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Contents

Improving crop productivity using small-scale irrigation technology in arid and semi-arid lands in Kenya. A farmer is inspecting his farm with drip irrigation system (top) and a mixed cropping system under irrigation (above)

To Our Readers

On behalf of the Soil and Water Management & Crop Nutrition (SWMCN) team from both the Section and the Unit, I would like to thank you all for your valuable support and inputs. In this Newsletter, you will see several developments in the SWMCN Subprogramme which provide information and technical support to Member States in the areas of land and water management for sustainable agriculture. I would like to mention some following highlights of these developments:

IAEA International Atomic Energy Agency

The updated website (http://www-iswam.iaea.org/dapr/srv/en/home) on "Direct Application of Phosphate Rock (DAPR)" is the product of successful collaboration between the Joint FAO/IAEA Division and IFDC scientists (IFDC-An International Centre for Soil Fertility and Agricultural Development; http://www.ifdc.org). This DAPR website will guide decision makers through the feasibility of using phosphate rock (PR) as a source of phosphorus (P) for crops, instead of the more costly and energy-intensive soluble phosphate fertilisers. This web tool also helps to determine the amount of P required by crops. Phosphate rock (PR), which exists naturally in different regions of the world, can be applied to many crops where soil types and fertility conditions are suitable. However, PR is a finite resource and could eventually become limited for agricultural production, hence the recent warning by IFDC scientists (http://www.ifdc.org) and again at the OECD workshop (What Future for the Agriculture and Food Sector in an Increasingly Globalised World; 30-31 March 2009; Paris, France; http://www.oecd.org/). An improvement in the efficient use of P fertiliser is therefore a 'must' to ensure the conservation of this resource and to prevent the mining of soil nutrient (P) fertility.

Improving land productivity for sustainable agricultural production requires worldwide attention not only to avoid nutrient mining but also to promote soil conservation measures. These measures will mitigate land degradation and enhance the accumulation of soil organic matter, which can act as a storehouse of nutrients for plant growth and enhance both soil quality and soil water storage capacity. Isotopic techniques can help to assess the relative importance of different soil conservation measures in soil erosion control, soil quality enhancement and soil organic matter accumulation. Information obtained can then help to target the most appropriate soil conservation measures for specific areas. Towards this aim, a new coordinated research project (CRP D1.20.11) on area-wide precision conservation to control land degradation and soil erosion, has been initiated (see section on New Coordinated Research Projects). The first Research Coordination Meeting (RCM) for this CRP will be held at IAEA, Vienna in June (see section on Forthcoming Events).

More crops per drop, regardless of whether this drop of water comes from rainfall or irrigation require a holistic, system-wide approach, which takes into account not only the management of the available rainfall or irrigation, but also the management of soil resources and their constituents. This is to ensure that the benefits of available water for crop production are not constrained by less water-efficient crops and poor soil fertility and soil quality. This means a combined approach of using more efficient irrigation systems, shifting to crops or cropping systems with better water and nutrient utilisation efficiency and developing better soil and farm management practices. Two CRPs which address these issues, one on managing irrigation water to enhance crop productivity (D1.20.09) and the other on optimizing water-conservation zones in agricultural catchments (D1.20.10), are currently underway (see section on Status of Coordinated Research Projects). A particular highlight is the forthcoming field campaign in Beijing, China (see section on Forthcoming Events) to provide comprehensive isotopic measurement of ^{18}O- and ^{2}H- in soil moisture content and plant transpiration for the CRP D1.20.09. This isotopic data will then be used to partition evapotranspiration into soil evaporation and plant transpiration, the two major components that influence the estimation of crop water requirement and water use efficiency. Information obtained will be used to compare with those derived from neutron probes and conventional methods (see section on Status of Coordinated Research Projects). The support from the Chinese Agricultural Academy of Sciences (CAAS) and other Chinese institutions together with enthusiastic participation from 12 Member States and private industry will no doubt promise to bring about a highly successful field campaign.

We are working closely with our FAO colleagues to address issues relating to sustainable land and water management for crop production. The involvement of CGIAR (Consultative Group on International Agricultural Research) Centres (e.g. CIMMYT, IITA, IRRI, TSBF-CIAT and WARDA) and Advanced Research Institutes (currently 20 ARIs from countries such as Australia, Canada, France, Germany, New Zealand, UK and USA) in our CRPs will continue to enhance the success of our deliverables to Member States.
I would like to take this opportunity to thank our colleagues from FAO, CGIAR, ARIs and National Agricultural Research Stations in Member States for their support and involvement.

Wishing our Readers all the best.

Long Nguyen
Head
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Staff News

Ms. Eveline Kopejtka after working for the SWMCN Section for over 3 years since 28 November 2005, has joined (16 February 2009) the Department of Safeguards as a Senior Secretary for the Division of Operations (A). Although we were sad to lose Eveline's excellent inputs to the work of the Section, we would like to congratulate Eveline for her excellent advancement. We wish Eveline every success in her new position.

Mr. Steve Burgess left the Section at the end of April after completing a 5-month contract as a consultant. We thank Steve for his inputs and we wish him and the family well for the future.

Ms. Brigitte Leopold joined the SWMCN Section on 2 March to temporarily fill the vacant secretarial position following Ms. Eveline Kopejtka's departure. Brigitte is a native Austrian with secretarial experience in private companies. We welcome Brigitte to the Team.

Mr. Karuppan Sakadevan joined the SWMCN Section on 17 April 2009 as soil-water ecophysiologist. He will be working on both coordinated research and technical cooperation projects relating to soil and water management in agriculture, particularly in catchments with multiple land uses and land characteristics. Karuppan comes from the Murray-Darling Basin Authority, an independent Australian Government Agency for managing the land and water resources of the Murray-Darling Basin, the biggest river basin in Australia.

Feature Articles

Use of ^{32}P to calibrate and simulate dynamics of plant-available phosphorus in cultivated Malagasy soils

by Rabeharisoa L. [1], Randriamanantsoa L.[1], Andriamaniraka H.[2], Morel C.[3]

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The IAEA technical cooperation project MAG5015 'Optimization of phosphate fertilization of Ferralsols in the Highland Areas of Madagascar' was initiated in 2004 with the objective to enhance food security of small landholders in the "Tanety" (upland in Malagasy) areas of Madagascar by increasing crop productivity through appropriate management of soil and nutrients inputs in rainfed cropping systems and to build national capacity in the use of nuclear and related techniques. The project focuses mainly on the improvement of P availability in Malagasy cropping systems through a better understanding of the phosphorus cycle in the soil.

Challenge

In Madagascar, with a population having crossed the 20 Millions mark, the increasing need for food requires finding new surfaces for cultivation. "Tanety" soils cover about 30 % of the potential agricultural areas (about 3 Mha) but are infertile because of chemical constraints (acidity, aluminium toxicity and low contents of plant-available nutrients) often encountered in Ferralsols . Especially, Ferralsols have high contents of Fe- and Al-oxyhydroxides and therefore are characterised by a high ability to react with ionic phosphate species (Pi) leading to an extremely low Pi concentration in solution, available for the crops.

As a consequence, improving phosphorus availability is a prerequisite to raise production and productivity of the Malagasy agriculture and to improve food security during the next decades. In addition, mineral P fertilizers are a non-renewable and expensive resource for farmers and must be used with efficiency. So, the question of P, as a limiting factor for crop production, has to be addressed. The IAEA technical cooperation project MAG5015 therefore aims at analyzing how to improve P cycling in Malagasy cropping systems.

The study

The study was based on a long-term field experiment of the Non-Governmental Organization Land and Development "TAFA", initiated in 1992 in the Central Highlands of Madagascar (19°47'S; 47°06'E). The region elevation is about 1600 m a.s.l. with a typical upland tropical climate. Two cropping systems (with three replicates) were screened year after year. One treatment was based on no-till (NT+r) (Photo 1) with crop residues retained forming a mulch and direct seeding; the other treatment was con-

ventional tillage (CT-r) (Photo 2) with crop residues removed as fodder for cattle (i.e. the traditional tillage practice in the Highlands of Madagascar). The succession was a two-year rotation consisting of maize (Zea mays L.) (Photo 3) and soybean (Glycine max L.) (Photo 4). In both systems, manure (5 t ha^{-1} $year^{-1}$), mineral NPK fertilizers (100 kg N, 42 kg K and 30 kg P ha-1) and lime (500 kg ha-1) were applied at the same rate every year. Dry matter of yields and crop residues and their P contents were determined to calculate annual P balances. After 12 years of experimentation, samples were taken up from the 0-20 cm layer of soil, air-dried, sieved (<2mm), and stored before analysis. The plant-available soil P has been assessed using a processes-oriented approach which consists of determining both the concentration of Pi in solution (CP, mg P l^{-1}) and dynamics of diffusive Pi (Pr, mg P kg^{-1}) at the solid-to-solution interface as a function of both CP and time. Its calibration was obtained in batch studies by coupling sorption experiments with subsequent 32Pi labelling of Pi in solution and isotopic dilution kinetics.

Preliminary findings

Cumulated yields for 12 years of experimentation were almost twice under NT+r (36.6 t ha^{-1}) as compared with CT-r (19.7 t ha^{-1}). However, despite the large difference in crop yield, the cumulative P balance was significantly but only slightly lower for NT+r (+329 kg P ha^{-1}) than for CT-r (+353 kg P ha^{-1}) in which crop residues were exported.

The average concentration of P_i in solution (C_P values) was significantly lower in CT-r (0.013 mg P l^{-1}) than in NT+r (0.024 mg P l^{-1}). This result is consistent with significant modifications observed in diffusive P_i dynamics at the solid-to-solution interface of soil. A decrease in rapid reactions rates and an increase in slow reactions rates for the NT+r treatment. These changes were mainly related to variations in pH and organic C content between treatments. Organic C content significantly increased in the NT+r treatment from 2.1 to 2.6% and pH from 4.77 to 4.95. As a consequence, plant-available soil P, i.e. the sum of ionic P in solution and diffusive P ions from soil, was 14 mg P kg^{-1} for CT-r and 63 mg P kg^{-1} for NT+r considering a functioning period of one day.

The returns of crop residues in NT+r treatment increased not only plant-available P but also organic carbon, organic nitrogen, and exchangeable calcium, potassium, and magnesium, as compared with the CT-r treatment. The no-till based cropping systems with P inputs seems to be a promising strategy for improving both P cycling through the agro ecosystems and soil P availability.

Impact

The expected outcome of the MAG5015 project is to better understand plant-available soil P dynamics in order to improve agricultural practices in Malagasy soils, particularly under on-farm conditions of no-tillage cropping systems. The project team is involved with research teams from all over the world (Belgium, Brazil, Burkina Faso, France, Madagascar, Martinique, Senegal, Switzerland) to study for instance the impact of soil pH on the availability of phosphorus, to assess how appropriate irrigation management can help to overcome phosphate deficiency or to better understand the role of organic phosphorus for plant nutrition in the Ferralsols of Madagascar.

Long term (>10 years) field experiment of NGO TAFA in "Tanety" soils at Andranomanelatra (19°47'S; 47°06'E)

Photo 1. NT+r

Photo 2. CT-r maize/soybean

Photo 3. NT+r maize/soybean

Photo 4. NT+r maize /soybean

CT-r: conventional tillage with crop residue removed
NT+r: no-till with crop residues retained forming a mulch

Thermometric tools to measure plant water use

by Burgess S.

SWMCN Section, IAEA

Agriculture is under increasing pressure to deliver maximum productivity and meet food security whilst also delivering environmental protection/benefits through responsible land and water management. Poor water management in particular has the potential to cause erosion, eutrophication, groundwater contamination, secondary salinisation and wastage of precious water resources.

