An emerging agricultural practice offers new promise for a climate-smart future

February 20 2023, by Elaina Hancock

Credit: Oregon Department of Forestry, CC BY 2.0 , via Wikimedia Commons

UConn Department of Natural Resources and the Environment researcher Wei Ren sees the interconnections between the systems in nature and how each component impacts the others. In Connecticut, rich

in forests and farmland, Ren sees the potential that could position the state at the forefront of a climate-smart agriculture (CSA) approach using an emerging sustainable practice called biochar.

Though it sounds like a nu-metal band name, scientists theorize that biochar—a charcoal-like substance made from burning organic material like agricultural and forest waste—has been a traditional agriculture practice used by humans for centuries.

Ren's group recently published an article in *Renewable and Sustainable Energy Reviews*, where they synthesized global data from nearly 600 studies on biochar to analyze its potential as a climate-smart agricultural practice.

CSA is an integrative approach that goes further than sustainable farming methods. It aims to sustainably ensure crop yields to feed a growing population while positively impacting the livelihoods of the people living and working in the area. CSA enhances soil health and builds climate resilience, while aiming to mitigate greenhouse gas emissions.

Examples of CSA management practices include cover crops, practicing no-till or reduced till, and integrated nutrient management strategies.

Ren's group compiled troves of data on biochar research to get a comprehensive understanding of the practice, its merits, challenges, and limitations.

"We wanted to evaluate biochar as climate-smart practices through field observations/measurements, big data analysis, and numerical modeling," Ren says. "We evaluate if this sustainable agricultural practice can serve as a climate-smart agricultural practice in terms of food production, soil health, and environmental sustainability. We hope to quantify related

water and nutrient footprints and the potential to promote climate resilience."

What is biochar?

Biochar can be made from any organic (carbon-containing) material, such as wood waste or crop residues. The material is then heated at high temperatures in the absence of oxygen in a process called pyrolysis. The result is a charcoal-like material called biochar. As a soil amendment, biochar has the potential to help build resilience.

Biochar is like a long-term carbon investment, because it takes a long time to break down, and therefore increases the soil's carbon content. If those same carbon-rich materials were incorporated into the soil instead of being made into biochar, they would quickly break down, releasing greenhouse gases like methane and carbon dioxide as they decompose. The same is true if the materials were simply burned; however, by turning them into biochar, the carbon is sequestered and remains earthbound.

Additionally, biochar acts almost like a sponge and can improve a soil's capacity to hold water and nutrients, making the soil more nutrient-dense and resilient to droughts, while sustaining crop yields. In Connecticut, biochar could also help turn a form of waste in the form of tree trimmings and other wood waste into this valuable, resilience-building material.

Global data synthesis

Through the analysis, Ren and co-authors found that, like other CSA practices, biochar application is context-dependent, but generally it helps improve soil quality. As a result, they are proposing its use more broadly,

including in Connecticut.

"Through the global data synthesis, you can see that across different soil and climate conditions, biochar, together with other practices, can help farmers to sustain food production. It can also reduce greenhouse gas emissions, reduce nitrogen leaching, and save soil water," says Yawen Huang, the study's lead author and a postdoc fellow supervised by Ren.

Though the analysis showed that some of the laboratory experiments may have overstated biochar's capabilities, the researchers plan to explore what it can do by performing more field experiments to understand when and where to use biochar.

"We still need to consider biochar together with other traditional sustainable practices for nutrient management and irrigation treatments in different locations considering different climate conditions," says Ren. "We can achieve the goal of climate-smart agriculture, and in the case of biochar, Connecticut is an ideal place for exploring and applying biochar as a CSA approach. We have so many trees and natural resources here. Studies show that biochar made from trees can largely reduce nitrous oxide emissions, which is almost 300 times more potent than CO_2 in its global warming potential."

Ren points out one vital aspect of sustainable and climate-smart practices—that waste can often be repurposed. Ren's vision is to use tree waste from forest management to make biochar used by farmers here in Connecticut.

"We would just use waste materials; it is the sustainability cycle," Ren says. "The forest owners have the potential to make the biochar from their own resources to benefit cropland or farmland. You can use the crop residues or other non-agricultural organic wastes and return them back to the soil too. I want to expand the concept of climate-smart

agriculture and forestry to create a climate-smart landscape. Let's think about if we can manage the natural resources, farmland, wetlands, and other natural systems together. Can we use these climate-smart practices for linking forest and agriculture? Our state has the potential to play a leading role on the national level in the application of biochar."

Ren's background is in ecosystem ecology and climate change adaptation, and she approaches agriculture as an interdependent component of the earth system, for instance, the way agricultural interacts with atmospheric, soil, and aquatic systems. When viewed through this lens, sustainable studies call for collaborative efforts and she says that UConn, as a land grant university, is an especially good venue for these kinds of efforts since the information is delivered to the farmers via UConn Extension.

"As I mentioned, CSA practices need to happen at the right time and location and must consider the combination of other natural and human factors," Ren says. "It calls for an integrated and interdisciplinary effort that cannot be done just sitting in front of a computer or in the lab. We can deliver the new findings to our extension researchers, who then deliver them to farmers. The feedback from the farmers can guide us in our further effort to advance science in this field. Again, that's a sustainable loop."

Ren's team is in the process of applying for additional funding to push the project forward. The team is connecting with local biochar producers and planning to keep the production local, considering the need to save energy for transportation.

"With the pandemic, customers tended to shift their food habits towards more locally grown products. This transition calls for more resilient and sustainable food systems. Climate-smart agriculture is an important concept to guide us to achieving sustainable agriculture. It also serves as

a natural-based climate solution for building a climate-resilient future."

More information: Yawen Huang et al, A global synthesis of biochar's sustainability in climate-smart agriculture—Evidence from field and laboratory experiments, *Renewable and Sustainable Energy Reviews* (2022). DOI: 10.1016/j.rser.2022.113042

Provided by University of Connecticut