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To Our Readers

Greetings to you all from the Soil and Water Management & Crop Nutrition (SWMCN) Section and its SWMCN Laboratory (formerly known as the Soil Science Unit) for the New Year. We wish you every happiness in 2011 and every success in all your endeavors. Looking back to 2010, I would like to thank you for your unfailing support to the SWMCN Subprogramme, even when difficult situations posed many challenges. With your support, we have successfully launched and maintained several initiatives to assist Member States through research and development, fellowship training and technical support, to enhance soil productivity, improve soil quality and enhance nutrient and water use efficiency for crop and livestock production. Thanks to the commitment of the SWMCN Team (past and current members), the dedication of our counterparts in many different countries and funding support from the IAEA Technical Cooperation Department, our successful results from a Regional Asia-Pacific Project on the use of fallout radionuclides to assess the extent of soil erosion under different farming practices in the Asia -Pacific region have recently been published by the IAEA as an ***RCA Success Story in 2010*** (RCA is an abbreviated term for Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology).

In this Newsletter under the Feature Article and Status of Coordinated Research Project (CRP) headings, you will see that stable isotopes can be combined with fallout radionuclides to effectively identify hot spots in critically-degraded areas of agricultural catchments and hence help to target cost-effective measures to conserve soil quality for production and reduce not only soil erosion, but also others forms of soil degradation such as soil salinization.

With increasing water scarcity in many parts of the world resulting from the competition for water use from non-agricultural sectors and the impacts of climate change and variability on rainfall distribution, salinization, which is the process of soil and water salinity development and aggravation, can seriously affect crop and livestock production and ultimately farmers' livelihoods. In the Feature Article of this Newsletter, you will find an Abstract relating to a review paper on salinization conducted by the SWMCN Subprogramme which was recently published in the internationally-recognized Advances in Agronomy Journal. In October of this year, I was in Valencia, Spain, to attend the '***Global Forum on Salinization and Climate Change'*** as a Member of both the Organizing and Scientific Committees**.** The Forum highlighted the increasing concern in many Member States with this global issue of salinization.

A successful integrated approach, involving soil-water management and crop improvement, is evident in the number of technical cooperation projects (TC) that the SWMCN and Plant Breeding and Genetics Sections have been jointly involved in during 2010. Since integrated cropping-livestock production systems are increasingly practiced in many parts of the world, an holistic farm management approach, taking into account the interaction between soil, water and livestock is important to ensure sustainable land productivity for livestock farming. Towards this aim, the SWMCN Section and the Animal Production and Health Section have joined forces to review the importance of water management for livestock productivity. The abstract of this review paper, which will be published in an international journal, is reproduced in the Feature Article for your information.

In celebrating the success of 2010, we are looking forward to 2011 with commitment and reliance on your continuing support and guidance. Information on soil carbon sequestration, as influenced by different farming practices including irrigation, fertilizer applications, cropping systems and livestock grazing intensity is important for Member States to enhance soil productivity and to minimize greenhouse gas emissions such as carbon dioxide from farmlands. The use of laser-based technology to quantify soil carbon dioxide emissions across the agricultural landscape on an area-wide basis, as shown in the Feature Article section, will provide us with a helping hand in our quest for further information.

In 2011, the SWMCN Subprogramme will be busy planning a major workshop entilted 'Coping with Climate change and Variability through Minimizing Soil Evaporation Wastage and Enhancing More Crops per Drop'. This workshop will be held in Trieste, Italy (9-13 May), with funding and organizational support from the Abdus Salam International Centre for Theoretical Physics (ICTP).

With the International Symposium on 'Managing Soils for Food Security and Climate Change Mitigation and Adaptation' to be organized by the SWMCN Subprogramme at IAEA in Vienna (23-24 July 2012), we anticipate a busy time ahead in 2011 for the whole SWMCN Team, who will be involved in the planning of this Symposium. I would welcome any comments or suggestions that you may have regarding the organization of this Symposium.

The retirement of Gudni Hardarson, Head of the SWMCN Laboratory at the end of this year, will leave a big gap for us to fill in 2011. We in the SWMCN Subprogramme wish to thank Gudni for his almost 30-year support to the SWMCN Laboratory and the SWMCN Subprogramme. We wish Gudni all the best for his retirement.

Once again, my best wishes to you all for 2011.

Long Nguyen
Head
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Staff News

Congratulations to **Mr. Lionel Mabit**. Lionel is seen here receiving his Merit Award from Deputy Director General and Head of the Department of Nuclear Applications (Mr. W. Burkart) in recognition of his excellent work supporting the Soil and Water Management and Crop Nutrition Subprogramme in the assessment and development of soil management practices to mitigate soil erosion and enhance land productivity.

Mr. Christian Resch joined the Soil and Water Management and Crop Nutrition Laboratory on 3 May 2010 as a laboratory technician. He is supporting Mr. Leopold Mayr in stable isotope analyses. Christian completed the 'Kolleg Technical Chemistry and Environmental Technology' in Vienna and thereafter worked as a petro-chemist for the 'Erdölinstitut'. He contributed to petroleum related research projects, performed environmental and petroleum analyses and conducted periodic samplings at gasoline stations in Austria. Afterwards he joined Austria Tabak and worked as a product developer, where he was involved in project management, product design and maintenance, and support for production plants in Austria and abroad. We welcome Christian in the SWMCN Section.

Ms. Shubha Rana joined the SWMCN Section on 13 September 2010 as a temporary secretarial assistant replacing Ms. Ksenija Ajvazi, who is on maternity leave. Ms. Rana is a Nepalese national. She was previously working with the IAEA Department of Management, Office of Procurement Services. We welcome Shubha in the SWMCN Section.

Ms. Belén Vallina Gonzalez joined the SWMCN Section on 4 October 2010 as an intern from Spain. She will be reviewing literature, producing brochures relating to the work of the SWMCN Subprogramme in soil and water management activities in Member States, and assisting in updating the SWMCN website. She recently completed her PDEng. in Biotechnology. Belén worked previously with the Technology Unit of the Agri-business Branch of the United Nations Industrial Development Organization (UNIDO) as an intern for nearly 6 months. We welcome Belén in the SWMCN Section.

Ms. Patcharin Dornhofer after working as an intern for nearly 15 months in the SWMCN laboratory since 22 June 2009 has joined the Food and Environmental Laboratory as of 20 September 2010. We thank Patcharin for her contribution and wish her well for the future.

On behalf of the Section and the Laboratory, Long thanked **Gudni Hardarson** for his long service to the SWMCN Subprogramme (almost 30 years) and particularly to the SWMCN Laboratory (formerly known as Soil Science Unit) as Head of this Laboratory and wished him well in his retirement.

Feature Articles

Water requirements for livestock production: a global perspective

By A.C. Schlink [1], M. L. Nguyen [2] and G.J. Viljoen [1]

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The following article is an Abstract of the paper jointly written by the two above Subprogrammes of the Joint FAO/IAEA Programme. This article will be published in Scientific and Technical **Review** of the Office **International** des Epizooties, 2010, 29 (3). It highlights the importance of water management for sustainable livestock production.

Water is a vital but poorly studied component of livestock production. It is estimated that livestock industries consume 8% of the global water supply, with most of that water being used for intensive, feed-based production. This study takes a broad perspective of livestock production as a component of the human food chain, and considers the efficiency of its water use. Global models are in the early stages of development and do not distinguish between developing and developed countries, or the production systems within them. However, preliminary indications are that, when protein production is adjusted for biological value in the human diet, no plant protein is significantly more efficient at using water than protein produced from eggs, and only soybean is more water efficient than milk and goat and chicken meat.

In some regions, especially developing countries, animals are not used solely for food production but also provide draught power and fertiliser for crops, as well as using fibre and crop by-products that would otherwise go to waste.

The livestock sector is the fastest-growing agricultural sector, which has led to increasing industrialisation and, in some cases, reduced environmental constraints. In emerging economies, increasing involvement in livestock is related to improving rural wealth and increasing consumption of animal protein. Water usage for livestock production should be considered an integral part of agricultural water resource management, taking into account the type of production system (e.g. grain-fed or mixed crop-livestock) and scale (intensive or extensive), the species and breeds of livestock, and the social and cultural aspects of livestock farming in various countries.

Limited availability of water or the presence of contaminants in the supply has a significant impact on animal health and productivity. The water demands of livestock may also compete with those of the human population and water required for crop production. Crops can make direct use of rainfall or stored water through irrigation, whereas animals consume crops or pastures, leading to potential reductions in water efficiencies for food production. This water must be added to the water directly consumed by the animals to maintain life as well as to the water used during product processing. This apparent 'inefficiency' of water use has been highlighted in recent accounting models of global water use.

This paper considers the role of livestock production and the efficiency of its water usage in producing protein for human consumption. The issues of water efficiency and the role of livestock in environmental pollution have been used to question the continued role of livestock as a human food source. Models of water efficiency are in an early stage of development, compared to those of livestock pollution, but water efficiency issues have the potential to gravely affect livestock production. The current models imply that livestock production is an efficient source of human food. However, unfavourable perceptions could lead to reduced demand by consumers and policy planners, who may believe that the negatives of livestock production far outweigh the positives, in both the developed and developing worlds. If this attitude towards livestock production is allowed to go unchallenged, it will have severe long-term implications for livestock producers and professionals, such as farmers, veterinarians and production specialists. Veterinarians have long played a role in ensuring that livestock have access to clean and adequate water supplies but, to date, have been reluctant to enter the broader debates of water competition between different production systems and efficiency of water use by livestock.

This paper highlights the background to the role of livestock production in the global economy and provides a broad overview of water usage by livestock. The authors propose an alternative way of assessing the efficiency of water use by livestock: through the concept of human, dietary utilisable protein. This approach has not been considered by previously published models.

All the global models are in the early stages of development and do not specifically address the issues of developed and developing countries, or their various production systems. However, the models are starting to highlight the role of global trade in effective water transfer between countries. At this point, they are not appropriate for considering the inherent complexity of livestock usage of water, which varies significantly between regions, due to historical differences, as well as differences in production systems and species. The authors recognise that such considerations must be included in more detailed studies of water use in the future.

Rational Utilization of Salt Affected Soils and Saline Waters for Crop Production and the Protection of Soil and Water in Agricultural Catchments

By K. Sakadevan and M.L. Nguyen

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Sustainable management of land and water resources in arid and semi-arid regions is of concern as a result of increased population pressure and the need for more food and fibre. Soil and water salinity is widespread across the arid and semiarid regions of Australia, the Arabian Peninsula, Central Asia, North Africa, North America and South Asia, where it is a major constraint for agricultural productivity and the livelihoods of the rural population. Globally, salinity spreads across at least 75 countries and about 20% of irrigated land is affected by salinity. Recent estimates suggest that up to 50% of irrigated land has become saline in some of these regions. While both natural processes (primary) and anthropogenic activities (secondary) cause soil and water salinity, the latter contributes more to loss of agricultural productivity in these regions.

In addition to anthropogenic activities global climate change also accelerates soil and water salinity through the following processes:

- Unpredictable evaporation and transpiration: Climate change alters the evapotranspiration and water balance at the land surface, and changes the groundwater recharge. In shallow aquifers, the groundwater responds to these changes quickly and moves towards the surface bringing salt with it and accelerating soil salinization (Yu et al., 2002).
- Reduction in rainfall: Current best estimates suggest that in arid and semi-arid catchments, a reduction in rainfall due to climate change will result in up to double the reduction in run-off from catchments and river flow. Under such conditions, river salinity will increase as a result of reduced river dilution (CSIRO, 2008).
- Influence of tidal waves: In coastal areas, the risk of soil and water salinization under climate change is even higher because the increased sea level and frequency of tidal waves brings salt water into inland freshwaters and is lost then to groundwater, making it saline. In low-lying areas, salty river water moves to the land surface causing soil salinization (Nicolls et al., 2007).
- Disconnection between floodplains and rivers: Continuous drought in some arid and semi-arid regions accumulates salt in floodplains. At the end of the drought cycle the accumulated salt is mobilized and released to the river making the water saline. This process may continue for years and affect environmental assets downstream of irrigated landscapes (Junk and Wantzen, 2003).

Bangladesh, Indonesia, Egypt, countries in the Arabian Peninsula and small island countries and atolls in the Pacific are particularly vulnerable to soil and water salinization, as the coastal areas of these countries are affected by increased tidal waves (Bindoff et al., 2007).

Globally, economic losses due to salinization of agricultural land is estimated at US$11.4 billion per year in irrigated land and US$1.2 billion per year in non irrigated areas (Ghassemi et al., 1995). There will also be additional economic losses as a result of the offsite impacts of soil salinization (data only available for Australia).

Soil and water salinity can be addressed through improved irrigation and agronomic practices that reduce further salinization (mitigation) and the sustainable use of salt affected soils and saline water to grow salt tolerant crops and forage (adaptation). The successful use of salt-affected soils and saline water takes the pressure off using freshwater for agriculture. Significant advantages of addressing soil and water salinity through an integrated approach include: (1) the use of salt-tolerant crops, forages, and halophytes for human and animal consumption and bio-fuel production, (2) development of agro-forestry through planting forage crops within the interspaces of salt-tolerant trees which can co-exist with forage crops and salt-tolerant shrubs, (3) development of appropriate surface and subsurface drainage systems to remove excess water and salt from the soil, (4) alternate and/or blended use of saline and fresh water to minimize salt accumulation in the soil, and (5) maintenance of proper irrigation scheduling to ensure that adequate water is available for crop growth and at the same time removal of excess salt from crop-rooting zone. Monitoring the effectiveness of the above mentioned technologies is important to maximize the benefits. Finally, appropriate policy and institutional interventions which encourage the general community to accept the technology are also required. Isotopic and nuclear techniques play a key role in developing and monitoring the technology for the sustainable use of salt-affected soils and saline waters and protect land and water resources.

The global response options for soil and water salinization particularly, in arid and semi-arid regions, were recently reviewed by the SWMCN section and published in *Advances in Agronomy* (Volume 109, Chapter 2, 55-74).

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Recording Surface CO_2 Concentration and Isotopic Measurements for Sequestration Research with a Gas Analyzer Mounted on a Mule

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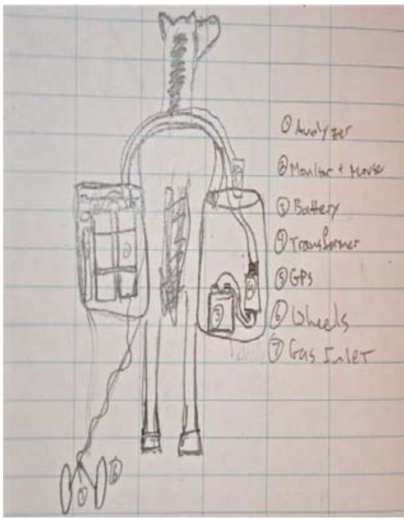
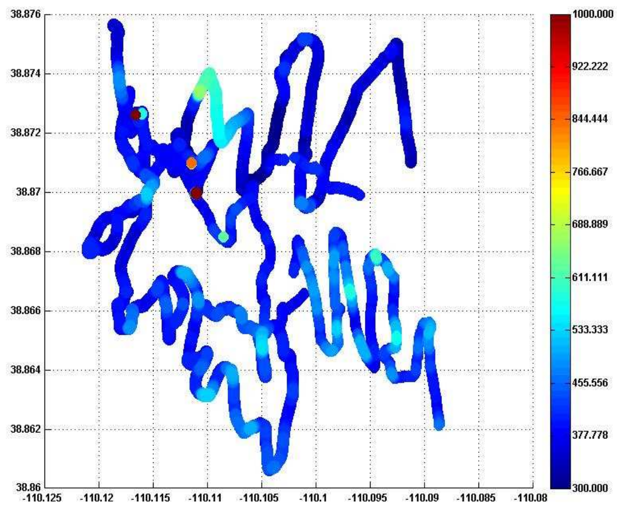
Alex is working for Picarro Inc. a manufacturer of laser-based instruments using cavity ring-down spectroscopy (CRDS) for measuring isotope ratios and concentrations in a variety of compounds including greenhouse gases and isotopes in CO_2 and water. Its customer applications include air quality monitoring, hydrological and isotopic tracing, soil and water management studies, food safety and food origin monitoring, water cycle and ecological studies, and atmospheric research.

In the United States of America, a number of government and private organizations are in the process of constructing carbon sequestration projects as part of efforts to address greenhouse gas levels in the atmosphere. Very little is known, however, about the behavior of carbon after it is injected into sequestration receptacles (mines, sub-surface chambers, underground tanks etc.) and, more importantly, whether carbon sequestered underground can easily escape in minute or gross quantities. Detecting these fugitive emissions would be difficult even in easy to access environments but in many cases sequestration projects are cited in locations where access is intermittent or difficult to obtain due to weather or geographical features.