There are numerous tools for assessing water use management in agriculture, viticulture and horticulture. Plant-focused tools have an advantage in that they can identify exactly what the crop/tree is doing in among all the various other factors such as evaporation, drainage and run-off. By contrast, soil or atmospheric measurements require careful analysis to disentangle the effects of aggregated processes. That is not to say plant-based techniques are without their challenges and disadvantages. Perhaps the most powerful tool at our disposal is thermometric xylem flux measurement. Here we use heat as a tracer to determine the flow of water inside the plant tissues. Usually installed at the base of the plant, these devices are wrapped around, or implanted (as thin needles) into, the stem. Small amounts of heat are applied and then monitored with temperature sensors using a range of algorithms to calculate flow rate. A strong knowledge of plant vascular architecture, experimental design, and mathematical principles is a vital contributor to the use of these deceptively simple devices. A growingly popular algorithm called the heat ratio method (HRM) is particularly sensitive to fine-scale flow dynamics and is good for measuring flows even in drought conditions, at night, or other low water use times where other systems fail.

Sap flow measurements can be use to analyse the effects of rain pulses, irrigation events, soil water deficit etc. Because they provide real-time readings every 10-30 minutes throughout the year, water flow behaviours can be given close scrutiny to help schedule irrigation for a range of conditions. Modern telemetric links can deliver the data to the desktop of the farm manager on demand. Although skill of interpretation is required, there is a wealth of information on plant water use dynamics hidden in each daily trace, in the same way a heart-monitor trace provides health information to a doctor. Sap flow devices such as HRM can be combined powerfully with other techniques such as neutron moisture meters, soil isotopic measurements, etc. to improve understanding of transpiration and evaporation in the soil-plant system.

Sap flow training activities in SWMCN

In April, as part of Stephen Burgess's work as consultant with the Soil and Water Management & Crop Nutrition Section, he provided in-depth theory-based lectures and practical demonstrations to Soil Science Unit staff and fellows from Bangladesh, Mali, Kenya, Eritrea and Zimbabwe on the use of thermometric techniques to measure xylem sap flow in intact plants. Focusing chiefly on the HRM method which Mr Burgess himself developed in 1996, participants were given insights and ideas on how and why this type of technique might be useful in their research activities.

Conservation Agriculture and Soil Carbon Sequestration;

Between Myth and Farmer Reality

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ABSTRACT: Improving food security, environmental preservation and enhancing livelihood should be the main targets of the innovators of today's farming systems. Conservation agriculture (CA), based on minimum tillage, crop residue retention and crop rotations, has been proposed as an alternative system combining benefits for the farmer with advantages for the society. This paper reviews the potential impact of CA on C sequestration by synthesizing the knowledge of carbon and nitrogen cycling in agriculture, summarizing the influence of tillage, residue management and crop rotation on soil organic carbon stocks and compiling the existing case study information. To evaluate the C sequestration capacity of farming practices, their influence on emissions from farming activities should be considered together with their influence on soil C stocks. The largest contribution of CA to reducing emissions from farming activities is made by the reduction of tillage operations. The soil C case study results are not conclusive. In 7 of the 78 cases withheld, the soil C stock was lower in zero compared to conventional tillage, in 40 cases it was higher and in 31 of the cases there was no significant difference. The mechanisms that govern the balance between increased or no sequestration after conversion to zero tillage are not clear, although some factors that play a role can be distinguished e.g. root development and rhizodeposits, baseline soil C content, bulk density and porosity, climate, landscape position and erosion/deposition history. Altering crop rotation can influence soil C stocks by changing quantity and quality of organic matter input. More research is needed, especially in the tropical areas where good quantitative information is lacking. However, even if C sequestration is questionable in some areas and cropping systems, CA remains an important technology that improves soil processes, controls soil erosion and reduces tillage-related production costs.

SWMCN Seminar Series

Mid-Infrared Spectroscopy for characterizing soil and plant properties: Advantages and limitations

By Gerd Dercon

SWMCN Section, IAEA

Gerd Dercon works as a soil and crop scientist for the Soil and Water Management and Crop Nutrition Section of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, since October 2007. He is coordinating research projects (CRP) and providing technical support for technical cooperation (TC) projects in the field of land management, conservation agriculture, soil organic matter dynamics, soil carbon sequestration, and fate of agrochemicals in agricultural systems.

ABSTRACT

The speaker will discuss the principles and applications of Mid-Infrared Spectroscopy, in particular Diffuse-Reflectance Infrared Fourier-Transformed (DRIFT) Spectroscopy, important to many fields of soil and plant sciences. The applications will encompass those utilized for the analysis of soil and plant properties in a broad spectrum of fields including the assessment of spatial variability in soil properties within soil profiles (Vancampenhout et al., 2008) and soil quality at landscape level (Cobo et al., 2008; Schmitter et al., 2009), soil organic chemistry as a proxy for climate and vegetation in paleosols (Vancampenhout et al., 2008) and plant quality characterization (Kühnle et al., 2008).

Infrared spectroscopy is based on the principle that molecules have specific frequencies at which they rotate or vibrate corresponding to discrete energy levels .In practical terms, this means that light energy in the mid infrared range (4000 to 500 cm^{-1}) is focused onto the soil sample. Part of this light is absorbed and the remaining light is reflected back into the spectrometer and analysed. The resulting spectrum presents the nature of the sample. The precise properties of the sample can be predicted using Partial Least Squares (PLS) sta-

tistical analysis, once the equipment has been calibrated.

Due to advances in spectrometer capacity and spectral data processing techniques, infrared spectroscopy has been widely used in characterizing the properties of soil samples, such as soil organic matter content and its fractions, cations, total nitrogen, clay minerals, and carbonates. However, prediction at present is limited to those properties that are in equilibrium with the soil particles (CSIRO, 2009). Extractable nitrate, phosphorus, sulfur and micronutrients cannot yet be precisely assessed, as these occur in the soil solution around and between soil particles.

Since 1993, DRIFT spectroscopy is rapidly gaining field in the study of soils and soil organic material since it is fast, accurate, cost effective and can be used without major sample preparation. Because of the low costs of the analyses, it is of particular interest for applications in landscape variability surveys and precision agriculture (need for high spatial density of the sampling locations).

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/ Lagoda, Pierre
ALG5021	Optimizing Irrigation Systems and Surface Water Management	Heng, Lee Kheng
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	Shu, Qingyao Adu-Gyamfi, Joseph Jackson
BKF5007	Improving Voandzou and Sesame Based Cropping Systems Through the Use of Integrated Isotopic and Nuclear Techniques	Spencer, Marie Madeleine/ Dercon, Gerd
CHI5048	Integrated Watershed Management for the Sustainability of Agricultural Lands	Ferris, Ian Glen/ Mabit, Lionel
CMR5014	Creation of a Nuclear Analysis Laboratory in CATEN for Food Safety	
CMR5016	Development of N and P fertilizer management for Sustainable Intensification of Agricultural Production in Cameroon	Heng, Lee Kheng
CPR5015	Assessment of Soil Erosion and Effectiveness of Soil Conservation Measures	Dercon, Gerd
ECU5024	Improving Productivity of the African Palm through Better Fertilization and Water Management Practices	Dercon, Gerd
ELS8009	Study of Sedimentation in the Reservoirs of the Four CEL Hydroelectric Power Stations	Vitvar, Tomas/Dercon, Gerd
ERI5004	Improving Crop Productivity and Combating Desertification	Adu-Gyamfi, Joseph Jackson/ Lagoda, Pierre
HAI5003	Enhancing Crop Productivity through the Application of Isotope Nuclear Techniques	Heng, Lee Kheng/ Ferris, Ian Glen
INS5035	Application of Nuclear Techniques for Screening and Improving Cash Crop Plants in Coastal Saline Lands	Shu, Qingyao/ Dercon, Gerd
INS5037	Applying Nuclear Techniques for Screening and Improving Cash Crop Plants in Coastal Saline Lands	Dercon, Gerd/ Shu, Qingyao
IRQ5017	Optimization of Land Productivity through the Application of Nuclear Techniques and Combined Technologies	Shu, Qingyao/ Nguyen, Minh-Long
IVC5029	Improvement in Yield of Plantain and Cassava through the Use of Legume Cover Crops	Hardarson, Gudni
IVC5031	Improving Plantain and Cassava Yields through the Use of Legume Cover Crops	Hardarson, Gudni/ Spencer, Marie Madeleine/ Lagoda, Pierre
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
MLI5021	Sustainable Intensification and Diversification of Sorghum Production Systems in the Southern Zone of Mali, Phase-1	Heng, Lee Kheng
MLI5022	Assessment of Erosion and Sedimentation in the Niger Watershed with the Use of Radioisotopes, Phase-1	Mabit, Lionel
MON5014	Application of Isotopes in Soil and Plant Studies	Hardarson, Gudni
MON5015	Implementation of the Fallout Radionuclide Technique for Erosion Measurement	Dercon, Gerd
MOZ5003	Sustaining the Management of Soil Fertility	Dercon, Gerd
NAM5008	Increasing Crop Productivity and Resource Use Efficiency in the Northern Communal Areas	Heng, Lee Kheng
NAM5009	Using Mutation Breeding and Integrated Soil Plant Management Techniques to Develop Sustainable, High Yielding and Drought Resistant Crops	Lokko, Yvonne Rosaline Naa/ Heng, Lee Kheng
NER5012	Improvement of the Productivity and Sustainability of Cowpea with Finger Millet	Spencer, Marie Madeleine Dercon, Gerd
QAT5002	Developing Biosaline Agriculture in Salt-affected Areas in Qatar	Shu, Qingyao Nguyen, Minh-Long
RAF5058	Enhancing the Productivity of High Value Crops and Income Generation with Small-Scale Irrigation Technologies	Heng, Lee Kheng
RAS5043	Sustainable Land Use and Management Strategies for Controlling Soil Erosion and Improving Soil and Water Quality (RCA)	Dercon, Gerd
RLA5051	Using Environmental Radionuclides as Indicators of Land Degradation in Latin American, Caribbean and Antarctic Ecosystems (ARCAL C)	Dercon, Gerd/ Voigt, Gabriele Margarete
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)	Ferris, Ian Glen/ Maestroni, Britt Marianna/ Dercon, Gerd
SAU5003	Improving Fertilization under Saline Conditions for Sustainable Crop Production	Shu, Qingyao/ Nguyen, Minh-Long
SEN5030	Integrated Approach to Develop Sustainable Agriculture in Senegal	Spencer, Marie Madeleine/ Dercon, Gerd
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
SRL5038	Application of Isotope Techniques for Soil Erosion Studies	Dercon, Gerd

SUD5030	Increasing Productivity of Selected Crops Using Nuclear Related Techniques	Shu, Qingyao/ Adu-Gyamfi, Joseph Jackson
TAD5005	Developing Soil Conservation Strategies for Improved Soil Health	Dercon, Gerd
TUR5024	Improving Crop Productivity through Nuclear and Related Techniques	Nguyen, Minh-Long
UGA5029	Developing Soil Conservation Strategies	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	Lokko, Yvonne Rosaline/ Heng, Lee Kheng
ZIM5014	Developing and Promoting Strategies for Improved Crop Production	Heng, Lee Kheng

Forthcoming Events

FAO/IAEA Events

Second 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)

Scientific Secretaries: Lee Heng and Long Nguyen

The second RCM will be held from 22 to 26 June 2009 in Beijing, China. The main objective of this RCM is to review the progress of the CRP and to discuss the future activities including detailed work plan in line with project objectives. Another purpose of this meeting is to conduct training on the use of isotopic technique for separating soil evaporation and crop transpiration against conventional methods. Approximately 16 persons from 12 countries are expected to attend, as well as two representatives from IAEA.

Final Research Coordination Meeting (RCM) of the Coordinated Research Project (CRP) on Integrated Soil, Water and Nutrient Management in Conservation Agriculture (D1.50.09)

Scientific Secretary: Gerd Dercon

The fourth and final RCM of this CRP will be held from 5 to 9 October 2009 at IAEA Headquarters in Vienna. All chief scientific investigators (both contract and agreement holders) are expected to attend the meeting.

The objective of the meetings is to: (1) present and discuss the results obtained for the whole duration of the CRP, (2) evaluate achievements in accordance with project objectives and expected outputs, and (3) review manuscripts prepared for the production of the IAEA-TECDOC publication.

