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To Our Readers

The end of 2009 is fast approaching. I would like to thank you all for the support that you have provided in your role within coordinated research projects (CRPs) or as a counterpart in technical cooperation projects (TCPs). I am also indebted to research institutions and local scientists who have provided vital support to the successful implementation of the research coordinated meeting (RCM) on managing irrigation water in China. Without your support and commitment, we would not be able to accomplish all the objectives outlined in our CRPs and TCPs for 2009. In this Newsletter, you will find interesting information on some of the activities that you and the Soil and Water Management & Crop Nutrition (SWMCN) Subprogramme have engaged in during the course of 2009 to address land and water management issues for food security and environmental sustainability.

With your continuing support and commitment, the SWMCN Subprogramme is looking forward to meeting new challenges in 2010. One of these challenges will be a development of new initiatives on soil and water management practices with the aim of providing not only sustainable food production but also enhancing soil carbon sequestration and minimizing emissions of greenhouse gases (GHG) such as carbon dioxide, nitrous oxide and methane. Two new coordinated research projects will be initiated in 2010 to investigate the impacts of mulch and non mulch and soil management on soil carbon sequestration, GHG emissions and soil quality. Another challenge is to enhance the successful outcomes of our activities in Member States.

Your active involvement in the dissemination of information to farming communities and policy makers will go a long way towards ensuring the adoption and sustainability of our collective results.

The activities of the SWMCN Subprogramme in soil and water management and crop nutrition are increasingly important not only to ensure land productivity for food security, but also to enhance soil resilience against the impacts of climate change and variability on soil erosion and degradation. This view is consistent with the increasing emphasis expressed by the international scientific and policy communities through various forums on the important role of sustainable land (soil and water) management for climate mitigation and adaptation. Examples include the Land Day organized by the UN Convention to Combat Desertification (UNCCD) on 6 June 2009 and the Copenhagen FAO Side Event on Climate Change and Food Security (10 December 2009). The SWMCN Subprogramme will need your full help and support to address sustainable land management for climate change and mitigation.

The year 2009 has brought both good and sad news for the SWMCN Subprogramme. The passing of Dr. Jerry Richie in June came as a big shock to all of us in the SWMCN Subprogramme. Jerry had been a key member of our coordinated research networks on the use of fallout radionuclides as tracers to measure soil erosion-sedimentation patterns across agricultural landscapes and also to assess the impacts of various conservation measures and land use practices on mitigating soil erosion and improving water quality in lakes, reservoirs and floodplains. We treasured his friendship, understanding and support to all team members within the CRPs that Jerry has been involved with and I am grateful that I had the opportunity to work with Jerry. We would like to extend our sincere condolences to Jerry's family and colleagues at the Agricultural Research Service, U.S. Department of Agriculture (USDA), Beltsville in their sad loss.

In November, I received the good news from Lancaster University that Professor William Davies and his team at the Lancaster Environment Centre, United Kingdom received a Queen's Anniversary Prize for Higher and Further Education Award for their work on soil-microbe-plant interactions and plant stress signalling with the ultimate aim of economically viable crop yields under water limiting conditions. This work which has been carried out as part of an IAEA- funded technical contract shows how the signals at roots in drying soils send to the shoots can help plants cope more successfully with drought and produce better yield. Our warmest Congratulations to you, William.

In celebrating the successful implementation of our activities in 2009, I would like to thank you all again for your valued contributions. I would also like to thank all of my team members in the SWMCN Subprogramme both in the SWMCN Section and the SSU for their inputs and commitment. The support of the SSU in fellowship training, analytical support to CRPs and research and development is critical to the successful achievements of the SWMCN Subprogramme. Last but not least my thanks to the Director and colleagues of the Joint FAO/IAEA Programme of Nuclear Techniques in Food and Agriculture Programme and Division for their support of the SWMCN Subprogramme. I wish you all good health and a very successful 2010.

Long Nguyen
Head
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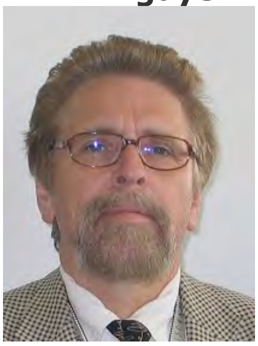
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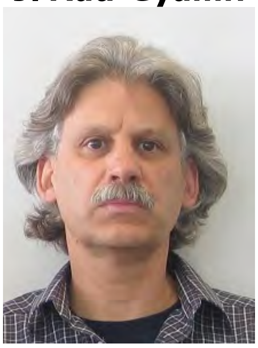
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Staff News

Ms. Patcharin Jankong joined the Soil Science Unit, FAO/IAEA Agriculture and Biotechnology Laboratory, Seibersdorf on 22 June 2009 as an intern from Thailand under the supervision of Lionel Mabit. Patcharin will be associated with field research investigations, laboratory work, research data analysis and publications related to the use of Fallout Radionuclides (FRNs) for soil erosion and sedimentation investigation in support of the SWMCN Subprogramme activities. Patcharin's previous work and study include environmental research issues focusing on pollutants analysis in the environment (e.g. soil, water, plants and fish) and soil remediation (especially the effect of rhizosphere factors such as fertilizer, bacteria, and mycorrhiza on soil phytoremediation) which she had conducted during her PhD studies at Mahidol University, Bangkok (Thailand) in collaboration with Karl-Franzen University, Graz (Austria).

Mr. Moncef Benmansour, from the Centre National de l'Energie des Sciences et des Technique Nucléaires (CNESTEN), Rabat, Morocco, joined the Soil Science Unit as a consultant for 2.5 months from 06 July to 11 September 2009. He has extensive expertise in radiometric techniques, in the use of nuclear techniques in the environment and agriculture fields and has participated in many IAEA projects (e.g. Regional TC projects and CRPs). During his period in IAEA, Moncef has been working with Lionel Mabit in Seibersdorf in soil subprogramme activities for producing a manual entitled ''Soil erosion assessment using nuclear techniques' for IAEA Member States on the use of fallout radionuclides (FRN) to investigate soil erosion and sedimentation processes. It is proposed to publish the manual as part of an IAEA Training Course Series.

Mr. Sasa Linic joined the Soil Science Unit on 8 June 2009 as a Consultant. Sasa has a Master Degree in Environmental Science (Natural Resource Management and Ecological Engineering) from University of Natural and Applied Life Sciences (BOKU), Austria and Lincoln University, New Zealand. Sasa will work with Joseph Adu-Gyamfi in the area of soil-water-plant relationship with a major focus on mechanisms of tolerance of crops to abiotic stress and crop-water productivity using isotopic tracers (^{13}C, ^{18}O and ^{2}H) and also provide support to the CRP on 'Managing irrigation water to enhance crop productivity under water limited conditions using nuclear techniques'.

Ms. Rebecca Hood joined the SWMCN Subprogramme in January 2009 as a consultant on a part time basis. Having left the Soil Science Unit in 2004, Rebecca went on to organise the Joint European Stable Isotope Users group Meeting (JESIUM 2004) in Vienna, after which she re-joined FAO-IAEA, this time in the Entomology Unit where she applied her stable isotope expertise to insects. This fruitful collaboration resulted in numerous publications in the fields of mosquitoes, fruit flies and tsetse and culminated in a manual on the Use of Stable Isotopes in Entomology. After the birth of her second child in 2006 Rebecca returned to work on the Nitrogenome Project at the University of Vienna which attempted to link microbial function to soil nitrogen processes. She currently works on developing methods for measuring greenhouse gas emissions and carbon sequestration. In addition she has been working on numerous articles and outreach materials for eventual publication.

Feature Articles

Nutrient balances in African land use systems across different spatial scales: a review of approaches, challenges and progress

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Nutrient balances are useful tools as indicators of potential land degradation and for optimizing nutrient use, and are thus highly relevant in the African context. A comprehensive literature review on nutrient balances in Africa was carried out to illustrate the main approaches, challenges, and progress, with emphasis on issues of scale. The review showed nutrient balances being widely used across the continent. The collected dataset from 57 peer-reviewed studies indicated however, that most of the balances were calculated at plot and farm scale, and generated in East-Africa. Data confirmed the expected trend of negative balances in the continent for nitrogen and potassium, where >75% of selected studies had mean values below zero. For phosphorus, only 56% of studies showed negative mean balances. Several cases with positive nutrient balances indicated that soil nutrient mining cannot be generalized across the continent. Land use systems of wealthier farmers mostly presented higher nitrogen and phosphorus balances than systems of poorer farmers ($p<0.001$). Usually plots located close to homesteads also presented higher balances than plots located further away ($p<0.05$). Partial nutrient balances were significantly higher ($p<0.001$) than full balances calculated for the same systems, but the later carried more uncertainties. A change in the magnitude of nutrient balances from plot to continental level did not show any noticeable trend which challenges prevailing assumptions that an increasing trend exists. However, methodological differences made a proper inter-scale comparison of results difficult. The review illustrated the high diversity of methods used to calculate nutrient balances and highlighted the main pitfalls, especially when nutrient flows and balances were scaled-up. Major generic problems were the arbitrary inclusion/exclusion of flows from the calculations, short evaluation periods and difficulties in setting spatial-temporal boundaries, inclusion of lateral flows and linking the balances to soil nutrient stocks. A need to properly describe the methods used and to report the estimates (i.e. using appropriate units and measuring variability and error) were also highlighted. The main challenges during scaling-up were related to the type of aggregation and internalization of nutrient flows, as well as issues of non-linearity and spatial variability, resolution and extent, which have not yet been properly addressed. In fact, gathered information showed that despite a few initiatives, scaling-up methods are still incipient. Lastly, promising technologies and recommendations to deal with these challenges were presented to assist in future research on nutrient balances at different spatial scales in Africa and worldwide.

For further details refer to the following article:

J.G. Cobo, G. Dercon, G. Cadisch, 2009. Nutrient balances in African land use systems across different spatial scales: a review of approaches, challenges and progress. Agriculture Ecosystems and Environment (in press).

Assessment of anthropogenic and geogenic radionuclides in an undisturbed Slovenian forest soil

P. Jankong[1], L. Mabit[1], P.C. Martin[2], A. Toloza[1], R. Padilla-Alvarez[2], V. Zupanc[3]

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The Challenge

The measurement of natural background radiation and anthropogenic radionuclides in soils has been carried out in many countries for several decades to establish base line data of radiation levels. Through weathering and erosive processes, the landscape redistribution of these nuclides depends on their physicochemical behaviours. So far, the knowledge of radionuclide concentration levels in Slovenia is limited to a few investigations and use of the anthropogenic ^{137}Cs radionuclide has not yet been employed as a soil tracer in Slovenia. Therefore, the purposes of this study were: (i) to collect inventory information of naturally occurring isotopes (^{40}K, ^{226}Ra, ^{232}Th, ^{235}U and ^{238}U) and man-made radionuclides (^{137}Cs) as well as their depth/vertical distribution in soil; (ii) to complete radio-ecological surveys in Slovenia and provide information regarding the external dose-rate based on the depth distributions of the gamma emitters in the soil of the study area; (iii) to undertake a complementary characterization of the chemical composition of the soil, in addition to revealing the major differences in the abundance of some elements through the soil depth profile; and (iv) to establish a reference inventory value of ^{137}Cs fallout in order to prepare a future investigation of ^{137}Cs as a soil tracer in the Slovenian agro-environment.

Experimental design and preliminary results

Twenty soil profiles (0-40 cm) divided into four different increments of 10 cm were collected in an undisturbed forest in Pomurje, east Slovenia using a 40 × 30 m grid and a bulk density cylinder to estimate the initial fallout of ^{137}Cs and also to establish the natural level of radioactivity in this area, taking into account the activities level of ^{40}K, ^{226}Ra, ^{232}Th, ^{235}U and ^{238}U in soil and their depth distributions. From this information, radium equivalent activity (Ra_{eq}), the gamma-absorbed dose rate (D) and annual effective dose rate (E) has been calculated for this forested site. The average mass activity concentrations for depth increments of ^{137}Cs, ^{40}K, ^{226}Ra, ^{232}Th, ^{235}U and ^{238}U are presented in Figure 1, representing a total average areal activity of 7316 ± 2525 Bq m^{-2}, 326745 ± 24572 Bq m^{-2}, 26517 ± 1,720 Bq m^{-2}, 30280 ± 2172 Bq m^{-2}, 4190 ± 290 Bq m^{-2} and 33504 ± 6412 Bq m^{-2}, respectively, for ^{137}Cs, ^{40}K, ^{226}Ra, ^{232}Th, ^{235}U and ^{238}U. These results showed that on average, the top soil mass activity of ^{40}K is 7 to 8 times higher than ^{137}Cs mass activity. Unlike the constant vertical distribution of other naturally occurring radionuclides (^{226}Ra, ^{232}Th, ^{235}U and ^{238}U), the ^{40}K mass activity increased with depth (Figure 1).