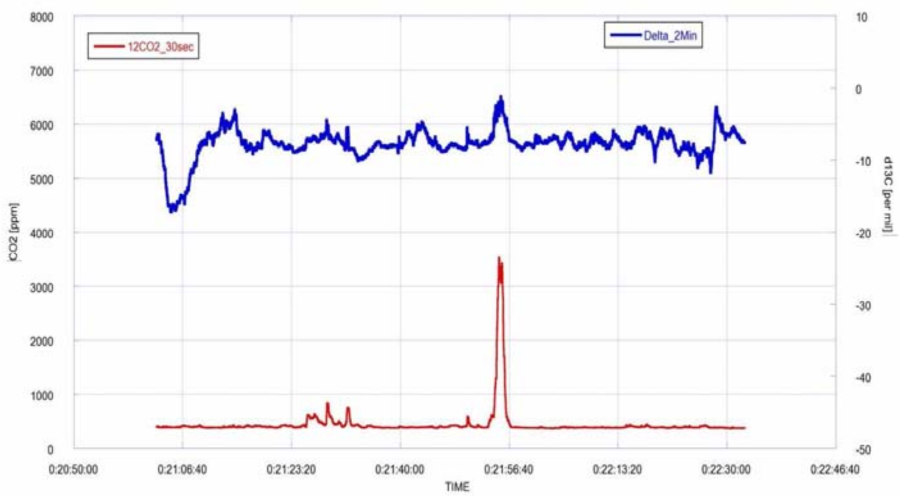
A team from Stanford University, led by Samuel Krevor, a Post Doc researcher working with Prof. Sally Benson (Director of the Global Climate and Energy Project at Stanford University) are performing research on this topic using a novel approach of mounting a high-precision molecular gas analyzer on a pack mule to survey CO_2 concentration and ^{13}C isotopic signature measurements across an area well-known for natural CO_2 emissions activity. Krevor and Benson placed a Picarro G1301-i analyzer (for CO_2 concentration and isotopic CO_2 signatures) in one saddle bag and placed a battery to power the analyzer, an inverter, a GPS device and other equipment in the other saddle bag. They extended the sample gas inlet tube from the analyzer and taped it to the mule's leg to secure the tube close to the ground where the best readings would be obtained. Krevor and Benson then taped the tube to a small two-wheeled cart made from two sets of bicycle training wheels to allow for sampling at a steady distance from the surface.



The survey goal is to produce a high resolution dataset for the area of known seepage activity. The team performed their experiments in the high desert near Green River, Utah, in the Western United States of America. Over the course of the survey, CO_2 signatures were as expected (360 ppm, $\delta^{13}C = -8$ for the majority of the survey). But the team found elevated signals from a 'hotspot' CO_2 emission source. The elevated signals are indicated by the colored dots.



Krevor and Benson reported in their blog that the 'initial findings that the CO_2 concentration increase seems to correspond with an increase in the isotopic signature of the gas. The increase is fairly modest for the given concentration increases.' This matches past research which has found that the $\delta^{13}C$ of exsolving gas has an isotopic value of -6 - slightly positive of atmospheric ambient CO_2.



The use of pack animals for measurement of CO_2 seepage could provide a relatively simple and effective mechanism for CO_2 sequestration research and benchmarking in the developing world where sequestration projects often are located in remote locales. Further, the Stanford mule rig could easily be adapted for measurement of CO_2 fluxes off farms and other agricultural areas for effective measurements of carbon absorption as well as measurement of isotopic composition of fluxes off fields as part of broader carbon budgeting efforts. The use of carbon isotopes as tracers for CO_2 emissions, as well, could provide an excellent tool for researchers in the developing world to build detailed maps of the sources and sinks of carbon resulting from agricultural land use and land policies.

For more information, please visit the Stanford Surface Monitoring Blog at http://surfacemonitoring.blogspot.com/.

The use of oxygen Isotopes of phosphate to trace phosphorus sources and cycling in soils

By J. Adu-Gyamfi

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Phosphorus (P) is an essential element in plant, human and animal nutrition. Soils with low P status are widespread in many regions of the world and their P deficiency limits plant growth and reduces crop production and food quality. Phosphorus has one stable isotope (^{31}P) and several radioisotopes (from ^{26}P to ^{30}P and from ^{32}P to ^{38}P), but the only two isotopes (^{32}P and ^{33}P) that are suitable for agronomic studies, have very short half-lives (<26 days), making it difficult to undertake any long term research. Because P has only one stable isotope, researchers have started to explore the potential of oxygen isotopes in both inorganic and organic P compounds (δ^{18}O-PO_4) to study and understand P dynamics in both cropping and livestock production systems to improve soil fertility and food productivity. Such information is very important for future management of P for sustainable intensification of agricultural production, to ensure food security in the long term and furthermore to minimize the adverse effects of excess P on the environment.

In order to analyze the δ^{18}O-PO_4 in soils from different soil P fractions (eg H_3PO_4, H_2PO_4-, HPO_4^{-2}, and PO_4^{-3}), phosphate must be extracted from the soil, purified and converted to Ag_3PO_4. Tambunini et al (2010) have recently developed protocols for estimating δ^{18}O-PO_4 for soils with different soil P status and plant-availability in different countries. Soils receiving different farm management practices (e.g., fertiliser or manure applications) showed different δ^{18}O-PO_4 signatures, indicating the potential of δ^{18}O-PO_4 as an isotopic tracer for studying P cycling, tracing P sources and ultimately providing a better understanding of soil P dynamics in agro-ecosystems.

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Neutron radiography—A new tool for non-destructive study of roots for enhanced crop productivity

By J. Adu-Gyamfi

Soil and Water Management & Crop Nutrition Subprogramme, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency - IAEA

Roots— the hidden half of the plant— play an important role in improving soil and crop productivity because of their central importance in capturing and utilizing soil water and nutrients for plant growth. Despite its importance, root research has received very little attention, but roots are the key to a second green revolution (Nature Vol 4666). Neutron radiography imaging (NR) is one of the current promising non-destructive techniques available to study in-situ root development in soils and also to quantify the spatial distribution and flux of water in the soil-plant system in near real time. NR is a non-invasive imaging technique that measures the attenuation of thermal neutrons (much like photons in X-ray radiography), to characterize the internal composition of material. The imaging facilities consist of a neutron source, a special collimator (a beam-forming assembly that determines the geometric properties of the beam and contains filters that reduce the intensity of accompanying gamma rays), and a two dimensional image detector which is recorded by a CCD camera to produce the digital images (Figures 1a and b).

This technique has proved to be an excellent means of measuring soil water content and plant root water uptake and dynamics in pot culture at a spatial resolution of 0.2 mm both in the USA (the University of California-Davis) and in Switzerland (Eidgenössische Technische Hochschule Zürich), ETH-Zürich, in collaboration with the Paul Scherrer Institute, Villigen. The obvious drawback of NR is that it requires access to specialized facilities and thus, the availability of neutron-imaging facilities currently limits widespread application to soil and root studies. However, technological development and increased investment will result in NR becoming a standard method for in-situ quantification of root development and architecture, and in-situ measurement of soil water content for soil cores taken from the field.

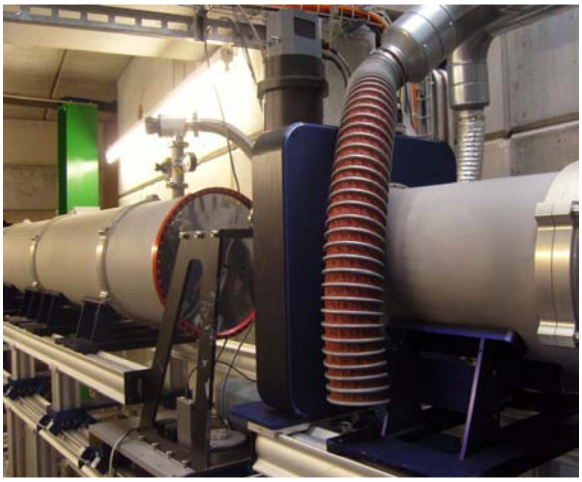

Figure 1a The cold-neutron image set-up for studying in-situ root development

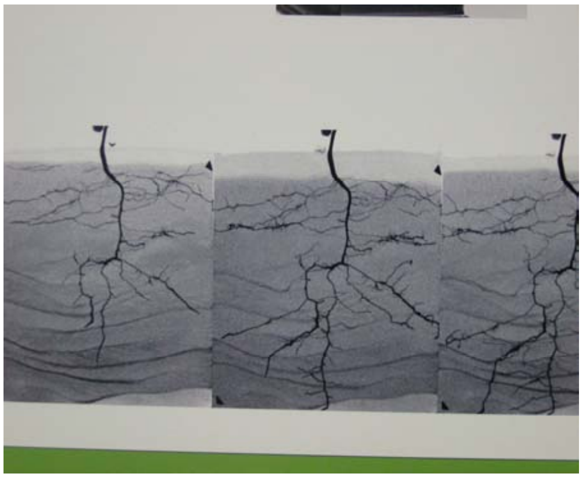

Figure 1b Neutron radiograph of roots in Al containers

Potential use of stable isotopes in amino sugars as tracers for soil organic matter translocations from critically degraded areas in farm lands

By S. Bodé and P. Boeckx[1]

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Hypothesis and challenge

Soil erosion and subsequent sedimentation are natural processes caused by water, wind and ice. Anthropogenic activities such as deforestation, overgrazing, changes in land use, non-sustainable farming practices and global climate change tend to accelerate soil erosion. The result is degradation of the landscape which has an impact on soil fertility, crop productivity, water pollution, and sedimentation in lakes, reservoirs and floodplains. New methods are emerging to assess carbon storage and mobilization within a catchment in order to investigate the relationship between sites with critical soil erosion (source) and deposition areas (sink). Compound specific stable isotope analysis (CSSIA) is a promising approach to fingerprint soil organic matter (SOM) via its molecular components. Evidence is emerging that CSSIA of plant root derived fatty acids (Gibbs, 2008) also enables us to establish carbon source-sink relationships in catchments that are affected by considerable erosion and deposition processes.

To a certain extent, micro-organisms derive their building blocks from plant-root derived organic compounds (Denef et al. 2009). Cell walls of fungi, bacteria and actinomycetes are partially constructed from polymers of acetylated amino sugars. Because of the relative stability of these compounds after cell death, amino sugars have been used to quantify the relative contribution of the different functional groups to living and dead soil microbial communities, which in turn can be used to explain land use changes. We therefore hypothesize that the relative abundance of the different amino sugars, together with their isotopic composition (^{13}C and ^{15}N) is characteristic of a particular land use and management practice. For these reasons CSSIA of amino sugars could become a tool to track and quantify soil erosion hotspots. Methods to determine the $\delta^{13}C$ and $\delta^{15}N$ of amino sugars using gas chromatography/combustion/isotope ratio mass spectrometry (GC-c-IRMS) have been proposed in the literature. However, due to the laborious method used for sample preparation (derivatisation), the likelihood that the obtained $\delta^{13}C$ values are uncertain, is too high for this method to be used for natural abundance studies (Decock et al. 2009). Therefore, the first challenge was to develop and validate a high-performance liquid chromatography isotope ratio mass spectrometry (HPLC-c-IRMS) methodology with improved accuracy and precision.

Method development

The amino sugars extraction procedure was based on the method described by Zhang and Amelung (1996). In short dry and 2mm sieved soil was hydrolysed with 6M HCl for 8 hours at 105°C. The filtrate was then dried at 45°C at reduced pressure before being re-dissolved and applied on cation exchange resin in H^+ form. The neutral and negatively charged compounds were then washed out with water. The amino sugars were eluted with 12 mL of 0.5 M HCl. The eluate was dried again under reduced pressure, re-dissolved in 1 mL of H_2O, dried and kept refrigerated until analysis. The chromatography separation was performed on an anion exchange column using 2mM NaOH and a column temperature of 15°C to elute the basic amino sugars (glucosamine, mannosamine and galactosamine), while for muramic acid 2mM $NaNO_3$ was added to the 2mM NaOH and the column was set at 30°C (see Bodé et al. 2009 for details).

Evaluation

Reference amino sugar solutions were analyzed with the two developed methods. Different amounts of the basic amino sugars glucosamine and galactosamine were injected (ranging from 0.5 to 100 nmol) and the isotopic composition and peak areas of the individual amino sugars were determined. The $\delta^{13}C$ obtained for the individual amino sugars was compared to the isotopic composition of the pure reference material as determined by µEA[2]-IRMS analysis (Figure 1b). The repeatability and obtained $\delta^{13}C$ values were not significantly concentration dependent as long as the injected amount was higher than 1.5 nmol. Beneath this amount the repeatability decreased rapidly (Figure 1a).

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[1] The authors currently participate in the Coordinated Research Project D1.20.11 on Integrated Isotopic Approaches for an Area-wide Precision Conservation to Control the Impacts of Agricultural Practices on Land Degradation and Soil Erosion. For more information on this CRP, please see under Status of Coordinated Research Projects (CRPs).

[2] Micro element analysis

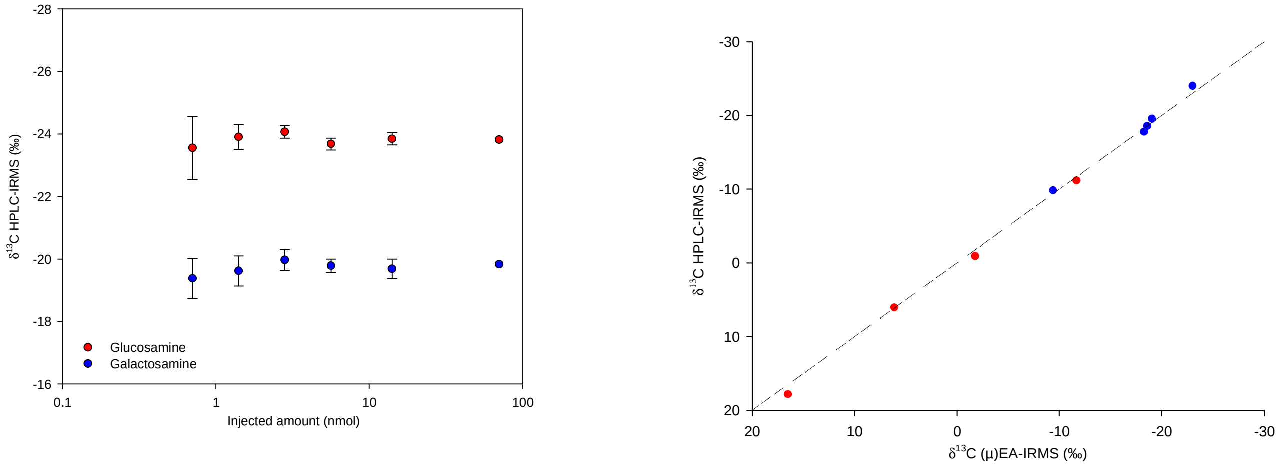

Figure 1. (a) Determination of the isotopic composition of reference amino sugars in function of injected amount (error bars represent plus minus one standard deviation). (b) $^{\delta}VPDB^{13}C$ as determined by HPLC-c-IRMS compared to $\delta VPDB^{13}C$ determined by µEAIRMS. The blue dots are the reference amino sugars (Glucosamine, galactosamine, manosamine and muramic acid) at natural abundance; the red dots are ^{13}C enriched glucosamine solutions; the full line is the 1:1 line

To assess the recovery of the hydrolysis step and the accuracy of the $\delta^{13}C$ determination of soil amino sugars, soil samples were spiked with different amounts of glucosamine, galactosamine and muramic acid. The recovery for Glucosamine, galactosamine and muramic acid were 72, 91 and 78 % respectively (Table 1). The isotopic composition of the amino sugars in these spiked samples was measured and compared to its theoretical isotopic composition.

$$\delta^{13}C_{theo} = \frac{N_{soilAS}.\delta^{13}C_{soilAS} + N_{spike}.\delta^{13}C_{spike}}{N_{soilAS} + N_{spike}}$$

Table 1. $\delta_{VPDB}{}^{13}C$ (‰) and concentration of amino sugar in a soil extract as measured by HPLC-c-IRMS. The recovery and deviation in absolute values of the calculated $\delta^{13}C$ values of soils spiked with glucosamine, galactosamine and muramic acid is also presented.

	Soil extract (n=4)		extraction of spiked Soil (n =2)	
	concentration[1] (mg kg^{-1} soil)	HPLCIRMS	recovery (%)	$\lvert\Delta\delta^{13}C\rvert$ [2] (‰)
Glucosamine	885 (± 14)	-26.3 (±0.2)	72 (±5)	0.3 (± 0.4)
Galactosamine	299 (± 13)	-25.2 (±0.1)	91 (±13)	0.3 (± 0.3)
Muramic acid	26 (± 2)	< LoQ	78 (±5)	0.7 (±0.2)

1 The recovery of xylose was used to correct losses during purification steps

2 $\Delta\delta^{13}C$ (‰) is the difference between the measured $\delta^{13}C$ of soil samples spiked with 20, 50 and 100 µg reference standards and the theoretical (δ13Ctheo) calculated by summation of the relative contribution of $\delta^{13}C$ from soil native amino sugars and $\delta^{13}C$ from amino sugars used to spike the soil.

Conclusions

A HPLC-c-IRMS methodology, to determine $\delta^{13}C$ and the concentration of individual amino sugars present in soil, excluding a derivatisation step, has been successfully developed. This newly developed method could prove to be very useful in several research areas including dynamics of amino sugars in soils and these compounds could be used as fingerprints to pinpoint the origin of sediments in a catchment. The method provided reproducible, accurate and precise measurements for the determination of $\delta^{13}C$ of amino sugars as well for their quantification. The next step will be to assess whether different land uses (deciduous vs. pine forest, extensive vs. intensively managed grassland, and conventionally tilled vs. no-till arable land) can be differentiated via $\delta^{13}C$ (HPLC-c-IRMS) and $\delta^{15}N$ (GC-c-IRMS).