The participants will be requested to present an overview of their results which should be in line with the expected outputs and specific objectives of the project. A circular has been sent to the participants informing them of the upcoming meeting. Further information about administrative arrangements will be communicated later.

A full manuscript which will be published subsequently in the IAEA-TECDOC series is expected from each participant prior to the meeting.

First Research Coordination Meeting (RCM) of the Coordinated Research Project (CRP) on 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

The first RCM for this CRP will be held at IAEA headquarters from 8 to 12 June 2009. Participants from fifteen countries (eight research contract holders, three technical contract holders, three agreement holders and five observers) will attend this meeting. For more information about this CRP please refer to the New Coordinated Research Projects Section. The purpose of this meeting is to (i) discuss common objectives, (ii) review individual experimental plans of the research and technical contract holders, (iii) examine the overall log frame and work plan of the project, and (iv) develop detailed experimental and sampling protocols for identifying hot spot areas of land degradation in agricultural catchments for effective soil conservation measures (precision conservation).

Non-FAO/IAEA Meetings

- 10th International Meeting on Soils with Mediterranean Type of Climate, 22 to 26 June 2009, Beirut, Lebanon. http://www.iuss.org/10IMSMTC%20final%20announcement%20(pdf).pdf
- 16th Nitrogen Workshop, 28 June to 1 July 2009, Turin, Italy. http://www.nitrogenworkshop2009.org/
- 6th International Symposium on Ecosystem Behaviour, 29 June to 3 July 2009, Helsinki, Finland. http://www.environment.fi/syke/biogeomon2009
- 11th International Symposium on Soil and Plant Analysis, 20 to 24 July 2009, Santa Rosa, California. http://www.spcouncil.com/symposium.htm
- 2nd World Congress of Agroforestry, 23 to 28 August 2009, Nairobi, Kenya. http://www.worldagroforestry.org/wca2009/
- 2nd Bishkek Global Mountain Summit (BGMS-2), 1 to 3 October 2009, Bishkek, Kyrgyz Republic. http://bgms.kgportal.com/eng/
- XVI International Plant Nutrition Colloquium, 26-30 August 2009, Sacramento, California, USA. http://ipnc.acdavis.edu

- Interdrought-III 3rd International Conference on Integrated approaches to improve crop production under drought prone environments, 11-16 October 2009, Shanghai, China. http://www.interdrought.org/index.jsp
- 5th Conference of the Africa Soil Science Society (ASSS) on Soils and New Challenges for Sustainable Development in Africa, 22 to 28 November 2009, Yaoundé, Cameroon. http://www.asssonline.org/ or http://www.asssland.org/

Past Events

Duty Travel

China for TC project RAS/5/043 on "Sustainable Land Use and Management Strategies for Controlling Soil Erosion and Improving Soil and Water Quality"

Technical Officer: Gerd Dercon

Gerd Dercon travelled to Beijing, China, from 19 to 23 January 2009 for the review of the outcomes of the RAS/5/043 project and collection of the information for the final technical report and brochure.

The objective of the RCA Project RAS/5/043 was to develop sustainable land and water management strategies using fallout radio nuclides (FRN) for reducing soil erosion and improving soil and water quality in the East Asia and the Pacific region.

RAS/5/043 project involved participants from the following 14 Member States: Australia, Bangladesh, China, India, Indonesia, Republic of Korea, Malaysia, Mongolia, Myanmar, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam.

The specific objectives of the project were to: (i) measure soil erosion and deposition over several spatial and time scales by combined use of Caesium-137, Lead-210 and Beryllium-7; (ii) establish the soil redistribution-soil quality relationship under different land management practices by using the results obtained; (iii) develop guidelines to assess soil quality based on results obtained from (i), (ii) and (iv) apply management practices developed as a result of the soil redistribution – soil quality relationship for effectively improving soil and water quality as well as to increase organic carbon storage in soil.

At this final coordination meeting, the participating Member States concluded that the FRN technology has been successfully used by the participating countries in the RCA project RAS/5/043 to assess soil erosion, to evaluate soil conservation measures, and to better understand the link between soil redistribution and soil quality. The cross-departmental and interdisciplinary approach (collaboration between nuclear and soil science institutes) used by most participating Member States was one of the key reasons of this success. The expertise gained in the regional project RAS/5/043 can be used to further train scientists and technicians from the region. The Institute of Environment and Sustainable Development in Agriculture (IEDA), Chinese Academy of Agricultural Sciences (CAAS), can continue to play such an important role in training, because of its well-developed expertise, commitment and infrastructure.

The proficiency test conducted during the project in China also showed that the current analytical resources in the East-Asia and Pacific region are sufficient to further successfully implement the FRN technology.

Partnerships have been established between participating institutions and end-users, which led to the formulation and execution of development projects for enhancing the adoption of improved soil conservation and water management practices. However, in order to further increase and to ensure the impact, it is recommended that projects such as RAS/5/043 project, involve end-users at the development stage of the project.

The participating Member States from across the East Asia and the Pacific region have expressed their interest in a new regional project with a focus on capacity building in the use of innovative techniques such as Compound Stable Isotopic (CSI) techniques, which are complementary to the use of fallout radionuclides, and spatially distributed models to identify precisely critical areas of land degradation and thus improve soil conservation strategies (precision soil conservation) at an area-wide basis. In addition, the participants indicated that there is a need for better understanding of the soil quality dynamics influenced by soil redistribution. Soil quality mapping is a high priority for many countries to ensure sustainable food production, conservation of land and water resources and the protection of farmers' environment.

Turkey for TC project TUR/5/024 on "Improving Crop Productivity through Nuclear and Related Techniques"

Technical Officer: Long Nguyen

Long Nguyen travelled to Ankara, Turkey, from 9 to 12 February 2009 *to* evaluate final results and achievements of the TUR/5/024 project. This project involved counterparts from the three organizations: (i) Saraykoy Nuclear Research and Training Center (SNRTC) of the Turkish Atomic Energy Agency (Dr. Halitligil and Messrs. Hamza Sirin, Yusel Durna and Hakan Kislal), (ii) Soil and Research Institute, Ministry of Agriculture (Dr. Sama Kale and Mr. Faki Ergul) and (iii) Nidge Potato Research Institute, Ministry of Agriculture (Messrs. Husseyin Dnaran and Murat Nam).

The main objectives of the TUR/5/024 project were to investigate nitrogen use efficiency, crop water requirements, soil organic matter and structural conditions under two rotation systems using vetch (Hungarian Vetch-Potato-Wheat-Hungarian Vetch-Potato; HV-P-W-HV-P) and alfalfa (Alfalfa-Alfalfa-Potato, A-A-P] as green ma-

nure for subsequent crops (wheat or potatoes) in the Nigde Region of Turkey. Two nitrogen (N) fertiliser treatments were imposed on these two rotation systems: the N_0 treatment (No N fertilizer was applied) and the N_1 treatment applied as ammonium sulphate fertilizer (applied as ^{15}N labelled urea with 10% ^{15}N atom enrichment) at the rate of 10 kg N/ha for Hungarian vetch, 20 kg N/ha for alfalfa (Bilensoy variety), 150 kg N/ha for wheat (Yakar variety) and 250 kg N/ha for potatoes (Agria variety).

The 4-year results showed that the use of cropping rotation with green manure can enhance soil quality and improve crop productivity for poor-textured soils in the Nidge Region. Alfalfa was found to enhance soil organic matter accumulation, particularly within the 30-90 cm depth (probably because of its deep roots), as well as soil cation exchange capacity, soil structural stability and soil water holding capacity. In contrast, vetch was found to have only a short-term impact on soil structural stability.

Although the TUR/5/024 project has now reached its conclusion after 4 years of IAEA funding, the counterparts are enthusiastic at extending the experimental study to account for the 'long-term' effects of crop residues/crop rotation on soil carbon accumulation, N use efficiency and soil N status.

The Saraykoy Nuclear Research and Training Centre (SNRTC) of TAEK is a highly valuable counterpart for promoting the use of isotopic and nuclear techniques in food and agriculture through its assistance with training the trainers from Mauritius and Iraq on sustainable land and water management.

Sierra Leone for TC project SIL5012 Managing Irrigation Water for a Dry Season Sorghum/Legume Intercropping System for Income Generation and Soil Health

Technical Officer: Joseph Adu-Gyamfi

Joseph Adu-Gyamfi travelled to Freetown and Rokupr (16-20 March 2009) to assess counterpart infrastructure and equipments in Laboratory and to discuss start up and implementation of a newly approved Technical Cooperation project (SIL/5/012) "Managing Irrigation Water for a Dry Season Sorghum/Legume Intercropping System for Income Generation and Soil Health". Technical consultations with Project Counterparts and stakeholders during series of meetings resulted in (i) preparing a workplan for field and laboratory trials (ii) identifying essential equipment, consumable, and nominations for fellowship training and scientific visits anticipated in 2009 and 2010. The Technical Officer also visited the Rokupr Agricultural Research Institute (180 km from Freetown) to access the counterparts infrastructure and facilities in the Soils Laboratories, and later visited experimental sites of an on-going TC project SIL/5/008 "Contribution of nitrogen fixing legumes to soil fertility in rice-based cropping systems". The need for the on-going TC project SIL/5/008 and the newly initiated SIL/5/012 to work together in the area of water and nutrient management in sorghum-legume cropping systems and to share laboratory facilities and equipments was discussed and agreed. The TO later paid a courtesy call to the Director General, Sierra Leone Agricultural Research Institute (a former colleague of the CGIAR) who remarked that one of his top priority is to ensure that the Soils Laboratory at the Rokupr Agricultural Research Center is upgraded to become an income generating service Laboratory for soil and plant analyses. A visit to the FAO and UNDP offices helped to secure support for the newly initiated project and to streamline the process for the timely clearance and delivery of equipments/items meant for the project. (Photos 1, 2 and 3).

Photo 1. Farmers' practices of land preparation (slash and burn) for cultivation of upland rice.

Photo 2. Dryland vegetable production—a new small scale irrigation for income generation venture by women.

Photo 3. A former fellow demonstrating the use of Kjedhal distillation equipment for nitrogen analysis at the Soils Analytical Laboratory at the Agricultural Research Station, Rokupr, Sierra Leone.

What Future for the Agriculture and Food Sector in an Increasingly Globalised World? OECD Symposium

Technical Officer: Long Nguyen

Long Nguyen attended a two-day (30-31 March) OECD Symposium on "What Future for the Agriculture and Food Sector in an Increasingly Globalised World?" The Symposium was held at the OECD Conference Centre in Paris and included 2 key note addresses and 4 discussion panels. The two key note addresses were: (i) Global economic developments shaping future of agri-food (Mr. Cotis) and (ii) Competing claims: resources and climate change (Mr. Tim Searchinger).

The four panels involved the following major themes: (i) Innovation: What can technology and innovation contribute? (ii) Competing Claims: What are the main scarcities that will drive agro-food developments? (iii) Agriculture and its neighbours: What are the links with non-agricultural sectors? and (iv) Great Expectations: What is society expecting from the global food systems?

The Symposium highlighted key essential points and future trends that influence food and agriculture sectors. Of particular interests to the SWMCN Subprogramme are:

1. The challenge for agriculture in producing more food and biomass with less greenhouse gas emissions.
2. There is a need for sustainable increase in the total productivity of land, water, energy and other resources in the food and agricultural systems.
3. There is a need for strengthened knowledge transfer particularly in developing countries.
4. Recognition of growing scarcities in land, water, energy and nutrients. There is a need to enhance crop water productivity and water use efficiency, improve utilization of agricultural wastes, promote soil carbon sequestration and improve the conservation and efficient utilisation of fertilisers and soil nutrient reserves (major elements and micro-nutrients).
5. There is a need for a holistic and system-wide approach to emerging challenges in agriculture. Thus there is a need for multidisciplinary studies.