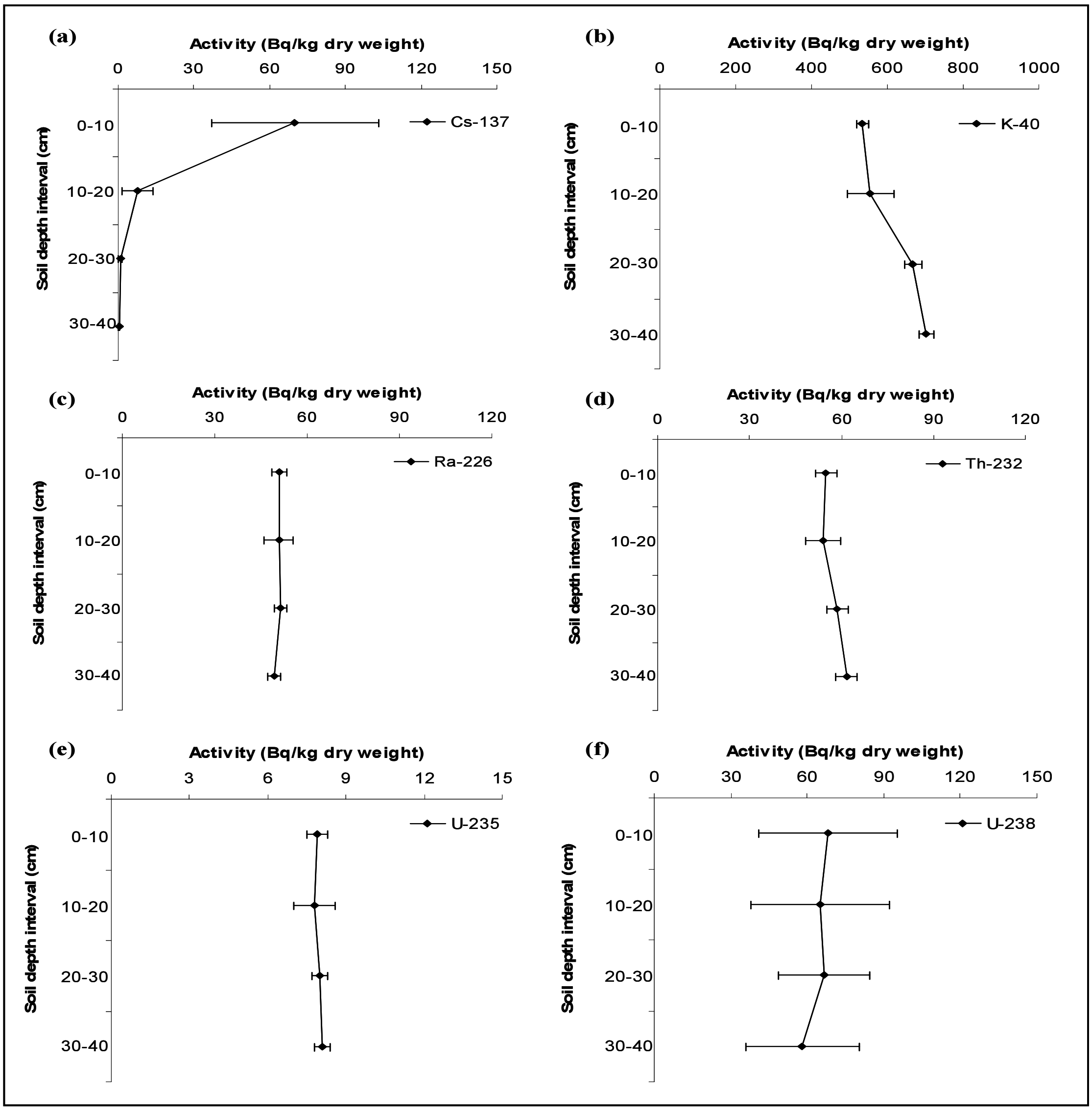

Figure 1. Vertical distribution of mass activity of ^{137}Cs (a`), ^{40}K (b), ^{226}Ra (c), ^{232}Th (d), ^{235}U (e), and ^{238}U (f). (Data presented as mean ± SD (n = 20)).

Based on this observation, the radium equivalent activity (167 ± 7 to 187 ± 5 Bq kg^{-1}) and the external gamma dose rate (79 ± 3 to 90 ± 2 nGy h^{-1}) which generates the annual effective dose of natural occurring radioistopes (97 ± 4 to 110 ± 3 µSv a^{-1}) increase with depth of 10 % and 11 % respectively (Table 1). The results obtained from this study show that the values of Ra_{eq} and E are below the limit of 370 Bq kg^{-1} and 1.0 mSv a^{-1} recommended by UNSCEAR (1982) and ICPR (1991), respectively. However, the external gamma dose rate (D) that ranged from 79 ± 3 to 90 ± 2 nGy h^{-1} is higher than the world average set at 57 nGy h^{-1} by UNSCEAR (2000).

Table 1. Assessment of radium equivalent activity, external gamma dose rate and annual effective dose in the study area.

Soil depth interval (cm)	Radium equivalent activity Ra_{eq} (Bg/kg)	External gamma dose rate D (nGy/h)		Annual effective dose E (µSv/a)	
		Naturally occurring radionuclides*	^{137}Cs	Naturally occurring radionuclides [a]	^{137}Cs
0-10	167 ± 7**	79 ± 3	8.2 ± 3.9	97 ± 4	10 ± 5
10-20	168 ± 15	80 ± 7	0.9 ± 0.7	98 ± 9	1.1 ± 0.9
20-30	182 ± 7	87 ± 3	0.12 ±	107 ± 4	0.15 ± 0.11
30-40	187 ± 5	90 ± 2	0.06 ±	110 ± 3	0.07 ± 0.04

*Naturally Occurring Radionuclides = ^{232}Th, ^{40}K and ^{226}Ra, ** Mean ± SD, n = 2*

To achieve a complete characterization of the soil, the mass fractions of 51 elements were determined by Energy dispersive X-Ray fluorescence (EDXRF) analysis. The XRF results (Table 2) showed a similar profile shape for the total concentration of K, Th, and U to their radioactive component (^{40}K, ^{232}Th, ^{235}U and ^{238}U). The 30-40 cm soil layer is apparently enriched in Al and Fe. It was also observed that the total K and Mg contents behave in the same way increasing with depth. The specific vertical migration of these elements in soil can be associated with a podzolisation processes that could take place under the acidic condition of the forest soil. Assessment of the initial ^{137}Cs fallout in undisturbed forest site using nuclear techniques, is a first step to investigate soil redistribution in Slovenian agro-environment. The depth distribution of ^{137}Cs in this undisturbed site showed an exponential decreased with depth (Figure 1). As expected for a reference site, this will be used for future soil redistribution investigations. 98 % of ^{137}Cs is concentrated in the first 20 cm of the soil and the activity in the 30-40 cm soil layer was below detection limit.

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Table 2. Concentration of some elements in the forest soil obtained by XRF technique.

Soil interval (cm)	Concentration (µg/g)*						
	Si	Al	Fe	K	Mg	Th	U
0-10	(280 ± 8) ×10^3	(72.3 ± 2.1) ×10^3	(30.9 ± 1.2) ×10^3	(16.6 ± 0.4) ×10^3	(9.54 ± 0.78) ×10^3	14.1 ± 0.7	4.99 ± 0.77
10-20	(284 ± 4) ×10^3	(81.7 ± 2.6) ×10^3	(35.4 ± 1.6) ×10^3	(18.4 ± 0.4) ×10^3	(12.0 ± 0.7) ×10^3	14.5 ± 0.8	4.27 ± 1.20
20-30	(273 ± 4) ×10^3	(90.5 ± 1.5) ×10^3	(39.9 ± 1.7) ×10^3	(20.4 ± 0.2) ×10^3	(14.6 ± 0.6) ×10^3	14.6 ± 0.8	3.83 ± 0.70
30-40	(262 ± 7) ×10^3	(94.2 ± 1.6) ×10^3	(46.4 ± 2.1) ×10^3	(20.9 ± 0.2) ×10^3	(15.8 ± 0.7) ×10^3	16.6 ± 0.5	5.53 ± 0.83

** Data are presented as mean ± SD, n = 20*

Conclusion

The results showed that of the profile activities of the naturally occurring radionuclides only ^{40}K exhibits variation in distribution with depth. As expected in classical undisturbed soils, a typical decreasing exponential distribution has been observed for ^{137}Cs. The D value is approximately 30 to 40 % more than the global average. The base-line level of ^{137}Cs in this Slovenian forest soil was established at 7316 ± 2525 Bq m^{-2} with a coefficient of variation of 34 % and this value will be used as an initial inventory for future ^{137}Cs investigation to assess soil erosion and sedimentation processes.

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A first investigation using joint radioactive tracers (137Cs & 210Pbex) to document soil redistribution rates in Morocco

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The challenge

Despite the severity of land degradation in Morocco, there is only limited data available on the actual magnitude of soil erosion rates. Since the mid 1990s, few studies have reported the use of the ^{137}Cs approach and the use of excess lead-210 ($^{210}Pb_{ex}$) as a soil tracer has never been tested in Morocco. The objectives of this innovative investigation were to test the combined use of ^{137}Cs and $^{210}Pb_{ex}$ to assess long-term soil redistribution rates and to establish a sediment budget for a Moroccan agricultural field using both a classical assessment of soil redistribution rates and spatialization tools.

Experimental design

The site under investigation is a one hectare agricultural field in a semiarid climate, located in Marchouch, 68 km south east of Rabat (Morocco). The soil in the field is a clay soil with a mean slope gradient of 17%. The land use is dominated by cereals under conventional tillage (plough depth ~ 16 cm). In the experimental site, 50 soil core samples were collected along 5 parallel transects.

The initial ^{137}Cs and ^{210}Pb fallout were assessed through 12 core samples collected in an undisturbed pasture located 3 km from the studied field.

Soil samples were dried, sieved and homogenized prior to measuring ^{137}Cs, ^{210}Pb and ^{226}Ra by γ-spectrometry using a HPGe 'N Type' detector (45 % efficiency). Areal activities of ^{137}Cs and $^{210}Pb_{ex}$ were converted into soil redistribution rates using the conversion model MBM 2.

Soil redistribution rates obtained from ^{137}Cs and ^{210}Pb isotopes were analyzed using a geostatistic approach and a classical interpolation concept (inverse distance weighting (IDW)). Applying the protocol of Mabit and Bernard (2007), maps of soil redistribution were established and a sediment budget for the whole field was calculated using the GIS Surfer 8.00 package.

Main results

Vertical distribution and inventories of ^{137}Cs and $^{210}Pb_{ex}$

(i) For the reference site, the vertical distributions associated with both radionuclides were similar and concentrated in the top 10 cm, with a clear exponential decrease with depth. The ^{137}Cs concentration was highest at the surface (0-3 cm) with a value of 13 q kg^{-1} while the $^{210}Pb_{ex}$ concentration was 25 Bq kg^{-1} at the soil surface. The reference inventory values were estimated at 3305 Bq m^{-2} (n = 12; CV of 30%) and 1445 Bq m^{-2} (n = 12; CV of 18%) for $^{210}Pb_{ex}$ and ^{137}Cs, respectively.

(ii) For the cultivated site, as a result of tillage, the concentrations of both radionuclides were almost uniform throughout the plough layer (~ 16 cm) ranging from 1.9 to 5.9 Bq kg^{-1} and from 2.2 to 16.7 Bq kg^{-1} for ^{137}Cs and $^{210}Pb_{ex}$, respectively. Along the transects, the ^{137}Cs areal activities ranged from 600 to 1900 Bq m^{-2} and the $^{210}Pb_{ex}$ areal activities ranged from 1700 to 5000 Bq m^{-2}. The uncertainties associated with $^{210}Pb_{ex}$ are generally higher than those corresponding to the ^{137}Cs due to the low intensity of ^{210}Pb gamma rays and the background contribution in this energy range.

Classical assessment of soil redistribution rates as derived from ^{137}Cs and $^{210}Pb_{ex}$

From ^{137}Cs measurements and the use of the conversion Mass Balance Model II (MBM II), the erosion rates (over ~50 years) in the field study ranged from 4 to 30 t ha^{-1} a^{-1}. Eroded zones in the upslope part of the field represented 82% of the total area, while soil deposition occurred in the lower slope position on the remaining 18% of the area. From $^{210}Pb_{ex}$ data, the erosion rates (over ~ 100 years) ranged from 8 to 27 t ha^{-1} a^{-1}. The eroded and depositional areas represent 84% and 16%, respectively. Using the average values of transects, the results provided by ^{137}Cs and $^{210}Pb_{ex}$ techniques were comparable (Table 1).

Table 1. Sediment budget and soil redistribution assessment from ^{137}Cs and $^{210}Pb_{ex}$ using a simplified approach (Benmansour *et al.,* 2010).

Soil redistribution magnitude	^{137}Cs	$^{210}Pb_{ex}$
Mean erosion (t ha^{-1} a^{-1})	17.9	15.0
Mean deposition (t ha^{-1} a^{-1})	6.3	4.1
Gross erosion (t ha^{-1} a^{-1})	15.4	12.9
Gross deposition (t ha^{-1} a^{-1})	1.2	0.8
Net erosion (t ha^{-1} a^{-1})	14.3	12.1
Sediment delivery ratio (%)	92%	93%

Additional soil redistribution evaluation using spatialization approach

Experimental variograms for soil redistribution rates calculated from the data provided by the ^{137}Cs and $^{210}Pb_{ex}$ results were fitted. Following the optimization of variographic parameters and cross-validation analysis, the geostatistical study of the data reported a very weak autocorrelation with a high nugget effect, a non significant coefficient of correlation (r^2) < 0.4 and a low ratio scale to sill close to 0.4. As suggested by Mabit and Bernard (2007) in the case of weak or absent spatial structure, the use of classical methods of interpolation is recommended. Therefore, a simple spatialization of the data using IDW2 was used to map soil redistribution based on ^{137}Cs and $^{210}Pb_{ex}$ results. Contour maps and soil redistribution budgets were established using the IDW2 (Figure 1 and Table 2). Similar results regarding soil redistribution magnitude were obtained for ^{137}Cs and $^{210}Pb_{ex}$. The high sediment delivery ratio (SDR), corresponding to the net/gross erosion ratio rate which was obtained using ^{137}Cs and $^{210}Pb_{ex}$ approaches showed that most of the mobilized sediment was moved out of the field.

This is a logical result based on the fact that soil cultivation is conducted along the main slope direction, on a slope that reaches 17%. This high SDR also reflects the fact that using ^{137}Cs and $^{210}Pb_{ex}$ techniques the eroded area represents 93 to 96% of the field surface and the deposition area covers only 7 to 4%.

Table 2. Sediment budget and soil redistribution assessment for (A) ^{137}Cs and (B) $^{210}Pb_{ex}$ using IDW2 interpolation.

