IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture

Soils Newsletter

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

ISSN 1011-2650

Vol. 39, No. 1, July 2016

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To Our Readers

The Soil and Water Management & Crop Nutrition (SWMCN) Subprogramme had a busy start of the year as we are preparing to join the global community to celebrate the International Year of Pulses 2016 (IYP2016). In this year, we will emphasize the work of the Subprogramme on using nitrogen-15 stable isotope for quantifying biological nitrogen fixation in Member States and the roles of pulses in improving soil fertility and in reducing greenhouse gases (GHGs) emission from agricultural production systems. As part of the event of IYP2016, a training course will be held this summer in Seibersdorf on the use of nitrogen-15 techniques for improving nitrogen management in agro-ecosystems. This course will focus in particular on how to assess, with isotopes, the capacity of grain legume crops (pulses) to capture nitrogen from the atmosphere. In addition, a joint event will be organized between SWMCN Subprogramme and the Plant Breeding and Genetic Section on 'Enhancing Pulses for Food Security by Nuclear Applications' before the annual General Conference in September 2016. This event will feature the roles of pulses for food security, poverty reduction and how nuclear applications can contribute towards pulse productivity.

A new coordinated research project (CRP) on "Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystems" will be launched this year, with the first research coordination meeting (RCM) planned in July 2016. This CRP aims at developing combinations of nuclear techniques to assess changes in soil erosion, and to distinguish and apportion impacts of climate variability and agricultural management on soil erosion in upland agro-ecosystems.

The SWMCN Subprogramme is currently providing technical support to a total of 7 CRPs and 46 Technical Cooperation Projects (TCPs), with about 40 new TC proposals received for the 2018–2019 cycle from all over the world, focusing on topics including soil erosion measurement and conservation, soil fertility and nutrient management, greenhouse gases emission as well as agricultural water management. All these projects will contribute to make agriculture more resource use efficient and climate smart.

In the SWMCN laboratory in Seibersdorf exciting Research and Development is being carried out. With the arrival of the CO_2 and N_2O Isotope Analyzers last year, the SWMCNL is now developing protocols for conducting real-time, in situ measurement of CO_2 and N_2O emissions and its isotopic compositions for greenhouse gas tracing. Similarly, some new work determining the sources of nitrate from the isotopic composition of dissolved nitrate is currently being carried out. Similarly, a new TECDOC on sampling and sample preparation for isotope and nuclear analysis to guide scientists on sampling and processing of soil, water and plant materials has just been published. The work on sediment source fingerprinting techniques to identify critical sources of land degradation was further tested using Compound Specific Stable Isotopes Analysis (CSSI) techniques. A new publication on the use of cosmic-ray neutron probes to monitor landscape scale soil water content in agricultural systems from the SWMCNL is also now available on the SWMCN website. The SWMCN Subprogramme, especially the SWMCNL, gave a total of 16 oral, poster and PICO presentations at the recent European Geosciences Union (EGU) General Assembly in Vienna, covering diverse topics on carbon and nitrogen cycling, soil erosion, soil conservation and climate change; it is a great achievement from the effort of the team in the laboratory.

The SWMCN Section continued to go through staff changes during the past six months. In April this year, Mr Karuppan Sakadevan, Soil-Water Eco-physiologist left the Section after completing seven years' service. Ms Kyoko Makovicky, team assistant left the Section for a new position in the IAEA Tokyo office. The contributions of Karuppan and Kyoko to the SWMCN Subprogramme have been enormous and I am grateful for their dedication and support. On the other hand, two new staff members, Ms. Janet Chen and Mr Emil Fulajtar, joined the Subprogramme. Janet will focus on the development of new protocols to trace greenhouse gas emission and monitor soil organic carbon sequestration using stable isotope techniques. Emil will be providing technical support in the area of soil erosion on the use of fallout radionuclides techniques. I would also like to take this opportunity to thank all our counterparts for their contributions to the work and achievements, and to all the readers for your support. I also want to thank all my team members in the SWMCN Subprogramme for their continued hard work and dedication given to me all this while.