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Combined use of ^{137}Cs and stable isotopes to assess soil degradation in mountainous grasslands of Switzerland

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The Challenge

Current concerns to ensure a sustainable use and management of European soil and agricultural water resources generate an urgent need to obtain reliable quantitative data on the extent and actual magnitude of soil erosion. Soil loss and its triggering processes are still subject to a high degree of uncertainty in European mountainous areas. Investigations to describe and predict soil erosion in such areas of reduced accessibility are urgently needed to improve quantification and process understanding (Asselman *et al.*, 2003; Alewell *et al.*, 2008). This multi-isotopic approach aims to assess soil loss and the quantitative relevance of different erosion processes in a sub-alpine catchment of the Central Swiss Alps (Urseren Valley).

Experimental design

The approach used in the present study combines direct measurement of sediment yield during the growing season of 2007 with long-term soil erosion assessment based on in-situ and laboratory fallout radionuclide (i.e. ^{137}Cs), and stable carbon (^{13}C) and oxygen isotope (^{18}O) measurements in agricultural lands. Remote sensing was also used to up-scale the obtained information.

Main results

The comparison of the different soil erosion assessment techniques from nine slopes resulted in large discrepancies. Erosion rates measured with sediment traps during the growing season were below 1.5 t ha^{-1} a^{-1} (Konz *et al.*, 2009). However, ^{137}Cs based erosion rates indicated high erosion rates of up to 37 t ha^{-1} a^{-1}, which were in agreement with the significant visible erosion damage observed at the study sites (Figure 1; Konz *et al.*, 2009). The high erosion rates revealed by the ^{137}Cs technique can be explained by the fact that ^{137}Cs measurements integrate a longer soil erosion time period from April 1986 (Chernobyl being the main source of ^{137}Cs fallout in this area) until today, including erosive processes during the winter season and snow melt in spring, as well as during intensive rain storm events in summer. Thus, in the Urseren Valley, soil erosion processes during the growing season seemed to have only a minor influence on the mean annual soil erosion rates, if no extreme and exceptional events occurred. The results highlighted that winter processes, especially mechanical translocation by snow movement (gliding, ablation and avalanches), are of major importance (Figure 2). Inventories of ^{137}Cs on grasslands with differing fractional vegetation cover[3] showed significant

[3] Fractional vegetation cover is a dynamic variable which changes on a daily basis, yet to this point most models simply include a climatological value for the percent healthy vegetation cover. Remote sensing from satellites now provides enough detailed and continuous coverage of the Earth's surface to provide an indirect, NDVI-based vegetation cover product.

differences. Consequently, it is necessary to consider fractional vegetation cover for soil erosion modelling in the Alps (Meusburger *et al.*, 2010) supported by satellite imagery.

Figure 1.Visible evidence of soil erosion on a south exposed slope in the Urseren Valley, Switzerland

Stable carbon and oxygen isotopes were found to be useful indicators of carbon transport from oxic upland to anoxic wetland soils. Hence a stable carbon isotopic signature might function as an early warning isotopic tool to differentiate long and short-term erosive processes from upland to wetlands (Schaub and Alewell, 2009; Schaub et al., 2009). Moreover, the combined measurements of stable carbon isotope signatures with ^{137}Cs based erosion rates indicated that soil organic carbon is degraded during detachment and transport processes (Alewell *et al.*, 2009). Although it is not possible to conclude from the data that eroded soil organic carbon is generally degraded during detachment and transport, the proposed method is suitable for gaining additional information on process dynamics during soil erosion from upland to wetland soils, sediments or water bodies.

Figure 2. Eroded sites some days after snowmelt (left) and soil scrap caused by an avalanche (right) in the Urseren Valley, Switzerland

Conclusion and perspectives

The results of this study highlighted the importance of comparing and combining results from different nuclear and conventional techniques to increase the understanding and quantification of the different soil erosion processes. Measurements of soil redistribution magnitude based on ^{137}Cs indicated that subalpine grasslands are highly prone to erosion. Future research should aim to (i) verify the expected high soil erosion rates induced by winter and related snow dynamics and (ii) apply stable isotope approaches (i.e. ^{13}C, ^{18}O) in other watersheds under various agro-climatic conditions.

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Linking spatial-temporal variations of crop yield with soil deposition along paddy rice terraces

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In tropical mountainous regions of South East Asia, intensive cultivation of annual crops on steep slopes makes these areas prone to erosion resulting in decreasing soil fertility. Soil deposition in the valleys, however, can enhance soil fertility, depending on the quality of the sediments, and influence crop productivity. The aim of the study was to assess (i) the spatial-temporal variation in grain yield along two rice terrace cascades in the uplands of northern Vietnam, (ii) possible linkage of soil deposition with the observed variation in grain yield, and (iii) by using carbon isotope (13C) discrimination and 15N natural abundance techniques whether spatial variation in soil water or nitrogen availability masked the effect of soil deposition on spatial variation of crop yield. In order to evaluate the impact of seasonal conditions, fertilizer use and the quality of deposited soil on rice performance, ^{15}N and ^{13}C stable isotope compositions from rice leaves and grains taken after harvest were examined and combined with soil fertility information and rice performance, using multivariate statistics.

The observed grain yields for the non-fertilized fields, averaged over both cascades, accounted for 4.0 ± 1.4 Mg ha^{-1} and 6.6 ± 2.5 Mg ha^{-1} in the spring and summer crop respectively; while in the fertilized fields, grain yields of 6.5 ± 2.1 Mg ha^{-1} and 6.9 ± 2.1 Mg ha^{-1} were obtained. In general, the spatial variation of rice grain yield was strongly and significantly linked to sediment induced soil fertility and textural changes, such as soil organic carbon (r 0.34/0.77 for Cascade 1 and 2 respectively) and the sand fraction (r -0.88/-0.34). However, the observed seasonal alteration in topsoil quality, due to soil deposition over two cropping cycles, was not sufficient to fully account for spatial variability in rice productivity. Spatial variability in soil water availability, assessed through ^{13}C discrimination, was mainly present in the spring crop and was linearly related to the distance from the irrigation channel and in Cascade 2 overshadowed the expected yield trends based on soil deposition. Although the $\delta^{15}N$ signatures in the plants indicated sufficient N uptake, grain yields were not always found to be significantly influenced by fertilizer application. These results show the importance of integrating information on soil deposition with soil fertility analysis of rice paddy fields. Furthermore, where the effect of inherent soil fertility on rice productivity is masked by soil water or nitrogen availability, the use of ^{13}C and ^{15}N stable isotopes and their integration with conventional techniques show a potential to enhance the understanding of the influence of erosion – deposition and nutrient fluxes on crop productivity, at toposequence level.

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[4] The authors are currently participating in Coordinated Research Project D1.20.11 on Integrated Isotopic Approaches for an Area-wide Precision Conservation to Control the Impacts of Agricultural Practices on Land Degradation and Soil Erosion. For more information on this CRP, please see Status of Coordinated Research Projects (CRPs).

For further details refer to the following article:
P. Schmitter, G. Dercon, T. Hilger, M. Hertel, J. Treffner, N. Lam, T. Duc Vien, G. Cadisch, 2010. Linking spatio-temporal variation of crop response with sediment deposition along paddy rice terraces. Agriculture, Ecosystems and Environment (in press).

A SWMCN success story on sustainable soil management of activities in Tajikistan

The following feature article was published on the Website of Technical Cooperation IAEA on 27 September 2010 (http://tc.iaea.org/tcweb/news_archive/UNDAF/default.asp). This is reproduced here for your information

United Nations Development Assistance Frameworks (UNDAFs): helping to ensure the integration of nuclear techniques with other development initiatives and plans

The IAEA and the Department of Technical Cooperation in particular, rely on harmonious and collaborative work with numerous partners over a broad range of policy levels to promote peace and development through the peaceful application of nuclear science and technology.

The Strategy and Partnership Section (TCSPS) of the Division of Programme Support and Coordination is at the forefront of developing and maintaining successful partnerships with the IAEA's Department of Technical Cooperation. Part of the work of TCSPS involves streamlining the Country Programme Framework (CPF) process and building networks that support the United Nations one house approach.

Country Programme Frameworks are programming tools that provide a frame of reference for technical cooperation between the IAEA and its Member States in the medium term (4-6 years). They provide a concise framework for national development needs or problems that can be addressed using nuclear science and technology. In support of the IAEA's efforts to align and provide leverage for its technical cooperation activities within the larger development context, the CPF preparation process now makes extensive use of national development plans and United Nations Development Assistance Frameworks (UNDAFs). UNDAFs are the planning framework for the development operations of the UN system at the country level and not only help to ensure that the application of nuclear techniques is integrated with existing development initiatives and plans, but also assist identifying areas where such techniques might be usefully deployed.

In the past two years, 13 UNDAFs have been signed, reflecting the IAEA's focus on optimizing development activities at the country level. Currently the Secretariat is engaged in 22 ongoing UNDAF processes to ensure that the TC programme is aligned with the national development priorities reflected in these frameworks.

One outstanding example of the work that is possible within the UNDAF framework is demonstrated in a soil conservation project in Tajikistan (TAD5005) entitled 'Developing Soil Conservation Strategies for Improved Soil Health', part of a technical cooperation effort that began with the assessment of soil erosion and sedimentation for land use.
In former years limited capacity to monitor national resources has led to poverty due to widespread soil erosion that has affected agricultural lands. A lack of essential soil redistribution information made it impossible for the nation to assess, monitor and address the processes of accelerated natural resource degradation.

The technical cooperation project was developed as a result of Tajikistan's identified need for improved national capacities and facilities to provide the basis for soil erosion modelling and land use planning. The IAEA is providing expert advice in field sampling design, laboratory set-up and data interpretation and training, to contribute to a better understanding of the main factors affecting Tajikistan's soil redistribution. As a result of this assistance, sustainable natural resource management will be possible, based on the identification of cost-effective soil conservation measures. This project has become associated with the project on Sustainable Land Management in the High Pamir and Pamir-Alai Mountains (PALM), an integrated transboundary initiative of the governments of Kyrgyzstan and Tajikistan and has involved numerous partners:

- The Global Environment Facility (GEF), the UN Environment Programme (UNEP) and other donors who provided financial support to PALM
- The State agencies for environment protection and forestry in Tajikistan and Kyrgyzstan
- Partnerships were established with the University of Bern's Centre for Development and Environment through the National Centre of Competence in Research (NCCR) North-South, and with scientists from Moscow State University

- GEF directed complementary resources to the project through the PALM mechanism
- The United Nations University (UNU) helped to coordinate project activities.

These partners are working with the same Tajik counterparts as the IAEA, in particular the Tajik Soil Science Institute and the Tajik Academy of Agricultural Science, to offer complementary services and assistance.

Increased awareness of Tajik soil erosion trends and the appropriate mitigation and control options will provide the basis for land use planning and decision making and will promote soil and water conservation techniques for sustainable agriculture development in Tajikistan. The establishment of capacity and facilities for efficient and accurate soil erosion assessment in Tajikistan will support soil erosion surveillance not only within the country, but also in the vast mountainous territories of Central Asia. The collaborative work of this project is an example of how partnerships can optimize land resource use to benefit the socioeconomic development of a country and a region.

More information on the PALM project can be found at http://www.ehs.unu.edu/palm/

Fallout radionuclides as indicators of soil degradation and potential loss of agricultural production in Latin American and Caribbean countries

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Background

Land degradation affects about 300 million ha of land in the Latin American and Caribbean region: 51% of this is agricultural land (180 million hectares). The ARCAL Regional Strategy Profile identifies the deficient use of agricultural soil and the resulting permanent loss of productive agricultural areas as one of the most important environmental and alimentary problems in the Latin American and Caribbean continental areas (Alimentary Security, A3, PER-ARCAL, 2007-2013). In recent times, extensive natural areas have been dramatically diminished by various human interventions. In this continental context, regional or national difficulties normally present specific characteristics and relevancies and distinct intervention needs. Indicators of the present soil conservation status are essential for an assessment of national economic impact and an evaluation of social consequences.

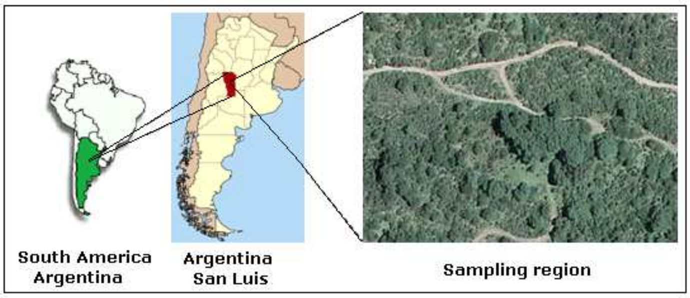
Large-scale soil erosion evaluations cannot be based on direct conventional measurements because of methodological restrictions and excessively high temporal and spatial variability. Quantitative predictions which are more precise than a qualitative erosion risk determination must be carried out. Three Fallout Radionuclides (FRNs), such as Caesium-137 (^{137}Cs), Excess Lead-210 ($^{210}Pb_{ex}$) and Beryllium-7 (^{7}Be), have proved to be by far the most successful tracers of soil movement. A key feature of the use of ^{137}Cs is its ability to provide retrospective information on medium-term rates of soil redistribution based on a single sampling campaign. ^{137}Cs measurements provide information on rates of soil redistribution averaged over a period of about 50 years, while ^{7}Be, with its short half-life of 53 days, offers a potential for documenting soil redistribution over much shorter-timescales than ^{137}Cs and $^{210}Pb_{ex}$. A number of studies have exploited this potential and have used ^{7}Be measurements to document the soil redistribution rates associated with individual events (one month of heavy rainfall) or recent short periods of heavy rainfall.

In view of the above, the project **'Using Environmental Radionuclides as Indicators of Land Degradation in Latin American, Caribbean and Antarctic Ecosystems', RLA/5/051**, was approved for 5 years from 2009-2013. The project aims to enhance regional capacity for sound assessment of land degradation and improved national and regional policies for soil conservation in Latin America, Caribbean and Antarctic ecosystems through the use of fallout radionuclide based techniques.

Within the framework of the ARCAL RLA/5/051 project, research groups from 15 countries in the region (i.e. Argentina, Bolivia, Brazil, Chile, Cuba, Dominican Republic, El Salvador, Haiti, Guatemala, Jamaica, Mexico, Nicaragua, Peru, Uruguay and Venezuela) have started in 2010 to implement intensive field campaigns and laboratory and modelling activities focused on employing fallout radionuclides as tracers of soil erosion and redistribution in representative agroecosystems of the region. It aims to assess soil degradation in the region and to assist policy makers in the participating countries to select the right approaches and tools to diagnose the state of land degradation and the consequences of human intervention under different agro-ecological conditions.

Case study from Argentina

As part of the RLA/5/051 project activities, the Grupo de Estudios Ambientales (GEA, IMASL, Universidad Nacional de San Luis/Conicet), in Argentina, identified the best strategy for using FRNs (in particular ^{7}Be) in this part of the region. The study site was located in central Argentina (S 33°9'; W 66°18'); 15 km north of San Luis City (Province of San Luis). In this region the average annual temperature is 17ºC, while in summer (December–March), the mean temperature is 23ºC. Annual rainfall ranges from 600 mm to 800 mm.



In San Luis rainfall varies seasonally, with a dry season from May to October and a rainy season from November to April. Rain samples were collected using rainwater collectors placed, one meter above the ground to avoid soil contamination and they were filtered without further treatment. In total 58 precipitation events were collected and ^{7}Be activity concentrations were measured by gamma spectrometry.

The ^{7}Be activity concentrations in rainwater ranged from 0.7 ± 0.3 Bq l^{-1} to 3.2 ± 0.7 Bq l^{-1}, with a mean value of 1.7 Bq l^{-1} (sd = 0.53 Bq l^{-1}). The magnitude of precipitation ranged from 1 to 59 mm. Taking into account the ^{7}Be content in rainwater and the regional precipitation regime, the ^{7}Be atmospheric depositional flux was estimated at 1140 ± 120 Bq $m^{-2}a^{-1}$. As a consequence of this rainwater activity concentration was independent of rainfall, with a linear relationship found between the activity density deposition and the rainfall (Figure 1).

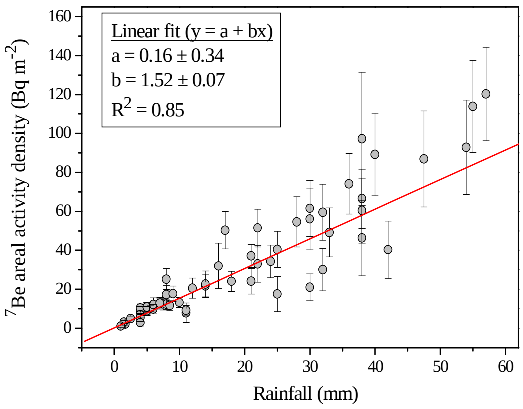


Figure 1. ^{7}Be areal activity deposition (Bq m^{-2}) vs. rainfall (mm) the ^{7}Be content and vertical distribution in soil, an area was selected where land

The distribution of ^{7}Be in the soil reached to a depth of 1 cm. No differences in the ^{7}Be content of the soil have been found between samples taken within and outside of the exclusion runoff plots. This result suggests that in this site there is no soil mobilization (sedimentation or erosion), and therefore it can be identified as a reference site for studies using ^{7}Be as an indicator of soil erosion and redistribution rates.

