Ensuring Healthy Crops in a Changing Climate

Soil and water resources are under increasing stress because of climate change.

Due to a variety of extreme weather events – from heat waves, droughts and floods to seawater intrusion caused by rising ocean levels – freshwater resources are becoming less available. Given the ever-increasing demand for water, efficient water use is key to ensuring sustainable water availability, particularly for agricultural activities.

Climate change can lead to salinity and soil erosion, as well as a lack of soil moisture, which can seriously affect agricultural production. Appropriate soil and water management are needed to prevent these conditions being further exacerbated. According to the Food and Agriculture Organization of the United Nations (FAO), it takes up to one thousand years for just 2 to 3 centimetres of topsoil to form and 33 per cent of soil globally is already degraded.

Climate-smart agriculture can help ensure higher crop yields, contributing towards healthier agrifood systems.

Nuclear science and technology can be used to determine the amount of soil moisture and soil nutrient levels for crop production, as well as to quantify soil erosion using fallout radionuclides.

The IAEA and the FAO, through the Joint FAO/IAEA Centre of Nuclear Techniques in Food and Agriculture, have enabled farmers to use cosmic ray neutron sensors to determine the moisture level in soil in real time over large areas of agricultural land. Using this information, the IAEA, through the Joint FAO/IAEA Centre, develops climate-smart agricultural packages to help farmers apply the proper amounts of nutrients and water for improved crop production despite irregular weather patterns.

The IAEA, through the Joint FAO/IAEA Centre, has been working with Namibia to increase water use efficiency in the northern part of

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the country since 2020. Approximately 92 per cent of Namibia is very arid, arid or semi-arid. Most of the country's small farmers depend on rainfall for their crops, but due to climate change Namibia now experiences unpredictable rainfall, and severe droughts, which are causing serious food shortages.

By building national capacity to apply nuclear techniques and to use cosmic ray neutron sensors, the IAEA has been able to help farmers to assess the moisture levels in their fields and to determine the amount of water necessary for healthy crops. Based upon these real-time measurements, drip irrigation systems were installed. These systems save water by delivering exactly the right amount of water directly to the roots of plants. Farmers participating in the project have increased their crop yields by up to 70 per cent for crops like maize, tomatoes and peppers while at the same time reducing their water use by 80 per cent.

To address soil degradation in Namibia, isotopic techniques, such as N-15, were also used to quantify the amount of nitrogen fixed by the cowpea crops for their ability to add nitrogen to the soil. By rotating cowpea with other crops like sorghum, the need for expensive fertilizers in participating fields in Namibia has decreased, with a savings in fertilizer expenses of at least 30 per cent.

The Science

Cosmic rays are high energy particles that move through space, mostly originating from the Sun. When cosmic rays pass through the Earth's atmosphere, they produce high energy neutrons. When these neutrons reach the Earth's surface, they penetrate the soil and some of them collide with hydrogen atoms causing them to become low energy neutrons. As these hydrogen atoms are usually present in water (H2O), scientists can use cosmic ray neutron sensors to measure the number of low energy neutrons to determine soil moisture.

Cosmic ray neutron sensors provide an accurate picture of soil moisture at the field level – up to 20 hectares from one fixed cosmic ray neutron sensor. This level of detail can be more useful to decision-makers than relying on individual site-specific soil moisture sensors, which can be costly when monitoring soil moisture for agricultural purposes in larger areas. The cosmic ray neutron sensors are relatively small, and do not interfere with agricultural practices.

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23-05017E