Lee Heng
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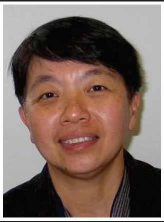	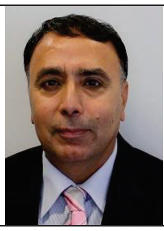		
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		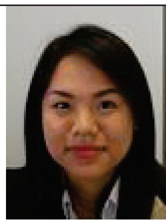	
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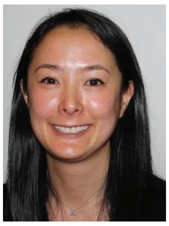
Staff News

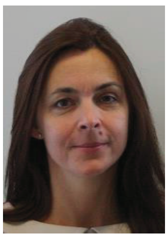


Janet Chen joined the SWMCN Laboratory as Junior Professional Officer in February 2016 to work on the development of isotope techniques for assessing soil organic carbon and nitrogen cycling within the context of climate-smart agriculture. She graduated from Washington State University (USA) with an MSc focusing on botany and did her PhD research at the University of Wyoming (USA) in the field of ecology. Until present, Janet has spent her academic and postgraduate career studying nitrogen and carbon dynamics at the soil-microorganism-plant interface using natural and tracer isotopic measurements, and field techniques in plant and ecosystem level physiology.

Amelia Lee Zhi Yi joined the SWMCN Laboratory as an intern in April 2016 to work on the use of N-15 and O-18 stable isotopes in identifying nitrate sources and quantifying their contribution to surface and ground waters. Amelia graduated from the University of Tokyo in Japan with an MSc in Environmental Science, focusing on hydrology. For her Master's research, she worked on developing the Iso-MATSIRO land surface model to trace the pathway of radioactive isotopes (^{131}I and ^{137}Cs) from the Fukushima Daiichi Nuclear Power Plant to water treatment plants in the Tokyo region. Prior to that, she studied Geology, majoring in Geochemistry, at Bryn Mawr College in Pennsylvania, USA and Environmental Engineering at Politechnika Krakowska (Cracow University of Technology) in Poland.

Emil Fulajtar joined the Soil and Water Management & Crop Nutrition Section on 1 June 2016 as a Soil Scientist. Emil graduated in geography and has a degree in soil science, M.Sc. from University of Ghent, Belgium in 1993 and a Ph.D. from the Comenius University in Bratislava, Slovakia in 2003. His field of expertise is in soil science, in particular in soil erosion. His experience with nuclear techniques began by studying the nitrogen cycle with the use of ^{15}N isotope. Later he specialized in soil erosion assessment through the use of fallout radionuclides (FRN) techniques (^{137}Cs, ^{210}Pb and ^{7}Be) and investigation of sediment sources with 13C and 15N stable isotopes. He carried out sediment dating using 13C signatures on C4 crops (such as maize and millet). Emil has a long association with the IAEA firstly through his participation in a CRP on "Assessment of Soil Erosion through the Use of 137Cs and Related Techniques as a Basis for Soil Conservation, Sustainable Agricultural Production and Environmental Protection (D1.50.05)" in 1996-2001, and later as a Technical Officer during a Special Service Agreement contract at SWMCN Section during 2006-2007. Before joining the IAEA, Emil worked as a research worker at the Soil Science and Conservation Research Institute (VUPOP) in Bratislava (1987-2001), later as a Science Officer of Cooperation in Science and Technology (COST) research networking programme at the European Commission (2001-2003) and the European Science Foundation (2003-2005). Mr Fulajtar has been the Head of the Soil Science Department at VUPOP since 2012. He has extensive experience in the management of international research projects associated with agriculture and environment. We welcome Emil to the Section and wish him a successful tenure in the Joint FAO/IAEA Programme.

Karuppan Sakadevan, Soil-Water Eco-physiologist completed his seven years of service with the Soil and Water Management & Crop Nutrition Section in April 2016 and returned to Australia. He joined the IAEA in April 2009 and implemented three coordinated research projects. During his period, Karuppan provided technical support to the Subprogramme, particularly on the IAEA's International Water Forum in 2011, International symposium on soil and climate change in 2012 including editing manuscripts for proceedings, and the conference to celebrate 2015 International Year of Soils. We wish Karuppan well in his future endeavours.



Malgorzata Rydeng joined the SWMCN Section from 1 September 2015 to 31 May 2016 as a team assistant. She worked on the implementation of planned events of the Sub programme of SWMCN by contributing to the Project Management and Organization's objectives and goals. She appreciated very much the team work in the Section.

According to her new assignment as team assistant, she moved to the Food and Environmental Protection Section. She has been working in the Section and Laboratories, supporting the implementation of Sub programme of FEP.