Figure 2 shows, in two soil profiles, the typical exponential decrease, with mass depth (x, kg m^{-2}), of areal activity density (A, Bq m^{-2}) of the ^{7}Be within the soil ($R^2 \geq 0.9$ for all profiles). These soil profiles correspond to September (dry season) and February (rainy season). Fitting has been performed with the equation: $A(x) = A_{ref} \exp(-x/h_o)$, with A_{ref} (Bq m^{-2}) representing the initial total areal activity density at an uneroded stable site or reference site in the study area, h_o (kg m^{-2}) the relaxation mass depth of the initial depth distribution of the ^{7}Be areal activity density in the soil, and x the mass depth. These parameters are indicated in the figure.

The annual depositional flux for the region was estimated based on consideration of annual precipitation values and ^{7}Be activity content in rainwater. The areal activity density in soil was estimated, considering both the rainwater mean activity concentration and the precipitation regime of the sampled region. The research predicts a marked seasonal variation in the ^{7}Be soil content. Soil activity density reaches 400-500 Bq m^{-2} in the annual wet period (December – March), while diminishing to 100-150 Bq m-2 in the dry period. The results of this work allowed good characterization of the ^{7}Be inputs into the soils of the study site, and indicated its potential application for assessing soil erosion and redistribution rates during short rainfall events and eventually improving current agricultural land management (e.g. conservation agriculture) in the region.

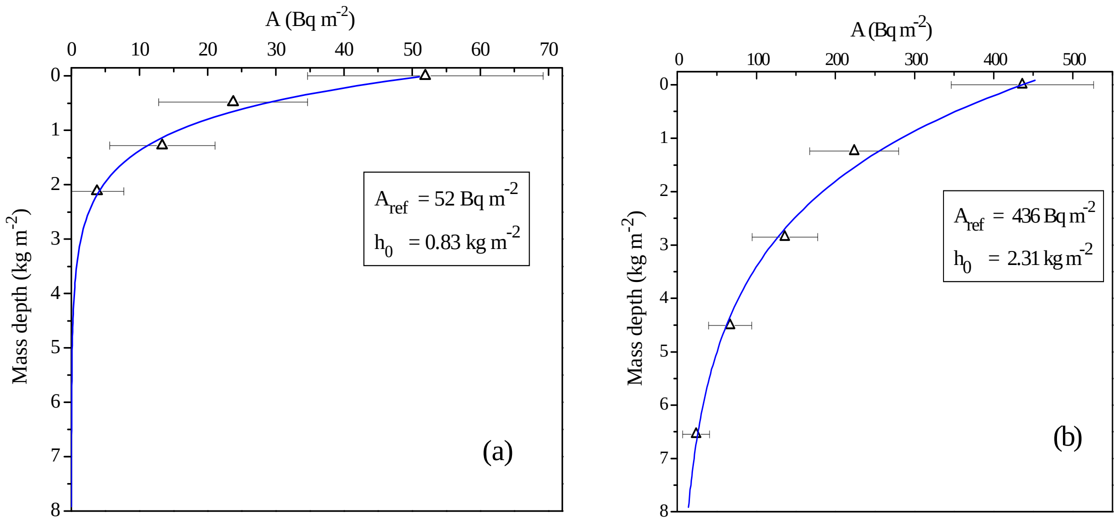


Figure 2. ^{7}Be distribution in soil for (a) September and (b) February

Project activities, action plans and strategies for each of the involved countries and more detailed information can be found on the projet website: http://gea.unsl.edu.ar.

N2AFRICA: Putting nitrogen fixation to work for smallholder farmers in Africa

By K. Giller

Plant Production Systems Group, Wageningen University, the Netherlands

Capturing free nitrogen from the atmosphere, also called nitrogen fixation, through the use of legumes as a rotation crop is a step forward in feeding the soil and improving farmers' incomes. Nitrogen fixation as measured by the stable nitrogen-15 isotope is a potentially important technique in the following project N2AFRICA, lead by Ken Giller from Wageningen University.

N2AFRICA is a large scale research project focused on 'Putting nitrogen fixation to work for smallholder farmers in Africa'. N2AFRICA is funded by 'The Bill & Melinda Gates Foundation' through a grant to Plant Production Systems, Wageningen University, in the Netherlands. It is led by Wageningen University together with CIAT-TSBF, IITA and has many partners in the Democratic Republic of Congo, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda and Zimbabwe.

Goals

At the end of the 4-year project we will have:

- identified niches for targeting nitrogen fixing legumes
- tested multi-purpose legumes to provide food, animal feed, and improved soil fertility
- promoted the adoption of improved legume varieties
- supported the development of inoculum production capacity through collaboration with private sector partners
- developed and strengthened capacity for legumes research and technology dissemination
- delivered improved varieties of legumes and inoculant technologies to more than 225,000 smallholder farmers in eight countries of sub-Saharan Africa.

Rationale

Successful BNF by legumes in the field depends on the interaction:

$$(G_L \times G_R) \times E \times M$$

that is: (Legume genotype × Rhizobium strain) × Environment × Management where environment encompasses climate (temperature, rainfall, day length etc. to encompass length of growing season) and soils (acidity, aluminum toxicity, limiting nutrients etc). Management includes aspects of agronomic management (use of inoculum, mineral fertilizers, sowing dates, plant density, weeding). Incidence of diseases and pests are also influenced by ($G_L \times G_R$) × E × M. Thus establishment of effective BNF depends on optimizing all of these components together. Legumes are often women's crops, grown for home consumption and they are thus often grown in poorer soils with little application of manure. They are also allocated less attention in terms of labour for crop management. This means that E and M often override the potential of the legume/rhizobium symbiosis for BNF.

A step-wise approach will be to enhance BNF by grain and forage legumes. As shown in Figure 1, substantial increases in BNF can be made based on existing legume and inoculant technologies (for $G_L \times G_R \times E \times M$) using current knowledge. Further substantial increases can be gained by increasing the area under legumes and retaining the legume residues in the field, which will be achievable within 4 years in many regions. Rhizobial strains with enhanced BNF efficiency can be selected (including field testing) within 3-5 years. Moving to a longer time scale breeding of legumes for enhanced BNF will probably take 10-15 years before varieties incorporating newly-identified traits can be moved to release. Adaptation to environmental stress in the legume/rhizobial symbiosis is poorly understood and there is a strong need for detailed plant physiology research in this area to support such breeding efforts to enhance BNF. Finally, genetic engineering approaches to enhance BNF hold promise, but may only lead to enhanced BNF in farmers' fields in 30-50 years.

Enhancing BNF and the scaling-up of legume integration in smallholder farming systems will be achieved in this project in the short-term (0-4 years) by introducing high quality rhizobial inoculants, selecting legume and rhizobial genotypes with enhanced potential for BNF and targeting these legume/rhizobium combinations within different agroecologies, with best-practice agronomy. This will lead to a major expansion of the area under legumes that fix substantial amounts of nitrogen which will also help to improve soil fertility for other crops.

The project will also focus on linking farmers to markets for legume grain. In many countries the major grain legumes we focus on – soybeans, cowpeas, groundnuts and the common bean – are becoming increasingly important cash crops for farmers, allowing diversification in cereal dominated cropping systems. At a later stage in the project, research and development on legume forages will be focused in farming systems where livestock are kept for meat and milk. Our confidence that we can achieve substantial impacts in increasing the amounts of N_2 fixed in smallholder agriculture in sub-Saharan Africa arises from experience in a number of 'success stories' which have already achieved such an impact with thousands of farmers.

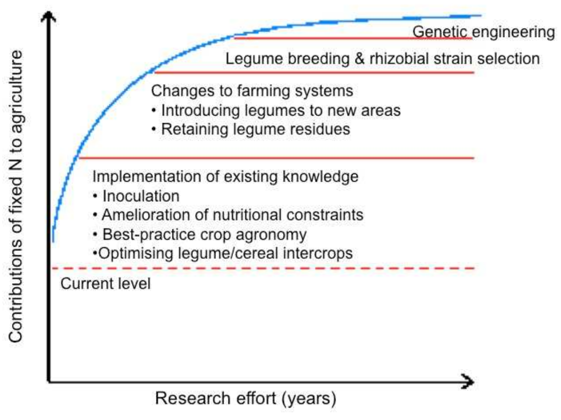


Figure 1. Potential returns to investment on research and development investment through different approaches to enhance the inputs from BNF (modified from Giller and Cadisch, 1995 Plant and Soil, 174: 255-277)

By working at a large scale – through which we will reach around 30,000 farms in each of the eight countries, lessons will be learned on the problems and opportunities for scaling up promising technologies within a wide range of farming systems.

The project, which started at the end of 2009, is designed around five objectives:

Objective 1. Establish a baseline of the current status of biological nitrogen fixation (BNF), identify farm enterprises and niches for targeting N_2-fixing legumes in the impact zones, and establish mechanisms for Monitoring and Evaluation (M&E) and impact assessment.

Objective 2. Select multi-purpose legumes providing food, animal feed, structural materials and high quality crop residues for enhanced BNF and integrate improved varieties into farming systems.

Objective 3. Select superior rhizobia strains for enhanced BNF and develop inoculum production capacity in sub-Saharan Africa, including private sector partners.

Objective 4. Deliver legume and inoculant technologies to farmers throughout sub-Saharan Africa.

Objective 5. Develop and strengthen capacity for BNF research, technology development, and application.

Progress to date

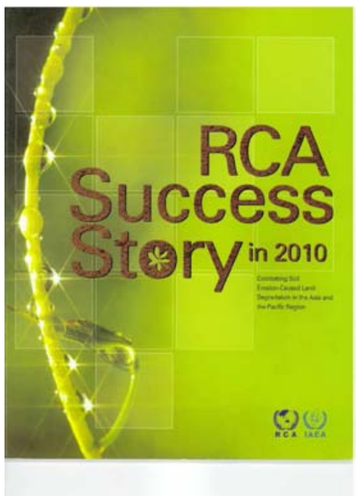
Since the start-up workshop held in Nairobi in January 2010, work has started in all eight countries. Due to the differences in seasons, the first activities started in the Democratic Republic of Congo, Rwanda and Western Kenya in March, in Ghana and Nigeria in June and the first planting in southern Africa (Malawi, Mozambique and Zimbabwe) will start in November. Adaptive trials and demonstrations have shown a strong response to inoculation in soybeans in nearly all locations, and a strong response to phosphorus fertilizer. In some cases other nutrients (K, Ca and micronutrients) are limiting and further trials will investigate the frequency of these problems in the different countries and target regions.

A major emphasis is also placed on training – through training of trainers in terms of lead farmers and extension agents, technician training in rhizobiology and inoculant handling, and science training in nitrogen fixation. A series of training videos and project updates can be found on the project website www.N2Africa.org on the N2Media page. If you are interested in learning more about the project and receiving updates on progress, send an email to n2africa.office@wur.nl.

Researchers and farmers visiting an N2Africa adaptive trial on soybeans in a farmer's field in Rwanda, April 2010

RCA Success Story in 2010
Combating Soil Erosion-Caused Land Degradation in the Asia and the Pacific Region

A full colour 36 page Success Story was published by SWMCN based on the results of the recently closed regional project RAS5043, entitled 'Combating Soil Erosion-Caused Land Degradation in the Asia and the Pacific Region'.



This was achieved thanks to the support of RCA. The RCA is an intergovernmental agreement among the IAEA Member States of South Asia, South East Asia and the Pacific, and the Far East (the abbreviation stands for 'Regional Cooperative Agreement for Research, Development and Training related to Nuclear Science and Technology').

Technical Cooperation Projects

Operational Projects and Technical Officers responsible for implementation

Project Number	Title	Technical Officer
AFG5003	Sustainable Increase in Crop Production in Afghanistan	Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
ALG5022	Nuclear Techniques for Sustainable Use of Saline Groundwater and Wastelands for Plant Production	Heng, Lee Kheng
ANG5005	Effect of Biofertilizer and Inorganic Fertilizer Uses on the Growth and Yield of Maize and Bean in Ferralitic Soils of Huambo	Hardarson, Gudni
BEN5005	Improving Maize and Yam-Based Cropping Systems and Soil Fertility	Adu-Gyamfi, Joseph Jackson
BGD5026	Increasing Agricultural Production in the Coastal Area through Improved Crop, Water and Soil Management	Adu-Gyamfi, Joseph Jackson in collaboration with the Plant Breeding and Genetics Section
BKF5007	Improving Voandzou and Sesame Based Cropping Systems Through the Use of Integrated Isotopic and Nuclear Techniques	Sakadevan, Karuppan in collaboration with the Plant Breeding and Genetics Section
CMR5016	Development of N and P fertilizer management for Sustainable Intensification of Agricultural Production in Cameroon	Heng, Lee Kheng
ECU5024	Improving Productivity of the African Palm through Better Fertilization and Water Management Practices	Dercon, Gerd
ECU5026	Improving the Efficiency of Irrigation in the Rio Chota Sub-Basin	Sakadevan, Karuppan
ERI5004	Improving Crop Productivity and Combating Desertification	Adu-Gyamfi, Joseph Jackson/ Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
HAI5003	Enhancing Crop Productivity through the Application of Isotope Nuclear Techniques	Sakadevan, Karuppan in collaboration with the Food and Environmental Protection Section
INS5035	Application of Nuclear Techniques for Screening and Improving Cash Crop Plants in Coastal Saline Lands	Dercon, Gerd in collaboration with the Plant Breeding and Genetics Section
INS5037	Applying Nuclear Techniques for Screening and Improving Cash Crop Plants in Coastal Saline Lands	Sakadevan, Karuppan in collaboration with the Plant Breeding and Genetics Section
IRQ5017	Optimization of Land Productivity through the Application of Nuclear Techniques and Combined Technologies	Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
IVC5031	Improving Plantain and Cassava Yields through the Use of Legume Cover Crops	Hardarson, Gudni
KEN5030	Assessing Nutrient and Moisture Use in Major Cropping Systems	Heng, Lee Kheng
MAG5014	Use of Environmental Radioisotopes for the Assessment of Soil Erosion and Sedimentation and for Supporting Land Management in the Province of Antananarivo, Madagascar	Mabit, Lionel
MAG5015	Optimization of Phosphate Fertilization of Ferralsols (classically deeply weathered red or yellow soils found in humid east Madagascar) in the Highland Areas of Madagascar	Nguyen, Minh-Long Dercon, Gerd
MAR5017	Investigating the N Dynamics in the Crop-Soil System of a Multiple Cropping System to Optimize Fertilizer Use	Nguyen, Minh-Long
MLI5022	Assessment of Erosion and Sedimentation in the Niger Watershed with the Use of Radioisotopes, Phase-1	Mabit, Lionel

Project Number	Title	Technical Officer
MON5015	Implementation of the Fallout Radionuclide Technique for Erosion Measurement	Dercon, Gerd
MOZ5003	Sustaining the Management of Soil Fertility	Dercon, Gerd
NAM5009	Using Mutation Breeding and Integrated Soil Plant Management Techniques to Develop Sustainable, High Yielding and Drought Resistant Crops	Heng, Lee Kheng in collaboration with Plant Breeding and Genetics Section
NIC8012	Applying Nuclear Techniques for the Development of a Management Plan for the Watershed of the Great Lakes	Dercon, Gerd
QAT5002	Developing Biosaline Agriculture in Salt-affected Areas in Qatar	Nguyen, Minh-Long in collaboration with Plant Breeding and Genetics Section
RAF5058	Enhancing the Productivity of High Value Crops and Income Generation with Small-Scale Irrigation Technologies	Heng, Lee Kheng
RLA5051	Using Environmental Radionuclides as Indicators of Land Degradation in Latin American, Caribbean and Antarctic Ecosystems (ARCAL C)	Dercon, Gerd and IAEA Environment Laboratories
RLA5052	Improving Soil Fertility and Crop Management for Sustainable Food Security and Enhanced Income of Resource-Poor Farmers (ARCAL CI)	Sakadevan, Karuppan
RLA5053	Implementing a Diagnosis System to Assess the Impact of Pesticide Contamination in Food and Environmental Compartments at a Catchment Scale in the Latin American and Caribbean (LAC) Region (ARCAL CII)	Dercon, Gerd in collaboration with Food and Environmental Protection Section
SAU5003	Improving Fertilization under Saline Conditions for Sustainable Crop Production	Nguyen, Minh-Long in collaboration with Plant Breeding and Genetics Section
SEN5030	Integrated Approach to Develop Sustainable Agriculture in Senegal	Dercon, Gerd in collaboration with Plant Breeding and Genetics Section
SEY5004	Developing Improved Nutrient Management Practices Using Nuclear and Related Techniques for Enhancing Sustainable Agricultural Productivity	Heng, Lee Kheng
SIL5008	Contribution of Nitrogen Fixing Legumes to Soil Fertility in Rice-based Cropping Systems	Hardarson, Gudni
SIL5012	Managing Irrigation Water for a Dry Season Sorghum/Legume Intercropping System for Income Generation and Soil Health	Adu-Gyamfi, Joseph Jackson
SRL5040	Study on Nitrogen Balance in Coconut-Based Agroforestry Systems Using Nitrogen-15 Isotope Dilution Technique	Hardarson, Gudni
SUD5030	Increasing Productivity of Selected Crops Using Nuclear Related Techniques	Adu-Gyamfi, Joseph Jackson in collaboration with Plant Breeding and Genetics Section
TAD5002	Assessment of Soil Erosion and Sedimentation for Land Use	Dercon, Gerd
TAD5005	Developing Soil Conservation Strategies for Improved Soil Health	Dercon, Gerd
ZAI5017	Use of Isotope Techniques in Relation with the Nitrogen Dynamic and the Quality of Organic Plant Material in Agricultural Soil Management	Nguyen, Minh-Long/Dercon, Gerd
ZAM5026	Improving Crop Varieties Through Use of Nuclear Techniques	Heng, Lee Kheng in collaboration with Plant Breeding and Genetics Section
ZIM5011	Combating Desertification in Agricultural Drylands	Heng, Lee Kheng
ZIM5014	Developing and Promoting Strategies for Improved Crop Production	Heng, Lee Kheng

Forthcoming Events

FAO/IAEA Events

Second regional training course for TC project RLA5051 on 'The Use of Environmental Radionuclides for Estimating Soil Erosion and Assessing the Effectiveness of Soil Conservation Measures (Part II)', 8-19 November 2010, Valdivia, Chile

Technical Officer: Gerd Dercon

The purpose of this training course is to provide basic knowledge and skills on the use of Fallout Radionuclides (FRN) techniques for estimating soil erosion and assessing the effectiveness of soil conservation measures. The course will focus on the use of (i) models to convert environmental radionuclides (^{7}Be and ^{137}Cs) measurements into soil redistribution rates and (ii) data visualization tools for soil related parameters, such as FRN data (SURFER).

