How AI and deeper roots can help soil store more carbon

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In 2020, global agricultural emissions were 16 billion tons of carbon dioxide equivalent (an increase of 9% since the year 2000) and globally, the 2020 farm gate emission represented nearly half of total agricultural emissions, according to the Food and Agriculture Organization of the United Nations (FAO).

In an article titled "Going deep: Roots, carbon, and analyzing subsoil carbon dynamics," published in *Molecular Plant*, lead author Angela Fernando, a consultant for the Alliance of Bioversity International and CIAT, and her collaborators have explained that improving soil carbon was a way for farmers to increase food production, achieve global net-zero carbon emissions, and address the impacts of climate change.

"The aim of the article was to summarize all the methods and ideas in one place, so that experts in the field would be able to make the most of them," she says.

Benefits of deeper roots

Fernando explains that deep tillage (which breaks up the soil prior to planting) and the decomposition of shallow roots causes soil carbon to re-enter the atmosphere, so deeper-rooting varieties and an understanding of the mechanisms behind different crop varieties are needed.

Fernando says that soil organic carbon is "like a cushion hidden in the soil" and that if roots are able to reach down around the two-meter mark, they are much less vulnerable to decomposition by microbes and can serve as reservoirs for nutrients and water when there are drought conditions.

Most current crop and forage varieties spread their roots out, but thanks to the discovery of the DRO1 gene that controls root angle, it is now possible for varieties of crops and forages to be developed that send their roots down to a depth of a meter.

"There's no new biomass, the roots are just tilted so that they are now growing straight down into the soil where they are not going to decompose and that means that soil carbon remains trapped down there," Fernando says.

Joe Tohme, Director of the Alliance's Americas Hub, said the discovery of DRO1 in 2013 was a "significant breakthrough" in research to adapt food crops to water stress, as deeper roots have access to subsoil water sources.

Measuring carbon

The researchers explain that one of the hardest challenges in soil carbon sequestration is still the basic task of measuring it.

Michael Gomez Selvaraj, digital agriculture scientist at the Alliance and co-author of the scientific paper, explains that samples are still being taken one-by-one as soil cores and then tested in a lab, but a combination of remote sensing and AI analysis is changing that.

"If you are surveying 400 hectares, 40 samples will not be a true representation of the soil carbon," Gomez says, "Also, most people who are measuring carbon are doing it to a depth of only to about 40 centimeters."

Gomez explained that improvements in measuring carbon via remote sensing and then applying AI analysis to that data will allow soil carbon to be quickly and accurately measured at the hectare scale.

"We have very good accuracy with the lab samples and remote samples and we now have a good AI model for calculating soil carbon," Gomez says. "We are applying it to scan huge pieces of land for its organic carbon and our hope is that in the future we go even deeper, to go to one meter below the ground."

"We don't want to disrupt the soil," Fernando adds. "We want to use non-destructive remote sensing tools."

The future

The researchers explain that if soil carbon can be measured more quickly, more accurately and across a large area, then soil carbon could be assessed more easily and farmers could more easily participate in carbon markets.

"To get a carbon certificate, you need to have accuracy, so we are working in a public-private partnership to develop a methodology to measure soil carbon that can pay off for the farmers," Gomez says.

On the plant-breeding side, the hope is that new deep-rooted varieties of rice and forage (food for livestock) can increase sequestration of carbon in the soil.

"In the future, gene-editing technologies, including CRISPR, hold promise for expediting the creation of crop varieties suited for efficient resource capture and carbon sequestration," Fernando says, "If we are successful, farmers can use these forage legumes to feed it."

More information: Ezhilmathi Angela Joseph Fernando et al, Going deep: Roots, carbon, and analyzing subsoil carbon dynamics, *Molecular Plant* (2023). DOI: 10.1016/j.molp.2023.11.009

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