Feature Articles

Livestock Production and its Impact on Nutrient Pollution and Greenhouse Gas Emissions

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The livestock sector provides more than one third of human protein needs and is a major provider of livelihood in almost all developing countries. While providing such immense benefits to the population, poor livestock management can potentially provide harmful environmental impacts at local, regional and national levels which have not been adequately addressed in many countries with emerging economies. Twenty six percent of global land area is used for livestock production and forest lands are continuously being lost to such production. The intensification of livestock production led to large surpluses of nitrogen and phosphorus at the farm in many parts of the world with non-point source pollution of water resources that became a national concern. The sector is one of the largest sources of greenhouse gases (GHG) contributing around 14.5% of all human induced GHG emissions, a major driver of use and pollution of freshwater (accounting 10% anthropogenic water use) and contributed to the loss of biodiversity. About 60% of global biomass harvested annually to support all human activity is consumed by livestock industry, undermining the sustainability of allocating such large resource to the industry.

The Soil and Water Management and Crop Nutrition Section of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture reviewed the impacts of livestock production on nutrient pollution and greenhouse gas emissions as part of the coordinated research project on "Optimizing Soil, Water and Nutrient Use Efficiency in Integrated Cropping-Livestock Production Systems". The review paper has been accepted by "Advances in Agronomy" and will be published in August 2016.

The review showed that while the livestock sector is significantly important for global food security and economic activity, the interaction between livestock production and the environment is both a political and biophysical threat to the sustainability of the industry. As the intensity of livestock production increases to feed the increased global population, appropriation of more resources to support the expansion is required and this will put enormous pressure on ecosystem beyond their capacity leading to the collapse of the ecosystem and seriously affect services provided by the ecosystem. Additionally, in grasslands and permanent pastures, changes in livestock management by enabling maximum ground cover, minimal soil compaction and efficient nutrient utilization are difficult to achieve as the intensity of livestock production increases leading to more land and water quality degradation. Further, the increased livestock intensification and demand for limited water resources will force stakeholders to think carefully about the impacts of livestock production on water resources.

Without any corrective measures livestock intensification leads to (1) large areas of grazing land with high concentrations of N and P polluting surface and ground waters, (2) more native forest clearance feed crop production with losses of natural habitats and biodiversity, (3) increased anthropogenic greenhouse gas emission with climate change and extreme weather events, and (4) the degradation of arid and semi-arid land with continued marginalization of rural poor. As more forest is cleared the natural hydrology of the landscape changes with unpredictable discharge and flooding. However, there is optimism towards a sustainable livestock industry by addressing the conflicting demands for livestock production and environment. This sustainability can be achieved through innovative new technologies that will reduce the environmental impacts of livestock production and improve efficiency in the sector. Encourage efficiency through adequate policies, institutional support and market prices for the resources being used in livestock production is important for the sector to expand and play a major role in global hunger, nutrition and poverty reduction.

Proper incorporation of livestock manure into forage production systems would be an effective way of recycling manure to improve soil fertility and quality and reduce impacts of livestock management on water quality degradation. Forage production removes and recycles more nutrients from the soil than other crops especially when plants of high biomass yield with relatively high nitrogen (N) uptake capacity, tolerance to wet soil conditions, prolonged vegetative growth, and tolerance to frequent harvest are used. This will maximize manure nutrient utilization and reduce N and phosphorus (P) movement to surface and ground water. When using livestock manure for forage production careful consideration will be given to the N and P concentrations of manure. Integrating cropping with livestock production system reduce overall fertilizer consumption leading to reduced losses of N and P from the system compare to stand alone cropping or livestock production systems.

Stocking density in intensively managed pastures is an important factor controlling the extent and magnitude of the environmental impacts of livestock production. At low stocking density the number and frequency of hooves decreased leading to enhanced nutrient cycling and biodiversity, and at high stocking density damage to pasture may occur leading to soil erosion, runoff and water quality degradation. Reducing stocking density may be one option to reduce the environmental impacts. However, at low stocking density the economic return may be affected. The challenge is to optimize the stocking density taking into consideration factors such as soil texture, topography and the drainage system that reduces the environmental impacts of grazing without compromising the economic return of small farm holders. The development of GHG mitigation strategies and the ability to understand and adapt to changing environment are critical for sustaining livestock production system and reducing its GHG emissions.

