Nuclear techniques for assessing irrigation technology and improving irrigation scheduling

Introduction
Irrigation is practiced worldwide on around 20% of the cropland but it contributes to approximately 40% of world food production. Agriculture accounts for nearly 70% of global freshwater use. However the average water use efficiency in irrigated agriculture is still less than 40%, the remaining 60% being lost to runoff, evaporating from the soil and/or as excess water draining away below the crop roots. With the increasing demand for food to feed a growing global population and with increasingly unpredictable rainfalls due to climate change and erratic weather events, there is an urgent need to improve the management of irrigated agriculture, and in particular to improve irrigation scheduling, to produce more crops per drop of water and to achieve greater water savings. There is an equally urgent need to identify the most water efficient technology for specific crops and environments to help ensure that the world’s increasingly scarce water resources will be available and sufficient for future generations.

Improving agricultural irrigation management

Improvements in agricultural irrigation management practices may be achieved by:

→ Optimising irrigation scheduling and using more efficient irrigation systems, such as drip-irrigation rather than flood-, sprinkler or furrow irrigation.

→ Improving soil fertility to ensure that crop growth is not limited by nutrient or physical constraints and hence every drop of water can be fully utilised for growth.

→ Maximizing water uptake by crops through demand-based irrigation scheduling that takes account of the specific water needs of different crops, their growth stages and the prevailing environmental conditions.

→ Minimizing the contribution of soil evaporation relative to plant transpiration in the total water removal from crop fields through evapotranspiration. The ability to quantify these two components provides information on factors, such as irrigation volume and soil surface coverage that play key roles in the conservation and management of water.

Nuclear technologies to improve irrigation management

The soil moisture neutron probe (SMNP) is an instrument that measures soil water content for crop production. During the measuring process, the probe emits neutrons that collide with hydrogen atoms in soil water. This collision slows down the speed of the neutrons. The change in the speed of the neutrons is detected by the probe and provides a reading that corresponds to the soil water content. The SMNP is currently the most suitable instrument...
to accurately measure soil moisture under saline conditions. It is also widely used to calibrate other moisture sensors for direct use in farmers’ fields. The variation in the composition of isotopes ($\delta^2\text{H}$ and $\delta^{18}\text{O}$) in the water vapour surrounding plants makes it possible to separate evapo-transpiration into its individual components of soil evaporation and plant transpiration. These measures are used to develop guidelines that enable farmers to minimise soil evaporation in their efforts to optimise water use efficiency.

**Country achievements**

With data gathered through these nuclear and isotopic technologies many countries have successfully assessed irrigation technologies and improved irrigation scheduling to maximise the water use efficiency of specific crops under various environmental conditions:

- **Turkey** was able to reduce the water needs of its potato crops in arid and semi-arid regions by 50%. The required investment of US $200/ha, offset by an annual saving of an estimated US $2000/ha, has generated strong interest from farmers, so that the area under drip irrigation has increased from 500 ha to 4000 ha in only three years.

- **Kenya** developed low-cost, small-scale drip irrigation systems that generated 2.6 times the yield of field-grown tomato crops while using only 45% of the water traditionally applied by hand. This saved labour and generated an important additional income for many resource-poor farmers. When practiced in greenhouses, this technology increased the estimated net earnings by a further factor of 20.

- **Vietnam** reduced soil water evaporation during the flowering season in coffee plantations from 17% to 5%, i.e. to less than a third, by covering the soil surface with old branches and tree leaves during the dry season. Implemented on all 380,000 ha of coffee plantations in the Tay Nguyen Central Highlands would essentially save 66 million m$^3$ of water during the bud development and flowering stage from December to January in a region suffering increasingly from droughts and water shortages. This will save farmers time and costs in transporting water over large distances. It will also provide a strong economic incentive to local farmers to increase water use efficiency in coffee plantations.

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1 These country achievements are examples only. For a more complete list see www-naweb.iaea.org/nafa/swmn

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For further information, please visit:
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