Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and FAO/IAEA Agriculture and Biotechnology Laboratory, Seibersdorf

Soils Newsletter

Vol. 34, No. 1 July 2011

http://www-naweb.iaea.org/nafa/index.html
http://www.fao.org/ag/portal/index_en.html

ISSN 1011-2650

Contents

To Our Readers	1
Staff	4
Staff News	5
Country Impact Reports	6
Feature Articles	18
Technical Cooperation Projects	28
Forthcoming Events	30
Past Events	32
Status of Coordinated Research Projects (CRPs)	37
Laboratory Activities	40
Publications	43
Websites	44

Maasai people are pastoralists by nature. Circumstances have changed them to agro pastoralists

To Our Readers

2011 started at a hectic pace and on a positive note for the team members of the Soil and Water Management & Crop Nutrition (SWMCN) Section and the SWMCN Laboratory following an announcement by the IAEA Director General (DG) that the use of nuclear techniques for water is to be one of the major IAEA focuses for this year. In addition, it will also be a major theme for the IAEA Scientific Forum entitled: *'Water Matters: Making a Difference with Nuclear Techniques'*, which will be held in September (21-22 September 2011) at the Vienna International Centre. This theme encompasses the three pillars of the IAEA's activities which include water resource assessment, agricultural water management, and aquatic pollution control.

From the agricultural water management perspective, the DG's announcement gives both the SWMCN Section and the SWMCN Laboratory an excellent opportunity to promote and disseminate the importance of nuclear techniques to enhance water use efficiency and ensure more crops per drop in both rainfed and irrigated agricultural systems in Member States. Together with input from our counterparts in coordinated research projects (CRPs) and technical cooperation projects (TCPs), we have critically examined the achievements of the IAEA-funded studies on agricultural water management. Some of these studies and their impacts on enhancing water use efficiency and crop productivity in Member States are reported in this issue of the Soils Newsletter in the Impact Reports Section.

IAEA
International Atomic Energy Agency

Feature Articles

Combined Use of Neutron Thermalization and Electromagnetic Sensing in Assessing Soil Water Dynamics

By R.C. Schwartz and S.R. Evett
Soil and Water Management Unit, USDA-ARS, Bushland, TX

Agriculture is by far the largest consumer of available fresh water accounting for 70% of withdrawals worldwide. Meeting increased future demands for food and fibre will, by and large, need to be met by improving the efficient use of both irrigation and precipitation for crop production (FAO, 2002). Field research aimed at evaluating the efficiency of water use by crops invariably requires monitoring changes in soil water with time (e.g. Ibragimov et al., 2011). Such monitoring integrates the irrigation, precipitation, evapotranspiration and deep drainage history that affects the aggregate response of the system, which is manifested as soil water storage. These dynamic processes are important in evaluating the efficiency with which crop cultivars, irrigation strategies, cropping and tillage systems utilize available soil water for grain and biomass production.

The neutron probe has been particularly effective in estimating soil water content because of its large measurement volume and linear response to changes in soil water (Hignett and Evett, 2002). However, neutron thermalization techniques suffer from poor spatial resolution which is problematic near the surface where there are steep soil water content gradients. Data acquisition at sub-daily intervals using the neutron probe is also impractical and restricts measurements to temporal resolutions that are unable to capture highly dynamic hydrological processes. When properly calibrated, automated soil water monitoring with proven electromagnetic (EM) sensors can facilitate measurements at short time scales associated with infiltration and evaporation processes near the surface.

Accurate soil water estimation using EM sensors, including time-domain reflectometry (TDR), usually requires a soil-specific calibration. These sensors respond, in part, to changes in the real permittivity of the soil which is largely governed by changes in soil water content. Difficulties arise from these techniques because all EM sensors are sensitive to both real and imaginary parts of the permittivity with the imaginary part describing signal losses that become more significant at lower frequencies (<100 MHz). An additional difficulty in soils with high clay contents (>250 g kg^{-1}) is that bound water associated with clay surfaces has a much lower real permittivity than bulk water. As a result, measurements using EM sensors are frequency dependent and sensitive to changes in temperature and the bulk electrical conductivity (EC) of the soil. If not accounted for, these effects can lead to large errors in water content (> 0.05 m^3 m^{-3}) and unrealistic changes in soil water content with time (Schwartz et al., 2009a). For sensors that determine the true travel time of an EM pulse such as TDR, ancillary measurements of soil temperature and bulk EC incorporated into physically based soil dielectric models (e.g. Evett et al., 2005; Schwartz et al., 2009b) have led to accurate assessments of soil water content that compare closely to neutron probe measurements in fine-textured soils (Fig. 1). Equivalent success with lower frequency, capacitance-type sensors has been lacking. Fig. 1 shows that soil water estimated with the neutron probe represents a weighted average across a volume that includes shallower soil depths which results in water contents slightly less than TDR estimates at 0.3 m.

Long-term monitoring of soil water with TDR near the surface combined with neutron probe measurements at deeper depths has been proven to be an effective means to partition infiltration and soil water evaporation to evaluate tillage and cropping systems (Schwartz et al., 2010) of agricultural soils. In Bushland, TX, soil water content has been monitored throughout a five year period under sweep-tillage and no-tillage management and through phases of a wheat-sorghum-fallow rotation to examine the temporal dynamics of infiltration and soil water evaporation (Fig. 2). In that study, storage estimated using neutron probe measurements exhibited a similar soil water balance to TDR, but fail to show dynamics associated with infiltration and evaporation.