The livestock industry has an overwhelming social importance in almost all developing countries as it is supporting rural population through year round income and human nutrition. Over the years the economic importance of livestock production has been given widespread attention. Even though it is possible to reduce the environmental impacts of livestock production at a reasonable cost, it has not been given priority in the past. Adequate institutional support and political willingness are important to reduce environmental impacts including GHG emissions and land and water quality degradation. A sustainable and profitable livestock system is possible through improved technologies, practices, and policies that promote incentives to stakeholders and balance the trade-off between sustainability and profitability of the system.

Further research, appropriate policy development and institutional support are important to ensure the competitiveness of the industry. Research focus can be directed towards integrating crops with livestock and incorporating silvi-pastoral systems are some options for sustainable livestock production and improve the system's environmental and climate footprints. Identifying sources of N_2O and CH_4 emissions from soils could help develop management plans that control source availability and overall GHG emissions reduction under livestock production.

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Assessing Soil Conservation Efficiency of Traditional Agricultural Practices by FRN Techniques: Example in the Highlands of Madagascar

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1. The challenge

Soil degradation induced by human activity is a major concern in Madagascar. More than 30% of the island's total soil area, covering 184 338 km^2, is degraded. Moreover, soil erosion and sedimentation cause not only on-site degradation of agricultural fertile soils in Madagascar, but also off-site problems such as downstream sediment deposition in floodplains, water streams and reservoirs. Therefore, there is a clear need to acquire reliable data on the pattern and magnitude of soil redistribution under various agricultural practices to promote effective conservation strategies.

2. The technique

Nuclear techniques such as ^{137}Cs and ^{210}Pb$_{ex}$ possess specific characteristics that make them effective soil tracers for erosion studies (IAEA, 2014). These fallout radionuclides (FRNs) have been initially uniformly distributed across the landscape via precipitation. After fallout, they are rapidly adsorbed onto fine soil particles. The determination of ^{137}Cs and ^{210}Pb redistribution provide information on medium-term (~50 years) and long-term (~100 years) average soil erosion/sedimentation rates and patterns, respectively. One of the main advantages of using both FRNs includes the potential for deriving complementary retrospective estimates of soil redistribution magnitudes based on a single site visit.

3. The study

The study area is located 40 km east of Antananarivo, in Madagascar highlands. To evaluate the effectiveness of traditional Malagasy soil conservation strategies for controlling soil erosion processes, two adjacent cultivated fields were selected, i.e. an unprotected field and a terraced field, as well as an undisturbed reference site in the vicinity of these agricultural fields (Figure 1). Soil samples were collected along transects using a motorized corer. The ^{137}Cs and $^{210}Pb_{ex}$ analyses were performed at the "*Institut National des Sciences et Techniques Nucléaires*" (INSTN-Madagascar) using a high resolution and low background N-type HPGe gamma detector. The Improved Mass-Balance Model conversion (MBM2) was employed to estimate the soil redistribution rates.

4. The results

The sloped field showed downward movement of soil particles (see Rabesiranana et al., 2016), in the terraced field, soil are retained and redistributed within the plot limiting off-site sediment delivery (Figure 2). At the terraced field, ^{137}Cs and $^{210}Pb_{ex}$ inventories reached 145 Bq m^{-2} to 280 Bq m^{-2} and 2141 Bq m^{-2} to 4253 Bq m^{-2}, respectively. At the unprotected field, the ^{137}Cs and $^{210}Pb_{ex}$ inventories values ranged from 110 Bq m^{-2} to 280 Bq m^{-2} and 2026 Bq m^{-2} to 4110 Bq m^{-2}, respectively. The net soil erosion determined for the unprotected field were 7.4 t ha^{-1} y^{-1} and 5.9 t ha^{-1} y^{-1} for ^{137}Cs and $^{210}Pb_{ex}$ methods, respectively. In contrast, at the terraced field, the net soil erosion rates reached only 3.4 t ha^{-1} y^{-1} and 3.8 t ha^{-1} y^{-1} for ^{137}Cs and $^{210}Pb_{ex}$ methods, respectively.

Moreover, FRNs timeframe discrimination highlights that at the unprotected field, erosion has increased for the last 50 years (from ^{137}Cs data) compared to the last 100 years (from $^{210}Pb_{ex}$ data). On the opposite, it has decreased at the terraced field.

Our results demonstrate that soil terracing reduces soil erosion as well as sediment delivery and, therefore provides an efficient solution to protect soil resources of the Malagasy highlands.

