1C_1$	$T_1F_2C_1$	$T_1F_3C_1$
700°C (T_2)	$T_2F_1C_0$	$T_2F_2C_0$	$T_2F_3C_0$	$T_2F_1C_1$	$T_2F_2C_1$	$T_2F_3C_1$

PROCEDURES:

Biochar production

Each batch of biochar was produced at a low pyrolysis temperature (300-350°C) and a high temperature (600-700°C) utilizing a mechanical pyrolysis unit. At each of the two temperatures, the three locally sourced feedstocks were hand pruned branches of 'Cabernet Sauvignon' grape, 'Fuji' apple and 'Duke' blueberry. Pruning material were collected from growers' fields in the same method and timeline as commercial pruning operations of the respective crops. The physicochemical properties of all the biochar treatments were analyzed, including surface area, pH, Electrical conductivity (EC), and content of ash, C, N, and other nutrients, by methods according to the International Biochar Initiative.

Greenhouse trial

Soil for the greenhouse evaluation trial was collected from an active blueberry field site in eastern Oregon, which has been pre-acidified to the desired soil pH (4.5 - 5.5) to support blueberry production. The biochar treatments (listed above) were individually blended at 20% volume with Atkins Sandy Loam Soil (soil type in eastern Oregon) and added to 4-L pots planted with 'Duke' blueberry plants sourced from Fall Creek nursery. Each pot was placed in a greenhouse at the OSU campus in Corvallis in a split-split plot design with six replications (figure 1). After four months of growth, leaf area, shoot and root dry weight, and leaf nutrient concentrations of each plant were examined. Soil samples were analyzed for pH, EC, Cation Exchange Capacity

Figure 1: Potted 'Duke' blueberry exposed to experimental treatments in the greenhouse.

(CEC), soil C, and macro and micronutrients. Each pot was watered as needed and fertilized weekly using a dilute solution of organic fertilizer. Leachate collected from each pot was analyzed for pH and EC to identify salt and pH parameters. After the four-month greenhouse trial, the biochar treatments that produced optimal blueberry growth were selected for an evaluation in a field setting (not included in this proposal). The outcome of this project has produced data to help guide grower's decisions and has been utilized to secure increased funding for an expanded field-based trial which is underway.

SIGNIFICANT ACCOMPLISHMENTS:
Results identified plants grown with biochar produced at a low pyrolysis temperature (350°C) from apple feedstock had greater leaf greenness (SPAD reading; Figure 2) and leaf area than control treatments. Grape pomace co-composted with biochar produced at the low temperature from apple feedstock resulted in greatest aboveground biomass than those grown alone with biochar, woodchips, composted grape pomace, or in unamended soil (Figure 3). The grape pomace was co-composted with biochars to make the pH conditions suitable and increase nutrients in the amendment. Although the pH of the soil and the raw biochar was high (6.72 and 8.5), leachate pH averaged 4.5 to 5.5 in each treatment. Overall, the data suggest that amending soil with biochar from apple feedstocks at a low pyrolysis temperature, when co-composted with grape pomace, appears to be a promising means of promoting plant growth in highbush blueberry relative to amending soil with only biochar or grape pomace alone. By sourcing local feedstock materials and making biochar on-site, the production costs are reduced when implemented on a large-scale. An economic analysis is underway in a new field trial assessing the optimal treatments from the current greenhouse study.

