School of Energy Resources
Center for Carbon Capture and Conversion

AN ASSESSMENT OF PLANT GROWTH AND SOIL PROPERTIES USING COAL CHAR AND BIOCHAR AS A SOIL AMENDMENT

WHAT THIS STUDY IS ABOUT

In this study, three-year field observations were carried out on use of coal char (CC) and biochar (BC) as soil amendments in unirrigated semiarid rangeland soil to study their effects on soil health, crop yield and nutrient holding capacity.

The CC used in this study was prepared with the pyrolysis of the sub-bituminous coal of the Powder River Basin (PRB) at temperatures 650, 750, and 800 °C under oxygen-limiting conditions to produce three different varieties of coal chars: CC650, CC750, and CC800.

The biochar used in the study was comprised of dead wood pine chips and tree barks that were pyrolyzed at approximately 650 °C.

The manure used in this study was a farmyard manure from the Sustainable Agriculture Research and Extension Center (SAREC) cattle feeding facility, University of Wyoming. No inorganic fertilizers were used in this study.

The field experiment was carried out during the cropping seasons in 2018, 2019, and 2020 at the University of Wyoming's James C. Hageman Sustainable Agriculture Research and Extension Center (SAREC), in Goshen County, Lingle (42.13° N, 104.39° W), WY, USA.

WHY IT WAS NEEDED

Soil degradation due to loss of soil organic carbon is a serious concern in semiarid agroecosystems. Biochar and other organic char products have long been known to increase soil organic carbon.

Agricultural use of CC has the potential to put the coal back into the ground as a stable carbon, which is expected to improve soil properties and increase agricultural productivity, and turning coal into CC for soil amendment instead of burning coal at power plants could reduce atmospheric CO_2 while continuing to utilize the vast natural resource.

Until now, there have been no studies on the use of CC produced with different pyrolysis temperatures as a soil amendment, and this is probably one of the first studies of its kind that has used and compared CC and BC simultaneously in the field.

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WHAT THE RESEARCH TEAM CONCLUDED

This study demonstrated that use of CC and BC as soil amendments could increase soil organic carbon and cation exchange capacity (CEC) in semiarid rangeland soil. At the same time, CC and BC incorporated with manure (M) increased grass biomass production as well as soil organic matter (OM) and CEC. The high surface area and greater pore spaces of CC and BC can retain nutrients supplied from manure, holding soil moisture for extended periods in unirrigated drylands. Therefore, manure co-applied with CC and BC could be beneficial to increase plant productivity and improve soil properties in semiarid soil. As soil amendments, CC and BC provided a comparable grass biomass yield, indicating that both products behave similarly in soil.

The effect of the dry years on the unirrigated rangeland soil was reflected in the lower grass biomass production in 2018 and 2020 compared with the wet year 2019. In general, treatment with CC and BC incorporated with manure resulted in greater aboveground grass biomass in all three years' study periods. In the cropping years 2018 and 2019, CC650M and biochar with manure (BCM) resulted in a significantly greater grass biomass than the control.

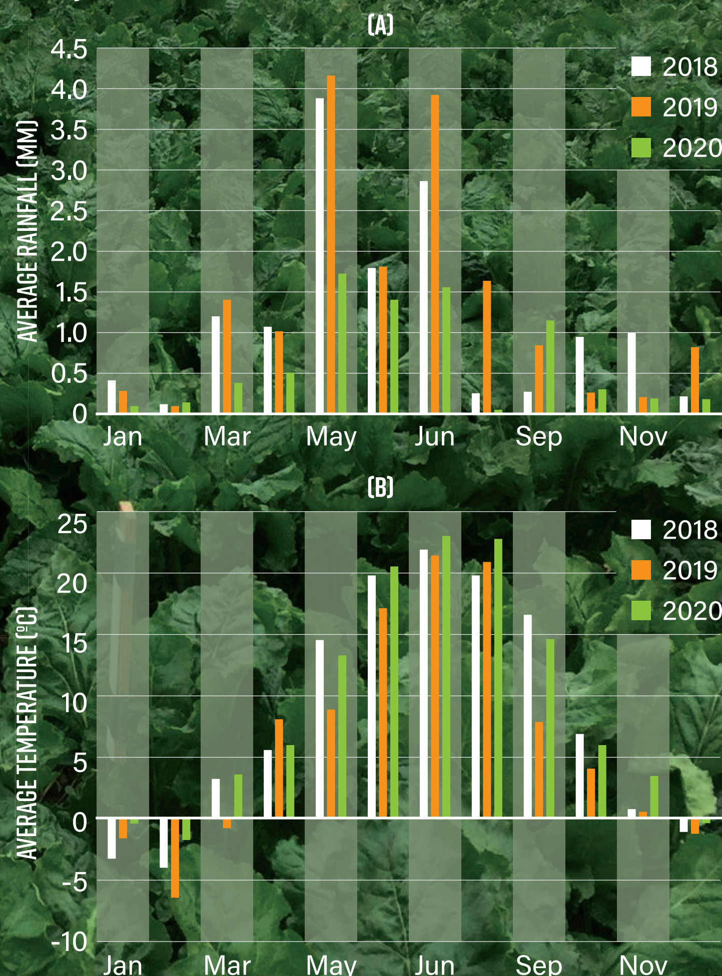
EFFECTS OF COAL CHAR, BIOCHAR, MANURE ALONE, AND COMBINED APPLICATION ON GRASS BIOMASS YIELD (G M^{-2})

	ABOVEGROUND DRY GRASS BIOMASS (G M^{-2})		
TREATMENTS	2018	2019	2020
CONTROL	99.8 ± 27.6^{c}	216.5 ± 17.2^{c}	98.6 ± 39.0^{b}
M*	161.1 ± 74^{abc}	247 ± 27^{abc}	105.7 ± 67^{b}
CC650	100.6 ± 51.1^{c}	240.3 ± 45.2^{bc}	135.6 ± 91.1^{ab}
CC650M*	**194.2 ± 57.6^{a}**	**307.1 ± 25.6^{a}**	**198.3 ± 41.3^{a}**
CC750	134.1 ± 33.2^{abc}	238.0 ± 34.7^{abc}	138.9 ± 78.0^{ab}
CC750M*	146.0 ± 51.1^{abc}	249.8 ± 40.6^{abc}	114.0 ± 35.4^{b}
CC800	115.2 ± 55.6^{bc}	219.1 ± 41.2^{c}	144.2 ± 74.6^{ab}
CC800M*	164.5 ± 50.6^{abc}	268.4 ± 37.2^{abc}	112.4 ± 47.7^{b}
BC*	147.1 ± 50.1^{abc}	251.0 ± 45.1^{abc}	126.0 ± 51.8^{ab}
BCM*	**188.8 ± 63.5^{ab}**	**292.6 ± 55.7^{ab}**	150.3 ± 30.6^{ab}

Mean weight of aboveground grass biomass (n = 12) with associated standard errors. Within a column, values not sharing a common letter are significantly different at α = 0.05 in the post-hoc Fisher's LSD test. Values in **bold** represent statistically significant difference from the control.

**M = Manure, BC = Biochar, BCM = Biochar with Manure*

Meteorological data showing monthly average rainfall (a) and monthly average air temperature (b) for the three growing seasons (2018, 2019, and 2020) at the study sites.



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Published in Agronomy 2024, 14(2), 320; https://doi.org/10.3390/agronomy14020320

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