What can the IAEA and nuclear technologies do for you?

Isotopic and nuclear techniques for improved agricultural water management

Introduction

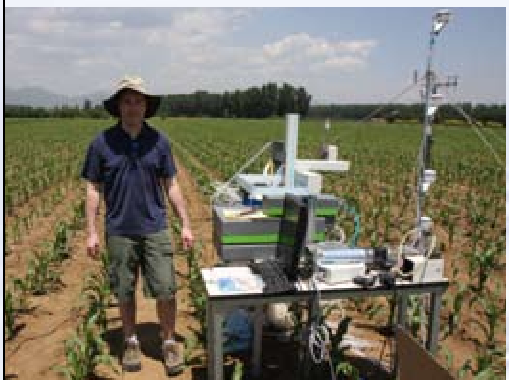
Agriculture currently accounts for about 70% of global freshwater use and the Food and Agriculture Organisation (FAO) of the United Nations (UN) forecasts that, by 2050, global water requirements for agriculture will increase by 50% in order to meet the increased food demands of a growing population. With an increasing scarcity of freshwater, due to indiscriminate use and a changing climate with extreme weather events of droughts and flooding, there is an urgent need to improve the management of this resource. Isotopic and nuclear techniques are useful and effective tools to assess the soil water status, particularly in the immediate vicinity of crop roots, to trace soil water movement and to identify hot spots of land degradation that deliver sediments and affect downstream water quality. Such information assists in developing strategies for sustainable agricultural water management.

The role of the Joint FAO/IAEA Programme

Through its Joint FAO/IAEA Programme on Nuclear Techniques in Food and Agriculture, research institutions and experimental stations in Member States co-operate in improving agricultural water management. Coordinated research networks and technical cooperation projects help solve practical problems of economic significance to developing countries using isotopic and nuclear techniques. The coordinated research networks typically involve collaboration among 10-20 institutions and provide limited funding to participants of around US $10,000 per year. Technical Cooperation projects transfer specific technologies to individual countries or groups of Member States, with budgets sufficient to ensure the bulk of the project costs.

To date, close to 100 Member States have received support from the IAEA, including technical and advisory services, research and laboratory support, training in the use of nuclear techniques and assistance in collecting, analysing and disseminating the derived information.

Nuclear techniques for improved water use efficiency



Using nuclear techniques to reduce soil water evaporation and enhance water use efficiency

Nuclear and isotopic techniques play an important and sometimes unique role in providing information essential to developing strategies aimed at improving agricultural water use efficiency, and hence in providing solutions to mitigate the increasing water scarcity.

- The soil moisture neutron probe (SMNP) is ideal for the measurement of soil water in the immediate vicinity of the crop roots, and providing accurate data on the accessibility to the crop of available water to establish optimal irrigation schedules. The SMNP is currently the most suitable instrument to accurately measure soil moisture under saline conditions. It is also widely used to calibrate conventional moisture sensors for direct use in farmers' fields.
- Both oxygen and hydrogen are components of water. The use of the isotopic signatures of oxygen (^{18}O) and hydrogen (^{2}H) in water vapour taken from field crops can facilitate the quantification of crop water uptake, i.e.

plant transpiration, and water lost through soil evaporation. It therefore provides information on factors affecting transpiration and evaporation, essential for improving the water use efficiency of crops.

→ Carbon (C) is an important building component of plants. Green plants assimilate carbon from atmospheric carbon dioxide through the process of photosynthesis. Carbon dioxide is composed of two stable isotopes, the less abundant ^{13}C and the lighter ^{12}C. During photosynthesis the plant discriminates against the heavier isotope in favour of the lighter one. The extent of this discrimination depends on environmental factors, such as water availability and salts in the soil. The variation in the relative abundance of the carbon isotopes can therefore be used as a surrogate marker of water stress, water use efficiency and crop tolerance to drought and salinity.

Nuclear techniques for enhanced water quality

Lowland rice paddy in tropical Asia destroyed by deposition of soil lost from upland fields

Traditional and recently developed isotopic techniques based on the use of stable isotopes, fallout radionuclides of caesium (Cs), lead (Pb) and beryllium (Be), and compound specific isotope analyses assist in determining agricultural activities that threaten water quality and in identifying hot spots of land degradation in agricultural landscapes.

→ ^{15}N isotope tools are used to trace the movement of applied ^{15}N-labelled nitrogen (N) fertilisers in soils, crops and water. Information on this movement is essential to identifying factors that potentially affect nitrogen fertiliser use efficiency and water quality in agricultural landscapes in order to improve farming practices.

→ Fallout radionuclides, such as caesium-137 (^{137}Cs), lead-210 (^{210}Pb) and beryllium-7 (^{7}Be), assist in (i) establishing changes in soil redistribution patterns and rates in large catchment areas and in (ii) evaluating the efficiency of soil conservation measures in controlling soil erosion and water quality.

→ Variations in the carbon-13 stable isotope (^{13}C) signatures in specific plant components and in soils (Compound Specific Isotope Analyses) are used to identify areas of land degradation and sources of water pollution in the agricultural landscape, and hence provide essential data to develop effective soil conservation strategies to protect water quality.

Key regional activities in Member States

Isotopic and nuclear techniques are used extensively by Member States to develop efficient and cost-effective soil conservation strategies to improve agricultural water management practices. Some regional examples that are currently generating extensive attention include:

Africa: Enhancing productivity of high value crops with small-scale irrigation technologies, such as drip irrigation to tailor watering schedules according to the specific needs and growth stages of crops.

Asia: Increasing agricultural productivity in coastal areas through improved crop-water-soil management strategies and adaptation of crop varieties to drought and saline soil conditions.

Latin America: Improving crop productivity through better soil conservation measures, such as zero or reduced tillage in combination with crop residue retention to minimise soil water evaporation.

Worldwide: Identifying hot spots of land degradation to establish or improve the efficiency of soil conservation measures in hilly and mountainous regions and to enhance water quality in the lowlands.

For further information, please visit:
The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
International Atomic Energy Agency, Wagramer Strasse 5, PO Box 100, 1400 Vienna, Austria
www-naweb.iaea.org/nafa/swmn