Soil redistribution magnitude	A	B
Mean erosion (t ha^{-1} a^{-1})	13.1	11
Mean deposition (t ha^{-1} a^{-1})	3.5	3
Gross erosion (t ha^{-1} a^{-1})	11	10.5
Gross deposition (t ha^{-1} a^{-1})	0.3	0.1
Net erosion (t ha^{-1} a^{-1})	11.7	10
Sediment delivery ratio (%)	94	95

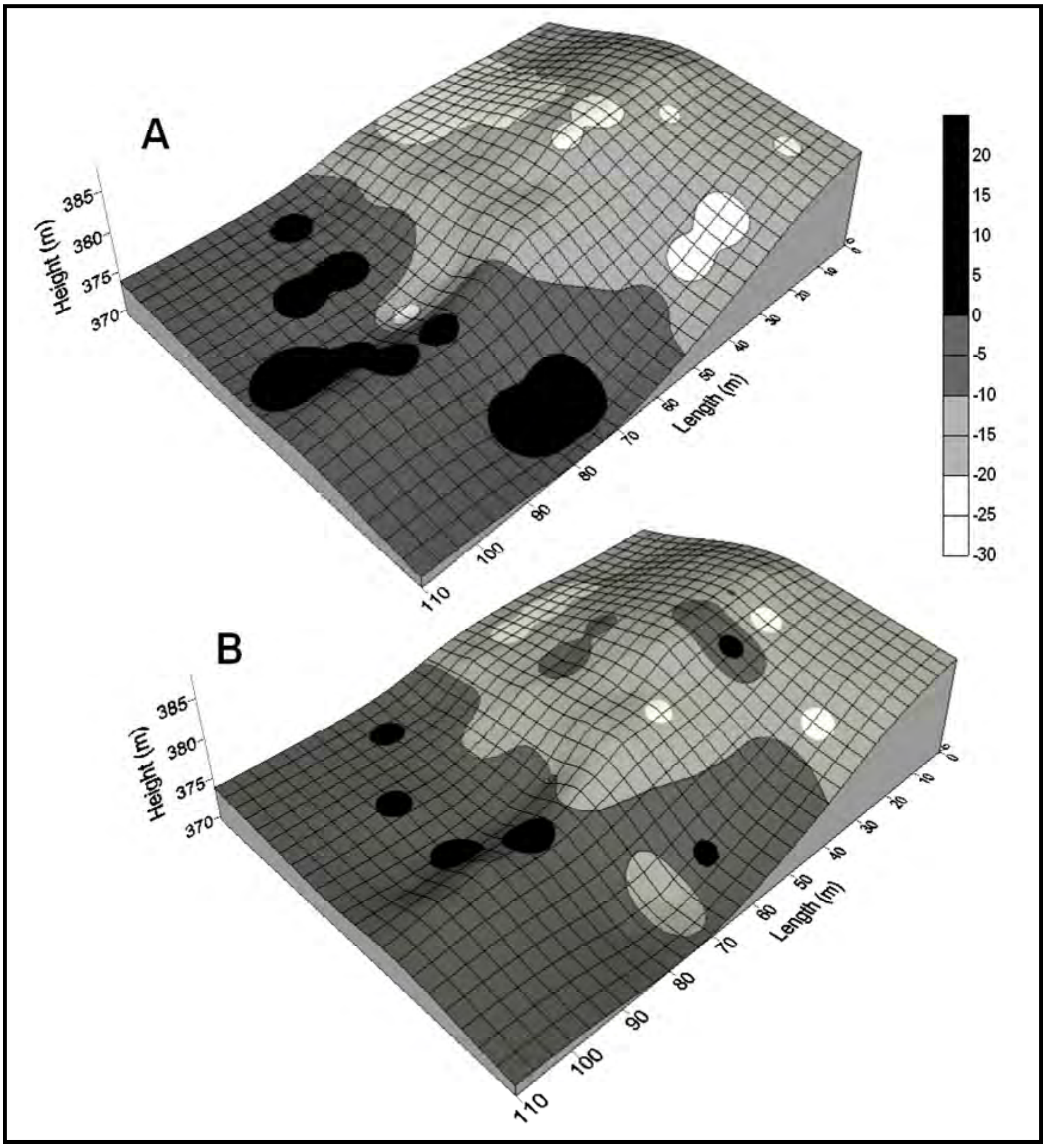

Figure 1. Maps of soil redistribution for (A) ^{137}Cs and (B) $^{210}Pb_{ex}$ using IDW2 (t ha^{-1} a^{-1}).

Conclusion

This study illustrates the potential benefit of the combined use of fallout ^{137}Cs and $^{210}Pb_{ex}$ and GIS to estimate long-term soil redistribution rates and to establish sediment budget of agricultural fields in Morocco. Under the experimental condition, the soil redistribution rates generated by the ^{137}Cs and $^{210}Pb_{ex}$ techniques using the simplified approach (MBM2 without interpolation of the data set) and the spatialization of the data were in the same order of magnitude. The relatively high erosion and low deposition rates obtained for this field can be attributed to the steep slope (slope that can reaches 17%) and to the soil cultivation (tillage) in the direction of the slope.

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Can yields and water use efficiency be improved by shading? Isotopes can help solve the question.

By Shabtai (Shep) Cohen

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Agricultural Research Organization, Ministry of Agriculture and Rural Development, Bet Dagan, Israel

Greenhouses produce is often of much better quality than field grown produce, and often growers in indoor intensive agricultural production can produce higher yields than their colleagues outdoors. But if light powers photosynthesis, or plant productivity, shouldn't the reduction in radiation incurred in the greenhouse decrease productivity? In Holland, a leader in greenhouse agriculture, growers clean cladding continuously just for that reason, in order to get the maximum light.

In semi-arid climates solar radiation levels far exceed those in Europe and water, not light, is often the limiting factor for crop production. In this case solar radiation heats the crop, causing water stress which forces the plants to decrease their water loss and productivity. But if the plant is well irrigated should it suffer from excess sunlight? It turns out that in many cases, especially in tree crops, even a well irrigated plant will show signs of water stress at high radiation levels in arid climates. This is the idea behind this IAEA-partially funded research project which investigated the plant's physiology, water use and yields for different shading treatments in Israel's semi-arid, high solar radiation, summer climate. Carbon isotope ratios served as a tracer to track the physiological changes in the leaves that accompany the changes in water use and productivity.

Productivity of citrus trees, which have well developed foliage on a limited hydraulic frame, increases significantly due to shading. This increase was always accompanied by a decrease in the ratio of C13 to C12, indicating that the small pores on the leaves, called stomata, were more open in the shade. Tree and crop water use was similar to that outside because of this response. Overall water use efficiency thus increased in the shade. Similar, results were obtained in shading trials with apple trees and banana plants.

Peppers grown under screens in arid southern Israel are irrigated with poor quality water and often suffer from accumulations of salinity in the soil. A trial with different irrigation strategies showed that when the plant suffered from high salinity the pores also closed and the carbon isotope ratios showed clear and unambiguous indications of this.

These results show the usefulness of carbon isotope testing for finding differences in water relations of plants in shading, irrigation and other treatments. We found that processing of leaves for isotopic analysis is easy compared to the field measurements needed for determining daily courses of leaf physiology and yields. If properly mixed, leaf samples from several trees can be combined and the variance in the isotopic ratios obtained from different plots will be very small.

Shading effects on yield and water use efficiency by green peppers (a) and bananas (b)

This means that with three or four samples from each treatment we get a very precise isotopic signal, and since most labs charge approximately $10 per analysis the analysis is relatively cheap. We have therefore begun to include carbon isotope analyses in all our irrigation trials.

Following is a case in point. In this year's irrigation trials in a persimmon orchard a malfunction in the irrigation system at the beginning of the season led to a full 24 hours of irrigation (and a lot of extra water) in our experimental plots. This may invalidate the full year of results, which means significant financial cost due to the need for another year of the trial. Last year's isotope results showed the treatment differences clearly and this year's results should give us an indication if the treatments were effective this year, in which case we can trust the yield results.

Another case is our current study of the use of cytokinins in the irrigation water to influence water relations. The concentrations we used were recommended by a chemical importer and used by the farmers without proper experimentation. Our experiments showed that these concentrations had no significant impact on water relations or yield in normal and deficit irrigation treatments. Sure enough, the carbon isotope signal showed clear signals for irrigation levels and no influence of cytokinin.

In conclusion, this project helped to establish that the relationship between $\delta C13$ and shading is consistent. The excellent resolution and precision of the measurements obtained with the field collection techniques used and the lab that did the processing indicate that this measure is a relatively cheap and accurate way to monitor differences in shading intensity and irrigation level.

SWMCN Seminar Series

FAO/IAEA Seminar
Biochar carbon negative Amazonian treasure - 'Cool Farming!'

By Rebecca Hood-Nowotny

SWMCN Section, Joint FAO/IAEA Division

Rebecca Hood joined the SWMCN Subprogramme in January 2009 as a consultant. She currently works on developing methods for measuring greenhouse gas emissions and carbon sequestration

ABSTRACT

Carbon mitigation strategies and mechanisms have been globally implemented in an attempt to prevent catastrophic climate change. Kyoto targets require reductions in greenhouse gas emissions and increases in carbon sequestration. Although a number of carbon neutral technologies have been adopted such as bio-fuel and alternative energies, these currently fail to meet global requirements. An innovative and rediscovered carbon negative strategy is biochar production and soil incorporation. Biochar production is a variant of bio-energy production, which yields energy and a biochar (charcoal) product which when added to soil locks away carbon for millennia. Biochar incorporation into soil has also been shown to double crop yields and decrease greenhouse gas emissions in low fertility soils. Scenario analysis has suggested that biochar sequestration could offset up to two thirds of the global annual net CO_2 accumulation (15 Pg C a^{-1}). Ironically ancient Amazonian people knew of the benefits of biochar, cultivating highly fertile Terra Pretas (Black Soils) by incorporation of char into their soils (Lehmann 2007).

Biochar is formed by partial combustion or pyrolysis of plant derived biomass or waste- stream products, yielding a continuum of black carbon (BC) compounds. It is biochar's aromatic-macromolecular structure that renders it more recalcitrant to microbial decomposition than uncharred organic matter and makes it a potential long-term carbon sink. Evidence from ancient Terra Preta and carbon dating suggest that biochar has a mean residence time in the range of 1000-10 000 years. To put this in perspective, when un-charred organic matter is added to the soil it is mineralized within months with a small portion of the carbon stabilized for hundreds of years. Another problem is that the application of large amounts of un-charred carbon to the soil can cause immobilisation of valuable inorganic nitrogen, leading to reductions in crop yield due to nitrogen deficiency. Biochar addition to soil does not cause significant nitrogen immobilisation because it is not assimilated by the soil microbial biomass.

Biochar addition has been shown to improve soil fertility, substantially increasing biomass production in tropical soils (Lehmann 2007, Steiner *et al*., 2006) probably due to the associated increase in soil cation exchange capacity (Liang *et al.,* 2006). Preliminary greenhouse experiment results suggest that the presence of biochar may reduce emissions of two potent greenhouse gases, nitrous oxide and methane (Rondon 2005).

The benefits of adding Biochar to low cation exchange capacity tropical soils are clear from the success of the fertile Terra Pretas and recent experiments (Glaser *et al*., 2002, Steiner *et al*., 2006). However for Biochar application to become an acceptable routine agronomic practice and have a major impact on global carbon budgets, a more detailed scientific understanding of the consequences of Biochar addition to soil is required.

Stable isotopes have and will play a key role in unravelling the complex chemical and physical interactions and benefits of Biochar. Stable isotope techniques allow the direct tracing of the pathways and processes that account for the environmental and nutrient benefits of Biochar. For example using ^{15}N labelled fertilizers, it is possible to directly trace the fate of applied nitrogen and calculate nitrogen use efficiency on addition of fertilizer and Biochar. It is also possible to study the effect of Biochar addition on the fundamental soil processes of nitrogen mineralization and nitrification using ^{15}N isotope dilution techniques. In addition it is possible to study the mechanisms associated with the reduction in potent greenhouse gas emissions such as nitrous oxide. Carbon isotopes enable us to unravel the carbon side of the story; recent work using carbon isotopes has shown that the carbon added as Biochar is highly resistant to soil microbial attack and therefore acts as an extremely long term carbon sink in soils. Using the isotopes of hydrogen and oxygen it will also be possible to determine the impact of Biochar on soil-water interactions.

The beauty of isotopic techniques is that they enable us to study soil processes in policy relevant time frames over seasons rather than decades, which means policy makers are armed with sufficient knowledge to make informed decisions about national and international carbon policies, which will ultimately determine the future of the planet.

AquaCrop for Agricultural Water Management

By Lee Heng

SWMCN Section, Joint FAO/IAEA Division

Lee Heng joined the Agency in June 2007 in the Soil and Water & Crop Nutrition (SWMCN) Section as a soil scientist. She currently provides technical support for both CRPs and TCPs in the area of soil-water-nutrient-crop interaction.

ABSTRACT

AquaCrop is a crop water productivity model developed by FAO. It resulted from the revision and update of the FAO Irrigation and Drainage Paper No. 33 'Yield Response to Water' (Doorenbos and Kassam, 1979), for estimating the yield response to water.

AquaCrop is particularly suited to addressing conditions where water is a key limiting factor in crop production. It is a water-driven model, i.e. crop growth and production are driven by the amount of water transpired (Tr) using a conservative parameter—biomass water use efficiency (or water productivity), normalized for atmospheric evaporative demand and carbon dioxide concentration. This normalization makes AquaCrop applicable to diverse locations and seasons, with the capability of predicting crop responses under future climate scenarios. AquaCrop attempts to balance accuracy, simplicity, and robustness. It uses a relatively small number of parameters and input variables requiring simple methods for their determination.

Some of the applications of AquaCrop include: (i) assessing water-limited, attainable crop yields at a given geographical location; (ii) comparing attainable yields against actual yields of a field, farm, or region, to identify the yield gap and the constraints limiting crop production - benchmarking tool; and (iii) developing irrigation schedules for maximum production for different climate scenarios.

During this presentation, case studies using maize and soybean crops and economic optimization under deficit irrigation in cotton production in Spain will be presented. Demonstration on the use of the software will also be given.

Non FAO/IAEA Seminar Use of Fallout Radionuclides at Basel University, 14th October 2009, Basel, Switzerland

By Lionel Mabit (Soil Science Unit FAO/IAEA Agriculture and Biotechnology Laboratory)

Lionel Mabit was invited as the guest speaker for the seminar course series *Kolloquien der Geographie – HS 2009* by the Department of Environmental Sciences, Institute of Environmental Geosciences, Basel University (Switzerland).