Kenya for Regional project RAF/5/058 "Enhancing the productivity of high value crops and income generation with small-scale irrigation technologies"

Technical Officer: Lee Heng

The first project coordination meeting of this regional project was held in Nairobi, Kenya from 30 March to 3 April 2009. Lee Heng and Mickel Edwerd, the Project Managing Officer attended this meeting. The Meeting was hosted by the Kenya Agricultural Research Institute (KARI), and attended by Project Coordinators (PCs) from 18 countries (Algeria, Benin, Burkina Faso, Botswana, Cote d'Ivoire, Ethiopia, Ghana, Kenya, Libyan Arab Jamahiriya, Mali, Mauritius, Niger, Nigeria, Sudan, Uganda, United Republic of Tanzania, Zambia and Zimbabwe). The objectives of the Coordination Meeting is to review the work done, progress made and results achieved by each participating country in soil and water management and crop nutrition; review/update the project document with emphasis on the project work plan; to evaluate project as a whole, highlighting both planned inputs and expected outputs and to identify key actions to be taken by each participating country to achieve the project output. The five-year project aims to develop and pilot test appropriate irrigation systems (methods and related water/nutrient management practices) for small-scale farmers for increasing yield, quality of high value crops and farmers income to improved livelihood (Photos 1 and 2). The participants presented both their country reports and work plan in accordance with the list provided in the Agenda. FAO representative in Kenya (Castro Macaranda), Assistant NLO (David Otwoma, National Council for Science and Technology), Programme Manager of the Improved Management of Agricultural Water in Eastern and Southern Africa (IMAWESA) & ICRISAT in Nairobi, Kenya (Prof Bancy Mati) and Irrigation Specialist of World Bank (Dr Markus Moeller) were among those gave presentation at the meeting.

Photo 1. Cabbage grown in canals in bricks and bed irrigation in Burkina Faso (Photo by J. Bayala).

Photo 2. Treadle pump in Kenya (Photo by I. Sijali).

More Crops per Drop-FAO's AquaCrop Model Development

Technical Officer: Lee Heng

Lee Heng attended the FAO's AquaCrop meeting held at Instituto de Agricultura Sostenible, CSIC, Alameda del Obispo in Cordoba, Spain from 13-15 April 2009. Participants to the meeting include Prof. Elias Fereres (Host), Prof. Theodore Hsiao from University of California-Davis, Dr. Dirk Raes from K.U. Leuven University, Department of Earth and Environmental Sciences and Dr. Gabriella Izzi from FAO. AquaCrop is FAO crop-model to simulate yield response to water of several herbaceous crops. It is designed to balance simplicity, accuracy and robustness, and is particularly suited to address conditions where water is a key limiting factor in crop production. AquaCrop is a companion tool for a wide range of users and applications, including yield prediction under climate change scenarios. The AquaCrop model has been officially launched in January 2009 at http://www.fao.org/nr/water/aquacrop.html.

A long list of topics was discussed; these include:

1) The revision of the Irrigation and Drainage Paper n. 33, "Yield response to water" (Doorenbos and Kassam, 1979), in which the reporter is responsible in one of the chapters of the new publication. 2) New features and validation needed for the next update of the model, this includes the effects of nutrient, salinity and water table. 3) Work distribution for validating additional crops to be included in the model. 4) AquaCrop workshops to be held in Member States, sponsored by University of Bonn, the Bonn-Rhein-Sieg University of Applied Sciences. In addition, the reporter took the opportunity to hold discussion with Prof. Ted Hsiao who is also a Technical Contractor in IAEA's CRP on "Managing irrigation water to enhance crop productivity under water-limiting conditions". The reporter also visited Department of Agronomy, University of Cordoba for a method to compute canopy cover needed in the same CRP.

Consultants Meeting on Sustainable crop production through improved management of herbicides in conservation agriculture using nuclear techniques

Technical Officers: Gerd Dercon and Long Nguyen

The three-day (10 to 12 December) Consultants Meeting (CM) on Sustainable crop production through improved management of herbicides in conservation agriculture using nuclear techniques" was held at the Vienna International Centre in Vienna, Austria.

This CM aimed at assessing the processes and pathways of herbicides within agricultural ecosystems and identifying the main issues involved in optimizing the use of herbicides through improved soil and land management practices to mitigate the impact of herbicides on the quality and thus productive capacity of the soil. In addition, the CM explored isotopic, nuclear and complementary non-nuclear techniques, which can be effectively applied to give more insight into the interactions between herbicide, soil parameters and crop residues at field and/or landscape level and to track the fate of herbicides within agro-ecosystems.

The consultants in collaboration with the IAEA/FAO team from the Soil and Water Management and Crop Nutrition (SWMCN) and the Food and Environmental (FEP) Subprogrammes finally designed a CRP in synergy with the FEP-managed CRP entitled "Integrated analytical approaches to assess indicators of the effectiveness of pesticides management practices at a catchment scale".

Non FAO/IAEA Events

General Assembly of the European Geosciences Union, 19-24 April 2009, Vienna, Austria

The General Assembly of the European Geosciences Union took place in Vienna from 19 to 24 April 2009. Around 9100 researchers from all over the world attended this meeting covering all disciplines of the Earth, Planetary and Space Sciences. 26% of the participants were students. This year the programme included almost 13 000 oral and poster presentations during the week.

Lionel Mabit and Arsenio Toloza (SSU) provided an update of the Soils subprogramme investigation in the Mistelbach watershed using Caesium-137 (^{137}Cs) and unsupported Lead-210 ($^{210}Pb_{ex}$) entitled '*Measurements of the effectiveness of conservation agriculture at the field scale using radioisotopic techniques and runoff plots'* was presented under the Soil System Sciences Section 1 (The scale problem in soil erosion studies) of the Assembly.

Steve Burgess and Long Nguyen (SWMCN Section) presented a poster paper titled "Nuclear and non-nuclear techniques for area-wide assessment of water use efficiency and ecohydrology outcomes among mixed land uses" on 23 April 2009 in the same General Assembly.

Visitors

Mrs. Veerle Vanacker (Department of Geography, University of Louvain, Belgium), Mr. Gerard Govers (Physical and Regional Geography Research Group, University of Leuven) and Mr. Pascal Boeckx (Laboratory of Applied Physical Chemistry - ISOFYS, Ghent University, Belgium) visited the Headquarters in Vienna on April 23 2009 to explore potential collaboration with the SWMCN subprogramme.

New Coordinated Research Projects (CRPs)

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 Coordinated Research Project was approved in October 2008 and first RCM for the project will be held at IAEA, Vienna from 8 to 12 June 2009. There are eight research contract holders (Chile (1), China (2), Morocco, Poland, Russian Federation, Syrian Arab Republic and Vietnam), three technical contract holders (Germany, New Zealand and UK) and three agreement holders (Australia, Canada and UK). 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 measures (precision conservation). Specific research objectives are (i) to develop the combined use of FRN techniques 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 and apportion the amount of source soils (land-degraded areas) from main land uses/management (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 create the basis to develop decision support tools for implementing precision conservation and contributing to sustainable land management.

Some of the expected outputs from this CRP include:

- Validation of the use of FRN for establishing soil redistribution patterns and rates over several temporal scales on an area-wide basis (catchment).
- Harmonized protocols for the application of CSSI techniques at the catchment scale in a range of environments and land use systems.
- Modelling and other approaches 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 spots diffuse pollution areas.
- Better understanding of the land use/management impacts on soil redistribution and the location of hot spots diffuse pollution areas on an area-wide scale.
- Enhanced capacity in Member States to conduct applied research on comprehensive soil redistribution studies with the aid of nuclear and related techniques.

Status of Coordinated Research Projects (CRPs)

Selection for Greater Agronomic Water Use Efficiency in Wheat and Rice Using Carbon Isotope Discrimination (D1.20.08)

Technical Officer: Lee Heng

As mentioned in the previous Newsletter, the final RCM of this CRP was held in November 2008 at IAEA Headquarters in Vienna. Final reports from all participants have been received and are being reviewed for the production of an IAEA's-TECDOC publication.

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

Technical Officer: Gerd Dercon

The fourth and final research coordination meeting (RCM) of the CRP was held in Vienna, Austria, in October 2007 with Felipe Zapata acting as scientific secretary. In October 2008, the CRP results were successfully presented to the members of the Committee for Coordinated Research Activities (CCRA) of IAEA.

Nineteen manuscripts have been finalized and edited for the production of an IAEA TECDOC, and its preparation of the TECDOC is now in its final phase.

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}Pbexc and ^{7}Be for measuring soil erosion and sedimentation over several spatial and temporal scales.

A wealth of valuable information on soil redistribution and 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.

Eleven contract holders from Brazil, Chile, China (2), 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) have participated in this CRP.

Integrated Soil, Water and Nutrient Management in Conservation Agriculture (D1.50.09)

Technical Officer: Gerd Dercon

The overall objective of this CRP is 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 the specific objective, which is 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.

This CRP has a total of ten participants comprising seven research contractors from Argentina, Brazil, India, Morocco, Pakistan, Turkey and Uzbekistan, two technical contractors (Australia and Chile), one agreement holder (CIMMYT-Mexico). In addition, one individual contractor (Mr. Bernard Vanlauwe) conducts 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.

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 and Mr. Mahmut Basri Halitligil from the Sarayköy Nuclear Research and Training Center was the host of the third RCM in Ankara (Turkey) in April 2008.

The CRP is entering its final phase, and has created an interesting database on soil-water-plant interrelationships in conservation agriculture.

The fourth and final RCM is scheduled to be held from 5 to 9 October 2009 at the IAEA's headquarters in Vienna.

Bram Govaerts (International Maize and Wheat Improvement Centre - CIMMYT), agreement holder in CRP D1.50.09 "Integrated Soil, Water and Nutrient Management in Conservation Agriculture" and a well-known scientist in the area of conservation agriculture in South America and Africa, published a review article in the "Critical Reviews in Plant Sciences" (28: 3, 97-122 (2009) on the potential of conservation agriculture systems for sequestering soil carbon.

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 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 (cereal and legume) crop genotypes with enhanced nitrogen (N) and phosphorus (P) use efficiency and greater productivity in low fertility soils. The specific research objectives are: i) to develop and validate screening protocols for plant traits that enhance N and P acquisition and utilization in major food cereal and legume crops grown in low fertility soils, ii) to employ validated screening protocols including the use of isotopic tracer techniques and induced mutations to identify genotypes with superior N and P acquisition and/or utilization. This might include mutants identified for novel traits, iii) to assess the selected genotypes with traits for enhanced nutrient acquisition and/or utilization in selected cropping systems, including yield and productivity. This assessment could include long-term sustainability of soil fertility.

This CRP has a total of 17 participants, ten research contract holders from Burkina Faso, Brazil, Cameroon, China, Cuba, Ghana, Malaysia, Mexico, Mozambique and Sierra Leone, five Agreement Holders from Australia (UWA), Benin (WARDA), Kenya (TSBF-CIAT), Nigeria (IITA), France (INRA), and two Technical Contractors from Germany (University of Hanover) and USA (University of Pennsylvania). The mid-term review reported in the previous SNL (Vol 31 Issue 2) showed that most of the participants made progress during the two and half years in developing protocols and employing these protocols to evaluate rice, maize, common beans, cowpeas and soybean genotypes in the laboratory, greenhouse and field experiments for identifying root traits conferring P and N acquisition. During the next two and half years, activities will focus on the understanding of the adaptation mechanisms by examining nutrient acquisition by crop genotypes from different soil N and P pools using ^{15}N and ^{32}P (in specific laboratories). In addition, some of the Agreement Holders will examine the variation in the ability of different crop genotypes to mobilise soil available P from the rhizosphere through the release of organic acids from plant roots. The third RCM is proposed to be held in Mozambique or Ghana during the second quarter of 2010.