The two-week training course will consist of theory and practical computer exercises to teach participants how to use the FRN conversion models for estimating soil redistribution and the SURFER software for data visualization. The course will be given by experts from the Universidad Austral de Chile, Chile. At the end of the training course participants will give a short presentation about the national sampling sites, presenting their datasets in the way they have learned during the course.

Regional training course for TC project RLA5053 on'Linking Soil and Pesticide Behaviour at a Landscape Scale', 15 November – 3 December 2010, IAEA, Vienna /Seibersdorf, Austria

Technical Officers: Gerd Dercon, Ian Ferris, Britt Maestroni and Minh-Long Nguyen

The purpose of this training course is to provide participants with an understanding of the link between soil components and pesticide behaviour. The training is organized in three modules: (1) measurement of soil sorption; (2) definition of local Pesticide Impact Rating Index (PIRI) parameters related to the soil compartment; and (3) assessment of spatial variability and pesticide transport processes.

Module 1 (15 – 19 November 2010) provides practical training on the analytical approaches to characterize the soil-water-air compartment, including pesticide soil partition coefficient (K_d) and the soil organic partition coefficient (K_{oc}). The use of the 'QuEChERS'-like method will be demonstrated as well as the quantification and confirmation of pesticide residues using gas chromatography coupled with mass spectrometry.

Module 2 (22 – 26 November 2010) focuses on the role of soil properties (clay content, mineralogical composition, soil organic matter content and aggregate stability) and site conditions (slope gradient, soil erosion, and soil hydromorphology) on the fate of pesticides in the soil and understanding spatial relations at a landscape scale. The training will also highlight how land management practices (e.g., conservation agriculture) influence pesticide behaviour, and how these practices can help to reduce pesticide impact on the environment.

Module 3 (29 – 3 December 2010) will explain the principles of spatial variability in soil properties and how this variability can be monitored and analyzed. Field work will demonstrate sampling procedures which will lead to a consideration of transport processes affecting pesticide movement across the landscape and their assessment.

Third Research Coordination Meeting (RCM) of the Coordinated Research Project (CRP) on 'Managing Irrigation Water to Enhance Crop Productivity under Water-Limiting Conditions: a Role for Isotopic Techniques' (D1.20.09), 6–10 December 2010, Hanoi, Vietnam

Scientific Secretaries: Lee Heng and Minh-Long Nguyen

Eight contract holders, four agreement holders and an observer from China are expected to participate in this 3rd RCM in Hanoi, Vietnam this December. Drs. Hai Sinh Duong, Institute for Water Resources Research of Vietnam and Nhan Dang, Institute for Nuclear Science and Technology at the Vietnam Atomic Energy Commission in Hanoi, will be the local organizers. The main objective of the third RCM is to review research results obtained during the reporting period in accordance with the project workplan, to assess overall progress in the implementation of the CRP and to draw up an activity plan for completion of the project, in particular formulating strategies for summarizing, publishing and disseminating the results. A field experiment to quantify the isotopic measurement in water vapour, plant and soil samples will be carried out using a Laser Spectroscopy method in an effort to improve the separation of soil evaporation and crop transpiration.

First regional training course of TC project RLA5052 on ‘Improving Soil Fertility and Crop Management for Sustainable Food Security and Enhanced Income of Resource-Poor Farmers (ARCAL CI)’, 28 March – 8 April 2011, Piracicaba, Sao Paulo, Brazil

Technical Officer: Karuppan Sakadevan

The purpose of this training course is to provide basic knowledge and skills on the use of isotopic and conventional techniques along with numerical modelling for assessing soil organic matter dynamics. The course will focus on the use of carbon-13 and nitrogen-15 to study the dynamics of carbon and nitrogen in agricultural ecosystems. Numerical modelling tools on soil organic matter will be used for ecosystem analysis, to test the consistency of data and to evaluate the effects of changes in management and climate on soil organic matter and nitrogen in agricultural ecosystems.

The two-week training course, which will be held at the Centro de Energia Nuclear na Agricultura of the University of Sao Paulo (Brazil), consists of both lectures and practical hands-on training in the use of a model (Century 5) for ecosystem analysis. The course will be given by experts from IAEA, the United States of America, Brazil and Paraguay. Finally, the participants will present their strategy for using the modelling tool in their respective countries.

Workshop on Coping with Climate Change and Variability through Minimizing Soil Evaporation Wastage and Enhancing More Crops per Drop, 9 - 13 May 2011, Miramare, Trieste, Italy

Technical Officers: Lee Heng and Minh-Long Nguyen

The Abdus Salam International Centre for Theoretical Physics (ICTP), together with the International Atomic Energy Agency (IAEA), is organizing a workshop on ‘Coping with Climate Change and Variability through Minimizing Soil Evaporation Wastage and Enhancing More Crops per Drop’. The focus of the workshop is on developing strategies for the efficient and effective use of limited water resources in both rainfed and irrigated cropping systems. The workshop will be held at ICTP, Trieste, Italy, from 9 - 13 May 2011.

The purpose of the Workshop is to provide training and information exchange on the use of nuclear and conventional techniques for enhancing more crops per drop. The lectures will include the basic principles of evapotranspiration and crop water use. Methods of calculating and measuring evapotranspiration and its partitioning into soil evaporation and crop transpiration, the two major sources of water loss from agricultural systems, will be presented. A quantitative framework for improving water use efficiency from field to area-wide scale will be discussed. Participants will have the opportunity to use FAO’s AquaCrop model to predict yield response to water under both rainfed and irrigated production systems.

The main topics are:

- Soil water balance and evapotranspiration – methodology, estimation, evaporation pan, soil moisture measurement using a neutron probe and other techniques.
- Methods of calculating evaporation and transpiration –conventional techniques.
- Separating transpiration (T) and evaporation (E) through isotopic and nuclear techniques: theory, methods and equipment.
- Water use efficiency and crop water productivity calculation and data requirements.
- Improving agricultural water productivity and enhancing crop water use efficiency using the FAO AquaCrop Model.
- Case studies: soil water balance studies; the use of AquaCrop under different irrigation management practices.

For application details please watch for an announcement in the ICTP website (http://www.ictp.it/) for online submission. Deadline for receipt of applications is 31 January 2011.

Non-FAO/IAEA Events

- European Geosciences Union General Assembly
  Dates: 3 – 8 April 2011; Place: Vienna, Austria
  Website: http://meetings.copernicus.org/egu2011

- Land Quality and Land Use Information in the European Union.
  Dates: May 26-27, 2011; Place: Keszthely, Hungary
  Website: http://landq2011.uni-pannon.hu

- 3rd International Symposium on Organic Matter Dynamics.
  Dates: July 11-14, 2011; Place: Leuven, Belgium-
  Website: http://ees.kuleuven.be/som2011

- 66th Soil and Water Conservation Society International Annual Conference.
  Dates: July 16-20, 2011; Place: Washington, DC, USA.
  Website: http://www.swcs.org

- Soil Science in a changing world.
  Dates: 18-22 September 2011; Place: Wageningen, The Netherlands
  Website:
  http://www.wageningensoilmeeting.wur.nl/UK

- International Congress: Water 2011 - Integrated water resources management in tropical and subtropical drylands.
  Dates: 19-26 September 2011; Place: Mekelle, Ethiopia.
  Website: http://ees.kuleuven.be/water2011

- 5th World Congress of Conservation Agriculture
  Dates: 26-29 September 2011; Place: Brisbane, Australia.
  Website: http://www.wcca2011.org/index.htm

- International Congress on Irrigation and Drainage (ICID).
  Date: 15-23 October 2011; Place: Tehran, Islamic Republic of Iran.
  Theme: Water productivity towards food security.
  Website: http://www.icid2011.org

- WaterMed 2011.
  Date: 19 to 21 October 2011; Place: Milan, Italy.
  Website:
  http://www.watermed.com/en_wtm/index_wtm.asp

- Challenges and opportunities for agricultural intensification of the humid highland systems of sub-Saharan Africa.
  Dates: 24-28 Octobre 2011; Place: Kigali, Rwanda.
  Website: http://www.cialca.org

Past Events

Duty Travel

Cambodia: to assist institutions to design project concepts in the field of food and agriculture for its IAEA programme cycle 2012/13 (5-9 July 2010)

Technical Officer: Gerd Dercon

Cambodia resumed membership of IAEA in November 2009 after several years of interruption. Mr. Gerd Dercon, together with colleagues M. Maksoudi, A. Cherf and E. Rosenblatt from IAEA, conducted a fact-finding and programming mission (i) to inform competent authority as well as the national scientific community about the IAEA technical cooperation programmes, (ii) to help national institutions identify potential nuclear techniques which can address national development problems and (iii) to assist national institutions to design project concepts in potential nuclear fields for consideration under the IAEA programme cycle 2012/13.

Mr. G. Dercon visited the General Directorate of Agriculture of the Ministry of Agriculture, Forestry and Fisheries and held discussions with its key scientists. The staff members were informed about the activities carried out at the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture across the five subprogrammes (Plant Breeding and Genetics; Soil and Water Management & Crop Nutrition; Animal Production and Health; Insect Pest Control and Food and Environmental Protection), and how isotopic and nuclear techniques can be used to enhance food security and safety, while protecting natural resources. Following this presentation, Mr. Gerd Dercon assisted the Cambodian team to identify their priorities for capacity building in the use of isotopic, nuclear and related techniques in the field of food and agriculture. After listing the priorities, concept notes were developed for the upcoming TC cycle of 2012.

In Cambodia, there is an acute need to improve rice production through better soil fertility, crop and water management. These issues will be given particular attention in the short and medium term due to their importance in enhancing the food security of the Country, as well as their contribution to the Country’s revenues. Cambodia has recently become a net exporter of rice, but the rice-based farming systems are still characterised by low productivity and poor income in farming households.

Mali: for Regional TC project RAF5058 on Enhancing the Productivity of High Value Crops and Income Generation with Small-Scale Irrigation Technologies (19-23 July 2010)

Technical Officer: Lee Heng

Lee Heng participated in the 3rd training course of the RAF5058 African Regional project in Bamako, Mali from 19-23 July 2010. The purpose of the course was to provide basic training in analysis of the determinants for adoption of agricultural water management technology, socio-economic assessment framework and analysis of the poverty impacts for agricultural water management systems. Dr. Regassa Namara from IWMI, Ghana, was the guest lecturer for this component of the course and the technical officer was in charge of the data analysis and the use of FAO’s AquaCrop Model for simulating yield response to water. The course was attended by the 19 participants of this regional project from Algeria, Benin, Botswana, Burkina Faso, Cote d'Ivoire, Ethiopia, Ghana, Kenya, Libyan Arab Jamahiriya, Mali, Mauritius, Morocco, Niger, Nigeria, Sudan, Uganda, the United Republic of Tanzania, Zambia and Zimbabwe plus, local Malian staff.

Participants in the regional training course of RAF5058 in Mali

Rome: to update information on the status and progress of AquaCrop calibration and validation and to develop a work plan for future collaboration with FAO on development of the AquaCrop Model (22-25 August 2010)

Technical Officer: Lee Heng

Lee Heng attended the update of the FAO’s AquaCrop core group meeting in FAO, Rome from 22 to 25 August 2010. The meeting was held to discuss the upcoming publication of FAO’s new Irrigation and Drainage Paper No. 33 on Yield Response to Water. Various chapters for the completion of the publication were reviewed and possible new title discussed. The Aquacrop model will form part of this publication. Pending work requiring completion was also discussed. The water productivity of fruit trees and vines will be included in the publication.

Mozambique: for the third Research Coordination Meeting (RCM) of the Co-ordinated Research Project (CRP D1.50.10) on Selection and evaluation of food crop genotypes tolerant to low nitrogen and phosphorus soils through the use of isotopic and nuclear-related techniques (23-26 August 2010)

Technical Officer: Gerd Dercon

Gerd Dercon travelled to Maputo, Mozambique, from 23 to 26 August 2010 as Scientific Secretary for the third RCM of this CRP.

The main purpose of this RCM was: (i) to review and discuss the results of the research obtained since the second RCM, (ii) to evaluate the main achievements in accordance with project objectives and the agreed work plan, (iii) to discuss further issues for implementing the last phase of the CRP, and (iv) to plan strategies for collecting and analyzing the information and disseminating research results.

The RCM was successfully held with the participation of eight research contractors from Brazil, Burkina Faso, China, Cuba, Ghana, Malaysia, Mexico and Mozambique, one technical contractor from the USA and two agreement holders from Australia and France.

The CRP team made good progress in addressing the critical issues of improving productivity of cereals (rice and maize) and legumes (common beans, soybeans and cowpeas) in low soil nitrogen (N) and phosphorus (P) soils.

D1.50.10 Participants in Maputo, Mozambique

Algeria: for ALG5022 on Nuclear Techniques for Sustainable Use of Saline Groundwater and Wastelands for Plant Production and RAF5058 on Enhancing the Productivity of High Value Crops and Income Generation with Small-Scale Irrigation Technologies (27 September – 1 October 2010)

Technical Officer: Lee Heng

Lee Heng travelled to Algeria for two purposes: (i) to conduct a mid-term review of the Algerian national project ALG5022 on *Nuclear Techniques for Sustainable Use of Saline Groundwater and Wastelands for Plant Production* and (ii) to follow up on the progress of the Algerian counterpart in regional project RAF5058.

The objective of the ALG5022 project is to establish a national programme for the utilisation of salt affected areas through human capacity building, identifying salt-tolerant plants of economic value and developing technologies for using saline soils and groundwater. Mr Laid Kradia, from the National Institute of Soil, Irrigation and Drainage (*Institut national du sol, irrigation et drainage*) in Relizane (400 km west of Algiers) is the counterpart for this project. Salinity is a major problem in irrigated areas in western Algeria. Of the 130000 ha under irrigation in this region, approximately 30% consists of very saline soils (EC > 8 dS m^{-1}). Due to this high salinity, many farmers have abandoned their lands. Low quality (EC > 4 dS m^{-1}) water is available for irrigation, but its use requires continuous monitoring of the changes in soil salinity. Through careful irrigation scheduling, selection of salt-tolerance crop species and drainage, the project demonstrated that salt-tolerant barley, oats and olive trees can grow in this highly saline region, with a barley grain yield of up to 2.5 t/ha being produced as fodder for the livestock. Salt-tolerants olive trees are also being grown with careful management of soil and an improvement in soil fertility. Farmers' field days will be organized to create awareness of the possibility of growing salt-tolerant crops on currently abandoned land. This will help reduce the problem of soil erosion and degradation and allow farmers to increase their livestock and generate extra income.

Farmer next to an olive tree grown under saline soil conditions

Lee Heng also visited Mr. Mohammed Semiani (the Algerian counterpart in the regional project RAF5058) and his team at the Bioclimatology Laboratory in Baraki, which is part of the National Institute for Agricultural Research (*Institut national de la recherche agronomique - INRA)*. During the visit Lee gave a presentation on the use of nuclear and isotopic techniques and the work of the Soil and Water Management and Crop Nutrition Section to the staff of INRA at its Headquarter in Algiers. Subsequently, meetings were held with Mr. Semiani and his team, where the status of the project was presented. The group has carried out studies on the crop water requirements of potato and sweet pepper crops and small-scale irrigation in the desert, 600 km south of Algiers as part of the regional project.

France: for The 11th European Society for Agronomy Congress (29 August – 2 September 2010)

Technical Officer: Gerd Dercon

At the 11th European Society for Agronomy (ESA) Congress, which was held in Montpellier, France, Gerd Dercon participated in the international symposium on 'Agronomy for Sustainable Development', as one of the four invited speakers in the panel discussion on conservation agriculture, focussing on its benefits and challenges, in particular in Africa, and research priorities for the future. This discussion was attended by more than 500 participants. Mr. Gerd Dercon also presented a collective poster on *Soil, water and nutrient management under conservation agriculture across agro-ecosystems from Latin America to the Pacific: An overview of main lessons learnt under an FAO/IAEA coordinated research project*, authored by G. Dercon, M.L. Nguyen, M. Aulakh, R. Boddey, R. Dalal, B. Govaerts, M. Halitligil, N. Ibragimov, M. Ismaili, S. López, W. Mohammad, M. Pulleman, B. Vanlauwe and E. Zagal, all participants of CRP D1.50.09 on conservation agriculture.

Both the interventions in the panel discussion and the poster paper were well received by the participants. Many participants showed great interest in the use of nuclear techniques to enhance the performance of conservation agriculture in the CRPs and in the TCPs supported by the SWMCN Sub-programme in the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture.