The main aim of his seminar entitled '*The use of fallout radionuclides (FRNs) to assess erosion and sedimentation processes from field to basin scale'* was to highlight various tools and protocols to upscale the use of FRNs to the watershed and basin scale.

After an introduction on soil degradation and a brief review of the advantages and limitations of using ^{137}Cs, ^{210}Pb and ^{7}Be as soil tracers, three examples were presented to illustrate FRNs investigations for establishing soil redistribution from field to basin scale.

- The first example looked at a study carried out in Quebec, Canada in a small 2.16 ha field. A full sediment budget (gross erosion, net erosion and sediment delivery ratio) was presented using ^{137}Cs, geostatistics and classical interpolation methodologies. A simple protocol was presented taking into account the spatial autocorrelation of the data set (caesium activity and soil movement rates).
- The second example, a study implemented in a 180 ha French watershed using ^{137}Cs and geostatistics approaches illustrated how spatialization tools allow the establishment of soil redistribution and a sediment budget at the watershed scale.
- The third example was a case study highlighting the support provided by the geographical information system (GIS) in the use of ^{137}Cs to evaluate a full sediment budget of the Boyer River watershed, a large Canadian basin of 217 km^2. GIS was used to build an oriented sampling strategy to select representative agricultural fields in the basin for analysis using ^{137}Cs methodology, taking into account the land use and soil-slope combinations divided into isosectors. The result of the sediment production of the different isosectors and a full sediment production at the basin scale was presented and risk areas identified.

This presentation also gave a selective overview of current and previous research activities of the Soil Science Unit (SSU) of the Joint FAO/IAEADivision of Nuclear Techniques in Food and Agriculture.

Technical Cooperation Projects

Operational Projects and Technical Officers responsible for implementation

Project Number	Title	Technical Officer
AFG5003	Sustainable Increase in Crop Production in Afghanistan	Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
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	Adu-Gyamfi, Joseph Jackson in collaboration with the Plant Breeding and Genetics Section
BKF5007	Improving Voandzou and Sesame Based Cropping Systems Through the Use of Integrated Isotopic and Nuclear Techniques	Sakadevan, Karuppan in collaboration with the Plant Breeding and Genetics Section
CHI5048	Integrated Watershed Management for the Sustainability of Agricultural Lands	Mabit, Lionel in collaboration with the Food and Environmental Protection Section
CMR5016	Development of N and P fertilizer management for Sustainable Intensification of Agricultural Production in Cameroon	Heng, Lee Kheng
ECU5024	Improving Productivity of the African Palm through Better Fertilization and Water Management Practices	Dercon, Gerd
ECU5026	Improving the Efficiency of Irrigation in the Rio Chota Sub-Basin	Sakadevan, Karuppan
ELS8009	Study of Sedimentation in the Reservoirs of the Four CEL Hydroelectric Power Stations	Dercon, Gerd
ERI5004	Improving Crop Productivity and Combating Desertification	Adu-Gyamfi, Joseph Jackson/ Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
HAI5003	Enhancing Crop Productivity through the Application of Isotope Nuclear Techniques	Sakadevan, Karuppan in collaboration with the Food and Environmental Protection Section
INS5035	Application of Nuclear Techniques for Screening and Improving Cash Crop Plants in Coastal Saline Lands	Dercon, Gerd in collaboration with the Plant Breeding and Genetics Section
INS5037	Applying Nuclear Techniques for Screening and Improving Cash Crop Plants in Coastal Saline Lands	Sakadevan, Karuppan in collaboration with the Plant Breeding and Genetics Section
IRQ5017	Optimization of Land Productivity through the Application of Nuclear Techniques and Combined Technologies	Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
IVC5031	Improving Plantain and Cassava Yields through the Use of Legume Cover Crops	Hardarson, Gudni
KEN5030	Assessing Nutrient and Moisture Use in Major Cropping Systems	Heng, Lee Kheng

Project Number	Title	Technical Officer
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
MLW4002	Supporting Capacity Building in Nuclear Science and Technology	Heng, Lee Kheng
MON5015	Implementation of the Fallout Radionuclide Technique for Erosion Measurement	Dercon, Gerd
MOZ5003	Sustaining the Management of Soil Fertility	Dercon, Gerd
NAM5009	Using Mutation Breeding and Integrated Soil Plant Management Techniques to Develop Sustainable, High Yielding and Drought Resistant Crops	Heng, Lee Kheng in collaboration with the Plant Breeding and Genetics Section
NIC8012	Applying Nuclear Techniques for the Development of a Management Plan for the Watershed of the Great Lakes	Dercon, Gerd
QAT5002	Developing Biosaline Agriculture in Salt-affected Areas in Qatar	Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
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
RLA5052	Improving Soil Fertility and Crop Management for Sustainable Food Security and Enhanced Income of Resource-Poor Farmers (ARCAL CI)	Sakadevan, Karuppan
RLA5053	Implementing a Diagnosis System to Assess the Impact of Pesticide Contamination in Food and Environmental Compartments at a Catchment Scale in the Latin American and Caribbean (LAC) Region (ARCAL CII)	Dercon, Gerd in collaboration with the Food and Environmental Protection Section
SAU5003	Improving Fertilization under Saline Conditions for Sustainable Crop Production	Nguyen, Minh-Long in collaboration with the Plant Breeding and Genetics Section
SEN5030	Integrated Approach to Develop Sustainable Agriculture in Senegal	Dercon, Gerd in collaboration with the Plant Breeding and Genetics Section
SEY5004	Developing Improved Nutrient Management Practices Using Nuclear and Related Techniques for Enhancing Sustainable Agricultural Productivity	Heng, Lee Kheng
SIL5008	Contribution of Nitrogen Fixing Legumes to Soil Fertility in Rice-based Cropping Systems	Hardarson, Gudni
SIL5012	Managing Irrigation Water for a Dry Season Sorghum/Legume Intercropping System for Income Generation and Soil Health	Adu-Gyamfi, Joseph Jackson

Project Number	Title	Technical Officer
SRL5038	Application of Isotope Techniques for Soil Erosion Studies	Dercon, Gerd
SRL5040	Study on Nitrogen Balance in Coconut-Based Agroforestry Systems Using Nitrogen-15 Isotope Dilution Technique	Hardarson, Gudni
SUD5030	Increasing Productivity of Selected Crops Using Nuclear Related Techniques	Adu-Gyamfi, Joseph Jackson in collaboration with the Plant Breeding and Genetics Section
TAD5002	Assessment of Soil Erosion and Sedimentation for Land Use	Dercon, Gerd
TAD5005	Developing Soil Conservation Strategies for Improved Soil Health	Dercon, Gerd
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	Heng, Lee Kheng in collaboration with the Plant Breeding and Genetics Section
ZIM5011	Combating Desertification in Agricultural Drylands	Heng, Lee Kheng
ZIM5014	Developing and Promoting Strategies for Improved Crop Production	Heng, Lee Kheng

Forthcoming Events

FAO/IAEA Events

Second Research Coordination Meeting (RCM) of the Coordinated Research Project (CRP) on Strategic Placement and Area-wide Evaluation of Water Conservation Zones in Agricultural Catchments for Biomass Production, Water Quality and Food Security (D1.20.10) 10–14 May 2010, Tartu, Estonia

Scientific Secretaries: Lee Heng and Karuppan Sakavedan

Nine contract holders, two technical contractors and three agreement holders are expected to participate in this RCM in Estonia. Prof. Ülo Mander from the Institute of Ecology and Earth Sciences, University of Tartu will be the local organizer. The participants will be presenting the major results and conclusions of their research since commencement of the project in December 2008. The data presented will be discussed in line with the objectives of the project, and adjustments will be made where necessary to the agreed work plan and experimental protocols. Brief training on the use of chambers for greenhouse gas emission studies will also be conducted. Ms. L. K. Heng will be Scientific Secretary of the RCM.

Agricultural biotechnologies in developing countries: Options and opportunities in crops, forestry, livestock, fisheries and agro-industry to face the challenges of food insecurity and climate change (ABDC-10), Guadalajara, Mexico, 1-4 March 2010

This FAO international technical conference is co-organized by FAO and the Government of Mexico, and co-sponsored by the International Fund for Agricultural Development (IFAD). The Consultative Group on International Agricultural Research (CGIAR), the World Bank and the International Centre for Genetic Engineering and Biotechnology (ICGEB) are major partners in this initiative. Participation at the conference is by invitation only.

Impetus for the conference comes from the need for concrete steps to be taken to move beyond the 'business-as-usual' approach and to respond to the growing food insecurity in developing countries, particularly in light of climate change that will worsen the living conditions of farmers, fishers and forest-dependent people who are already vulnerable and food insecure. The conference encompasses the crop, forestry, livestock, fishery and agro-industry sectors, as well as the entire range of agricultural biotechnologies currently available.

For more information visit:

http://www.fao.org/biotech/abdc/conference-home/en/

Non-FAO/IAEA Meetings

- SIBAE / BASIN Stable Isotope Conference: Stable Isotopes and Biogeochemical Cycles in Terrestrial Ecosystems: Coupling Plant and Soil Processes Across Spatial and Temporal Scales.
  Dates: 21–26 March 2010. Place: Conference Center of ETH Zurich at Monte Verita in Ascona, Switzerland
  Website: http://www.stableisotopes.ethz.ch
- ICIMOD's Fourth International Training Course on Low-cost Soil and Water Conservation Techniques and Watershed Management Activities.
  Dates: 15 March–6 April 2010. Place: Godavari, Kathmandu, Nepal.
  Website: http://www.icimod.org/?page=639
- International Conference on Balanced Nutrient Management for Tropical Agriculture, 12-16 April 2010, Kuantan, Pahang, Malaysia. This Conference sponsored by IMPHOS will be a platform for interested stakeholders to present their latest research and development findings, innovations, and ideas on issues on balanced nutrient management for tropical agriculture. The agenda will encompass topics on sustainable nutrient management for crop production, environmental management and socio-economic issues. For more information on the event, please visit website at: http://www.imphos.org/events/MSSS-IMPHOS%20Seminar(edit%202).pdf
- 19th World Congress of Soil Science. Soil Solutions for a Changing World.
  Dates: 1–6 August 2010. Place: Brisbane, Australia.
  Website: http://www.19wcss.org.au/index.html
- Fifth International Nitrogen Conference on: N2010 Reactive Nitrogen Management for Sustainable Development - Science, Technology and Policy. 5th International Nitrogen Conference, 3 -7 December 2010, New Delhi, India. The N2010 Conference is organized by Indian Nitrogen Group and International Nitrogen Initiative. The International Nitrogen Initiative is a global effort to optimize nitrogen's beneficial role in sustainable food production and to minimize nitrogen's negative effects on human health and the environment. The themes of the N2010 Conference include food security, energy security/industry, human health & environmental degradation, ecosystem health and biodiversity, climate change and integration. Additional information on the conference themes and registration is available at: http://www.n2010.org/

Past Events

FAO/IAEA Events

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 of this CRP was held at IAEA Headquarters in Vienna from 8 to 12 June 2009. Participants from fifteen countries (eight research contract holders, three technical contract holders, three agreement holders and five observers) attended this meeting. All participants presented their experimental work plans and discussed common goals and objectives of the CRP. The experimental workplan of each project was then fine-tuned in line with the CRP objectives. Detailed experimental and sampling protocols to identify hot spot areas of land degradation in agricultural catchments for effective soil conservation measures (precision conservation) were discussed. Special emphasis was placed on: (i) the use of fallout radionuclides (FRN) for establishing soil redistribution patterns and rates on an area-wide basis (catchment), (ii) development of soil sampling protocols for the application of compound specific stable isotope (CSSI) techniques to identify sources of pollution (e.g. cropland, grassland and forestland) in catchments, and (iii) the integration of isotopic techniques with other conventional non-nuclear approaches, including modeling to establish soil redistribution studies.

Participants at the first RCM.

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

Technical Officer: Gerd Dercon

The fourth and final RCM of this CRP was held from 5 to 9 October 2009 at IAEA Headquarters in Vienna. Eleven participants including eight contract holders, two technical contract holders and one agreement holder attended this RCM.

The objectives of the meeting were to: (i) present and discuss the results obtained for the entire duration of the CRP, (ii) evaluate achievements in accordance with project objectives, and (iii) review manuscripts prepared for the production of the IAEA-TECDOC publication.

The meeting successfully achieved all objectives outlined above. The main lessons learned from each of the projects and the overall recommendations in the following areas were discussed: (i) interactive processes related to conservation agriculture, (ii) the use of isotopic techniques to investigate these processes and (iii) the development of a joint database on the performance of conservation agriculture in different agroecological zones. The SWMCN Subprogramme will coordinate and all participants will contribute to the development of the database.

Participants at the final RCM.

Second RCM of CRP on Managing Irrigation Water to Enhance Crop Productivity under Water-Limiting Conditions: a Role for Isotopic Techniques (D1.20.09), 20 June – 1 July 2009, Beijing, China

Technical Officer: Lee Heng

Nine research contract holders, one agreement holder, two technical contractors, a staff member from the Soil Science Unit in Seibersdorf and the Scientific Secretary, Ms. Lee Heng, attended this RCM. Prof Xurong Mei, Director of the Institute of Environment and Sustainable Development in Agriculture (IEDA), Chinese Academy of Agricultural Sciences (CAAS), and Prof Baoguo Li, from the Chinese Agriculture University (CAU) were the local organizers. The participants presented the major results and conclusions of their research covering the period since the CRP started in November 2007. The progress of the individual projects and future activities including detailed work plans in line with project objectives were also discussed. A field campaign comparing the measurement of soil evaporation (E) and crop transpiration (T) using isotopic and conventional methods also took place concurrently until 1 July, 2009 at the China National Engineering Research Center for Information Technology in Agriculture (NERTICA). A one-day workshop on Laser Spectroscopy Isotopic Measurements of Water Samples was also organized at the field site. The President and CEO of Picarro Inc, Mr. Michael R. Woelk, gave a presentation at the opening of the workshop.