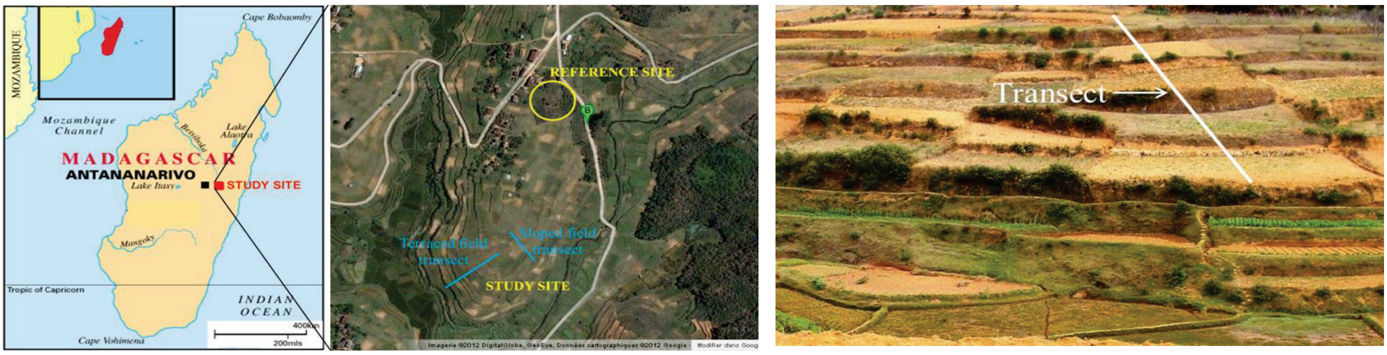

Figure 1. Study area location and picture of the terraced field investigated

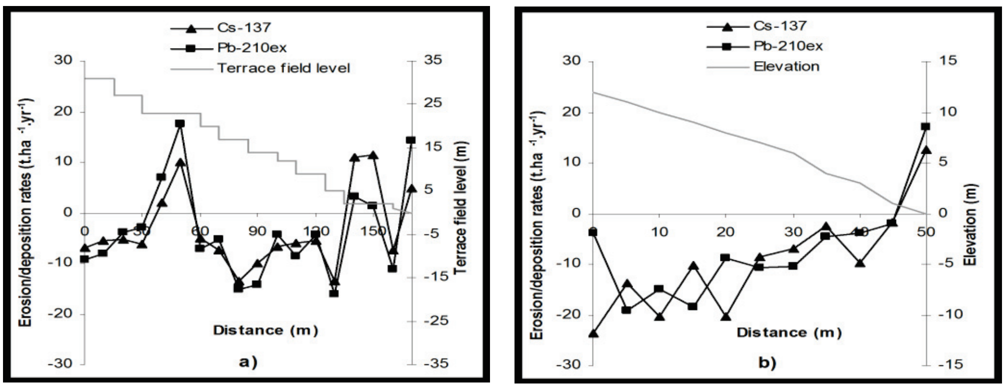

Figure 2. Soil redistribution rates along a) the terraced field and b) the unprotected field (NB: Figure. 2b is adapted from Rabesiranana et al. (2016))

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Salinity a Serious Threat to Food Security – Where Do We Stand?

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Over the past many years, overexploitation has shrunk the soil resources to an unprecedented level and there is great concern that it may not be able to provide the needed food to mankind in future, especially the food for the growing population. This shows that we are using soil resources as they are inexhaustible, continuing withdrawing from an account but never paying in and thus jeopardizing our and our children future. Thus soil resources are at the stake of diminishing capacity for ecosystem services including food production. Increasing human population, demographic pressures, climate change, increased competition between land and water resources, water scarcity, land degradation by salinity are likely to increase vulnerability to food security. The Food and Agricultural Organization (FAO) of the United Nations jointly with International Technical Panel on Soils (ITPS) has published the first-ever comprehensive report "status of the world's soil resources" and the overwhelming conclusion drawn is very astonishing "the majority of the world's soil resources are in only fair, poor or very poor conditions…" and conditions are getting worse in far more cases than they are improving. It also states that further loss of productive soils will seriously damage food production and food security, amplify food price volatility, and potentially plunge millions of people into hunger and poverty. Globally 33 percent land is in the state of degradation. The report offers evidence that this loss of soil resources and functions can be avoided (FAO and ITPS 2015). The latter part of the above quote gave hope; however, the question is how this damage can be reversed.