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

Technical Officers: Lee Heng and Long Nguyen

This CRP will be holding its second RCM in Beijing from 22-26 June 2009. In addition to reviewing work progress and discussing future workplan and direction, training session on field measurement of isotopic (Keeling plot and isotopic profile methods) versus conventional methods (Bowen ratio/energy balance, eddy covariance, sap flow sensors, microlysimeter, soil surface vapour pressure measurement, neutron probe and TDR) of determining evaporation and transpiration will be carried out. Site close to Beijing has been identified where technologies relating to isotopic and related techniques will be deployed to determine crop water productivity and water use efficiency. Thirteen participants from nine research contractors (Burkina Faso, China (2), Malawi, Morocco, Pakistan, Turkey, Vietnam and Zambia), two technical contractors (USA) and two agreement holders (Austria and Australia) and two IAEA staff will be attend the meeting.

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: Lee Heng and Long Nguyen

The first RCM of this CRP was held between 15 and 19 December 2008, at IAEA's Headquarters in Vienna. The purpose of the RCM was to discuss project experimental design and workplan for each participant and to establish standardized methodologies and protocols to be used by all participants in accordance with the workplan and objectives of the CRP. A total of eight contract holders from China, Estonia, Islamic Republic of Iran, Lesotho, Nigeria, Romania, Tunisia and Uganda are in this CRP. Three new agreement holders from France, UK and USA are also assisting in the CRP.

The objectives of the CRP on both catchment and wetland scales were revised during the meeting:

Catchment Scale:

- Long term goal: To optimize the system of wetlands, ponds and riparian zones for improved water storage and quality in agricultural catchments.
- Short term goal: To understand better the link between water and nutrient dynamics in wetlands, ponds and riparian zones and biomass production.

Wetland Scale:

- To assess nutrient/pollutant attenuation capacity of wetlands, ponds and riparian zones.
- To determine the capacity of wetlands, ponds and riparian zones for water storage.

So far, a majority of contract holders have submitted their report for the first 3-months characterizing the sites and a listserv has been developed to foster communication among the group, at http://pete.uri.edu/archives/rcp.html

Laboratory Activities

Selection of the most appropriates fallout radionuclides (^{137}Cs, ^{210}Pbex, ^{7}Be) for erosion and sedimentation investigation. Optimization of supportive services and training by the SSU for IAEA Member States

Lionel Mabit (SSU)

A joint review paper has been written in collaboration with some of our colleagues of the previous Co-ordinated Research Project D1.50.08 on "Assess the effectiveness of soil conservation techniques for sustainable watershed management using fallout radionuclides" (Prof. Des Walling from Exeter University in UK and Dr. Moncef Benmansour from the CNESTEN, Rabat, Morocco). This review was published recently in the Journal of Environmental Radioactivity (JER).

This review paper titled 'Comparative advantages and limitations of the fallout radionuclides ^{137}Cs, ^{210}Pbex and ^{7}Be for assessing soil erosion and sedimentation' has already been classified as the most downloaded JER's paper from Science Direct TOP25 Hottest Articles (information extracted from ScienceDirect TOP25 Hottest Articles October - December 2008), and has received a high interest from IAEA Member States through printing requests.

This contribution was produced at the final stage of the CRP D1.50.08 by the participants and supporting the implementation of the IAEA SWMCN subprogramme aims to review the advantages and limitations of each of the three FRNs (^{137}Cs, ^{210}Pbex and ^{7}Be) and to identify key knowedge gaps linked to their use. In addition, guidelines for selecting the most appropriate FRN and associated approach, in order to deal with a range of spatial and temporal scales and to investigate specific sets of agro-environmental problems, were provided. Key requirements for future work in Member States, related to the application of FRNs in soil erosion investigations, were also identified. These include the upscaling of the approach to the catchment scale and a shift from use of the approach as a research tool to a decision support tool.

To summarise, the selection and application of a particlar FRN for documenting or investigating soil erosion and redistribution should reflect the user's objectives, the advantages and limitations of each approach, and the human and material resources available.

The present state of knowledge regarding nuclear radioisotopic techniques in soil erosion investigations synthesized by this paper is available from the Soil Science Unit upon request.

Following this publication, the preparation of a practical training manual for the use of FRNs (^{137}Cs, ^{7}Be, ^{210}Pb) to investigate erosion and sedimentation processes has been initiated. The objective of this IAEA training course series publication supported by previous IAEA Technical Officers and selected members of the previous CRP D1.50.08 will be to present in a simpler manner to IAEA Member States basic training material to deal with FRNs, it will also complement Dr. Felipe Zapata's Handbook for the assessment of soil erosion and sedimentation using environmental radionuclides published by Kluwer Academic Publishers in 2002.

This also provides opportunity for the SSU/SWMCN team to welcome the 2.5 months consultancy of Dr. Moncef Benmansour (from July 6 to September 2009) in Seibersdorf laboratory to support the writing of this manual in collaboration with the SSU.

Update of previous investigations on the use of fallout radionuclides in Mistelbach-Austria

Lionel Mabit and Arsenio Toloza (SSU)

The aim of this study performed in 2006-2008 by the Soil Science Unit in collaboration with Boku University in Mistelbach watershed (Austria) was to evaluate the magnitude of deposition rates using ^{137}Cs and ^{210}Pbex and the erosion rates using runoff plot measurements. The final results published recently in the peer-reviewed journal Geoderma can be summarised as following:

(i) Erosion measurements (1994-2006) from runoff plots located in the upper part of an agricultural field just up-slope from a deposition area reached 29.4 t ha^{-1} · a^{-1} from the conventional tilled plot, 4.2 t ha^{-1} · a^{-1} from the conservation tillage plot and 2.7 t ha^{-1} · a^{-1} from the direct seeding treatment. Soil losses were reduced significantly by a factor of 10 using no tillage, direct seeding treatment.

(ii) Using the ^{137}Cs data that integrate the 1954–2007 period, the sedimentation rates down slope of the field containing the runoff plots were estimated at:
   - 26.1 t^{-1} • ha^{-1} • a^{-1} using the ^{137}Cs depth distribution profile
   - 20.3 t^{-1} • ha^{-1} • a^{-1} using the Mass Balance Model 2 (MBM2)

(iii) The erosion rates under conventional tillage are in agreement with the sedimentation rates estimated down slope of the field by the ^{137}Cs depth distribution profile and MBM2.

(iv) In the lowest part of the watershed a sedimentation rate of 50.5 t^{-1} • ha-1 • a^{-1} was highlighted by the ^{137}Cs depth distribution profile. This value was greater than the average erosion rate measured by the erosion plots because this area is more representative of sedimentation processes occurring in the study area due to its topographical position and the basin geomorphology.

(v) While ^{137}Cs produced exploitable results, the ^{210}Pb method was not applicable due to very low concentrations of ^{210}Pbex associated to a high uncertainty in the measurements and a high fallout variability.

SSU γ-laboratory measurements: Establishment of Minimum Detectable Activity (MDA) of some terrestrial gamma radionuclides

Lionel Mabit and Arsenio Toloza (SSU)

In the previous Soils Newsletter (Vol 31, No. 2, January 2009) we presented the preliminary results in evaluating ^{137}Cs fallout in an undisturbed Slovenian forested site prior to future erosion and sedimentation investigation. As the greatest part of the external irradiation comes from the main naturally occurring radionuclides, we studied the natural gamma geogenic background.

Laboratory analytical measurement precision concerning the following isotopes: ^{40}K, ^{226}R and ^{232}Th (terrestrial radionuclides used to evaluate the natural gamma dose ray) are presented in Table 1. Result of the Minimum Detectable Activity (MDA) is based on a 50 000s γ-analysis of 20 different core samples collected till 40 cm per 10 cm increments (total of 80 samples).

Table 1. Minimum Detectable Activity (Bq) and error measurements (%) of ^{40}K, ^{226}R, ^{232}Th per soil increments

Soil increments (in cm)	^{40}K	^{226}R	^{232}Th
0-10	2.4 (2.3 ± 0.5)*	0.9 (4.8 ± 0.8)*	5.3 (4.5 ± 3.3)*
10-20	1.9 (2.5 ± 0.4)*	0.7 (4.4 ± 0.5)*	3.8 (4.5 ± 3.1)*
20-30	2.1 (2.5 ± 0.3)*	0.6 (4.1 ± 0.5)*	3.8 (4.2 ± 2.7)*
30-40	1.9 (2.2 ± 0.6)*	0.6 (4.2 ± 0.5)*	3.8 (4.0 ± 2.3)*

** Error measurement at 2 σ (in %) ± Standard Deviation (in %)*

Phosphorus acquisition from sparingly soluble forms by maize and soybean in low- and medium-P soils using ^{32}P

Joseph Adu-Gyamfi, Martina Aigner and Doris Gludovacz

Plants differ greatly in their ability to grow on low P soils because they have developed specific physico-chemical mechanisms/processes to utilize P compounds in these low P fertility soils. Evaluating and identifying crop genotype in their ability to access and utilize sparingly soluble forms of soil P has been proposed as a possible means for overcoming P deficiency in soils and optimize P fertiliser use in cropping systems. Radio-isotopic techniques using the principle of isotopic exchange is a powerful means for characterizing soil P availability and sources of P pools to plants in soil-plant systems. The study aimed to evaluate the differential ability of maize and soybean to access and utilize soil P for plant growth from a range of soil P pools using carrier-free ^{32}P.

Glasshouse experiments were carriedout to evaluate the differential ability of maize (Zea mays) and soybean (Glycine max) to utilize soil phosphorus (P) for plant growth from total-P, available-P and inorganic (Ca-P, Al-P, and Ca-P) soil P pools using a carrier-free ^{32}P solution. Maize (DK 315) and a soybean (TGX 1910-4F) were grown in pots containing soils with 1 kg of a low available soil P. Two soils, one each from from Hungary (total P 302, available P 21 [Bray PII], 13.3 $mg.kg^{-1}$ [Olsen P], pH 5.6 (KCl), and Austria (total P 513, available P 46 (Bray P2), 13.3 $mg.kg^{-1}$ Olsen P, pH 5.6 (KCl)) were labeled with ^{32}P for 42 days or without ^{32}P (unlabelled) for 42 and 60 days. Total P in soils was determined using the colorimetric method after acid digestion, and available P (Bray P II and Olsen) was determined by colorimetric method after extraction. The inorganic soil P fractions were measured according to a fractionation scheme based on the Sekiya method. Briefly the

fractionation involved a sequential extraction of Ca-P (300 mg of soil extracted with acetic acid), Al-P (extracted with ammonium fluoride after the extraction of Ca-P) and Fe-P (soil after extraction of Al-P was washed twice with saturated sodium chloride and discarded and then extracted with and sodium hydroxide) and the P in extracts were determined by colorimetric method. The ^{32}P radioactivity in all the fractions (total-P, available-P, Ca-P, Al-P and Fe-P) was measured by liquid scintillation spectrometry (Packward 2000) using a flour solution consisting of 1mL solution and 9 mL of Aquasol-2 (NEN research product). Similarly, phosphorus in the ground plant materials were wet digested in a 4 ml H_2SO_4 and 3 ml H_2O_2 for 2 min till digest is colourless, and aliquots of the samples were diluted and the total P measured by the method of Murphy and Riley (1962) and ^{32}P was determined by the Liquid Scintillation Counter

The shoot and root biomass of maize and soybean were significantly greater when grown on the Austrian than on the Hungarian soils. The shoot P concentrations were higher for soybean (1.7-2.2 g kg^{-1}) than for maize (1.1-1.4 g kg^{-1}). The total radioactivity (dpm x 10^6) was higher in plants grown in Austrian than in Hungarian soil and the values reflected on the plant P uptake and shoot biomass of soybean and maize. The L- values (µgP .g $soil^{-1}$) of maize and soybean were higher in Austrian (72-78) than in Hungarian (9.6-20) soil. No significant differences in L-values were observed for maize and soybean grown on the Austrian, but for the Hungarian soil, the L-values were higher for maize (20.0) than for soybean (9.6) suggesting that in this low-P soil, maize was more efficient than soybean to take up soil P. The available P (Bray II) and the Ca-P were the fractions most depleted by plants followed by the Fe-P fractions in the two soils, but differences between the crops were not significant (Figure 1). When soil P is limited, maize and soybean are able to access P mainly from the available P (Bray II), Fe- and Ca-P sparingly soluble fractions and not Al-P from the soil.