Participant working in the field.

Duty Travel

Argentina for TC project RLA5051 on Using Environmental Radionuclides as Indicators of Land Degradation in Latin American, Caribbean and Antarctic Ecosystems

Technical Officer: Gerd Dercon

Mr. Gerd Dercon and Mrs. Jane Gerardo-Abaya of the Division of Latin America, Department of Technical Cooperation, participated in the first coordination meeting of the project on Using Environmental Radionuclides as Indicators of Land Degradation in Latin American, Caribbean and Antarctic Ecosystems (ARCAL C, RLA5051). The meeting was conducted in San Luis, Argentina from 4 to 8 May 2009 to discuss details of the project activities and the implementation of strategies to enhance laboratory facilities in the region and the training of counterpart staff.

This meeting was attended by representatives of the academic, nuclear, agriculture and environment sectors from the following countries: Argentina, Bolivia, Brazil, Chile, Cuba, Dominican Republic, El Salvador, Jamaica, Haiti, Nicaragua, Peru, Uruguay, Venezuela and Spain. Mexico was unable to participate due to the swine influenza pandemic which led to the cancellation of flights from Mexico to Argentina.

Land degradation affects about 300 million ha of land in the Latin American and Caribbean region, of this 51% is agricultural land (180 million ha). The ARCAL (Regional Cooperative Agreement for the Advancement of Nuclear Science and Technology in Latin America and the Caribbean) Regional Strategy Profile identified the unsustainable use of arable land and the resulting permanent loss of productive agricultural areas as one of the most significant environmental challenges to sustainable food production and water supply in Latin America and the Caribbean region.

Large-scale soil erosion evaluations cannot be based on direct conventional measurements because of methodological restrictions and high temporal and spatial variability in measurements. This can be addressed through quantitative assessments and predictions based on direct measurements using fallout radionuclide redistribution (Caesium-137, Lead-210 and Beryllium-7) and numerical modelling.

The project aims to enhance soil conservation and environmental protection in Latin American, Caribbean and Antarctic environments in order to ensure sustainable agricultural production and reduce on and off-site impacts of land degradation.

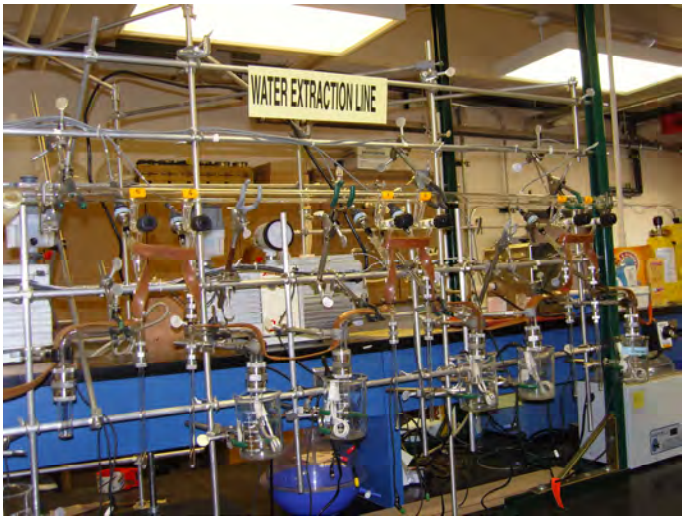
The expected outcome of this project is to enhance the regional capacity for sound assessment of land degradation and improved national and regional policies for soil conservation and environmental protection in Latin America, Caribbean and Antarctic ecosystems through the measurement of fallout radionuclide inventories. Soil redistribution rates will be determined to assess erosion/sedimentation rates and the effect of human intervention on soil ecosystems in selected areas of 14 countries in the region. This will lead to the development of more sustainable land management practices and soil conservation measures in order to ensure sustainable food security and natural resource protection.

Participants at the first coordination meeting of RLA5051.

USA to participate in the 16th International Plant Nutrition Colloquium and Scientific Visit to University of Wyoming for ^{18}O analysis in plant dry samples

Scientific Officer: Joseph Adu-Gyamfi

Mr. Joseph Adu-Gyamfi travelled to Sacramento (CA) and Laramie (WY) to participate and present a poster on 'Phosphorus acquisition from sparingly soluble forms by maize and soybean in low-P and medium-P soils, using ^{32}P', at the 16th International Plant Nutrition Colloquium in Sacramento, California (26 to 30 August 2009). The Conference, which brought together plant breeders and geneticists, socio-economists, human nutritionists and experts on climate change issues, aimed to highlight the importance of plant nutrition as a foundation science with an impact on all aspects of cropping system and environmental sustainability, human health and well being. Discussions on the implications of global climate change and plant responses to climate change were discussed. The issues of plant responses to rising CO_2 concentrations, the physiological mechanisms and the broader implications were highlighted. The need to use isotopic techniques to better understand the physiological mechanisms of plants adapted to rising CO_2 concentrations and multiple abiotic stresses was discussed. Mr. Joseph Adu-Gyamfi also visited the University of Wyoming to learn more about the cryodistallation method for extracting water from soil and plant samples for ^{18}O and ^{2}H analysis with the aim of improving the efficiency of the cryodistillation equipment currently used at the Soil Science Unit (Seibersdorf). Mr. Adu-Gyamfi also received briefings on recent mass spectrometry techniques to measure ^{18}O and ^{2}H in plant dry materials.



A cryodistillation water extraction line at the Stable Isotope Facility Laboratory, University of Wyoming, WY, USA.

Experimental site in the Snowy Range Mountains, University of Wyoming to identify sources and fluxes of water by trees under different agroforestry systems.

Benin Republic for TC project BEN5005 'Improving maize and yam-based cropping systems and soil fertility'

Technical Officer: Joseph Adu-Gyamfi

Mr. Joseph Adu-Gyamfi travelled to Cotonou and Sekou (19-23 October 2009) to participate and provide technical assistance to stakeholders at the start-up workshop, review/assess the operational capabilities and status of the laboratory and develop an inventory of existing equipment for field experiments. Technical consultations with Project Counterparts during a coordination meeting resulted in identifying project sites, essential equipment, consumables and nominations for fellowship training and scientific visits anticipated in 2010 and 2011. Technical adjustments to the workplan were discussed and agreed to by all of the Counterparts. The need for the Counterparts at the University of Abomey-Calavi (UCA) and the Institute of Agricultural Research of Benin (INRAB) to work closely together was realized.

Field evaluation of different soybean varieties for their biological nitrogen fixing abilities in Benin under TC project BEN5005.

Mali for TC project MLI5021 on 'Sustainable Intensification and Diversification of Sorghum Production Systems in the Southern Zone of Mali'

Technical Officer: Lee Heng

The purpose of this visit to Bamako (18-20 August 2009) was to assess progress in the field and evaluate achievement and completion of the project on 'Sustainable Intensification and Diversification of Sorghum Production Systems in the Southern Zone of Mali'. The objective of this project is to increase the production of sorghum in Southern Mali by improving the effectiveness of N fertilization. In this Phase-I, the aim was to assess the present soil fertility status, to conduct a base line survey of practices and crop yield and to initiate the development of improved N fertilization of sorghum production systems. Extensive soil sampling to determine the nutrient status of the soil was carried out in the village of Zanguena which is 120 km North West of Bamako. The performance, nitrogen and water requirements of high yielding sorghum varieties were also compared with local varieties at three farmers' field sites. ^{15}N fertilizer was used to evaluate the N uptake and use efficiency; soil moisture was also monitored in these studies. Use of legumes to increase soil fertility (biologically fixed N) is an important component of the project. Farmers actively participated in this project. Regular meetings were held with them and women in the village helped during harvest.

Farmers participating in the project discussing issues of concern.

Women in the village assisted with the harvest.

Consultants Meeting on 'Climate Land-use Energy and Water Strategies Tool (CLEWS)' 4–6 November 2009, IAEA

Gerd Dercon and Lee Heng gave separate presentations at the three-day Consultants Meeting organized by the IAEA Planning & Economic Studies Section (PESS) in Nuclear Energy. The purpose of this meeting was to initiate concrete suggestions for the development of a tool for resource planning which combines elements of Climate, Land, Energy and Water (CLEW) modelling at the Commission on Sustainable Development. In addition to the staff from the SWMCN Subprogramme, two external experts were invited by the PESS: Mr. Charlie Heaps (SEI and developer of LEAP) and Mr. Gunter Fischer (IIASA and developer of the AEZ land use model). Gerd Dercon gave a presentation on 'Selected overview of activities at the IAEA' while Lee Heng presented AquaCrop and its use for agricultural water management.

Non FAO/IAEA Events

'Seeking opportunities in times of crises', Colloquium for the inauguration of the Centre for Development Research at BOKU (Universität für Bodenkultur), 14 October 2009, Vienna

The great majority of poor and food insecure people in developing countries depend on resources such as land, water, plants, livestock, and fisheries for their living. Increasing environmental degradation, climate change and economic inequalities between rich and poor jeopardize peoples' ability to live secure and healthy lives. In the long run, this will result in a widening global divide, leading to unknown tensions affecting the global community.

The challenge is to implement effective strategies and policies that ensure access to natural resources, the right to food, human health, equal market opportunities, and well-being. BOKU and its partners are already developing approaches that work for vulnerable users of natural resources. Through the opening of the Centre for Development Research (CDR) BOKU hopes to strengthen this role. This colloquium, which marked the inauguration of the centre, asked what science can contribute to effective partnerships for overcoming local and global crises.

Lee Heng, Rebecca Hood, Karuppan Sakadevan and Gerd Dercon of the SWMCN Section participated in the inauguration of the CDR and the Colloquium, and explored the possible partnership and collaboration between IAEA and CDR with Professor Michael Hauser, Director of the CDR.

More information: http://www.boku.ac.at/15463.html

Visitors

- Dr. Abdul Rashid, Member (Bio-Sciences) Pakistan Atomic Energy Commission, Islamabad, Pakistan, 12 May 2009 to become familiar with the activities of the SWMCN Subprogramme and to discuss the training capability in Pakistan in the areas of biosaline agriculture and soil salinity management
- Ms. Afaf Abdulla Muftah, Atomic Energy Commission Tajoura Renewable Energy and Water Desalination Centre, Libyan Arab Jamahiriya, 16 June 2009 to become familiar with the activities of the SWMCN Subprogramme and to explore how these activities can help the Libyan Arab Jamahiriya in the areas of soil and water management for crop production and the conservation of finite natural resources.
- Mr. Eddie Loonstra, The Soil Company, Groningen, The Netherlands, 17 June 2009 to discuss the use of soil gamma ray sensor device (called the Soil Mole) for soil mapping of spatial variation in soil properties.
- Mr. Roman Strauss, ADCON Telemetry GmbH, Austria, 17 June 2009 to discuss the possible involvement of ADCON in helping Member States to use wireless sensor networks for soil moisture measurement and meteorological data provision
- Dr. Bettina Wolfgramm, Centre for Development (CDE), Department of Geography, University of Bern, Switzerland to discuss potential collaboration between the SWMCN Section and CDE with regards to the new National Centre of Competence in Research (NCCR) North-South Research Project in land management for Tajikistan and Ethiopia
- Ms. Vesna Zupanc, Centre for Agricultural Land Management and Agrohydrology, Department of Agronomy, Biotechnical Faculty, University of Ljubljana, Slovenia, 4 August 2009 to discuss collaborative research activities with the SWMCN Subprogramme.
- Dr. Ali Hassan, Director, Irrigation and Water Management Specialist Bangladesh Institute of Nuclear Agriculture (BINA), Mymensing, Bangladesh, 10 August 2009 to explore a potential project on agricultural water and land management for improving crop productivity and water use efficiency.
- Dr. Ibrahim Bakry AbdulRazzaq, Head, Soil & Water Resources Center, Ministry of Science & Technology, Baghdad, Iraq, 12 October 2009 to discuss capacity building in soil and water management for Iraqi scientists.
- Associate Prof. Dr. Basri Halitligil, Turkish Atomic Energy Authority, Saraykoy Nuclear Research and Training Center, Ankara, Turkey, 30 October, 2009 to discuss his project mission to Qatar to provide technical support to a TC project QAT5002 on biosaline agriculture.
- Mr. Bernhard Pacher and Mr. Roman Strauss, ADCON Telemetry GmbH, Austria, 19 November 2009 to consolidate the framework of collaboration between the SWMCN Subprogramme and ADCON resulting from the visit made by Mr. Strauss in June 2009.

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

The first RCM was successfully held at IAEA headquarters in Vienna from 8 to 12 June 2009. As agreed in the RCM, the first draft of a harmonized protocol for the application of CSSI techniques at the catchment scale in a range of environments and land use systems has been developed and sent to the CRP participants in October for further testing.

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

The expected outputs from this CRP include:

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

There are eight research contract holders (Chile, China (two), Morocco, Poland, Russian Federation, Syrian Arab Republic and Vietnam), three technical contract holders (Germany, New Zealand and the United Kingdom) and three agreement holders (Australia, Canada and the United Kingdom).

Status of Coordinated Research Projects (CRPs)

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

Technical Officers: Lee Heng and Long Nguyen

The overall objective is to improve the water productivity (production per unit of water input) of crops under water-limiting conditions. The specific research objectives are: (i) To quantify and develop means to manage soil evaporative losses to maximize the beneficial use of water - the transpirational component of evapotranspiration, (ii) To quantify and develop means to improve the amount of biomass produced per unit of transpiration, (iii) To devise irrigation and related management techniques to enhance the yield component of biomass production (Harvest Index).

The second RCM of this CRP was recently held during June-July 2009 in Beijing. All nine research contract holders (Burkina Faso, Malawi, Morocco, China (2 participants), Pakistan, Turkey, Vietnam and Zambia), two Technical Contractors (University of California-Davis and University of Wyoming-Laramie), an Agreement Holder (Universität für Bodenkultur, Vienna), a staff member of the Soil Science Unit, FAO/IAEA Agriculture and Biotechnology Laboratory and the scientific secretary Ms. Lee Heng, participated in this RCM. Significant progress has been made in each individual project since the start of the CRP in November 2007. With training conducted on the use of different techniques for measuring soil evaporation and crop transpiration (e.g. micro-lysimeters, line quantum sensors, camera imaging; stem flow, heat ratio gauges, vapour trapping systems for water vapour collection and oxygen-18 and deuterium (^{18}O & ^{2}H) isotopic signatures) during the field campaign in Beijing, it is expected that more extensive studies will be carried out in the coming year.

