The Effects of Biochar Use on Greenhouse Gas Emissions and Organic Farming in the Ohio Valley

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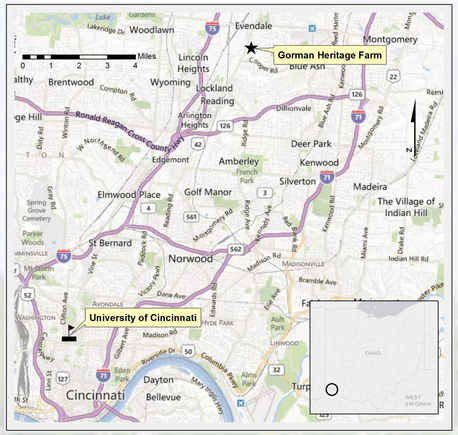
Biochar and Greenhouse Gasses

Greenhouse gases (GHGs) emitted through human activities contribute significantly to climate change. Globally, agriculture is the third largest source of carbon dioxide (CO_2) after fossil fuel combustion and deforestation. Agriculture is also a dominant source of methane (CH_4) and nitrous oxide (N_2O). Current agricultural practices deplete the organic carbon in the soil, negatively impacting fertility and moisture retention. Furthermore, our current agricultural paradigm relies on the creation of energy-intensive synthetic fertilizers to amend the soil, which then result in nutrient runoff and aquatic system eutrophication. Our research team and Gorman Heritage Farm investigated the potential GHG mitigation effects of biochar. Biochar is a type of processed charcoal and natural fertilizer that has also been studied as a carbon-sequestration pathway.

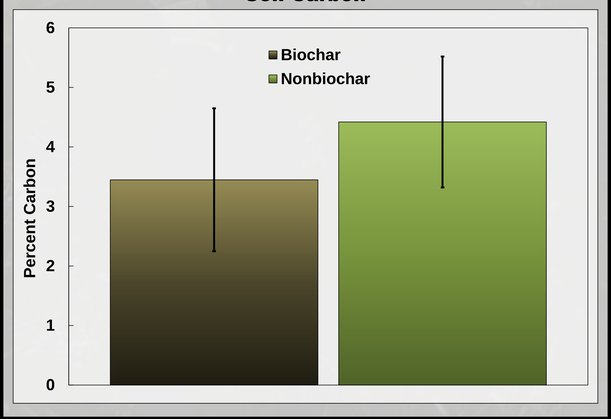


Methods

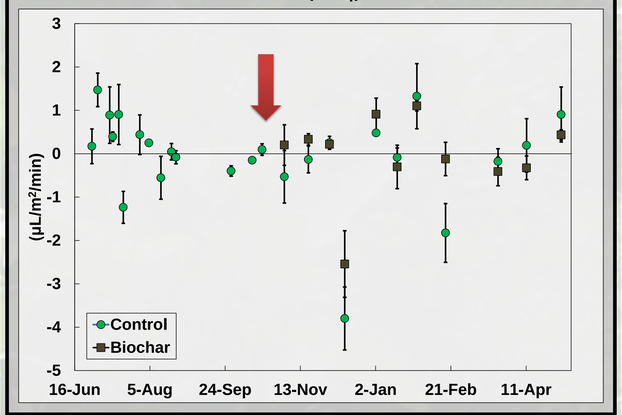
For four months, from June to October 2011, we measured GHG emissions from the soil at the Gorman Heritage Farm's organic market garden to establish a baseline. At the end of October we applied 15 pounds of biochar to a 1600 ft² patch of winter wheat in the organic garden. We then measured the emissions from the biochar treated patch and a control patch of soil for four more months in order to determine the effect of biochar on GHG emissions. Samples were collected following the protocol laid out by Parkin, *et al.* (2003):

- Each collection used three chambers to isolate gas samples.
- The sample vials were evacuated, labeled, and filled with 30 mL of air collected from inside the chambers.
- The samples were extracted at seven-minute intervals over a 28-minute period (five per chamber).
- The 10 mL vials were over pressurized and sealed with silicone glue to prevent contamination from outside air.
- The samples were analyzed using a Shimadzu GC-2014 gas chromatograph which measures the concentrations of CH_4, CO_2, and N_2O.

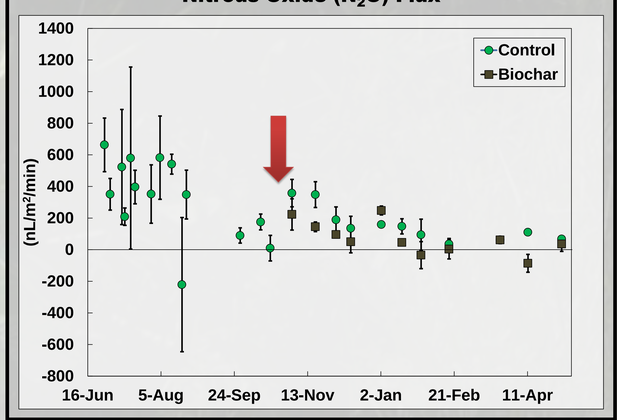
Soil Carbon



Methane (CH_4) Flux



Nitrous Oxide (N_2O) Flux



The use of biochar did not affect the rate of GHG emissions, and there was no statistical difference between the amount of carbon in the biochar-amended plots and the control plots. From this we concluded that the amount of biochar used was too small. Future studies may look at the effects of greater biochar use, and attempt to identify an application rate that produces significant results.