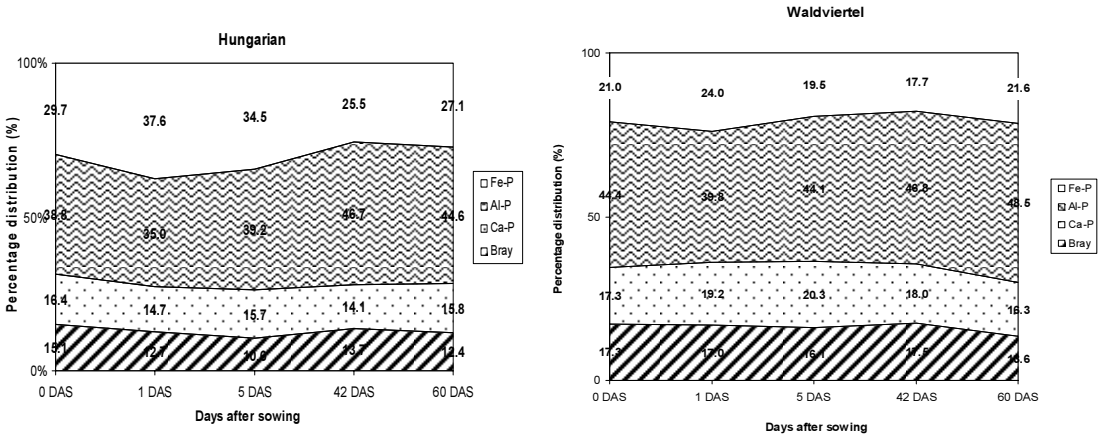

Figure 1. Percentage distribution of inorganic P pools (Ca-P, Al-P and Fe-P) in the Hungarian and Austrian soils at the different sampling dates.

Investigation of plant transpiration and soil evaporation based on Time Domain Reflectometry (TDR) and mass balance methods

Peggy Macaigne, Jose Luis Arrillaga and Leopold Mayr

Introduction

Agriculture is a major competitor for water, therefore there is an actual need to use it more efficiently (Gregory 2004). Though, adjusting water to crop demand is relevant, determining the optimum amount of water required for specific plant, soil, environment and climate is difficult. More investigations need to be carried out on this topic for a better understanding of the soil-plant-water interaction in cropped areas.

Objective of the study

The objective of the study is to investigate soil evaporation (E) and plant transpiration (T) at different stages of maize (Zea mays L., variety DK375) growth under two irrigation water levels with conventional measurement methods (mass balance and TDR).

Material and methods

The experiment was conducted in a glass-house located in IAEA's Seibersdorf Laboratories. Humidity and temperature of the glass-house were not controlled, but were recorded. Soil was a homogeneous 1:1 mixture of 5 mm sieved Seibersdorf soil and quartz sand.

Irrigation system

An automatic dripping irrigation system was built with a pump connected to a water tank and a pre-programmed

logger controlling the opening and closing of the valves. Soil humidity was followed by TDR probes introduced in each pot (Figure 1).

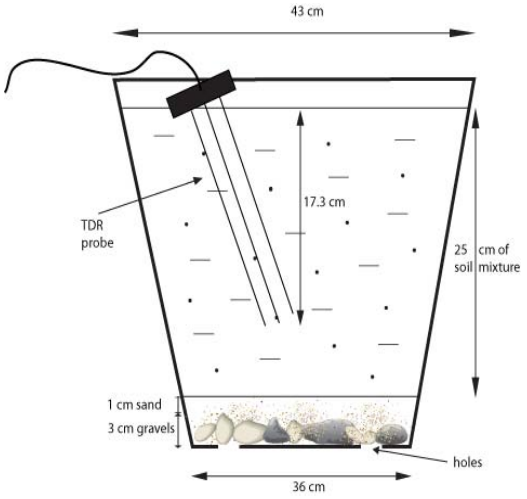

Figure 1. Schematic cross section of a pot with a TDR probe.

Opening time of each irrigation line was initially fixed according to three treatments namely (1) no water stress (T_1): soil at field capacity and pot cropped with maize; (2) water stress (T_2): soil at 20-60% of field capacity and pot cropped with maize; and (3) ((T_3): soil at 60% of field capacity and pot without crop. Water was then weekly adjusted to maintain soil humidity constant during the cropping season compensating plant requirements or soil evaporation losses for each treatment. It was assumed that weekly water losses recorded from T_1 and T_2 represented plant transpiration, while T_3 represented soil evaporation.

Pre-germinated maize seed (Zea mays L., variety DK375) were planted on 30 April 2008. After planting, corn cropped pots were covered with tight plastic sheets avoiding any soil evaporation (Photo 1).

Photo 1. Experiment in the glass-house at early stage: one week after plantation (7 May 08). White plastic sheets cover pots.

Results

Soil characteristics

Soil is a sandy loam (USDA soil classification) with 70.9% ±0.4 of sand, 17.6% ±1.5 of silt and 11.4% ±1.1 of clay. Field capacity was previously determined and approximates 30.1% +/-0.7%.

$ET = E + T$

Where ET is the actual evapotranspiration, E the evaporation and T the transpiration for the studied crop (in this case corn). ET can be estimated from ET_0 (which is the reference ET) by the following equation.

$ET = K_c \times ET_0$

Where K_c is the crop coefficient. ET_0 is the reference evapotranspiration calculated from FAO ET_0 calculator. In this study, we also estimated ET from weekly water mass balances, based on soil humidity data measured by TDR.

Figure 2 compares ET estimated from: (i) weekly variations of soil humidity for treatment 1 (T_1) and 2 (T_2); with (ii) FAO model (ET_0 calculator). Estimated ET with ET_0 calculator model is usually overestimated compared to values obtained from soil humidity and are closer to values calculated from treatment 1 (Field capacity).

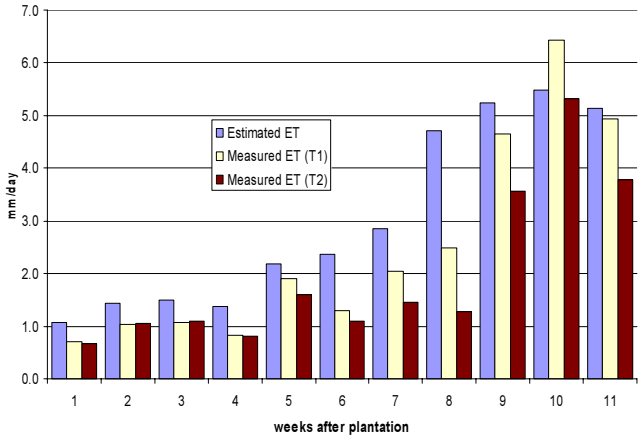

Figure 2. Comparison between estimated (ET_0 calculator) and measured daily evapotranspiration ($mm.day^{-1}$).

Figure 3 presents crop coefficient (K_c) from FAO recommended values (K_c for corn) or based on measurements and the following equation: $K_c = ET/ET_0$. Recommended K_c values are overestimated and rise slowly compared to the estimated ones. Calculated values also give a more accurate value for K_c than the recommended one by distinguishing different K_c for each water treatments. A higher K_c value was found for T_1 (no water stress) than for T_2 (water stress).

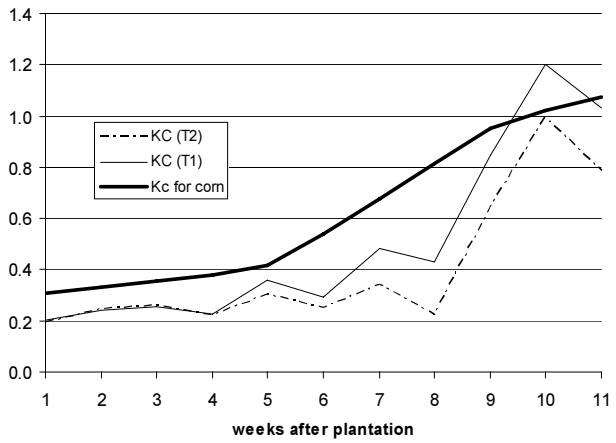

Figure 3. Comparison of crop coefficient based either on established data (K_c for maize) or on a comparison between ET_0 (calculated with climatic data and ET_0 calculator) and ET (from soil humidity measurements).

Conclusion

Ongoing soil water content measurements with TDR probes in cropped and uncropped pot experiments provided an accurate value for transpiration (T) and evaporation (E) rates, respectively. An estimation of ET related to each water treatment (field capacity: T_1 and water stressed: T_2). These values were then compared to ET calculated with climatic data and ET_0 calculator model, which slightly overestimates ET. This approach is the first step of the project, which will be completed by further ^{18}O data to estimate the ^{18}O isotopic signature of evaporation and transpiration.

References

Gregory, P. J. (2004). Agronomic approaches to increase water use efficiency. Water use efficiency in Plant. M. A. Bacon. University of Lancaster UK, Blackwell**:** 142-170.

A new weather station and soil moisture sensor for field experiments at Seibersdorf

Joseph Adu-Gyamfi, Lee Heng and Jose Luis Arrillaga

A new weather station (*i*METOS ag station from Pessl Instruments) was setup and installed in the Seibersdorf field experimental station (Photos 1 and 2). The weather station records temperature, relative humidity, dew point temperature, leaf wetness, rainfall, global radiation and wind speed. These data will be compared with an existing weather station installed nearly twenty years ago. The iMetos was also expanded to include soil moisture sensors and soil matric potential sensor (Decagon 10HS and MPS-1, respectively). The latter will also be used as part of the comparison of different soil moisture monitoring sensors (TDR, EnviroScan, Neutron Probe and Diviner) available in the field. The whole weather station and soil moisture sensor setup will be useful in providing evapotranspiration data and irrigation scheduling for the field experiment on 'Integrating soil water measurements and isotope tracer (^{13}C, ^{18}O and ^{2}H) techniques to evaluate wheat lines for tolerance to drought under pre- and post-anthesis water stress'. The study aims to relate soil water measurements with isotopic signatures of carbon and oxygen in plant leaves to select wheat lines tolerance to water stress at different growth stages and to compare the reliability of the different soil water monitoring equipments to estimate plant available water for wheat plants grown under different water stressed conditions plus to provide quantitative information on the use of isotope tracer techniques to evaluate wheat plants for tolerance to water stress at the different growth stages. The weather and soil data also will be useful for fellowship training in soil moisture instrumentation and soil water balance. The iMetos is powered by rechargeable batteries and a solar panel. It is a wireless internet based datalogging system which makes it convenient to view or download the data anywhere, anytime.

Photo 1. The imetos weather station and Decagon soil moisture sensors to be installed in the field at the Agency's Laboratory Seibersdorf.

Photo 2. The new soil moisture device 10HS being installed on the field.

Determination of nitrogen uptake and fertilizer use efficiency in maize (*Zea mays* L.) using the ^{15}N labeling method

Martina Šturm (Jožef Stefan Institute, Department of Environmental Sciences, Ljubljana, Slovenia) and Joseph Adu-Gyamfi

The Challenge

There is an increasing concern for maximizing the efficiency of fertilizer nitrogen (N) use in crop production systems and the ^{15}N techniques have been used extensively to study the uptake of applied N by plants and the nitrate concentration in soils at different depths. The ^{15}N labeling method, the isotopic signature of the enriched tracer can be pre-determined to ensure significant difference in atom % of ^{15}N between source and background level, even when fractionation occurs. This technique has been used extensively to trace fate of soil nitrate in cropping systems.