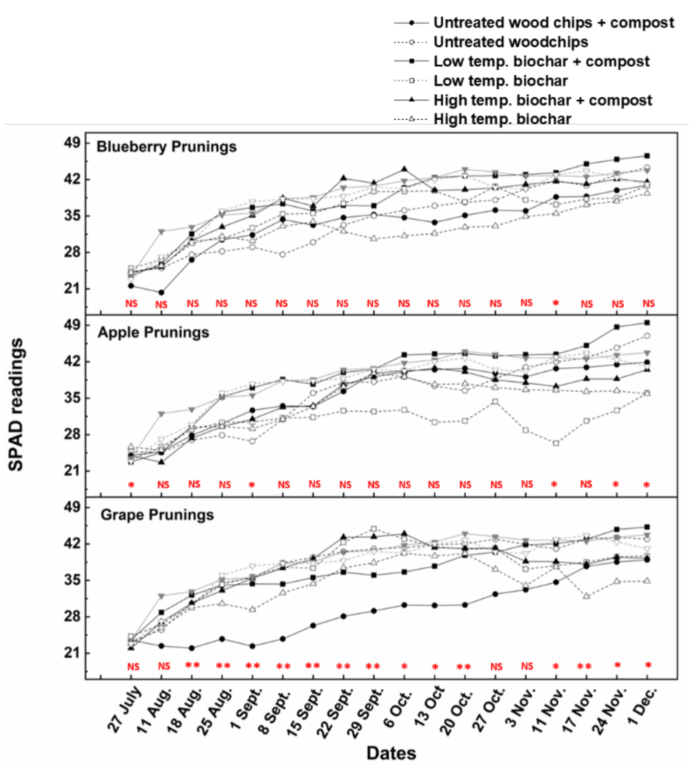

*Figure 2: SPAD meter readings measured on new, fully expanded leaves of 'Duke' blueberry at various time points. NS, *, **, Nonsignificant and significant at $P \leq 0.05$ and 0.01 respectively.*

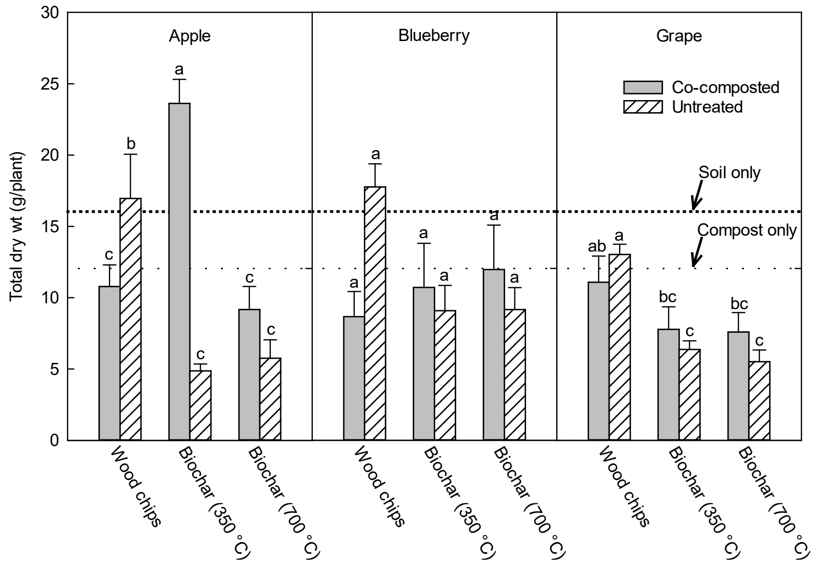

Figure 3. Total dry weight of 'Duke' blueberry plants grown in soil amended with apple, blueberry, or grape prunings that were chipped and either used "as is" (non-pyrolyzed) or pyrolyzed into biochar at 350 or 700 °C. Each amendment was untreated or co-composted with grape pomace prior to mixing them with the soil.

BENEFITS & IMPACT:

The results from this trial have identified a reduced cost organic amendment to improve blueberry establishment and growth. Additionally, the findings of the greenhouse study were upscaled to establish a long-term field trial in eastern Oregon at OSU's Hermiston Agricultural Research and Extension Center (HAREC). The overall impact of this research has the capacity to improve nutrient and water use efficiency, facilitate carbon storage in soil, and improve blueberry cropping system resiliency and sustainability.

ADDITIONAL FUNDING RECEIVED DURING PROJECT TERM:

We have been able to successfully acquire funding from the USDA Agricultural Research Service (ARS) to support a post-doctoral researcher (2 years of funding) to lead field trials at OSU HAREC and the USDA National Needs Fellowship program to support a Master of Science student. Additional funding has been generated to conduct an in-depth analyses of the soil microbial dynamics in the experimental field treatments.

FUTURE FUNDING POSSIBILITIES:

Future funding from the Oregon Blueberry Commission and the Washington Blueberry Commission is currently under review (as of 1/2022). We will use the potential future funding to expand the research objectives to further support eastern Oregon and Washington blueberry industries, as well as capture more data for a large-scale federal proposal.