Biochar and Plant Vitality

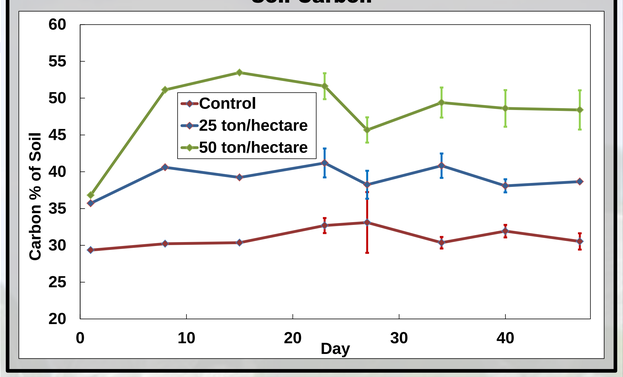
Biochar may increase the level of stored carbon in soil, reduce soil greenhouse gas emissions, and increase soil nutrition and water retention. Little specific data is known about the impacts of biochar on plant yields in an agricultural setting, however. In this project we investigated the effects of biochar on plant yields and soil chemistry. Tomato seeds were planted in a control plot and two other plots containing soil amended with 25 ton/hectare and 50 ton/hectare of biochar. Soil samples were taken and analyzed weekly for carbon content, and several plant metrics were collected. The results from this experiment can help us understand the potential benefits and drawbacks of using biochar.

Two seeds were planted ¼ inches deep in each pot, and after germination the plants were thinned to establish ten tomato plants in the control plot and each of the two experimental plots.

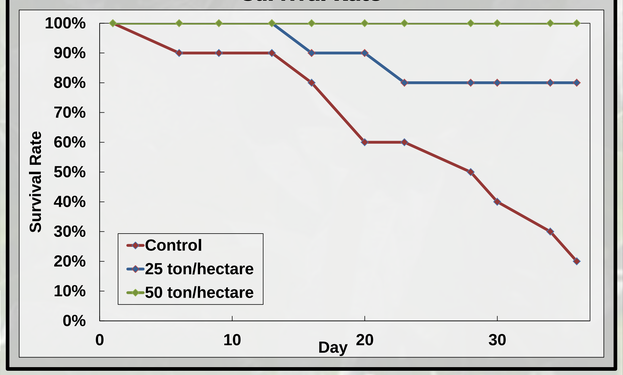
By the fourth week of the experiment, the effects of the biochar on the plants' heights and leaf counts had become more pronounced.

During the eighth and final week of the experiment, the remaining tomato plants were removed from their pots, dried, and massed.

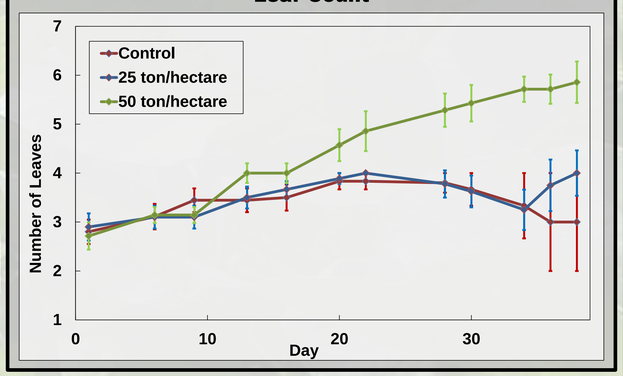
Soil Carbon



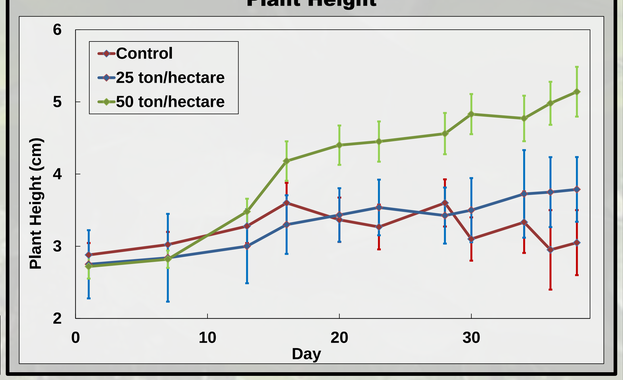
Survival Rate



Leaf Count



Plant Height



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- Forster, P., V. Ramaswamy, P. Artaxo, T. Berntsen, R. Betts, D.W. Fahey, J. Haywood, J. Lean, D.C. Lowe, G. Myhre, J. Nganga, R. Prinn, G. Raga, M. Schulz and R. Van Dorland. "Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change." [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. (2007)
- Dominic, W., J. Amonette, F.A. Street-Perrott, J. Lehmann, S. Joseph. "Sustainable Biochar to Mitigate GlobalnClimate Change." *Nat. Commun.* (2010) 1:56
- Lehmann, J., J. Gaunt, M. Rondon. "Bio-Char Sequestration in Terrestrial Ecosystems – A Review." *Mitigation and Adaptation Strategies for Global Change* (2006) 11: 403–427
- Major, J. (2009). "Guidelines on Practical Aspects of Biochar Application to Field Soil in Various Soil Management Systems." *International Biochar Initiative* (2009) 3-16
- Parkin, T., A. Mosier, J. Smith, R. Venterea, J. Johnson, D. Reicosky, G. Doyle, G. McCarty, J. Baker. "Chamber-Based Trace Gas Flux Measurement Protocol." USDA-ARS GRACEnet (2003)
- Robertson, G.P., et al. "Greenhouse Gases in Intensive Agriculture: Contributions of Individual Gases to the Radiative Forcing of the Atmosphere." *Science* (2000) 289: 1922