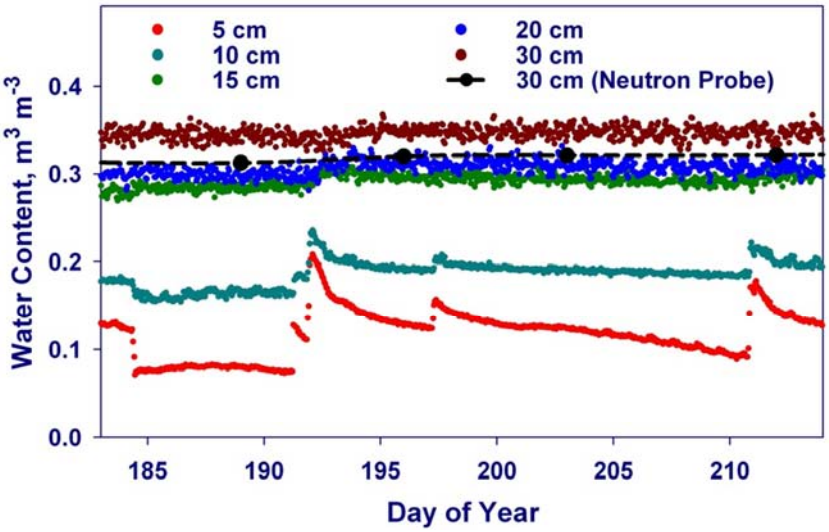

Fig. 1. Water contents estimated with the neutron gauge at 0.3 m depth and with TDR using calibrations of Schwartz et al. (2009b).

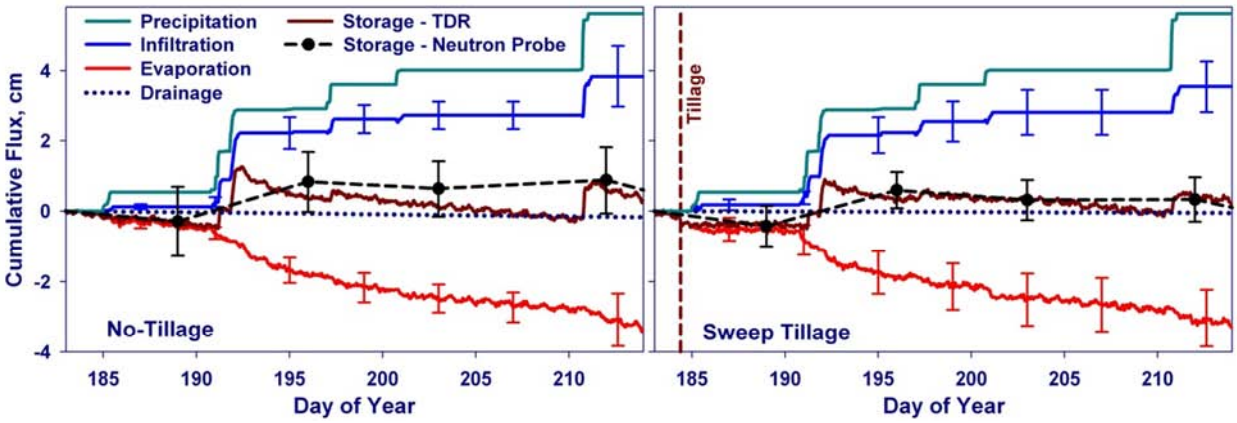

Fig. 2. Mean soil water storage and estimated cumulative fluxes within the 0- to 0.6-m control volume for the no-tillage and sweep tillage plots in July, 2008 during summer fallow following sorghum. Error bars represent the 95% confidence intervals.

References

Evett, S.R., J.A. Tolk, and T.A. Howell. 2005. Time domain reflectometry calibration in travel time, bulk electrical conductivity, and effective frequency. Vadose Zone J. 4:1020–1029.

FAO, 2002 Crops and drops: making the best use of water for agriculture. Rome, Italy: FAO. Information brochure. 28 pp.

Hignett, C. and S.R. Evett. 2001. Neutron Thermalization. Section 3.1.3.10 In Jacob H. Dane and G. Clarke Topp (eds.) Methods of Soil Analysis. Part 4 – Physical Methods. pp. 501–521.

Ibragimov, N., S. Evett, Y. Esanbekov, F. Khasanova, I. Karabaev, L. Mirzaev, and J. Lamers. 2011. Permanent beds vs. conventional tillage in irrigated arid Central Asia. Agron. J. 103:1002–1011.

Schwartz, R.C., S.R. Evett, M.G. Pelletier, and J.M. Bell. 2009a. Complex permittivity model for time domain reflectometry soil water content sensing: I. Theory. Soil Sci. Soc. Am. J. 73:886 –897.

Schwartz, R.C., S.R. Evett, and J.M. Bell. 2009b. Complex permittivity model for time domain reflectometry soil water content sensing: II. Calibration. Soil Sci. Soc. Am. J. 73:898–909.

Schwartz, R.C., R.L. Baumhardt, and S.R. Evett. 2010. Tillage effects on soil water redistribution and bare soil evaporation throughout a season. Soil Tillage Res. 110:221–229.