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 Karuppan Sakavedan

This CRP is in the second year of implementation. The first RCM was held at IAEA Headquarters in Vienna from 15 to 19 December 2008. There are eight contract holders (China, Estonia, Islamic Republic of Iran, Lesotho, Nigeria, Romania, Tunisia and Uganda), two technical contractors (USA and UK) and two agreement holders (France and USA) in the CRP. The objective is to assess and enhance ecosystem services provided by wetlands, ponds and riparian zones for improving water storage and quality in agricultural catchments. The specific objectives are: (i) to determine the capacity of wetlands, ponds and riparian zones for water storage, (ii) to assess the nutrient/pollutant attenuation capacity of wetlands, ponds and riparian zones, (iii) to better understand the link between water and nutrient dynamics in wetlands, ponds and riparian zones and biomass production and (iv) to optimize the system of wetlands, ponds and riparian zones for improved water storage and quality in agricultural catchments.

The participants have submitted progress reports and contract renewal requests which have been evaluated and renewed. The next RCM will be held in Tartu, Estonia in May 2010 to evaluate progress and discuss future work plans. Training on the use of closed chambers for measuring GHG fluxes from agricultural landscapes will be carried out during the RCM.

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

Technical Officer: Gerd Dercon

All nineteen manuscripts prepared as part of this project have been edited by Gerd Dercon for the production of an IAEA-TECDOC. They have also been reviewed by an independent reviewer (Gary Hancock). It is expected that the IAEA-TECDOC will be published shortly.

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

A wealth of information on soil redistribution and the effectiveness of soil conservation has been generated by the CRP using several fallout radionuclides and conventional techniques in a wide range of environments. In total over 150 scientific papers (peer-reviewed journals) have been 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 fourth and final Research Coordination Meeting (RCM) of this CRP was held in October 2009 at IAEA Headquarters in Vienna. This CRP had a total of ten participants comprising seven research contractors from Argentina, Brazil, India, Morocco, Pakistan, Turkey and Uzbekistan, two technical contractors (Australia and Chile) and one agreement holder (CIMMYT-Mexico). In addition, one individual contractor (Mr. Bernard Vanlauwe) conducted research on the evaluation of C and N dynamics in long-term trials in Sub-Saharan Africa focussing on tillage, residue management and rotational effects.

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

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

The CRP was also linked to several PhD and MSc dissertations and will form the basis for joint group publications at national and regional levels. Manuscripts for the IAEA-TECDOC of this CRP are now under review.

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 marginal lands. This CRP has a total of 17 participants with ten research contract holders (Burkina Faso, Brazil, Cameroon, China, Cuba, Ghana, Malaysia, Mexico, Mozambique and Sierra Leone), five agreement holders (UWA-Australia, WARDA-Benin, TSBF-Kenya, IITA-Nigeria, and INRA-France) and two technical contractors (University of Hanover-Germany, University of Pennsylvania-USA). The mid-term review, which was successfully conducted in September 2009 showed that the majority of the participants made significant progress during the first two years of the CRP in evaluating rice, maize, common beans, cowpeas and soybean genotypes in the laboratory, greenhouse and field for root traits conferring P and N acquisition. Major outputs from the CRP include:

1. Laboratory and field protocols for evaluation of root traits (architecture and morphology) contributing to enhanced N and P were developed in collaboration with Pennsylvania State University and are available online (http://roots.psu.edu)
2. Development of a new version of the SIMROOT model capable of simulating large diversity of root systems.
3. Protocols for fractionation of soil P using ^{32}P to elucidate mechanisms of P acquisition from different soil P pools developed and fine-tuned in the Seibersdorf Laboratories.
4. Protocols for plant trait N deficiency-induced leaf senescence were tested and refined under field conditions as a criterion for selecting N efficient maize and rice genotypes.

The protocols developed were used for rapid evaluation of 150-200 lines (landraces and cultivated) of rice, maize, common beans, soybeans and cowpeas collected from different environments and 20-30 lines with varying grain yield and root morphology were identified and selected for field validation. In addition, isotopic fractionation of soil phosphorus (using ^{32}P) was used to evaluate and select maize, common beans and rice for their ability to explore P from the different soil P pools.

In summary, the CRP is on schedule. During the next two and half years, the activities of the CRP will focus on understanding some of the mechanisms through which certain genotypes are able to use soil and applied N and P efficiently for high productivity, and the CRP will assess the effects of these genotypes with enhanced N and P use efficiencies on cereal-legume cropping systems performance and their long term effects on soil productivity. It is proposed that the third RCM will be held in Mozambique during the third quarter of 2010.

Activities of the Soil Science Unit, Seibersdorf

Integrating soil water measurements and isotope tracer techniques (^{13}C) to evaluate wheat lines for tolerance to pre- and post-anthesis water stress

Joseph Adu-Gyamfi, Sasa Linic, Lee Heng and Jose Luis Arrillaga

The Challenge

Plants discriminate against the heavy isotope of carbon (^{13}C) during photosynthesis and hence the isotopic ratio of ^{13}C to ^{12}C in plant tissues is used as a surrogate of water use efficiency (WUE), a function of plant stomatal openings. The technique commonly referred to as the carbon isotope discrimination ($\Delta^{13}C$) technique has emerged as a powerful tool for examining the balance between net photosynthesis (A) and stomatal conductance (gs) and it is therefore being used to evaluate C3 plants with increased WUE in water scarce environments. In addition, few studies have related soil water measurement using different soil monitoring equipments with isotopic signatures of carbon to evaluate wheat plants to water stress at different growth stages.

Materials and methods

Experimental Set-up

A field experiment was carried out on Seibersdorf soil (classified as Dystric Eutrocrepts) in IAEA's Seibersdorf Laboratories. The experimental field had twelve plots (excluding 2 plots without crops) each plot measuring 3 × 5 m. Aluminium access tubes (to a depth of 70 cm) for the neutron moisture gauge and plastic tubes (70 cm) for soil moisture measurements using the Diviner and the EnviroScan were installed in all plots to monitor the changes of soil water status within the plant root zone during the growth period. In addition, sensors for measuring soil moisture using the time domain reflectometer (TDR) were installed in 6 of the experimental plots. An automatic weather station (*i*METOS) recording hourly and daily temperature, relative humidity, solar radiation, daily precipitation, leaf wetness and wind speed was also installed. Two spring wheat (*Triticum aestivum L.*) varieties (SW Kronjet – V_1 and Xenos – V_2) were planted in the 3 × 5 m plots in a randomised split-plot design with 3 replications and two water regimes (post-anthesis water stress and pre-anthesis water stress).

Irrigation and Soil Water Measurements

Soil moisture content was monitored to a depth of 70 cm (at 10 cm intervals) every week using the Diviner 2000, EnvironScan, time-domain reflectometer (TDR) and neutron moisture probes (Troxler 4300 and CPN) for the purpose of irrigation scheduling and estimating water uptake by the plant root system. In addition, two soil moisture sensors (Decagon 10HS) and a soil matrix potential sensor (MPS-1) from the Automatic weather station were installed to a soil depth of 20 cm for continuous monitoring of soil moisture and soil matrix potential. The two water treatments (i) pre anthesis (plants were stressed till flowering and thereafter received adequate irrigation) and (ii) post anthesis (plants received adequate water till flowering and thereafter were stressed till maturity) began 17 days after sowing (DAS). The post-anthesis treatment received supplementary irrigation by manually applying water through a shower sieve at the rate of 35 L/min for 2 or 3 mins depending on the soil moisture readings.

Plant sampling and analysis

Plants were sampled at 17 (beginning of water treatment), 28, 38, 50 (tillering) and 87 (maturity) days after sowing. An area of 1 row (20 cm) × 25 cm was sampled at 17 and 28 DAS, 2 rows × 50 cm at 38 and 50 DAS. The above- and below-ground biomass was taken at each sampling day. At harvest, 8 rows × 2 m (for grain yield) and 4 rows × 2 m (for shoots) of the above ground biomass were taken. At each sampling period, plants were separated into roots, shoot, spikes, and grain (if available), and oven-dried at 70°C to a constant weight. Roots were thoroughly washed with tap water then with distilled water and oven-dried. Leaf and grain samples are being analyzed for $\Delta^{13}C$ (at Seibersdorf).

Results

The total rainfall during the growing season (May to August) was 582.2mm (with the highest precipitation of 80mm recorded in July) and average temperature was 18.7°C, ranging from 10°C in May to 28°C in July during the crop growing season. The solar radiation was highest in July with an average of 319.9 W/m² and the soil water content at 20 cm soil depth ranging from 11-29%. Total above ground biomass (Mg ha^{-1}) was 7.2 for V_1 and 6.6 for V_2 in the post anthesis, and 5.3 for V_1 and 4.6 for V_2 in the pre-anthesis treatment. Grain yields (Mg ha^{-1}) were 2.2 for V_1 and 2.0 for V_2 in the post anthesis and 1.8 for V_1 and 1.5 for V_2.

Fellows sowing wheat seeds in a field experiment to evaluate wheat varieties for tolerance to water stress using isotopic tracer techniques.

Wheat plants in the field.

Monitoring soil water in the field using a soil moisture neutron probe

Fellows monitoring soil water in the field using a time domain reflectometer.

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Figure 1 show values (%) of soil water measured using the neutron probe, Diviner, Enviroscan and TDR (Mini-trace and Trace) in 4 of the 12 plots at 40 cm depth. Estimates of soil water content using the neutron probe were similar to that of the TDR and not to the Enviroscan.

Tentative Conclusions

Results indicate that SW Kronjet (V_1) was more tolerant to water stress than Xenos (V_2). Pre-anthesis water stress had a more severe effect on biomass and grain yield than the post anthesis water stress treatment. Enviroscan seems to overestimate the soil water content compared to the other devices. Estimates of soil water content using the neutron probe were similar to that of the TDR. Analyses of $\Delta^{13}C$ in plant samples are in progress.

Reducing time for extraction of water from soil and plant samples through Cryo-distillation process

Sasa Linic, Peggy Macaigne and Joseph Adu-Gyamfi

The vacuum cryodistillation technique is widely used for plant and soil water extraction and investigations of water use efficiency, estimation of soil evaporation and plant isotopic signatures.

The cryodistillation device in the Agency's Laboratories (Seibersdorf) is currently designed to process eight samples at one time for sixteen hours. Recent improvements and fine-tuning of the methodology helped reduce the time for extraction from sixteen to four hours without affecting the efficiency of extraction. This reduction in time helps to extract more samples whilst maintaining the efficiency and quality of the extraction. Using this improved methodology, approximately 165 soil and plant samples have been analysed.

Efficient management of soil, crop and water in the coastal areas of Bangladesh for increased agriculture production (BGD5026)

Ahmad Ali Hassan (Bagladesh Institute of Nuclear Agriculture, Mymensingh) and Joseph Adu-Gyamfi

The challenge

In the coastal areas of Bangladesh, approximately 90% of the arable land remains fallow for 6-7 months after the rice harvest because of the shortage of fresh water and the salinity of the soil. However, coastal areas have the potential to produce some additional food crops, e.g. mustard, mungbeans, soybeans or sesame, which need relatively less water after an early harvest of rain-fed aman rice. Developing efficient soil and water management technologies for salinity management by identifying legumes and short duration rice varieties that can grow fast to escape the high salinity during the dry season will help increase the agricultural production and livelihoods of people living in the coastal lands.

The Project

This project aims to develop appropriate land and water management practices, using nuclear techniques and conventional methods to increase yield and cropping intensity through the introduction of additional crops in saline areas during the fallow period (November – June). It also aims to enhance integrated coastal resource management to support sustainable environment and increased livelihood opportunities and furthermore to develop human capacity for integrated coastal resources management.

The Impact

Two short duration and salt tolerant/escape varieties of rice and two varieties each of mustard/chickpea, and mungbean have been identified and evaluated under different water management systems by 'champion farmers'. A new improved production system (water management system plus the use of improved varieties) has enhanced food security by ensuring year-round utilization of the fallow land for the production of income generating crops (sesame, mung bean and mustard) in the coastal areas.