Agricultural land once used for food production has been diminished due to urbanization and land degradation via erosion, salinity, and compaction; salinity is one of these attracted most attention since centuries. The two main threats to the global productive and healthy soils, which are thought to be irreversible and the scientists have less control; are population growth (in year 1700 population was 0.6 billion, 1.6 billion in 1900, and 7.3 billion in 2015, with business as usual the population is projected to be 9.6 billion in 2050 and 10.9 billion by the year 2100), and subsequent urbanization.

In this article our focus is on salinity threats to soils and food security. It occurs mainly in irrigated agriculture in arid and semi-arid regions where rainfall is not sufficient to offset water requirement of crops and to leach soluble salts in the root zone. Soil salinity is seen as a major global issue owing to their adverse impact on agricultural productivity and sustainability. Salinity if not managed timely can reduce the crop yield and can completely eliminate the crop above certain salinity thresholds. Currently, no accurate and recent statistics exists on the global extent of salt-affected soils, and thus requires filling this gap urgently. Some estimates suggest 412 million hectares affected by salinity and 618 million hectares to sodicity.

Historical records also show that many civilizations failed due to increased salinity in agriculture fields, the most known one is Mesopotamia (now Iraq), because soil salinity undermines the resource base by decreasing soil quality. This could be natural or a symptom of misuse and mismanagement that jeopardizes the integrity of soil's self-regulatory capacity. The soil salinity is dynamic, globally spreading over more than 100 countries, and no continent, even Antarctica (originally thought to be free from salinity but glaciers), is not completely free from salinity. It occupies more than 20% of the global irrigated area. In addition to the generation of latest information on the global and regional extent of salinization, it is also essential to estimate economic losses due to salinization. Recently Qadir et al (2014) presented global annual cost of salt-induced land degradation in irrigated areas. World is losing 2,000 hectares of farm soil daily to salt-induced degradation. Salt-spoiled soils worldwide are 20% of all irrigated lands, extensive costs include US$27 billion + in lost crop value per year. In 1990 annual cost of salt-induced land degradation was US$ 264 per hectare, which increased to US$ 441 per hectare in 2013. With the pace of 2,000 hectares daily loss due to salinization, and assuming the business as usual, we leave it to the readers to project how soon the current irrigated land (310 million hectares currently producing 40% world food) will go out of agriculture production, and also forecast the population by then, and the fate of such decline on food supply.

With the business as usual and in general the present and future conditions do not look good for food sustainability. In authors' opinion, if threats to soils are properly diagnosed and understood using isotopic and nuclear as well as conventional technologies, diagnostics based good management practices are adopted, their pre- and post-project environmental impact assessment studied prior to the project implementation, we can curtail and even reverse soil degradation. The IAEA, in partnership with the Food and Agriculture Organization of the United

Nations (FAO) through the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, assists the Member States of IAEA in using nuclear techniques to combat salinity and adopting climate smart agricultural practices. These nuclear and isotopic techniques include: soil moisture neutron probe to accurately measure soil moisture under saline conditions for precise irrigation scheduling, N-15 to quantify biological N fixation by leguminous crops for enhancing soil fertility and fertilizer use efficiency of the applied chemical fertilizer, C-13 to screen plants for their salt-tolerance, and O-18 and H-2 for separating water losses via evaporation and transpiration to better manage water under saline condition. The SWMCN sub-programme has also initiated a coordinated research project (CRP) “Landscape salinity and water management for improving agricultural productivity (D1.20.13)” since 2013 to identify ways to improve crop productivity and sustainability through water and salinity management, define approaches and technologies to assess and monitor soil water content and salinity at field and area-wide scales, and reduce the impacts of climate change and variability on the widespread increase in landscape. In addition, through technical support, capacity building and technology transfer from IAEA, Algeria Technical Cooperation project was able to improve the management of barren land through accurate irrigation scheduling and use of saline groundwater and the introduction of salt-tolerant cereals. This approach resulted in a significant increase in yields as well the identification of ways for potential recovery of 42,000 ha of abandoned land in Algeria.

Farmer’s education on the management of saline soils, adoption of salt-tolerant crops (biosaline agriculture), efficient nutrient and water management, crop Management, post-harvesting and marketing, is the pre-requisite for technologies adoption. It is believed, that if the farmers receive specialized training in above subjects, agricultural intensification is possible leading to increased food production per unit area that will set the way forward to achieve food sustainability. This requires investments to strengthen Research-Extension-Farmers linkage, a key to successful agriculture in saline soils. In general soil education is basic infrastructure for the nation and better knowledge reduces risks in decision making.