Morocco: for the second Research Coordination Meeting (RCM) of the Co-ordinated Research Project (*CRP D1.20.11*) on *Integrated Isotopic Approaches for an Area-wide Precision Conservation to Control the Impacts of Agricultural Practices on Land Degradation and Soil Erosion* (27 September – 1 October 2010).

Technical Officer: Gerd Dercon

The second RCM of this CRP was held at the National Centre for Atomic Energy and Nuclear Sciences and Applications (*Centre National de l'Energie, des Sciences et des Techniques Nucléaires - CNESTEN)* in Rabat, Morocco, with Mr. Gerd Dercon as the Scientific Secretary. The RCM was successfully held with the attendance of all CRP participants consisting of eight research contractors from Chile, China (2), Morocco, Poland, the Russian Federation, the Syrian Arab Republic and Vietnam; four technical contractors from Belgium, Germany, New Zealand and United Kingdom, three agreement holders from Australia, Canada and the UK, and two observers from China and Germany.

The objectives of the meeting were to: (i) present, evaluate and discuss the overall achievements, and the way forward for each project and the CRP in general, (ii) discuss and share information on the strategies for developing the integrated use of both fallout radionuclides (FRN) and compound specific isotopic analysis (CSIA) to establish comprehensive soil redistribution patterns, to identify hot spots of critical land degradation in agricultural landscapes and for cost-effective implementation of *precision conservation* measures, and (iii) outline priorities and strategies for disseminating research results.

The CRP has made impressive progress in addressing the critical issues of the integrated use of both fallout radionuclides (FRN) and compound specific isotopic analysis (CSIA) to establish comprehensive soil redistribution patterns and to identify hot spots of critical land degradation in agricultural landscapes for cost-effective implementation of precision conservation measures.

D1.20.11 Participants in Rabat, Morocco

Non FAO/IAEA Events

Visitors

- Dr. Alfredo Nhantumbo, Faculty of Agronomy and Forest Engineering, Eduardo Mondlane University, Mozambique, visited the SWMCN Subprogramme during the 54th General Conference (20-24 September 2010) to discuss the current activities of TC project MOZ5003 on '*Sustaining the Management of Soil Fertility*' and future project planning.

- Dr. Ibrahim Abdul Razzaq, Ministry of Science and Technology (MOST), Agricultural Research & Food Technology Directorate, Iraq, visited the SWMCN Subprogramme as part of the biological nitrogen fixation training program for professional staff from Iraq under TC project IRQ5017 on '*Optimization of Land Productivity through the Application of Nuclear Techniques and Combined Technologies*' from 27 September to 8 October 2010. The aim of his visit was to discuss future capacity building in the area of soil and water salinity management, soil organic matter management, soil erosion assessment and soil conservation strategy planning.

- Dr. Vesna Zupanc of the Department of Agronomy, Biotechnical Faculty, University of Ljubljana, Slovenia, visited the SWMCN Subprogramme on 6 October 2010 to discuss results obtained from field experiments conducted by the University of Ljubljana in collaboration with the SWMCN Laboratory on the assessment of soil degradation through the ^{137}Cs method in Slovenia.

- Dr. Peter Cepuder, from Institut für Hydraulik und Landeskulturelle Wasserwirtschaft, Universität für Bodenkultur in Vienna visited the SWMCN Subprogramme on 27 October 2010 to discuss and analyse the isotopic data (water vapour, soil and plant) collected from the BOKU Experimental Station maize field. This experiment is part of the CRP on '*Managing irrigation water to enhance crop productivity under water-limiting conditions: a role for isotopic techniques*'.

- Mrs. Zeinabou Hamidou, National Institute for Agricultural Research of Niger (INRAN), and Mr. Sani Ousmane, Institute of Radio-Isotopes (IRI) from the Abdou Moumouni University of Niamey, Niger, visited the SWMCN Subprogramme from 15 to 26 November 2010. The aim of their visit was to analyse datasets on the impact of water stress on biological nitrogen fixation by cowpeas under a cowpea-millet based cropping system obtained from field experiments carried out in TC project NER5014 on '*Improving the Productivity of Cowpea/Finger Millet Based Cropping Systems*'.

Status of Coordinated Research Projects (CRPs)

Managing Irrigation Water to Enhance Crop Productivity under Water-Limiting Conditions: a Role for Isotopic Techniques (D1.20.09)

Technical Officers: Lee Heng and Minh-Long Nguyen

The CRP has entered its second phase after a successful mid-term review. The project is expected to end in mid 2012. The third RCM for this CRP will be held in Hanoi, Vietnam from 6 to 10 December 2010. The local organizers of that meeting will be Drs. Hai Sinh Duong (Institute for Water Resources Research of Vietnam) and Nhan Dang (Institute for Nuclear Science and Technology at the Vietnam Atomic Energy Commission in Hanoi).

The overall objective of this CRP is to improve the water productivity of crops (production per unit of water input) under water-limiting conditions, and the specific objectives are as follows: (i) to quantify and develop a means to manage soil evaporative losses to maximise the beneficial use of water through improving the transpiration component of evapotranspiration; (ii) to quantify and develop a means of improving the amount of biomass produced per unit of transpiration; and (iii) to devise irrigation and related management techniques to enhance the yield component of biomass production(Harvest Index). This CRP has a total of 12 participants comprising eight research contractors from Malawi, Morocco, China (2 participants), Pakistan, Turkey, Vietnam and Zambia, one technical contractor (Mr. D. Williams, University of Wyoming-Laramie, USA) and three agreement holders (Mr. T. Hsiao, UC Davis; Mr. P. Cepuder, Universitat fur Bodenkultur, Vienna and Mr. E. Fereres, IAS-CSIC and University of Cordoba, Spain). So far, almost all of the countries have managed to collect and analyse water vapour samples for isotopic composition in wheat, maize fields, orange and coffee plantations respectively, using either laser spectroscopy, semi-manual or simple ways to allow the separation of evaporation and transpiration through the Keeling Plot approach. The FAO's AquaCrop model was also used to compare the values obtained in some studies.

Strategic Placement and Area-wide Evaluation of Water Conservation Zones in Agricultural Catchments for Biomass Production, Water Quality and Food Security (D1.20.10)

Technical Officers: Karuppan Sakadevan and Lee Heng

This CRP is now approaching the end of its second year of implementation. The mid term review for the CRP will be carried out during 2011 for its extension to five years. The CRP is expected to be completed towards the end of 2013.

The overall objective of this CRP is to assess and enhance services provided by water conservation zones (wetlands, ponds and riparian zones) for optimizing water storage, nutrients, biomass production and food security within agricultural catchments. The specific objectives are: (i) to optimize water storage in water conservation zones for downstream irrigation use, (ii) to regulate nutrient cycling in water conservation zones to improve biofuel crops and fuel wood production and (iii) to optimize the use of water conservation zones for crop production.

There are eight contract holders (China, Estonia, the Islamic Republic of Iran, Lesotho, Nigeria, Romania, Tunisia and Uganda), two technical contractors (UK and USA) and two agreement holders (France and USA) in the CRP. The CRP commenced in December 2008 and the first RCM was held in Vienna. The second RCM was held in Tartu, Estonia from 10 - 14 May 2010. The work plans for individual projects were refined during the second RCM to reflect the project objectives. Three research groups were established in the refined work plan with the following focus: (i) water conservation zones that regulate nutrient cycling, protect downstream water quality, and generate biomass within an agricultural catchment (Estonia and Romania), (ii) water conservation zones that gather catchment runoff for improving food security through irrigation of crops (Islamic Republic of Iran and Tunisia); and (iii) water conservation zones that are a prime location for improving food security through crop production (China, Lesotho, Nigeria and Uganda).

This CRP has been linked to a number of national research projects through which Master and Doctoral students are currently being trained.

Integrated Isotopic Approaches for an Area-wide Precision Conservation to Control the Impacts of Agricultural Practices on Land Degradation and Soil Erosion (D1.20.11)

Technical Officers: Long Nguyen and Gerd Dercon

This CRP is in its third year. The second RCM of this CRP was held at the National Centre for Atomic Energy, and Nuclear Sciences and Applications (*Centre National de l'Energie, des Sciences et des Techniques Nucléaires - CNESTEN)* in Rabat, Morocco, from 27 September to 1 October 2010 with Mr. Gerd Dercon as the Scientific Secretary. The CRP has already produced a considerable number of results and created interesting analytical protocols. The first step for decision support matrices for tool selection has been made in the RCM. The CRP participants also further strengthened their networks, in particular the link between the teams focussing on Fallout Radionuclides (FRN) on the one hand and Compound Specific Isotope Analysis (CSIA) on the other hand, which help to integrate soil and sediment redistribution patterns with land use and management. Through the use of FRN and CSIA, remediation of land degradation (i.e. soil erosion) and conservation of soil quality will be further targeted. The mid-term review for the CRP will be carried out during 2011 for its extension to five years. This CRP is expected to be completed at the end of 2013.

The objective of the CRP is to develop integrated isotopic approaches to identify hot spot areas of land degradation in agricultural catchments for effective soil conservation measures (precision conservation). Specific research objectives are (i) to use the FRN with conventional techniques and spatial analysis to establish soil redistribution patterns and rates over several temporal scales on an area-wide basis (catchment), (ii) to develop and validate protocols for the application of compound specific stable isotope (CSSI) techniques to identify sources of pollution (eg. cropland, grassland and forestland) in the catchment, (iii) to integrate nuclear based approaches with other non-nuclear techniques through modelling and other tools to establish comprehensive soil redistribution studies on an area-wide basis and (iv) to develop decision support tools for implementing precision conservation and contributing to sustainable land management.

The expected outputs from this CRP include:

1. Better understanding of the land use/management impacts on soil redistribution and the location of hot spot diffuse pollution areas on an area-wide scale.
2. Enhanced capacity in Member States to conduct applied research on comprehensive soil redistribution studies with the aid of nuclear and related techniques.
3. Validated methods for establishing soil redistribution patterns and rates over several temporal scales on an area-wide basis (catchment) by using FRN.
4. Harmonized protocols for the application of CSSI techniques at the catchment scale in a range of environments and land use systems.
5. Models and other approaches developed for the integrated application of FRN and CSSI techniques to establish comprehensive soil redistribution studies in the catchment, including the identification of soil sources and hot spot diffuse pollution areas.

There are eight research contract holders (Chile (1), China (2), Morocco, Poland, Russian Federation, Syrian Arab Republic and Vietnam), four technical contract holders (Belgium, Germany, New Zealand and the UK) and three agreement holders (Australia, Canada and the UK).

In 2010 two of our CRP participants received a Doctorate Honoris Causa, i.e. Desmond Walling at the Warsaw University of Life Sciences (Poland) and Max Gibbs at the University of Waikato (New Zealand). The SWMCN Subprogramme wish to congratulate both Max and Des on receiving these awards and to thank them for their valuable contributions to CRP D1.20.11.

Selection and Evaluation of Food (Cereal and Legume) Crop Genotypes Tolerant to Low Nitrogen and Phosphorus Soils Through the Use of Isotopic and Nuclear related Techniques (D1.50.10)

Technical Officers: Joseph Adu-Gyamfi and Gerd Dercon

The third RCM was held in Maputo, Mozambique from 23-27 August 2010 to discuss the work done and results obtained since April 2008. The CRP is in its fourth year of implementation and is expected to be completed at the end of 2011.

The first RCM was held at the IAEA head quarters in Vienna between 16-20 October 2006. The second RCM was held in Morelia, Mexico from 21-25 April 2008. The project has a total of 16 participants with nine research contract holders (Burkina Faso, Brazil, Cameroon, China, Cuba, Ghana, Malaysia, Mexico, and Mozambique), six agreement holders (Australia, Benin, Germany, Kenya, Nigeria, and France) and one technical contractor (USA). The overall objective of this CRP is to develop integrated crop, soil and nutrient management practices to increase crop production in marginal lands by identifying and promoting the development of food crop genotypes (cereal and legume) with enhanced nitrogen (N) and phosphorus (P) use efficiency and greater productivity in marginal lands.

To date, the CRP team has made good progress and encouraging results are being obtained since its inception in 2006. These include:

1. The successful testing of 150-200 crop genotypes from four different food security crops (Rice, maize, common bean, soybean/cowpea) in 17 countries. Nitrogen and phosphorus use efficiency has been increased by at least 15%.
2. Root traits contributed to enhanced N and P efficiency under low N and P resulting in a 5-20% increase in biomass (depending on the crop type).
3. The establishment of roots with a specified branching angle interval as a suitable selection parameter for soil nitrogen use efficiency, while adventitious rooting and root hair formation were identified as suitable plant parameters for selecting phosphorus use efficiency.

Stable and radioactive isotopes (^{15}N and ^{32}P) are effectively used to assess nitrogen and phosphorus acquisition by the tested crop genotypes under diverse agro-ecological conditions. The team further improved protocols to assess root characteristics. The CRP is entering its final phase, and has created an interesting database on how cereal and legume crops can acquire N and P in low nutrient soils. This database will be further expanded and interpreted through similar analytical protocols, based on multivariate analysis (coordinated by Mexico, the USA and IAEA) within the last 14 months of the CRP.

Progress reports and requests for contract renewal in 2010 were evaluated in September-October 2010. The fourth and final RCM is scheduled to be held in the second semester of 2010 (October-November) at the IAEA headquarters in Vienna.

Integrated soil, water and nutrient management in conservation agriculture (D1.50.09)

Technical Officer: Gerd Dercon

This CRP was concluded in 2009. The fourth and final Research Coordination Meeting (RCM) of this CRP was held in October 2009 at IAEA Headquarters in Vienna. This CRP had a total of ten participants comprising seven research contractors from Argentina, Brazil, India, Morocco, Pakistan, Turkey and Uzbekistan, two technical contractors (Australia and Chile), and one agreement holder (CIMMYT-Mexico). In addition, one individual contractor (Mr. Bernard Vanlauwe) conducted research on the evaluation of C and N dynamics in long-term trials in Sub-Saharan Africa, focussing on tillage, residue management and rotational effects.

At the 11th European Society for Agronomy (ESA) Congress, 29 August – 2 September (Montpellier, France), Mr. Gerd Dercon participated in a panel discussion on conservation agriculture in Africa and presented a collective poster summarizing the main lessons learnt under this recently closed CRP. Manuscripts for the IAEA-TECDOC of this CRP are now under review. In addition, the CRP team has compiled all data into one comprehensive dataset, which will be the basis for an overview paper of this CRP.

The overall objective of this CRP was to enhance the productivity and sustainability of farming systems through a better understanding of the principles and practice of conservation agriculture. This should be achieved through specific objectives, which are to quantify the individual and interactive effects of conservation tillage practices, residue management, crop rotations, nutrient and water inputs to increase soil organic matter, resource use efficiency, agricultural productivity and environmental quality.

The CRP started in June 2005 with the first RCM held in Vienna. The second RCM was organized in September 2006 by the team of Mr. Mohammed Ismaeli from Morocco. Mr. Mahmut Basri Halitligil from the Saraykoy Nuclear Research and Training Centre was the host of the third RCM in Ankara (Turkey) in April 2008.

The CRP has created an interesting database on soil-water-plant relationships in conservation agriculture. New methodologies and research protocols based on isotopic and related techniques were introduced in the research schemes. Integration of the different results from many diverse agro-ecological areas made it possible to get insights into cross-cutting processes related to conservation agriculture and supports the interpretation and helps the explanation of site-specific results. This understanding will help to improve conservation agriculture systems across the world through implementation of projects under IAEA's Technical Cooperation Programme.

The CRP was also linked to several PhD and MSc dissertations and will form the basis for joint group publications at national and regional levels.

Selection for greater agronomic water use efficiency in wheat and rice using carbon isotope discrimination (D1.20.08)

Technical Officer: Lee Heng

This CRP was completed in 2008. The 18 manuscripts prepared by the project participants will be published as an IAEA-TECDOC by the end of 2010. The manuscripts were edited by Mr. P.M. Chalk, a retired IAEA staff-member, who initially programmed the CRP and implemented several key activities.

The CRP consisted of 11 contract holders from Algeria, Australia, Bangladesh, China (2), India, Morocco, Pakistan, the Philippines, Syrian Arab Republic and Yemen, and two agreement holders from Mexico and the USA. The CRP was conducted in collaboration with National Agricultural Research Systems (NARS) in Africa and Asia, and with two CGIAR Centers, The International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT). The objective of this CRP was to evaluate carbon isotope discrimination (CID or $\Delta^{13}C$) as a selection tool for yield and biomass of wheat under drought stress and for rice under salt stress.

Conservation measures for sustainable watershed management using fallout radionuclides (D1.50.08)

Technical Officer: Gerd Dercon

This CRP was concluded in 2007. All nineteen manuscripts prepared as part of this project have been edited by Gerd Dercon for the production of an IAEA-TECDOC. They have also been reviewed by an independent reviewer (Gary Hancock). It is expected that the IAEA-TECDOC will be published shortly. An overview paper on the lessons learnt in this CRP was submitted to the international peer-reviewed journal *Soil and Tillage Research* in October 2010.

Eleven contract holders from Brazil, Chile, China (two), Morocco, Pakistan, Poland, Romania, the Russian Federation, Turkey and Vietnam, two technical contractors

(Austria and the UK) and five agreement holders (Australia, Canada, Japan, Switzerland and the USA) participated in this CRP.