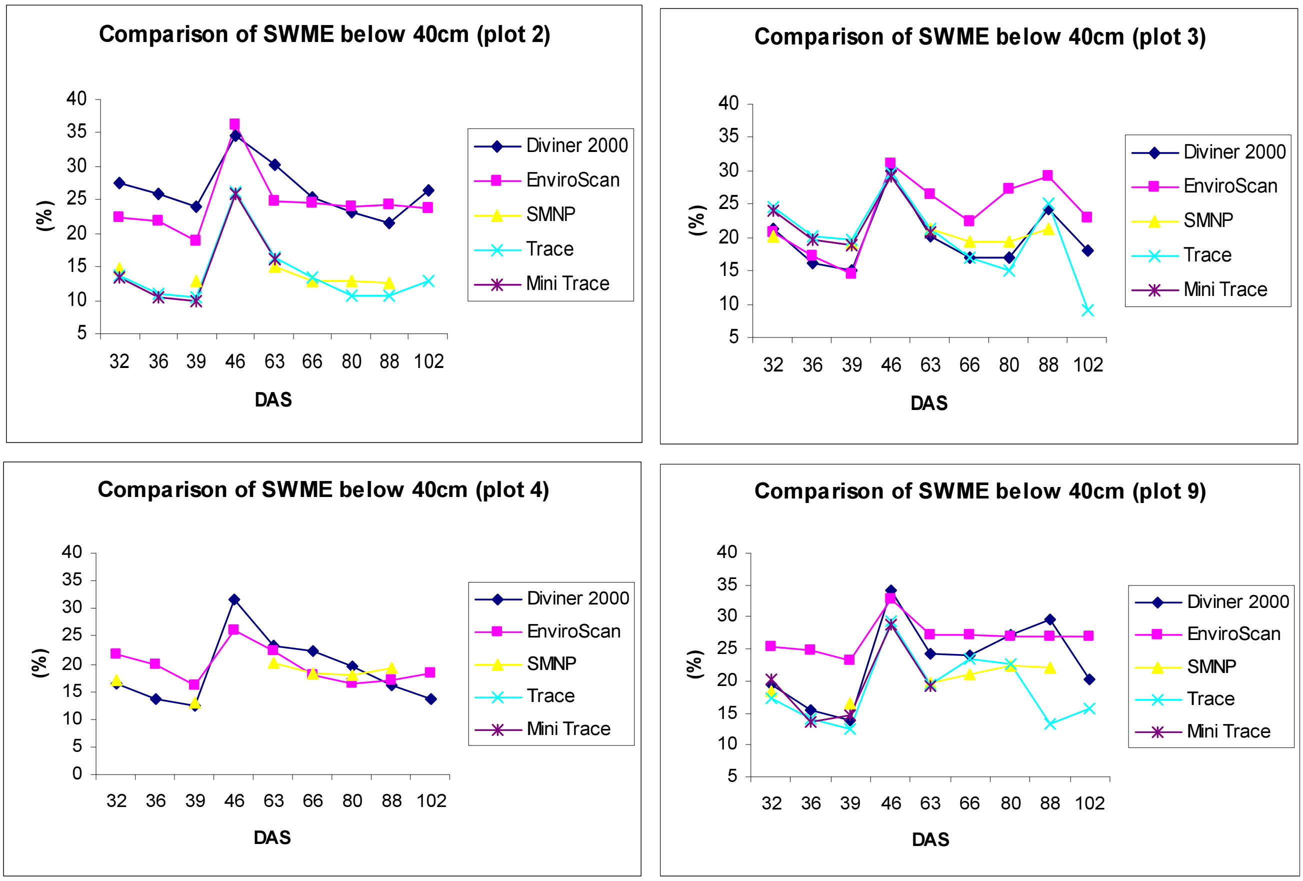

Figure 1. Comparison of soil water monitoring equipment (SWME) to estimate soil moisture in 4 different plots in the field during the experimental period. In plot 4 there was no installation of TDR. SWMP soil water neutron probe, trace and mini-trace are TDR capacitance probes.

Land left to fallow after rice cultivation due to soil salinity (Nov-Feb).

Turning adversity into opportunity: A farmer harvesting mung beans in May.

Impact of cryodistillation timing on isotopic signature of water extracted from plant roots

P. Macaigne and L. Mayer

Objectives

To determine the impact of cryodistillation extraction time on the isotopic signature of water extracted from corn roots.

Methodology

Since cryodistillation is a method often used to extract plant water for isotopic measurements, there is a need to increase the speed of the extraction process. West et al. (2006) recently reported that the minimum timing for extracting water from stems is 60 to 75 min and 20 to 30 minutes for leaves. The purpose of this experiment was to determine the minimum time required for extraction of root samples using the cryodistillation equipment built at IAEA laboratories in Seibersdorf.

A single corn root was cut into small root samples (about 2 cm). The roots were extracted for different time periods (hours) and each time period were replicated eight times. The extraction time period were +0.5; +1; +2; +4; +16; +24 hours. Water was extracted from the roots (with or without any desiccant) by cryodistillation at 70°C, and was analysed for ^{18}O with isotope ratio mass spectrometer.

Results and conclusion

Results are presented in Table 1. Standard deviations and mean data showed considerable variations (> 1 δ‰) between replicates for each test. Results show a stable mean isotopic signature ($-2.14 < \delta^{18}O < -2.83$) for an extraction time of between 1 and 24 hours (tests 2 to 6), whilst test 1 (0.5 h) yielded a comparatively depleted value for $\delta^{18}O$ (mean value of -4.88‰VSMOW). This shows that 0.5 hour is not enough to extract all water from roots, while 1 hour appears to be enough to preserve the ^{18}O isotopic signature of the extracted water from small maize root samples with our device.

Table 1. $\delta^{18}O$ isotopic signature (‰VSMOW) of extracted water for six different extraction times: 0.5, 1, 2, 4, 16 and 24 hours

	+0.5 hour Test 1	+1 hour Test 2	+2 hours Test 3	+4 hours Test 4	+16 hours Test 5	+24 hours Test 6
Rep 1	-3.32	-2.16	-2.89	-1.35	-2.22	-1.58
Rep 2	-3.80	-1.91	-4.62	-2.97	-1.48	-1.32
Rep 3	-4.70	-1.79	-0.71	-1.37	-1.77	-2.41
Rep 4	-5.80	-2.62	-1.63	-2.29	-0.40	-3.61
Rep 5	-4.53	-2.53	-2.27	-3.75	-4.35	-2.58
Rep 6	-5.07	-3.36	-1.39	-2.84	-2.86	-4.46
Rep 7	-7.55	-4.02	-1.47	-2.10	-1.90	-4.29
Rep 8	-4.24	-2.35	-	-2.72	-	-2.42
Mean	-4.88	-2.59	-2.14	-2.42	-2.14	-2.83
Standard Deviation	1.32	0.76	1.30	0.82	1.23	1.17

Reference

West, A. G., Patrickson, S. J. and Ehleringer, J. R., 2006. Water extraction times for plant and soil materials used in stable isotope analysis. Rapid communications in mass spectrometry 20, 1317–1321.

Assessment of Crop Water Productivity at different stages of crop development using Carbon Isotope Discrimination

Peggy Macaigne, Gerd Dercon, Lee Heng, Jose Luis Arrillaga, Leopold Mayr, Long Nguyen

Context

The SWMCN Subprogramme is currently finalizing a pilot study which aims to improve the assessment of Crop Water Productivity (CWP) using stable isotope techniques. The carbon isotope discrimination (CID) methodology has been widely used to investigate water use efficiency and water stress in crops and it has become a tool of choice to select cultivars and species, aiming to improve plant water use efficiency. However, studies on the use of CID to screen water use efficiency and water stress are mainly associated with harvest. Few studies have reported the use of CID during crop growth. In this study, the use of CID was tested as a tool for assessing water use efficiency during crop growth.

Materials and Methods

Maize from Austria, (*Zea Mays* L. DK 315) was grown under optimal water availability and water stressed conditions with optimum fertilizer application (100 kg N. ha^{-1} at planting and 100 kg N. ha^{-1} 40 days after planting, 50 kg P. ha^{-1} and 50 kg K ha^{-1}) in pots (46 kg) placed following a randomized block design inside a greenhouse located at the IAEA Laboratories in Seibersdorf, Austria. Soil water moisture was recorded using Time Domain Reflectrometry (TDR) linked to a data logger, while air temperature and relative humidity were measured inside the glass-house to estimate the vapour pressure deficit.

An early test determined field capacity around 30–32%. Automatic irrigation was adjusted on a weekly basis according to the soil moisture deficit measured during the previous week. Figure 1 displays soil moisture for the entire duration of the pot experiment. During the first three weeks of plant development, soil water was kept at field capacity (FC) for the first treatment (not stressed, TA) and at approximately 80% of FC for the second treatment to assure plant growth. After this period, water stress was increased in the second treatment (TB, down to approximately 50% of FC) to simulate a real stress for the plant. Even though attempts were made to keep the first treatment at FC, due to the rapidly increasing daily water demand of the maize, soil moisture dropped during the second part of the season, especially after the 7th week. This demand for water decreased after the 8th week until the end of the experiment.

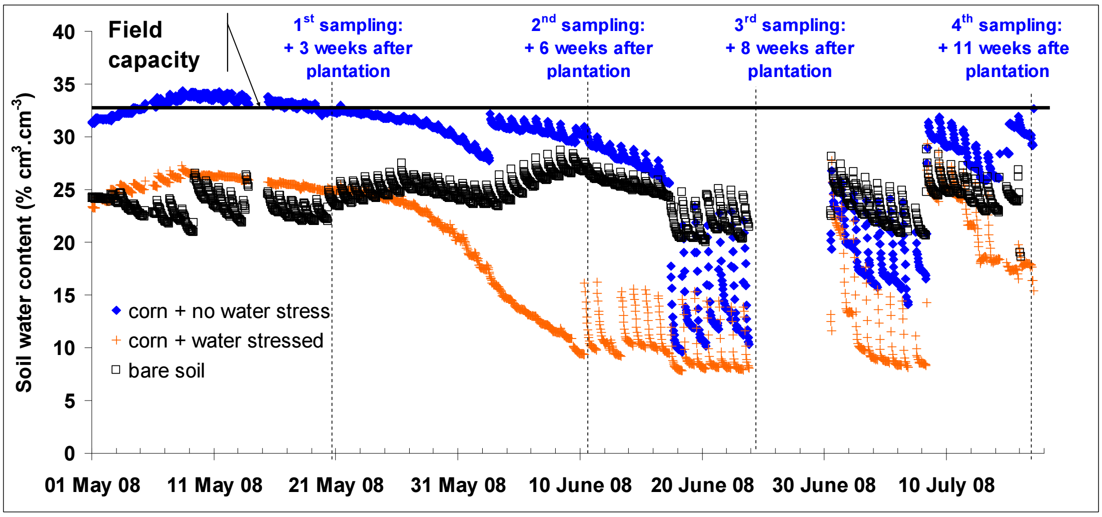

Figure. 1. Soil moisture for the entire duration of the pot experiment using Time Domain Reflectrometry.

Plants were harvested at 3, 6, 8 (flowering stage) and 11 (maize maturity) weeks after planting and were divided into leaves, flag leaves and grain for the two latest stages. These were then oven-dried at 70°C, ground and ball-milled, and analyzed for $\delta^{13}C$ concentrations with the Isotope Ratio Mass Spectrometer (Isoprime from GV-Instruments). For each analysed crop stage, crop water productivity (CWP) was calculated from planting until the sampling time, therefore it is indicated as cumulative CWP. ANOVA was performed to estimate the effect of crop stage and water availability on crop yield, $\delta^{13}C$ data and CWP.

CID is expressed as $\delta^{13}C$ ‰ vs. an international PDB standard (i.e. Pee Dee Belemnite), while CWP has been defined as the total biomass or crop yield (harvestable produce) over the amount of water transpired (T) (equation 1).

$$\mathrm{CWP} = \frac{\text{yield per unit area}}{T} \quad (1)$$

Results

Cumulative CWP increased during the first six weeks of crop development, and then suddenly decreased to a minimum (Figure 2).

Three weeks after planting, CWP showed expected behaviour with higher values for the water stressed plants as compared to the non-stressed ones.

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However six weeks after planting, unexpectedly high CWP were observed for both treatments, which can be attributed to the early stage of rapid plant development. In addition, CWP was lower for the stressed plants, which is the opposite to what is expected and found in the literature (Dercon et al., 2006). The reason for this observation could be decreased water availability between weeks 3 and 6 (Figure 1) for the stressed plants, which caused these plants to immediately stop growing, whereas the plants without water stress kept growing. Indeed at that time, soil moisture in the water stressed pots was close to the permanent wilting point, which was around 6-7% (Figure 1).

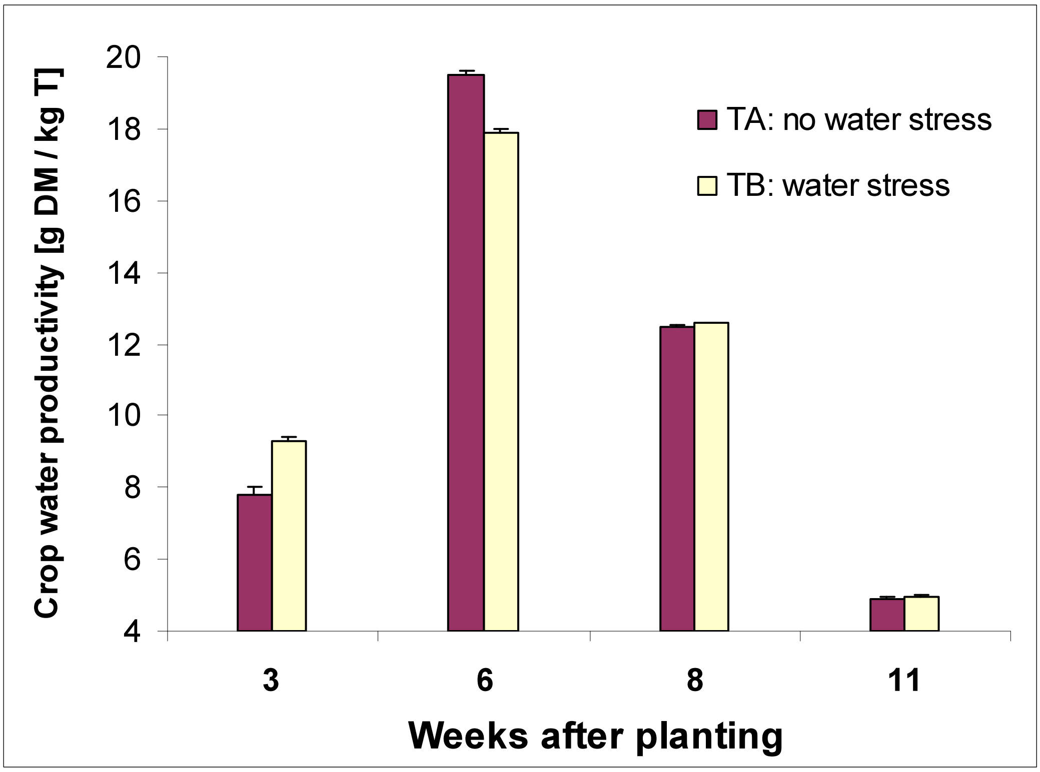

Figure. 2. The influence of water stress levels on cumulative crop water productivity at different stages of plant development (expressed in grams of dry matter per kg of transpired water per pot; TA = no water stress; TB = water stress) Error bars denote standard errors.

Towards the second half of the pot experiment, no significant difference in CWP was observed between the water stressed and non-stressed plants. This indicates that between 6 and 8 weeks the stressed plants started to use the available soil water more efficiently than the non-stressed plants and made up the difference in CWP during this period of 2 weeks.

