Climate Smart Agriculture

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By 2050, the world population will increase to more than nine billion people, and many will live in developing countries that already confront a food crisis. Currently, around 870 million people in the world are "under-nourished," they do not have enough food. In the next 40 years, the world will have to harvest 70% more food to feed everyone adequately.

This is a tough challenge as the effects of climate change are expected to bring longer and more frequent droughts, more floods, and more destructive weather in general. This threatens food security and will severely cut agricultural yields. With two billion more people to feed in the next 40 years, there is an urgent need for countries to adapt to climate change.

In agriculture, water shortages are every farmer's nightmare. In dry conditions, every drop must reach the plant's roots to keep it thriving. It is the soil's ability to absorb and hold water that will determine whether the soil can keep plants alive. Soil retains water when it hosts vital microorganisms. If the soil loses these microorganisms, it loses its ability to absorb water.

When the rains do finally arrive, they can wash out these microorganisms and have devastating effects on the soil's fertility. As the soils dry again, they cannot retain moisture and the crops die, leading to food shortages.

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"The soil is alive", explains Nguyen Long, head of the Soil and Water Management and Crop Nutrition Section of the IAEA. "If it contains a large number of living organisms, it will retain water and nutrients and plants will grow. Soil that contains organic matter acts like a sponge

and absorbs the water. That reduces runoff and erosion during heavy rainfalls," he says.

With the help of nuclear techniques, the IAEA helps countries "keep the soil alive" and adapt to the devastating effects of climate change. Through these techniques, scientists have managed to not only help soil adapt to climate change, but also to help reduce the emissions that cause it.

Climate Change Adaptation

High temperatures due to climate change dry out the soil and lead to the rapid evaporation of water from the soil, destroying the crops. Farmers can adapt to these changes through better irrigation techniques and by reducing the loss of water through the soil.

"With isotopic and nuclear techniques, we can help to conserve the water in the soil. We can also enhance the soil's ability to store organic matter and determine the factors that lead to the decomposition of the organic matter," said Nguyen.

Through laser technology and with the help of soil moisture neutron probes, scientists are able to analyse how much water is lost through evaporation from the soil, and how much is lost through transpiration from the plant. These tools measure the oxygen in the water vapour released and determine whether it comes from the soil or from the plant.

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The difference between the vapours lies in the atom: because the isotopic composition of the oxygen isotopes evaporated from the soil differs from that transpired from the plants, the scientists can determine exactly how much water was lost through evaporation from the soil. "We want the soil to lose as little water as possible. It is best if a larger proportion of the water transpires from the plant, because that means that the plant is thriving," Nguyen explains.

"On-farm management practices can then be put in place to reduce soil evaporation through mulching and soil conservation tillage, or improving irrigation schedules to ensure that crops receive water when they most need it," explains Nguyen. But for this, scientists need to know how much water is lost.

Using laser technology, research in a Vietnam coffee plantation demonstrated that covering the soil surface with a 5 to 10 cm layer consisting of old branches and leaves, called a mulch layer, reduced soil evaporation from 17% to 5%. Since this happened during the critical phase of the plant's bud development, it enhanced the sprouting of new buds and stabilized soil structure.

More efficient irrigation systems save water and nutrients, while increasing the resilience of the crop against drought. For example, water that directly reaches a plant's roots through a technique called drip irrigation is one of the most efficient ways to save water and increase harvest at the same time. A neutron probe uses nuclear technology to measure the soil water and find out when and where the plant needs water.

Climate Change Mitigation

Scientists agree that climate change is caused by increasing greenhouse gas emissions. Nuclear techniques can help reduce the release of greenhouse gases from soil and thus mitigate climate change.

"Climate change is driven by the emission or release of greenhouse gases from farmlands in the atmosphere. Nitrous oxide and carbon dioxide are two of the main greenhouse gases released from the soil. We try to manage the soil to reduce the level of release of that greenhouse gas into our environment," Nguyen says.

Plants absorb carbon dioxide for photosynthesis. By storing more carbon dioxide and nitrous oxide in the soil, the microorganisms in the soil thrive. The FAO/ IAEA Joint Division trains farmers in conservation agriculture to reduce the release of greenhouse gases. Through this practice, they retain crop residues on the soil surface and cultivate different crops every season through a procedure called crop rotation.

These practices reduce the runoff and soil erosion, because the soil can retain more water and nutrients. This technique also permits the soil to incorporate more carbon and to reduce carbon emissions from soils. With the help of nuclear

techniques, scientists analyse the carbon and oxygen isotopes released. The results give them an indication of how to lock as much carbon in the soil, which helps to keep the soil "alive".

While carbon dioxide is the most well-known greenhouse gas, experts say nitrous oxide is also damaging. The gas is produced and released naturally in the soil and is contained in many fertilizers. With the help of a soil moisture neutron probe, scientists can determine how much nitrogen the plant can absorb naturally.

This data allows them to provide the plant exactly the amount of nitrogen it needs and minimize nitrogen's release into the atmosphere. "Some plants can pick up the nitrogen from the air and use it as a fertilizer. If you know how much they can absorb, you don't have to use that much fertilizer," explains Nguyen. Through a technical cooperation project, the IAEA helped Slovenia improve its water and fertilizer use efficiency for commercial vegetables, hops and maize.

By using the techniques described above, scientists managed to increase nitrogen absorption by the plant from 45% to as much as 75% and prevented its unnecessary release into the atmosphere. They also managed to obtain the same crop yields with less than one third water.

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Helping Farmers Back Home

Growing Healthy Crops in Drought-Prone Kenya

Maasai farmer Mary Kashu is benefiting from an FAO/IAEA project that uses nuclear-enhanced drip irrigation technology to grow crops with very little water.

"Drip irrigation is a new technology for us, and since it's been introduced here we can plant our own vegetables and don't have to depend on livestock alone. We can improve our children's nutrition and raise some income. We can use the money to pay school fees and to maintain the pump to get more water from the borehole."

Louise Potterton/IAEA

Improving Agriculture in Sierra Leone

Soil Scientist Samuel Soki Harding was trained by the FAO/IAEA at the Kenya Agricultural Research Institute.

"I'm trying to acquire knowledge and skills in water management by using drip irrigation and the neutron probe, which measures soil moisture levels. In some parts of my country we have little rainfall and soil moisture shortage. So the farmers are getting poor harvests. The knowledge gained here will be shared with my institute at the Ministry of Agriculture."

Louise Potterton/IAEA

Training Scientists to Increase Harvests in Afghanistan

Soil expert Shahnawaz Rohani is being trained at the FAO/IAEA's Soil and Water Management and Crop Nutrition Laboratory.

"I'm here with five colleagues. We want to learn about the use of nuclear technology in soil and water management and crop nutrition. Back home, we will share this information with other people at the Ministry of Agriculture where we work. Isotope techniques will assist us in dealing with soil degradation through erosion, limited rainfall and drought."

Juanita Perez-Vargas/IAEA

Text: Louise Potterton & Juanita Perez-Vargas, Division of Public Information