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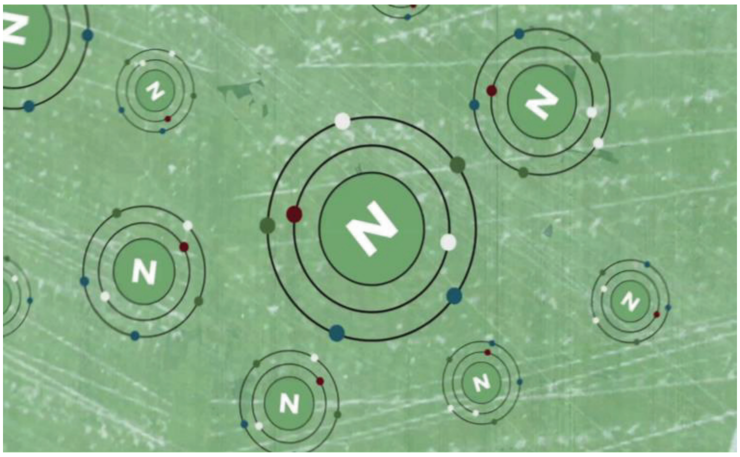
Announcement

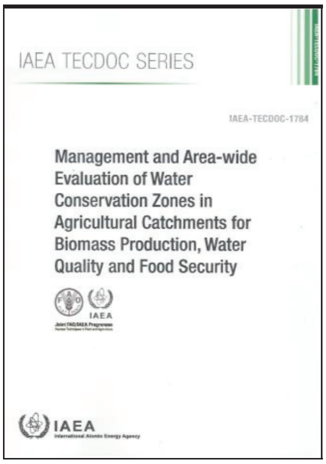
Animated Infographic on “Managing Nitrogen”

The SWMCN Subprogramme is proud to present another animated infographic on “Managing Nitrogen”, providing the general audience a simple and comprehensive illustration on the importance of nitrogen (N) for crop production and on the use of nitrogen-15 isotopic technique for tracing the fate of applied N fertilizers in soils, agricultural lands and the environment, and for quantifying the amount of N added to the soil by legumes through biological N fixation. The infographic on Managing N can be accessed through the following links: http://www-naweb.iaea.org/nafa/resources-nafa/Managing-Nitrogen-LR.mp4 and https://youtu.be/wC2f8hMd3-Y



New FAO/IAEA Publication: Management and Area-wide Evaluation of Water Conservation Zones in Agricultural Catchments for Biomass Production, Water Quality and Food Security

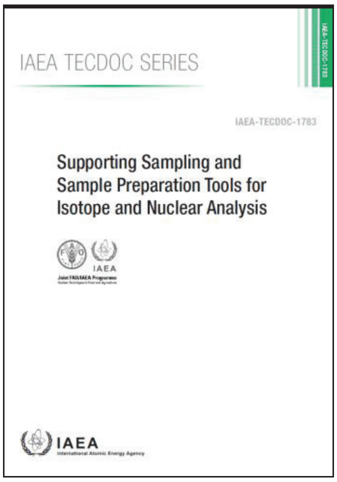
This FAO/IAEA publication (IAEA-TECDOC-1784) compiled the work carried out under the coordinated research project (CRP) ‘Strategic Placement and Area-Wide Evaluation of Water Conservation Zones in Agricultural Catchments for Biomass Production, Water Quality and Food Security’, involving twelve participants from ten countries (China, Estonia, France, Islamic Republic of Iran, Lesotho, Nigeria, Romania, Tunisia, Uganda and the United States of America). The overall objective of this CRP was to assess and enhance ecosystem services provided by water conservation zones (wetlands, ponds and riparian buffer zones) for improving the capture and storage of water and nutrient within agricultural catchments and their use for crop production.