Experimental Design

An experiment was set up on a field at the International Atomic Energy Agency's Laboratories, Seibersdorf. Maize (*Zea mays* L.) was grown on 1 m^2 plots with 3 replications. The soil used was Seibersdorf soil (Typic Eutroscrepts) with a coarse clay loam texture. Some of the physical characteristics of the soil used are particle size distribution (13.0 % clay, 15.6% silt and 71.4% sand), permanent wilting point 7.08 (% vol), bulk density (1.6 g. cm^{-3}) particle density (2.61 g. cm^{-3}) and water content at saturation 48.2 vol %. The soil pH (KCl) was 7.50 and had 7.91 $g.kg^{-1}$ organic C. The soil used had a total N 0.60 $g.kg^{-1}$, total P 906 $mg.kg^{-1}$, available P 233 $mg.kg^{-1}$ mg/kg (Bray P2) and 26.1 $g.kg^{-1}$ (Olsen P), EC (25^{o}C) 130 $\mu S.cm^{-1}$., total C 17.5 g kg^{-1} OC 1.1 g kg^{-1} and cation exchange capacity (CEC) as measured by the cobalt hexamine method was 17.5 $cmol(+)kg^{-1}$. Labelled $K^{15}NO_3$ (5.29 at % ^{15}N excess) was applied in solution at a rate of 100 kg N ha^{-1} and phosphorus at 40 kg P ha^{-1} kg P/ha, The soil moisture neutron probe (SMNP), tensiometers and time domain reflectometry (TDR) were used to monitor the soil moisture content.

Three maize plants from each plot were sampled at 15, 36, 63, 79, and 99 days after sowing (DAS) separated into roots, shoots and cobs, weighed, dried and grinded for analysis. Soil samples were taken at 8 days before sowing (-8 days), 0, 36, 79 and 99 DAS at 0-20 and 20-40 cm depth Soil and plant samples were analyzed for total N and ^{15}N using a continuous flow IRMS Europa 20-20 with ANCA-SL preparation module (PZD Europa Ltd, U.K.), connected to an elemental analyzer. Nitrogen uptake (i.e. N yield), the portion of N derived from the fertilizer (% Ndff) and derived from soil (% Ndfs), fertilizer N yield and % fertilizer use efficiency were calculated for each replicate. Results were verified statistically with Students t-test using the Statistica 6.0. Significant differences are given on a 95 % level.

Main Results

Soil and Plant N

Total soil nitrogen (N) concentrations did not vary significantly ($p>0.05$) at 0-20 cm and 20-40 com soil depth during the growing period (Table 1), whereas enrichment with ^{15}N increased heavily at both depths after the addition of the enriched fertilizer, compared to initial soil sampling (Figure 1). The N content as well as ^{15}N enrichment was greater in upper than the lower soil layers. Fluctuations in N and ^{15}N concentration during the growing season after fertilization are not statistically significant and are explained by natural soil heterogeneity.

Table 1. N and ^{15}N concentrations in soil from 0-20 cm and 20-40 cm depth at 8 days before (-8) and 36, 79 and 99 days after sowing

Days after	%N (dry basis)		at % ^{15}N excess	
sowing	0-20 cm	20-40 cm	0-20 cm	20-40 cm
-8	0.41 ± 0.02	0.33 ± 0.01	0.003 ± 0.000	0.003 ± 0.000
36	0.41 ± 0.01	0.37 ± 0.04	0.017 ± 0.006	0.011 ± 0.003
79	0.41 ± 0.01	0.38 ± 0.02	0.013 ± 0.001	0.007 ± 0.000
99	0.45 ± 0.01	0.39 ± 0.03	0.018 ± 0.003	0.008 ± 0.003

Data are means ± S.D. (n=3).

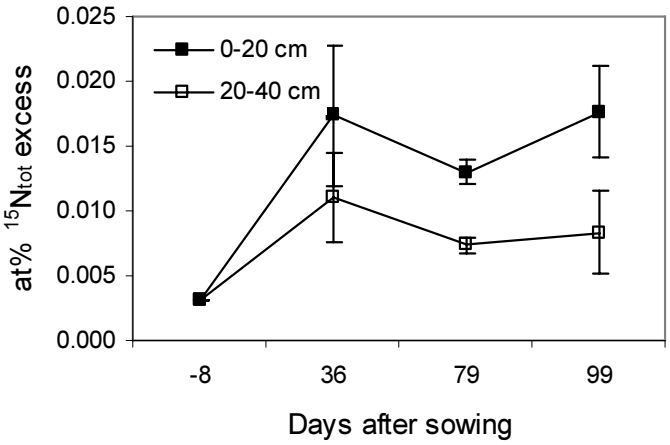

Figure 1. at % ^{15}N excess in soil at 8 days before and 36, 79 and 99 days after sowing.

Dry matter accumulation increased with DAS whereas there was a decrease in N concentration (%) in different maize parts during the growing period (Figures 2a and 2b).

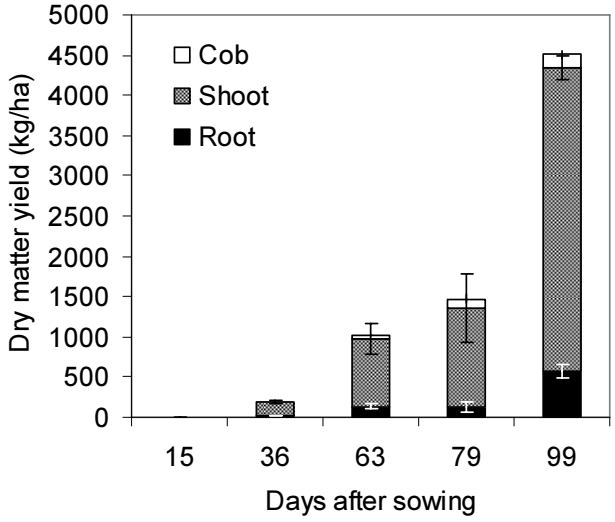

Figure 2a. Dry matter yield in different parts of maize at 15, 36, 63, 79 and 99 days after sowing.

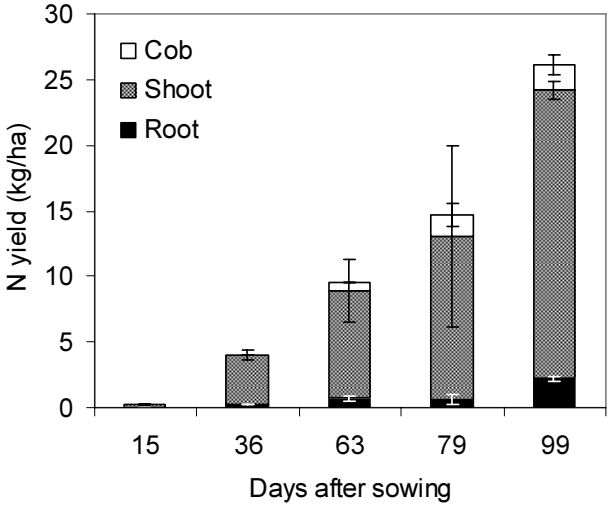

Figure 2b. Nitrogen yield in different parts of maize at 15, 36, 63, 79 and 99 days after sowing.

At final harvest, about 92 % of N taken up by maize was distributed to the aboveground parts of maize (Figure. 2b).Significant intra-plant variations ($p<0.05$) in N concentration and % ^{15}N excess were observed. Highest N concentrations were observed in cobs and lowest concentrations in roots; whereas highest enrichments with ^{15}N were recorded in shoots and lowest in roots (Figure 3).

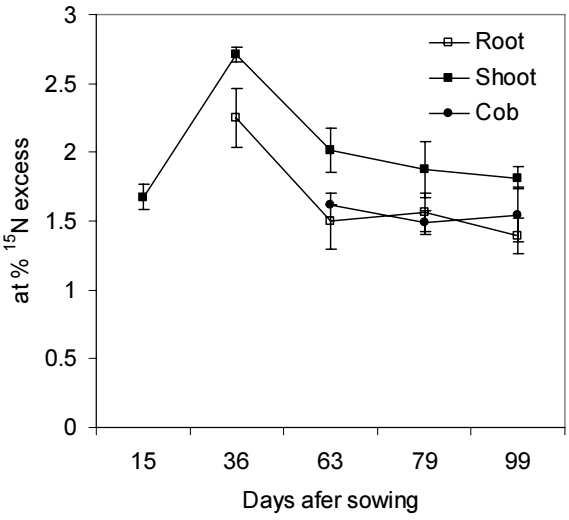

Figure 3. Intra-plant and temporal variations of at % ^{15}N excess in maize at 15, 36, 63, 79 and 99 days after sowing.

N uptake and atom % ^{15}N excess in shoots increased markedly from 15 to 36 DAS (from 0.2 to 4 kg N/ha and 1.674 to 2.708 at % ^{15}N excess, respectively). Enrichment with ^{15}N decreased after 36 DAS, with growth period in all maize parts, which can be explained by increased contribution of soil N, which is highly depleted with ^{15}N compared to the total plant N during the growth period. Using the ^{15}N-labelled fertilizer the proportion of plant N derived from soil N (Ndfs) and from fertilizer N (Ndff) was calculated. The %Ndff by maize was 33.3 %, whereas the %Ndffs was 66.7% .The fertilizer plant N recovery was about 9%.

Conclusion

Experiments with ^{15}N labeled fertilizers, though relatively expensive compared to non-isotope methods, provide precise and quantitative data on the fertilizer use efficiency. The ^{15}N method, used on the presented maize experiment, provides a direct and quick means to obtain the needed information that is valuable for the design of better fertilizer N strategies as well as for the provision of sound recommendation for the application of fertilizer N.

Photo 1. Sampling soil water for ^{15}N-nitrate analysis in the field.

Fellows

Name	Country	Area of Training	Period
Domingos Moises Chongolola Sanguvila (ANG09009)	Angola	Use of nuclear techniques in quantification of biological nitrogen fixation and rhizobial inoculation of grain legumes. The training requested is related to the IAEA's TC project entitled: Effect of Biofertilizer and Inorganic Fertilizer Uses on the and Yield of Maize and Bean in Ferralitic Soils of Huambo Grow	20 April to 20 July
Hasanuzzaman Md. (BGD07018)	Bangladesh	Training in new developments in soil water and monitoring technology including field use of hydroprobes (Neutron probe) and Time Domain Reflectometry to estimate soil moisture under saline conditions The training requested is related to the IAEA TC project BGD5026	14 April to 14 September
Gebremariam Samuel Bereket (ERI08010)	Eritrea	(i) The use of N-15 stable isotope techniques to quantify the contribution of nitrogen by grain legumes in cereal-based cropping systems (ii) N-15 detection techniques and interpretation of data (iii) the use of the carbon isotope discrimination the use of the carbon isotope discrimination techniques to evaluate crop plants tolerant to drought conditions The training requested is related to the IAEA's TC project entitled: Improving Crop Productivity and Combating Desertification (ERI5004).	6 April to 6 July

Sintim Joshua Osei (GHA07007)	Ghana	(i) Training on soil water monitoring using neutron probe (ii) Soil water balance calculations - to bring soil water data from Ghana 5032 project as part of training (iii) Processing weather data - to bring weather data from Ghana 5032 project along The training requested is related to the IAEA's TC project entitled: Enhancing Production and Use of Cassava(GHA5032)	16 April to 16 July
Kwena Kizito (KEN09015)	Kenya	1) Group training on theory and practical exercises on biological nitrogen fixation (BNF), rhizobial technology and methods of estimating soil water status (the use of neutron moisture guages and other soil water measuring devices). 2) Integrated soil, water, and nutrient management using isotope and radiation techniques. These include (i) Field measurement using neutron probe and other relevant devices, (ii) Field quantification on the use of N15 and carbon-13 for nutrient dynamics and nitrogen and water use efficiencies. (iii) Field experiments on water and nutrient interaction. (iv) synthesizing current data on maize and bean from KARI. The training requested is related to the IAEA's TC project entitled: Assessing Nutrient and Moisture Use in Major Cropping Systems (KEN5030).	13 April to 13 July
Soumare Mahamadou (MLI08002)	Mali	On the use of soil moisture measuring techniques for better management for crop productivity in Mali. The training requested is related to the IAEA's TC project entitled: Sustainable Intensification and Diversification of Sorghum Production Systems in the Southern Zone of Mali, Phase-1(MLI5021).	14 April to 14 May
Collis Mukungurutse (ZIM08006)	Zimbabwe	(i) Safe handling of P-32 labelled materials and disposal of radioactive wastes; radiation protection and safety regulations. (ii) Basics training on the principles and practical applications of P-32 isotopic exchange kinetics technique to study soil P status, its changes with the use of P nutrient sources in glasshouse and control environment experiments. Training in techniques and methods of labelling plant material and the type of experiment required. Total P analyses and isotopic measurement of P-32 activities with a liquid scintillation counter in soil and plant samples; Application rates and mode of application of P-32 fertilizer. The training requested is related to the IAEA's TC project entitled: Combating Desertification in Agricultural Drylands (ZIM5011).	14 April to 14 July

Analytical services

The Soil Science Unit performed 12024 stable isotope measurements during the year 2008 as shown in Tables 1 and 2. Most of the analyses were for supportive research and training with some 3700 for CRPs and 100 for TCPs.