Figure 3 shows the influence of water stress levels on $\delta^{13}C$ values in maize at 4 stages of plant development (3 weeks, 6 weeks, 8 weeks (flowering stage) and 11 weeks (maize maturity)) in different plant parts (leaves, flag leaves and the maize cob). Despite the higher CWP for the stressed plants at three weeks (Figure 2), statistical analysis did not reveal any difference in $\delta^{13}C$ values in maize during the first 3 weeks after planting. As $\delta^{13}C$ values in maize are also influenced by nitrogen availability (Dercon et al., 2006), this can only be explained because at the beginning of the crop growth the well-watered plants initially suffered partial nitrogen stress due to movement of nitrogen below the rooting zone which created some nitrogen stress; while the water stress was not severe enough to affect water and nitrogen availability in the water-stressed treatment.

However, after the early stage of plant development, significant water stress and plant part effects were observed in $\delta^{13}C$ values ($p < 0.05$). The water–stressed plants presented more negative $\delta^{13}C$ values than the well-watered samples. The data also showed clearly that $\delta^{13}C$ values in the flag leaves is a very good indicator of water stress and CWP, and proved, as it was suggested by the CWP data, that after 6 weeks the stressed plants started to use the available soil water more efficiently as compared to the non-stressed plants. The combination of information on CWP and the $\delta^{13}C$ values also showed that the stressed plants drastically reduced their speed of development between week 3 and 6.

Conclusion

The present study highlighted the use of ^{13}C isotopic discrimination in maize to assess water stress and Crop Water Productivity at different stages of plant development.

Furthermore the effect of nutrient availability needs to be considered in the use of CID as a tool to assess crop water productivity.

Reference

Dercon, G., Clymans, E., Diels, J., Merckx, R., Deckers, J. 2006. Differential ^{13}C isotopic discrimination in maize at varying water stress and at low to high nitrogen availability. Plant and Soil, 282, 313–326.

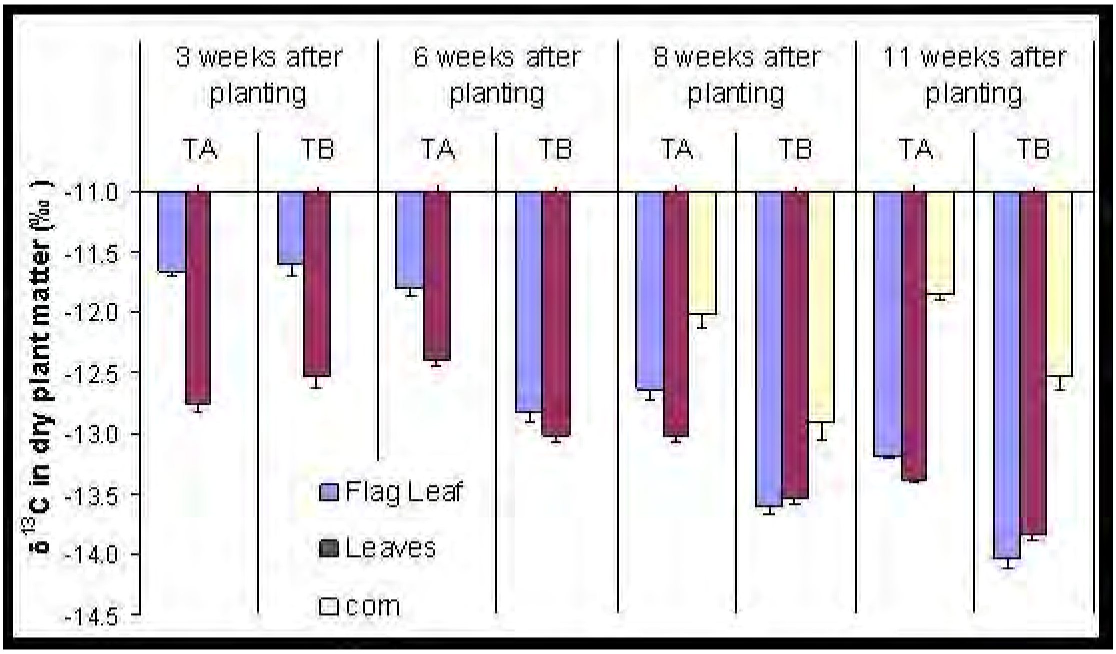

Figure. 3. The influence of water stress levels (TA = No water stress; TB = Water stress) on $\delta^{13}C$ values in maize at 4 stages of plant development (3 weeks, 6 weeks, 8 weeks: flowering stage and 11 weeks: maize maturity) in different plant parts (leaves, flag leavesf and the maize cob). Error bars denote standard errors.

Scientific Visitors

Name	Country	Period
Mr Nhantumbo, Alfredo	Mozambique	19-24 July 2009
Mr Hassan, Ahmad Ali	Bangladesh	10-14 August 2009
Mr Felix, Jean Fenel	Haiti	17-28 August 2009
Mr Abdul Razzaq, Ibrahim Bakry	Iraq	12-16 October 2009
Mr Razzaque, A.H.M.	Bangladesh	12-16 October 2009
Mr Toure, Sidi	Mali	2-6 November 2009
Mr Atawoo, Mohammad Alfaz	Mauritius	9-13 November 2009
Mr Chikwari, Emmanuel	Zimbabwe	10-20 November 2009

External Quality Assurance

Martina Aigner

The second Proficiency Test (PT) on ^{15}N and ^{13}C in plant materials jointly organized by the University of Wageningen, The Netherlands and the IAEA Soil Science Unit Seibersdorf, Austria has been successfully completed. The Wageningen Evaluating Programs for Analytical Laboratories (WEPAL, http://www.wepal.nl) is accredited for the organization of Interlaboratory Studies by the Dutch Accreditation Council.

Fifteen IAEA-funded stable isotope laboratories participated in PT-round 'IPE 2009.2', three more than in 2008.

It was agreed between the Soil Science Unit and the PT-organizer to include one ^{15}N-enriched plant material (0.5 to 2.5 atom %, i.e. 370 to 6000 δ ‰ 'delta per mille') per year into the IPE test sample set. A bulk amount of uni formly ^{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 together with 3 other – non-enriched -

plant samples. 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 2009 (round IPE2009.2) was covered by the IAEA.

Twenty-four participants who were registered in the 'IAEA Soil Science Unit PT scheme' in previous years were provided with the WEPAL test sample set IPE 2009.2 consisting of the four test samples of 20 g plant material each. Fifteen laboratories reported isotope abundance data within the deadline. The Soil Science Unit also participated in this round of PT. A special IAEA-evaluation report for the results of the ^{15}N *enriched test sample* was provided to all participants in October 2009. Certificates for successful participation were submitted to laboratories fulfilling the requirements for high analytical standards established by the IAEA-Soil Science Unit.

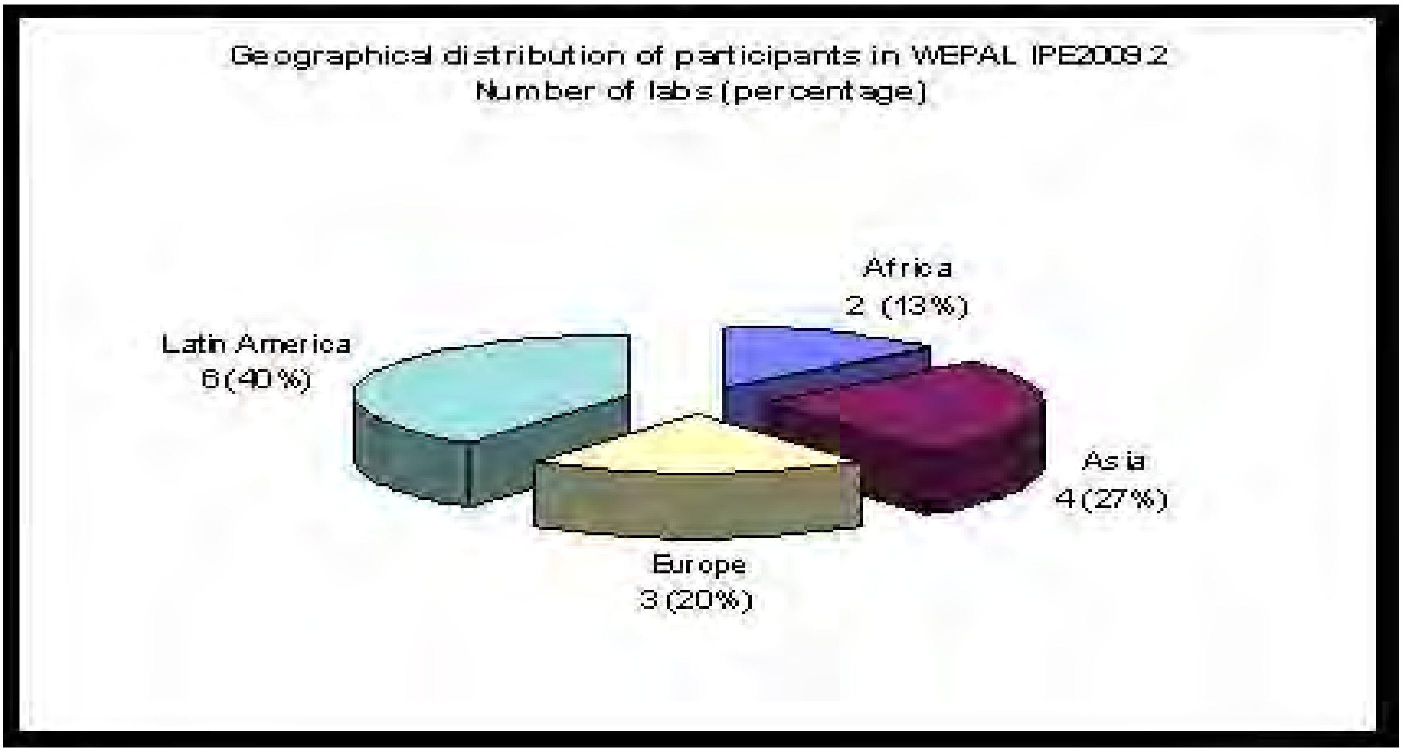

Figure 1. Geographical distribution of IAEA participants.

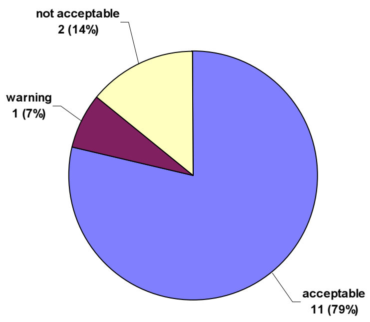

Figure 1- ^{15}N abundance determination

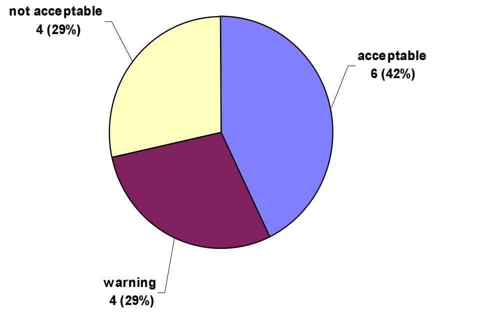

Figure 2 – total N determination (N-elementary and N-Kjeldahl)

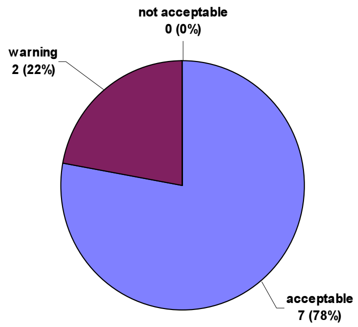

Figure 3 - ^{13}C abundance determination

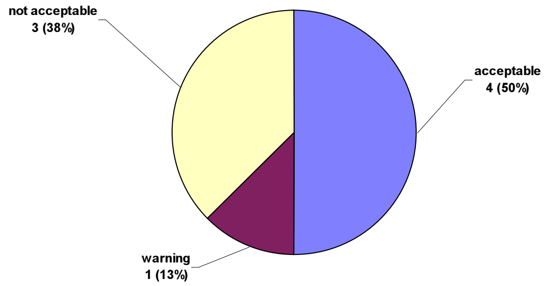

Figure 4 - total C determination

Figure 2. Performance of IAEA-participants in IPE2009.2 on the ^{15}N-enriched test sample.

Conclusions

Some laboratories were still confused about how to report their ^{15}N-data correctly and some reported total N and C in [weight %] instead of [g/kg]. These laboratories might have analysed correctly, but calculated and reported the results wrongly. It is of high importance for the analyst to know, in which unit the data should be provided, how to calculate the isotope abundance correctly and how to get a feeling for the order of magnitude of the reported data.

'To simplify the evaluation, from the next PT- round on, only reporting of ^{15}N results as "delta per mille" (δ ‰) will be accepted by WEPAL. An Excel-spreadsheet will be provided to the participants for conversion from atom % to delta ‰ of ^{15}N-results".

The big advantage of comparing analytical data with those of a large and increasing number of analytical laboratories worldwide will provide much greater 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.

Publications

List of Publications

Adu-Gyamfi, J.J., Aigner, M., Gludovacz, D. (2009). Variations in Phosphorus acquisition from sparingly soluble forms by maize and soybean in low-P and medium-P soil using ^{32}P. Proceedings of XVI International Plant Nutrition Colloquium, Sacramento, USA 26–30 August 2009. 10 pages http://repositories.cdlib.org/ipnc/xvi/1317

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Cobo, J.G., Dercon, G., Cadisch, G. (2009). Nutrient balances in African land use systems across different spatial scales: a review of approaches, challenges and progress. Agriculture Ecosystems and Environment (in press).

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Mabit, L., Bernard, C. (2009). Spatial distribution and content of soil organic matter in an agricultural field in Eastern Canada, as estimated from geostatistical tools. Earth Surface Processes and Landforms (in press).

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Zapata, F., Nguyen, M. L. (2009). Chapter 7. Soil erosion and sedimentation studies using environmental radionuclides. In: Environmental Radionuclides-Tracers and Timers of Terrestrial Processes. Editor: Klaus Frolich. Elsevier; 295-315.

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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