How Ancient Soil Can Boost Forest Restoration Across the Globe

08 May 2023

Adding Amazonian dark earth to soils boosts plant growth, shows study.

Adding Amazonian dark earth (ADE) to soils can significantly boost plant growth, according to a study by Brazilian scientists published in Frontiers in Soil Science. ADE, also known as terra preta, is highly fertile due to its richness in nutrients and stable organic matter. The researchers conducted experiments on ADE and found that adding it to soil increased the growth and development of plants, as well as supporting a greater biodiversity of bacteria and archaea. The study suggests that ADE could be utilized to speed up ecological restoration projects around the world.

Between approximately 450 BCE and 950 CE, millions of Amerindian people living in today's Amazonia transformed the originally poor soil through various processes. Over many human generations, soils were enriched with charcoal from their low-intensity fires for cooking and burning refuse, animal bones, broken pottery, compost, and manure. The result is Amazonian dark earth (ADE) or *terra preta*, exceptionally fertile because rich in nutrients and stable organic matter derived from charcoal, which gives it its black color.

Now, scientists from Brazil show that ADE could be a 'secret weapon' to boost reforestation – not only in the Amazon, where 18% or approximately 780,000 km^2 has been lost since the 1970s – but around the world. The results were published in the journal *Frontiers in Soil Science.*

"Here we show that the use of ADEs can enhance the growth of pasture and trees due to their high levels of nutrients, as well as to the presence of beneficial bacteria and archaea in the soil microbial community," said joint lead author Luís Felipe Zagatto, a graduate student at the Center for Nuclear Energy in Agriculture of São Paulo University, Brazil.

Mimicking reforestation in miniature

The researchers conducted controlled experiments to mimic the ecological succession and changes to the soil that happen when pasture in deforested areas is actively restored to forest. Their aim was to study how ADEs, or ultimately soils of which the microbiome has been artificially composed to imitate them, can boost this process.

Zagatto and colleagues sampled ADE from the Caldeirão Experimental Research Station in the Brazilian state of Amazonas, and as a control, agricultural soil from the Luiz de Queiróz Superior School of Agriculture in the state of São Paulo. They filled each of 36 four-liter pots with 3kg soil, inside a greenhouse with a mean temperature of 34ºC to anticipate global warming beyond current temperatures in Amazonia between 22 and 28ºC.

One-third of the pots received only control soil, another third a 4:1 mixture of control soil and ADE, and another third 100% ADE. To imitate pasture, they planted seeds of palisade grass (*Urochloa brizantha*), common forage for livestock in Brazil, in each pot and allowed its seedlings to grow for 60 days. They then cut the grass and let only its roots remain in the soil – virgin territory for reforestation in miniature. The researchers then replanted each of the three soils with tree seeds: either with the

colonizing species Ambay pumpwood (*Cecropia pachystachya*), with *Peltophorum dubium* typical of secondary forests, or with *cedro blanco* (*Cedrela fissilis*), typical of climax forest.

The seeds were allowed to germinate, and the seedlings to grow for 90 days, after which the height, dry mass, and extension of the roots were measured. The scientists quantified changes in the soil's pH, texture, and concentration of organic matter, potassium, calcium, magnesium, aluminum, sulfur, boron, copper, iron, and zinc over the course of the experiment. With molecular methods, they also measured changes in microbial diversity in the soil.

Rich in nutrients and beneficial microbes

At the start, ADEs showed greater amounts of nutrients than control soil: for example, 30 times more phosphorus and three to five times more of each of the other measured nutrients, except manganese. ADE also had a higher pH and contained more sand and silt, but less clay. After the experiment, soils contained fewer nutrients than at the start, reflecting take-up by the plants, but 100% ADE soils remained richer in these than control soils, while nutrient levels were intermediate in 20% ADE soils.

Throughout the experiment, 20% or 100% ADE soils supported a greater biodiversity of bacteria and archaea than control soils.

"Microbes transform chemical soil particles into nutrients that can be taken up by plants. Our data showed that ADE contains microorganisms that are better at this transformation of soils, thus providing more resources for plant development," said joint lead author Anderson Santos de Freitas.

"For example, ADE soils contained more beneficial taxa of the bacterial families Paenibacillaceae, Planococcaceae, Micromonosporaceae, and Hyphomicroblaceae."

Growth boosted

The results also showed that adding ADE to soil improved the growth and development of plants. For example, the dry mass of palisade grass was increased 3.4 times in 20% ADE, and 8.1 times in 100% ADE, compared to in control soil. The addition of ADE also boosted the growth of the three tree species: seedlings of *cedro blanco* and *P. dubium* were 2.1 and 5.2 times taller in 20% ADE, and 3.2 and 6.3 times taller in 100% ADE, compared to in control soils. Ambay pumpwood didn't even grow in control soils or 20% ADE, but thrived in 100% ADE.

The researchers concluded that ADE can boost plant growth. "Our data point to a mixture of soil nutrients and adapted microorganisms [in ADE] to improve the establishment of plant trees in restoration," they wrote.

Senior author Dr. Siu Mui Tsai, a professor at the same institute, cautioned: "ADE has taken thousands of years to accumulate and would take an equal time to regenerate in nature if used. Our recommendations aren't to utilize ADE itself, but rather to copy its characteristics, particularly its microorganisms, for use in future ecological restoration projects."

Reference: "Amazonian dark earths enhance the establishment of tree species in forest ecological restoration" by Anderson Santos de Freitas, Luís Felipe Guandalin Zagatto, Gabriel Silvestre Rocha, Franciele Muchalak, Solange dos Santos Silva, Aleksander Westphal Muniz, Rogério Eiji Hanada and Siu Mui Tsai, 5 May 2023, *Frontiers in Soil Science.*

Source:https://scitechdaily.com/unearthing-the-amazons-dark-secret-how-ancient-soil-can-boost-forest-restoration-across-the-globe/