Table 1. Samples measured:

	^{15}N *enriched*	^{15}N *nat. ab.*	^{13}C *nat. ab.*	^{18}O *nat. ab.*	*Total*
D1-2008	0	0	1566	0	1566
D1-5009	279	0	449	0	728
TC	66	0	0	0	66
Seibersdorf	686	783	1151	1402	4022
Total	**1031**	**783**	**3166**	**1402**	**6382**

Table 2. Measurements carried out:

(including standards, blanks, test samples, replicates)

	^{15}N *enriched*	^{15}N *nat. ab.*	^{13}C *nat. ab.*	^{18}O *nat. ab.*	*Total*
D1-2008	0	0	2446	0	2446
D1-5009	471	0	763	0	1234
TC	112	0	0	0	112
Seibersdorf	1184	2098	2638	2312	8232
Total	**1767**	**2098**	**5847**	**2312**	**12024**

External Quality Assurance

Martina Aigner

Since the year 1995 the FAO/IAEA Soil Science Unit has been organizing annual Proficiency Tests (PT) on the analysis of plant materials for (enriched) ^{15}N and since the year 2004 also for ^{13}C isotope abundance as well as for the element concentrations of nitrogen and carbon.

Due to the re-organization of the tasks implemented by the FAO/IAEA in the year 2008 the Soil Science Unit has established a new collaboration with the University of Wageningen, The Netherlands, already organizing regular PTs on ^{15}N and ^{13}C in plant materials at the natural abundance level since several years (see the International Plant-analytical Exchange Programme *IPE* on their homepage, http://www.wepal.nl/website/about_wepal/Scope.htm).

The Wageningen Evaluating Programs for Analytical Laboratories (WEPAL) is accredited for the organization of Interlaboratory Studies by the Dutch Accreditation Council RvA since April 26, 2000 (registration number R002). The accreditation is based on the ILAC-requirements (Guidelines for the requirements for the competence of providers of proficiency testing schemes, ILAC-G13:2000). The accreditation covers the quality system of the organisation as well as all the parameters mentioned in the scope.

It was agreed between the Soil Science Unit and the PT-organizer to include one ^{15}N-enriched plant material (range: 0.1 – 2.5 % 15N atom excess) per year into the IPE test sample set. A bulk amount of uniformly ^{15}N-enriched plant material was produced by the FAO/IAEA Soil Science Unit and sent to WEPAL for milling, homogenization and bottling through the routine test sample production process for PTs. This ^{15}N-enriched material was sent out together with 3 other not enriched plant materials.

In February 2008 all participants in PTs previously organized by the Soil Science Unit were invited to participate in the WEPAL IPE programme. Participants were invited to perform analysis of any determinand 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 PT in 2008 (round IPE2008.2) was covered by the IAEA (Figure 1).

Twenty-four participants that were registered in the "SSU PT scheme" in previous years were provided with the WEPAL test sample set IPE 2008.2 consisting of the four test samples of 20 g plant material each. Eleven laboratories reported isotope abundance data within the deadline,

one IAEA-participant reported only Kjeldahl-N-data. The Soil Science Unit also participated in this round of PT.

Evaluation criteria for IAEA-participants

Calculation of Z-score

For all analytical data a Z-score is calculated according to the formula:

$$z = \frac{(X - X_{mean})}{sd}$$

in which:

X = the reported value

X_{mean} = the mean of all values after outlier elimination

sd = standard deviation of all values after outlier elimination

All participants received the quarterly evaluation report 2008.2 (April-June 2008) from WEPAL providing a description of the test sample preparation, statistical evaluation criteria, outlier calculation and results of all reported analytical results performed on all determinants. Participant's performance in 15N- and 13C atom abundance analysis was acceptable, if the z-scores of the 15N-enriched test sample were within the accepted control limits:

$-2 \leq z \leq +2$ acceptable results

$-3 \leq z \leq +3$ warning (doubtful results)

$-3 > z > +3$ not acceptable (out of control limits)

Data could also be compared to the data reported to WEPAL by the IAEA-SSU.

A certificate for "successful participation" is provided to stable isotope laboratories supported by the IAEA that showed proficiency in both the isotope- *and* elementary analysis of Nitrogen (i.e. ^{15}N isotope abundance and total N analysis, i.e. N-elementary or Kjeldahl-N) and / or Carbon (i.e. ^{13}C isotope abundance and C elementary) of the ^{15}N enriched test sample.

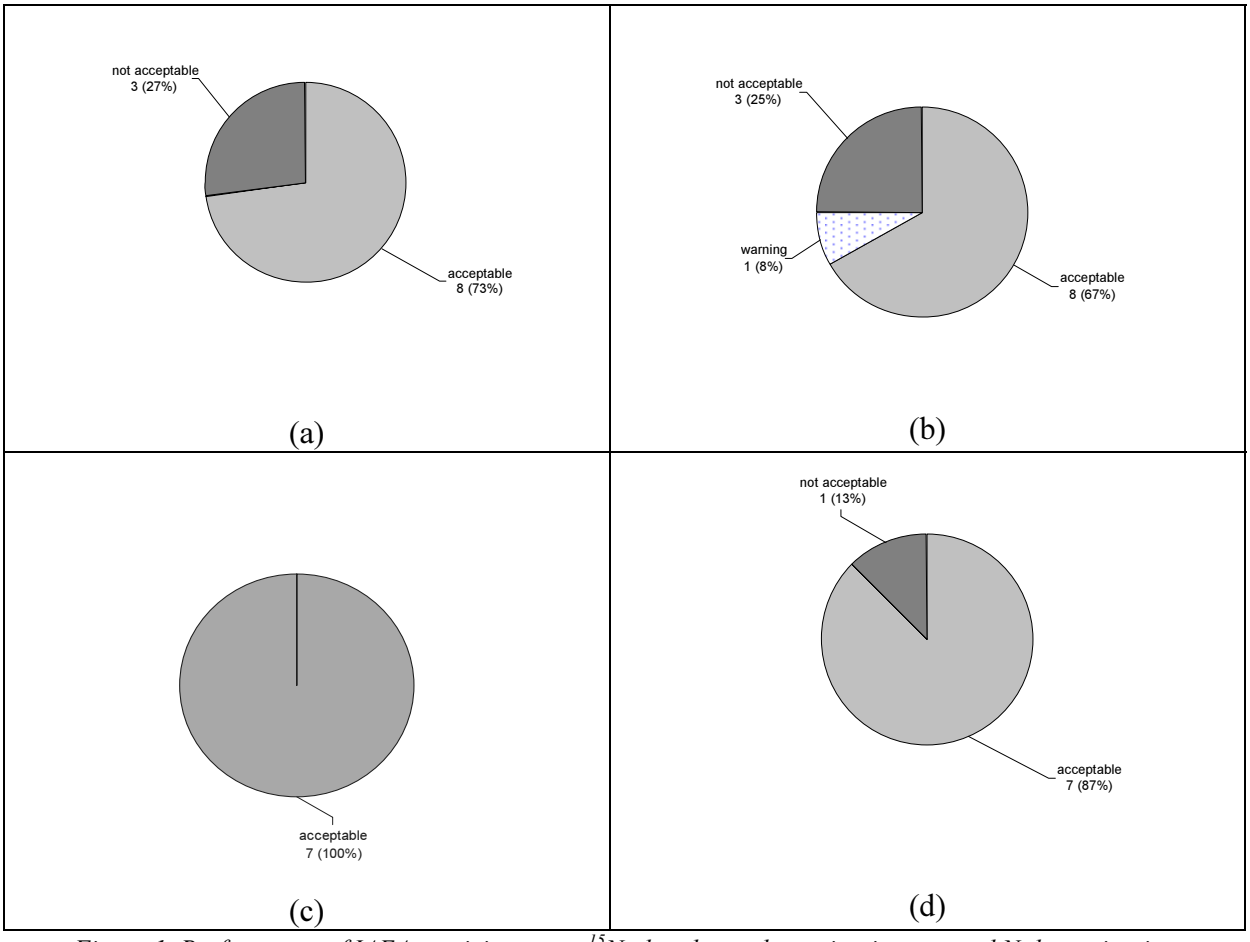

Figure 1. Performance of IAEA participants. a: ^{15}N abundance determination; c: total N determination (N-elementary and N-Kjeldahl); c: ^{13}C abundance determination; d: total C determination.

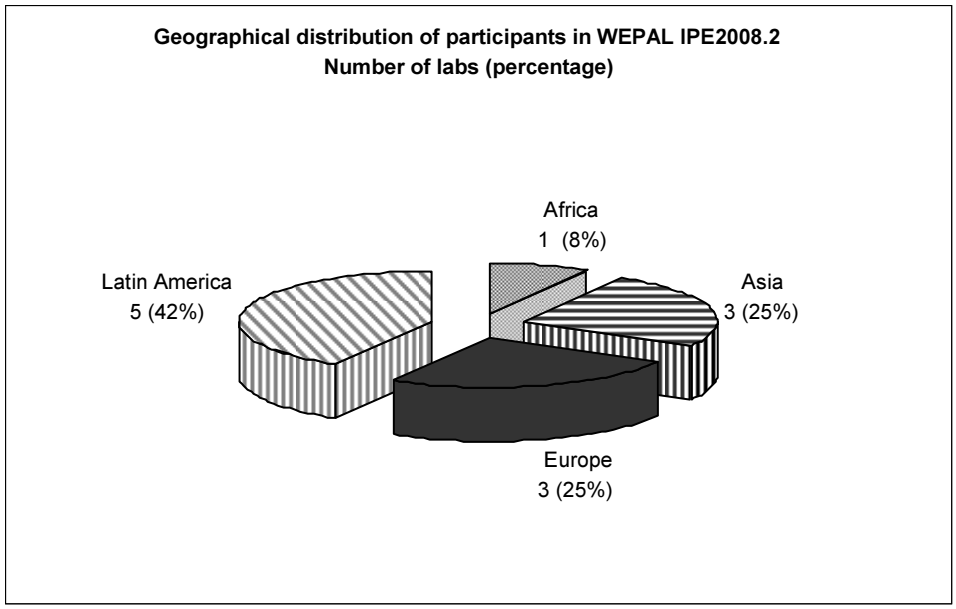

Figure 2. Geographical distribution of IAEA participants.

Conclusions

The first Joint Proficiency Test for stable isotopes in plant materials by WEPAL and IAEA was successful and will be continued in this form (Figure 2). The new PT round *IPE2009.2* has already been started and test samples were sent out in February 2009.

The big advantage of comparing analytical data to those of a large and increasing number of analytical laboratories worldwide will provide high confidence in the laboratory's analytical performance and is an invaluable tool for external quality control. It is hoped that in the future more stable isotope laboratories will make use of this opportunity to assess their analytical performance and provide evidence of the sustainable high quality of their analytical data.

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Websites

- Soil and Water Management and Crop Nutrition Section:
  http://www-naweb.iaea.org/nafa/swmn/index.html
- Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture:
  http://www-naweb.iaea.org/nafa/index.html
- FAO website: http://www.fao.org/waicent/FAOINFO/AGRICULT/Default.htm
- FAO/AGL (Land and Water Development Division):
  http://www.fao.org/ag/agl/default.stm

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