The overall objective of this CRP was to develop diagnostic tools for assessing soil erosion and sedimentation processes and effective soil conservation measures for sustainable watershed management. In this context, the participants developed fallout radionuclide methodologies with particular emphasis on the combined use of ^{137}Cs, $^{210}Pb_{exc}$ and ^{7}Be for measuring soil erosion and sedimentation over several spatial and temporal scales.

A wealth of information on soil redistribution and the effectiveness of soil conservation has been generated by the CRP using several fallout radionuclides and conventional techniques in a wide range of environments. In total over 150 scientific papers (peer-reviewed journals) were published by the CRP participants. Presentations have also been made at national and international scientific meetings.

Activities of the Soil and Water Management and Crop Nutrition Laboratory, Seibersdorf

Training the trainers in the use of fallout radionuclide-based techniques for assessing land degradation and improving soil conservation strategies

L. Mabit and A. Toloza

Soil and Water Management & Crop Nutrition Subprogramme, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency - IAEA

In the frame of the national Technical Cooperation Project IRQ5017 on *Optimization of Land Productivity through the Application of Nuclear Techniques and Combined Technologies* and the regional Technical Cooperation Project RLA 5051 on *Using Environmental Radionuclides as Indicators of Land Degradation in Latin American, Caribbean and Antarctic Ecosystems (ARCAL C)*, four senior scientists, three from Iraq (Mr. Al-Hasani, Ali Abbas Mohammed, Mr. Al-Obaidi, Husham Salman Hussien and Mr Tawfeeq, Husamuldeen Ahmed) and one from Jamaica (Mr. Williams, Lemuel Lloyd) received five-weeks training in the assessment of soil degradation using isotopic approaches (see Figure 1) at the SWMCN Laboratory.

Figure 1. From lectures to data treatment, a fully integrated FRN course organized at the SWMCN Laboratory

The objective of this course was to train the fellows in the use of Fallout Radionuclides (FRNs) with an emphasis on the application of the radio-caesium tracer technique (i.e. ^{137}Cs) to study soil erosion. The training aimed to transfer to the participants knowledge on tracking and quantifying soil redistribution at various spatial and temporal scales (from field to watershed scale) to improve soil resource sustainability and evaluate the effectiveness of soil conservation measures.

After an introduction to the basic principles of the use of FRNs, the fellows were trained in sampling design and soil sample collection by using mechanical soil corers through field work implemented at the experimental sites of Seibersdorf and Mistelbach (30 km north of Vienna). The training programme also included lectures and practical exercises on sample preparation, gamma measurements and the determination of the vertical distribution of radionuclides (i.e. ^{137}Cs, ^{40}K, ^{232}Th, ^{226}Ra) and the associated gamma dose rates. Computer exercises on data analysis and interpretation were organized. These practical exercises focussed on basic (e.g. radioactivity measurement, conversion of the most commonly used units, descriptive statistics) and advanced data treatment (e.g. FRNs conversion models, spatial analysis and mapping of soil redistribution and sediment budgeting).

The fellows also presented background information on soil degradation processes in Iraq and Jamaica and how nuclear techniques can support them in their studies to develop appropriate soil conservation strategies. The fellows will receive further support from the SWMCN subprogramme through the provision of advice on the analysis and interpretation of initial fallout radionuclides at undisturbed sites in their respective countries.

Finally, the fellows also provided support for CRP D1.20.11 on *Integrated Isotopic Approaches for an Area-wide Precision Conservation to Control the Impacts of Agricultural Practices on Land Degradation and Soil Erosion* through the collection of plant samples to establish a library of compound specific stable isotope (CSSI) values for a range of similar plant materials from around the world.

The estimation of soil evaporation and crop transpiration of a maize crop using stable isotopic composition of atmospheric water vapour

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[2] University of Natural Resources and Applied Life Sciences, Vienna, Austria

Evapotranspiration (ET) is a major component of water use in agriculture; it is the process by which water is lost directly by soil evaporation (E) and crop transpiration (T). Globally, the percentage of water utilized for crop yield through transpiration is less than 30 percent. The ability to quantify the evaporative and transpiration components will provide useful information about the dynamics of both processes and enhance understanding of how crops utilize water for plant growth so that management strategies can be developed to improve their use efficiency.

However, the separation of soil evaporation (E) and crop transpiration (T) from evapotranspiration is complex due to the dynamic nature of these processes. As the isotopic signature of water vapour ($\delta^{8}O$ and $\delta^{2}H$) from evaporation is distinct from transpiration and atmosphere, it is possible to partition soil E, crop T from ET using the Keeling Plot approach. This method was tested for a maize crop by the SWMCN Subprogramme in collaboration with the University of Natural Resources and Applied Life Sciences (BOKU) in September 2010 at the BOKU Experimental Station in Gross Enzersdorf (48° 11' 56.17’, 16° 34' 25.44) near Vienna.

By using the Picarro laser water isotope analyser from the SWMCN Laboratory, real-time water vapour isotope measurements were carried out at five heights (0.1, 1.0, 2.5, 3.5 and 5.0 m) above the maize crop (growth stage close to maturity). In addition, soil and plant (stem) samples were collected and soil and plant water extracted for isotopic signatures.

The relationship between $\delta^{18}O$ in the water vapour, soil water and plant solution is well correlated with $\delta^{2}H$ (Figure 1), with a slope of 6.8. This is slightly lower than the value of 8 obtained for the World Meteoric Line (WML) possibly due to the effect of evaporation. Both soil and plant water had higher isotopic values compared to atmospheric water vapour due to fractionation processes during soil evaporation. The relative humidity (RH) and air temperature ranged between 47-93 % and 14.3-22.5°C, respectively (Figure 2).

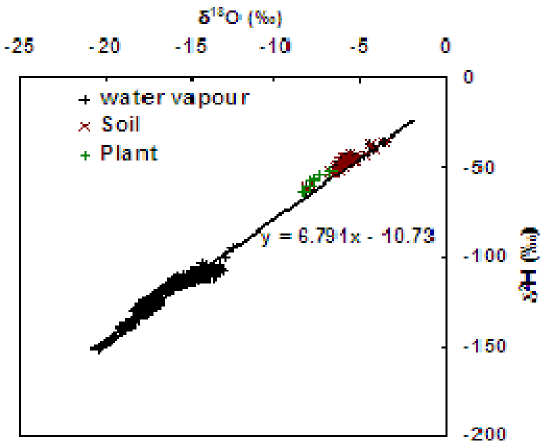


Figure 1. The $\delta^{18}O$ and $\delta^{2}H$ in water vapour, soil solution and plant stem samples.

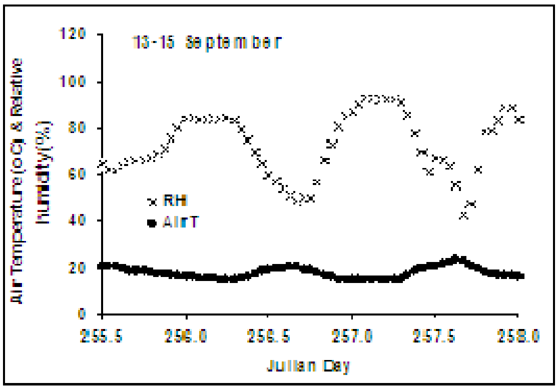
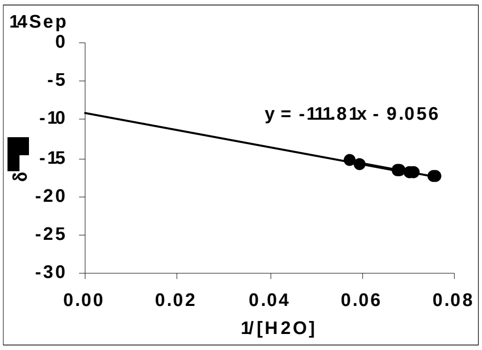


Figure 2. The hourly relative humidity and air temperature values during the study period.

The vertical profile of $\delta^{18}O$ in the water vapour showed different isotopic values during the measurement period and tended to be higher at a lower height (0.1 m) (Figure 3), indicating the different intensity of mixing across the plant canopy. With a higher air temperature on Day 257, the isotopic values at both heights, i.e. 0.1 and 5 m, increased significantly, however this increase was more pronounced at the height of 5 m, suggesting more plant transpiration.

These data were used to partition the amount of transpiration and evaporation from the total ET using the Keeling Plot approach (Figure 4). Preliminary calculations indicate that the proportion of T in the total ET was estimated to be 91% in this study, indicating high water use efficiency towards the end of the maize crop cycle due to greater canopy cover and a well established root system



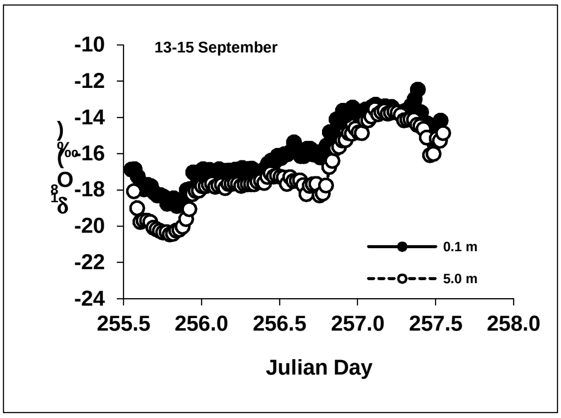


Figure 3. The $\delta^{18}O$ in the water vapour during the field study period at Gross Enzersdorf in Vienna.

Figure 4. The Keeling Plots of Oxygen-18 vapour composition versus the inverse concentration of vapour in a maize canopy.

The water vapour isotope analyser was set up in a maize field at BOKU Experimental Station in Gross Enzersdorf for online isotopic measurements of water vapour sampled at five heights above ground to determine the evaporation and transpiration components.

Salinity training for agricultural scientists from Iraq

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Soil and water salinity is one of the major problems affecting agricultural productivity and food security in Iraq. The main challenges are: (i) to develop appropriate irrigation technologies and scheduling to ensure year-round food production, (ii) to assess tolerance of different crops (varieties) to soil and irrigation water salinity and (iii) to reduce further salinization of soil and water. It is against this background that the Department of Science and Technology, Iraq, requested the SWMCN Subprogramme to provide intensive training for five professional and technical fellows on 'Managing soil and water in salt-affected soils for enhanced crop productivity using isotopic techniques' from 30 August to 8 October 2010 at the IAEA Laboratories, Seibersdorf. The programme consisted of: (i) lectures on soil and water salinity and how crop growth is affected (ii) practical glasshouse and field training on the monitoring of soil and water salinity and soil-plant-water interactions and finally (iii) data analysis and interpretation.

During the first week, the trainees were provided with an introduction to the principles of water movement in the soil-plant system and the factors influencing soil and water salinity and how salinity affects plant growth. During the subsequent weeks they were trained under both glasshouse and field conditions on soil water and salinity measurements. Training activities included glasshouse and field experimental design, electrical conductivity measurements in soil and water, soil moisture measurements using a neutron probe and conventional tools such as capacitance probes and Time Domain Reflectometry (TDR). The fellows also received training on the installation of suction cups for collecting soil water and the use of tensiometers for measuring water availability for crops.

As part of the training programme, two glasshouse experiments were established to study: (i) the effect of different levels of salt concentration in the soil on the growth of paprika (*Capsicum annuum* L.) and (ii) the effect of different levels of soil and water salinity on the growth of two varieties of rice (salt tolerant and salt sensitive rice, *Oryza sativa* L.).

Research fellow sampling soil water using suction cup samplers

In the field, the effect of salt addition on the growth of paprika and sorghum (*Sorghum Spp*.) was tested. Plant growth, salt distribution in the soil profile and the salinity of water collected from soil profiles using suction cups were measured. The carbon isotope discrimination technique (the isotope ratio of ^{13}C to ^{12}C in plant tissue), a surrogate of water use efficiency and a proxy of plant stomatal opening, was used to assess the tolerance of the different crops (paprika, rice and sorghum) to soil and water salinity. Data collected from both glasshouse and field were analysed by the fellows and support was provided to interpret data and present a report.

Fellows measuring soil and water electrical conductivity under a rice crop in the greenhouse

The training was a success and fellows enjoyed working with the team from the SWMCN Subprogramme. Though the training was only 6 weeks, this intensive training will assist the fellows to start work on improving crop production in salt-affected soils in Iraq.

Soil erosion in Jamaica is being reduced using nuclear techniques

L.L. Williams [1], L. Mabit [2] and G. Dercon [2]

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[2] Soil and Water Management & Crop Nutrition Subprogramme, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, International Atomic Energy Agency - IAEA

Mr. Williams received training in the use of fallout radionuclide based techniques for estimating soil erosion rates and assessing the effectiveness of soil conservation measures from 2 August until 17 September 2010 at the SWMCN Laboratories, in the context of the regional ARCAL project RLA5051 on 'Using Environmental Radionuclides as Indicators of Land Degradation in Latin American, Caribbean and Antarctic Ecosystems'. During his training Mr. Williams gave a seminar on soil erosion in Jamaica. A summary of this seminar is given below.

Jamaica is the third largest island of the Greater Antilles of the West Indies, situated south of Cuba, with a population of approximately 2.6 million. Jamaica has a maximum length, from east to west, of about 235 km; the maximum width is approximately 80 km. The total area of the country is 11244 km^2. Kingston is the capital and largest city of Jamaica. The mountainous island is divided into three main types of land forms: (i) series of interior mountain ranges dissected by steep ravines, (ii) upland plateau and hills, and (iii) coastal plains and interior valleys. The principal range, situated in the eastern section of the island, is the Blue Mountains with Blue Mountain Peak being the highest summit with 2256 m a.s.l. The climate is tropical and is affected by the northeast trade winds. The average annual rainfall is 1980 mm. The wettest periods are between May to July and September to October.

In 1945, more than 50 years ago, the awareness of the impact of soil degradation through soil erosion was highlighted by a report of the Economic Policy Commission acknowledging that: '*Steps should be taken to meet this grave concern and widespread menace before it is too late*'. Exploratory studies completed during the 1950s and 1970s listed the following causes of soil erosion: (i) unstable hillside agricultural practices (e.g. cultivation on the steep slopes, use of slash and burn and cultivation without implementing soil conservation measures); (ii) inappropriate selection of arable lands; (iii) illegal settlements on hillsides; (iv) unauthorized sand mining and quarrying; (v) improper construction and lack of road maintenance; (vi) thin and erodible soils; (vii) and unpredictable magnitude of climatic events (e.g. tropical storms).

The large scale removal of forest cover for lumber and charcoal production has greatly contributed to the deforestation of the island. Along with forest fires during extended periods of droughts, these are factors that helped compound the soil erosion processes. The effects of soil erosion in Jamaica have had significant on-site and off-site impacts that can be summarized as follows: (i) increased siltation of rivers and reservoirs, (ii) increased marine and coastal contamination and degradation, (iii) reduced tree and vegetative cover, (iv) reduced water quality and quantity, and (v) increased flooding and associated landslides resulting in loss of human lives, property, roads and crops. For example, in the aftermath of Hurricane Gilbert in 1988 the cost for repairing roads was estimated US$ 19 million.

Only scarce soil erosion data based on investigations using conventional techniques (e.g. USLE modelling or sediment traps) conducted in the 80's are available. These studies suggested the occurrence of important land degradation due to soil erosion in agricultural and forested lands reaching up to 300 t/ha/a. Recently, the use of nuclear techniques was promoted in Jamaica through its participation in the Regional Latin America Technical Cooperation Project RLA5051 on *Using Environmental Radionuclides as Indicators of Land Degradation in Latin America, Caribbean and Antarctic Ecosystems (ARCAL C).* This project aims to enhance the regional capacity for sound assessment of land degradation and improved national and regional policies for soil conservation and environmental protection throughout the region using fallout radionuclide inventories measurement. In Jamaica, to date, soil sampling equipment has been received and training in the use of fallout radionuclide (i.e. ^{137}Cs) based techniques for estimating soil redistribution rates has been completed. At Seibersdorf Laboratory Mr. Williams has been trained in the different aspects of the use of Fallout Radionuclides. During this fellowship, the selection of a suitable reference site was discussed and the sampling design finalized. Through this training the basis has been laid for the future successful implementation of the RLA5051 project activities in Jamaica. This will lead to the development of more sustainable land management practices and soil conservation measures in order to ensure sustainable food security and soil resource protection in Jamaica.

Example of accelerated soil degradation due to forest fires in Jamaica (Photo Mr. Williams)

Background information on the challenges for agricultural production in Iraq: Future perspectives in using nuclear techniques

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Mr. Al-Hasani, Mr. Tawfeeq and Mr. *Al-Obaidi received training in the use of fallout radionuclides for characterizing land degradation by soil erosion and assessing the effectiveness of soil conservation strategies from 2 August to10 September 2010 at the SWMCN Laboratory, in the context of the human development programme of Iraq on Optimization of Land Productivity by the Application of Nuclear Techniques and Package of Technologies. During their training the three fellows from Iraq gave a seminar on the background of agricultural land degradation in their country. A summary of this seminar is given below.*

In Iraq agriculture started 7000 years ago under the Babylonian and Sumerian civilizations. Close to 80% of the total area is potentially suitable for agriculture, however, only 27% of this surface is currently utilized for agricultural purposes. Iraqi agricultural production is mostly dependant on irrigation, with the Tigris and Euphrates basins being the major crop producing areas. The cultivated area under irrigation represents 70% of the arable lands and rainfed agriculture covers 30%.

Most Iraqi soils are highly calcareous ($CaCO_3$= 15-35%) with a typical pH of more than 7 and low soil organic matter content (<1%). Under such soil conditions many soil nutrients are unavailable for uptake by crops (e.g. phosphorus and trace elements). Moreover, soil degradation is a major threat to soil and water resources sustainability in Iraq and represents a serious limitation to achieving food security. Furthermore, because of climate change, rainfall has declined by 30% in recent years increasing desertification processes and the recurrence of heavy dust storms in the summer season but also during the winter, events that were quite unusual in the past.

The main challenges that farmers face in Iraq can be summarized as follows:

(i) Shortage of water

In arid and semi-arid regions, many crops cultivated during the hot spring and summer consume high amounts of water due to high transpiration and losses through soil evaporation. In addition, Iraqi's farmers still use traditional irrigation methods such as flooding. Therefore the available irrigation water resources are not sufficient to cover the agricultural water demand of the cultivated land. Adapted irrigation planning is needed to reverse this trend. Moreover, Iraq has also been suffering from a shortage of fresh water due to the establishment of dams up-stream in both the Euphrates and Tigris rivers.

(ii) Salinity

One of the major limitations to agricultural development in Iraq is an excessive salinity which affects 70 to 80 % of the agricultural land. Several factors have contributed to increased salinization of the Iraqi's soils such as: (i) the climatic conditions (high temperature and low precipitation); (ii) the mismanagement of agricultural lands by farmers; (iii) the shallow saline water table; (iv) the ineffective drainage systems; (v) the heavy texture of the soil; and (vi) the poor irrigation water quality.

Large areas of land have become salt-affected reducing their productivity and also the interest of the farmers, who have abandoned the affected areas. Development of effective drainage systems will facilitate and accelerate the desalinization of the affected soils. However, these processes and activities need large quantities of fresh water to remove the excess of salt accumulated in the soil profile.

(iii) Soil erosion by wind

During the last decade Iraq started to encounter atypical climatic events with increasing dust storms. Many reasons have contributed to the intensification of this phenomenon such as climate change, misuse of agricultural land, a shortage of fresh water and a reduction in rainfall. The main sources of this dust are the desert and the degraded agricultural lands abandoned by Iraqi's farmers due to the high salinity level.

The following nuclear techniques can potentially mitigate and control these constraints and threats for Iraqi's arable land:

- Use of fallout radionuclides (e.g. ^{137}Cs and/or ^{210}Pb) as soil tracers to assess wind erosion magnitude;
- Use of nuclear indicators (i.e. ^{22}Na, ^{36}Cl and ^{35}S) to monitor salt movement;
- Use of neutron probe techniques in irrigation scheduling and deficit irrigation practices;
- Use of ^{15}N for Biological Nitrogen fixation studies;
- Use of ^{32}P to investigate Phosphorus availability in calcareous soil and its linkage with soil amendments application.
- Investigation of the soil organic matter dynamic using the stable isotopic approach (i.e. ^{13}C).

A first step towards the use of radionuclides in assessing the effectiveness of terraced agricultural land to control erosion and enhance its productivity in the Yemen Highlands

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Background information and challenge

The Global Assessment of Human Induced Soil Degradation (GLASOD) survey carried out during the 1980's by the United Nations Environment Programme (UNEP) and the International Soil Reference and Information Centre (ISRIC) established that over 45% of the Yemeni territory is characterised by severe to very severe human induced land degradation (FAO 2005). The highlands in Yemen are particularly threatened by land degradation especially through soil erosion (Figure 1). Soil terraces in the highlands are of ancient origin, and these arable lands have been cultivated for the last 5000 years. So far, the oldest AMS-14C dated organic material (i.e. humic acids) from a soil of such old terraces (i.e. Anthrosol) in the Wadi[5] Al-Jidar area has an age of 4500-4700 cal a BP (ERL 11865). Due to high precipitation (~ 700 mm a-1) coupled with high rainfall erosivity, as well as the breakdown of many of the soil conservation measures, fertile soil is being lost through erosion (Pietsch, 2001).

As effective erosion control starts with the knowledge of soil erosion rates and mechanisms, the authors proposed to use nuclear techniques (i.e. the ^{137}Cs technique) to investigate soil removal by water erosion processes under the specific agro-ecological conditions of Yemen. Measurements of NOR (Naturally Occurring Radioisotopes) and FRNs (Fallout RadioNuclides) in agricultural Yemeni soils are, however, scarce, therefore the initial fallout of these soil tracers was determined. The two major objectives of this study were to evaluate the external gamma dose rate through radioisotopic background information based on NOR (i.e. ^{40}K, ^{226}Ra, ^{232}Th) soil content in the upper terrace soil, which was not used for agriculture, and to assess the initial FRN (i.e. ^{137}Cs) at the same location for the preparation of a future study on the magnitude of soil erosion affecting the terraced Yemen Highlands.

Experimental design and preliminary results

Two soil profiles in terraces (Anthrosols) with different thicknesses were selected and described following the FAO Guidelines (FAO, 2006). Substrates were defined as colluvial loams/ loamy sands (Pietsch and Lucke, 2008). Both soil profiles are developed in colluvial material from weathered basalt, the lowest layers of the profile on the toe slope are composed of wadi sediments. The oldest AMS ^{14}C dated colluvial layer in this profile of 6 m is 2400-2600 cal a BP (ERL 11914), the layer at 2.5 m depth is 1000 years old; the age of the soils in the upper terrace is unknown. Soils are calcareous, and moderately clay-enriched. For NOR and ^{137}Cs determination ten soil pits (0-40 cm) of the upper terrace were divided into 10 cm increments, described and sampled. After classical soil pre-treatment, each 10 cm increment of the different profiles was analysed through gamma spectroscopy at the SWMCN Laboratory.

The resulting mean mass activity per depth increments of ^{137}Cs, ^{40}K, ^{226}Ra, ^{232}Th are presented in Figure 2. The different NOR showed an almost constant vertical distribution of their mass activities (Figures 2b, 2c and 2d). Based on NOR information, the external gamma dose rate of the top soil (0-10 cm) was estimated at 41 ± 3 nGy h^{-1} (n = 10), 28% lower than the world average of 57 nGy h^{-1} (UNSCEAR, 2000). The contribution of ^{40}K, ^{232}Th and ^{226}Ra to the external dose rate in this upper terrace soil was 40%, 34% and 27% respectively.

The ^{137}Cs soil activity of the undisturbed top terrace showed as expected for an undisturbed site an exponential decrease with depth, with most of this isotope accumulated in the first 20 cm of the topsoil (see Figure 2a). Based on the ten soil profiles collected, the estimated population mean of ^{137}Cs baseline inventory was established at 3440 ± 1300 Bq m^{-2} (CV of 38%) with an allowable error of 27 % at 95 % confidence level (see Sutherland, 1991; Mabit *et al.*, 2010).

This value will be used as the ^{137}Cs base-line level for future assessments of soil erosion and redistribution rates for terraced soils in the Yemen Highlands. Because of insufficient high-resolution dating methods in agricultural Yemen terraces to determine discontinuities in terrace profiles caused by erosion, the assessment of past and current occurring soil erosion will be greatly enhanced by using FRN methods (i.e ^{137}Cs).

Acknowledgements

The authors would like to thank HE Mr. Abdul-Rahman Al-Eryani, Minister of Water and Environment in Yemen, for supporting this study.

[5] A wadi is a gully, streambed, or valley which is characterized by being extremely dry. Many wadis flood during the rainy season. Geologists believe that features like wadis were formed during periods when water levels on Earth were markedly different, and that these valleys were probably carved by streams and rivers which later dried up.

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Figure 1. Eroding terrace system in Wadi Al-Jidar/Hawar, Irian, Yemen (Photo: D. Pietsch)

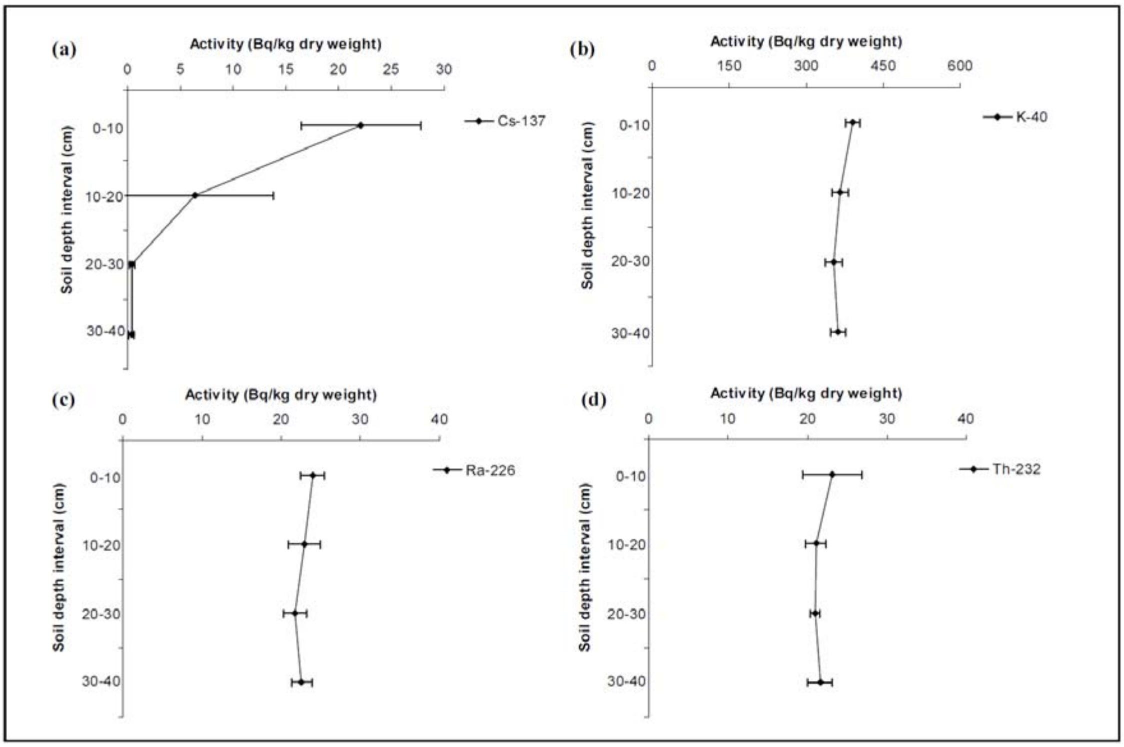

Figure 2. Vertical distribution of mass activity of ^{137}Cs (a), ^{40}K (b), ^{226}Ra (c), and ^{232}Th (d) in soil samples (Mean ± SD, n = 10)

External Quality Assurance

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In March 2010, twenty four stable isotope laboratories were invited to participate in the WEPAL IPE programme (http://www.wepal.nl/website/about_wepal/Scope.htm) and to perform analysis of any determinant offered in the WEPAL IPE scheme including ^{15}N (enriched and/or natural abundance level), total N (N-elementary), Kjeldahl-N, ^{13}C and total C (C-elementary). The participation fee for one round of the Proficiency Test (PT) in 2010 (round IPE2010.2) was covered by the IAEA.

The PT-participants were provided with the WEPAL test sample set IPE 2010.2 consisting of four test samples of 20 g plant material each. Ten laboratories (i.e. 42 percent) reported isotope abundance data within the deadline. The Soil and Water Management and Crop Nutrition Laboratory also participated in this round of PT (lab code 915). The deadline for reporting was 30 June 2010. The quarterly report 2010.2 (April – June 2010) was issued by WEPAL and sent to all laboratories in July 2010.

Analytical services conducted by the SWMCN Laboratory in 2010 (January to October)

a. Stable isotope analyses

a.1. Samples measured:

	^{15}N enriched	^{15}N natural abundance	^{13}C natural abundance	^{18}O natural abundance	Total
CRP	511	0	210	373	1094
TCP	207	31	79	0	317
Seibersdorf Laboratory research and training activities	756	1104	1738	123	3721
Total	**1474**	**1135**	**2027**	**496**	**5132**

a.2. Measurements carried out (including standards, blanks, test samples, replicates):

	^{15}N enriched	^{15}N natural abundance	^{13}C natural abundance	^{18}O natural abundance	Total
CRP	644	0	267	483	1394
TCP	274	53	121	0	448
Seibersdorf Laboratory research and training activities	1184	1662	2590	231	5667
Total	**2102**	**1715**	**2978**	**714**	**7509**

b. Anthropogenic and geogenic radioisotope analyses on soil matrix

	Isotope(s) analysed	Number of analyses
CRP	^{137}Cs	118
TCP	^{137}Cs	30
Seibersdorf Laboratory research and training activities	^{137}Cs, ^{40}K, ^{226}Ra, ^{232}Th	272
Total		**420**

Fellows and Scientific Visitors at the SWMCN Laboratory in 2010

In 2010 the Soil and Water Management & Crop Nutrition (SWMCN) Subprogramme received 20 fellows (43 Man Months) and 3 scientific visitors (1.5 Man Months) from Africa, the Middle East, Asia and Latin America, who were trained in the use of nuclear techniques to improve land, water and crop management for enhanced food security. In particular, Iraq was well represented, with 10 fellows and one scientific visitor. We wish all our fellows and visitors good luck in their future project activities.

a. Fellows

- Mr. Gherezghiher, Efrem, ERI/08006 (Eritrea), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 1 February to 31 July 2010.

- Mr. Kouassi, N'guessan Alphonse, IVC/09005 (Ivory Coast), Use of tracer technology to quantify biological nitrogen fixation, 12 April to 11 August 2010.
- Mr. Shiran Manjula Bamunusinge, SRL/10009 (Sri Lanka), Use of tracer technology to quantify biological nitrogen fixation, 12 April to 11 Mai 2010.
- Mr. Sumith Senarathne Ranaraja, SRL/10008 (Sri Lanka), Use of tracer technology to quantify biological nitrogen fixation, 12 April to 11 Mai 2010.
- Mr. Kimigo Jeremiah, KEN/09028 (Kenya), Use of tracer technology to quantify biological nitrogen fixation, 12 April to 12 July 2010.
- Mr. Lassayo, Francis Nabieu, SIL/09011 (Sierra Leone), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 12 April to 11 June 2010.
- Mr. Mpezeni, Tinkho Msimuko, MLW/10020 (Malawi), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 12 April to 9 July 2010.
- Mr. Tauro, Tonny P, ZIM/09003 (Zimbabwe), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 17 May to 16 September 2010.
- Mr. Mikka Shekundja Shilompoka, NAM/10006 (Namibia), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 17 May to 16 September 2010.
- Mr. Husham Salman Hussien, Al-Obaidi, IRQ/10049 (Iraq), Use of fallout radionuclides for quantifying soil erosion and sedimentation, 2 August to 10 September 2010.
- Mr. Husamuldeen Ahmed, Tawfeeq, IRQ/10050 (Iraq), Use of fallout radionuclides for quantifying soil erosion and sedimentation, 2 August to 10 September 2010.
- Mr. Ali Abbas Mohammed, Al-Hasani, IRQ/10052 (Iraq), Use of fallout radionuclides for quantifying soil erosion and sedimentation, 2 August to 10 September 2010.
- Mr. Lemuel Lloyd Williams, JAM/10003 (Jamaica), Use of fallout radionuclides for quantifying soil erosion and sedimentation, 2 August to 17 September 2010.
- Mr. Tariq J J Al-Temimi, IRQ/09046 (Iraq), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 30 August to 8 October 2010.
- Ms. Saham M Bajai, IRQ/09047 (Iraq), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 30 August to 8 October 2010.
- Ms. Baydaa H A Al-Ameri, IRQ/09048 (Iraq), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 30 August to 8 October 2010.
- Ms. Amal F H Al-Tamimi, IRQ/09049 (Iraq), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 30 August to 8 October 2010.
- Mr. Alaa A H Hussein, IRQ/09050 (Iraq), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 30 August to 8 October 2010.
- Ms. Suad Abduljabbar Abdulzahra, Al-Saedi, IRQ/10048 (Iraq), Use of tracer technology to quantify biological nitrogen fixation, 27 September to 29 October 2010.
- Ms. Ameerah Hanoon, Atiyah, IRQ/10053 (Iraq), Use of tracer technology to quantify biological nitrogen fixation, 27 August to 29 October 2010.

b. Scientific visitors

- Mr. Rabesiranana, Nairo, MAG/10001V (Madagascar), Use of fallout radionuclides for quantifying soil erosion and sedimentation, 4 to 15 January 2010.
- Mr. Munyinda, ZAM/09033V (Zambia), Use of nuclear techniques in studies of abiotic stress and water use efficiency, 6 to 15 April 2010.
- Mr. Ibrahim Bakry Abdul Razzaq, IRQ/10054 (Iraq), Use of tracer technology to quantify biological nitrogen fixation, 27 September to 8 October 2010.

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List of Publications in 2010

Cobo, J.G., Dercon, G., Cadisch, G. (2010). Nutrient balances in African land use systems across different spatial scales: A review of approaches, challenges and progress. Agriculture, Ecosystems and Environment, 136, 1-15.

Cobo, J.G., Dercon, G., Yekeye, T., Chapungu, L., Kadzere, C., Murwira, A., Delve, R., Cadisch, G. (2010). Integration of mid-infrared spectroscopy and geostatistics in the assessment of soil spatial variability at landscape level. Geoderma, 158, 398-411.

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- FAO website: http://www.fao.org/about/en/
- FAO/AGL (Land and Water Development Division): http://www.fao.org/nr/water/landandwater_what.html

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