New FAO/IAEA Publication: Supporting sampling and sample preparation tools for isotope and nuclear analysis

This FAO/IAEA publication (IAEA-TECDOC-1783) was developed to provide illustrated, step by step, comprehensive guidance for sampling and processing of soil, water and plant materials. It aims to assists scientists, technicians and students in Member States in implementing procedures and tools to take and prepare samples for isotope and nuclear analyses in their efforts to develop climate-smart agricultural practices for improved soil, water and nutrient management and to prepare and respond to nuclear emergencies in food and agriculture. The TECDOC includes the following modules: (i) Particulate organic matter separation, (ii) Method for the purification of inorganic phosphate in soil and sediment samples prior to analysis of the δ18O isotopic abundance in phosphate, (iii) Extraction of water from soil and plant samples for $^{18}O/^{16}O$ and D/H isotope ratio measurements, (iv) How to perform precise soil and sediment sampling? One solution: The Fine Increment Soil Collector and (v) Guidelines for measuring bulk density of soil. It can be found at:

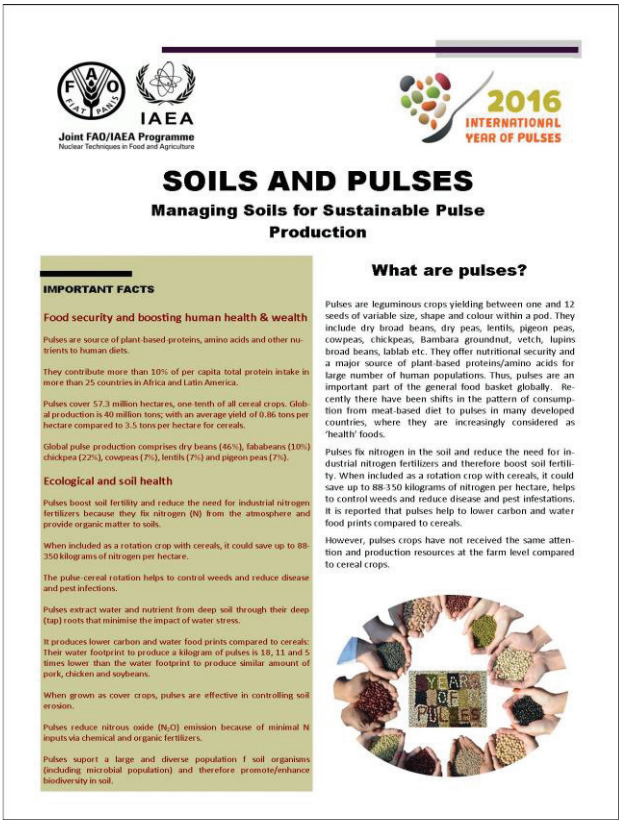
http://www-pub.iaea.org/MTCD/Publications/PDF/TE-1783_web.pdf.



Highlights

International Year of Pulses (IYP 2016)

The international community is coming together to celebrate 2016 as the International Year of Pulses. Soil and Water Management and Crop Nutrition Section in the Joint FAO/IAEA Division is highlighting its work supporting Member States to emphasize the importance of pulses and the role they play in restoring fertility of degraded land, reducing emissions of greenhouse gases from agricultural production systems and human nutrition.


IAEA
Joint FAO/IAEA Programme
Nuclear Techniques in Food and Agriculture
2016 INTERNATIONAL YEAR OF PULSES

SOILS AND PULSES

Managing Soils for Sustainable Pulse Production

IMPORTANT FACTS

Food security and boosting human health & wealth

Pulses are source of plant-based-proteins, amino acids and other nutrients to human diets.

They contribute more than 10% of per capita total protein intake in more than 25 countries in Africa and Latin America.

Pulses cover 57.3 million hectares, one-tenth of all cereal crops. Global production is 40 million tons; with an average yield of 0.86 tons per hectare compared to 3.5 tons per hectare for cereals.

Global pulse production comprises dry beans (46%), fababeans (10%) chickpea (22%), cowpeas (7%), lentils (7%) and pigeon peas (7%).

Ecological and soil health

Pulses boost soil fertility and reduce the need for industrial nitrogen fertilizers because they fix nitrogen (N) from the atmosphere and provide organic matter to soils.

When included as a rotation crop with cereals, it could save up to 88-350 kilograms of nitrogen per hectare.

The pulse-cereal rotation helps to control weeds and reduce disease and pest infections.

Pulses extract water and nutrient from deep soil through their deep (tap) roots that minimise the impact of water stress.

It produces lower carbon and water food prints compared to cereals: Their water footprint to produce a kilogram of pulses is 18, 11 and 5 times lower than the water footprint to produce similar amount of pork, chicken and soybeans.

When grown as cover crops, pulses are effective in controlling soil erosion.

Pulses reduce nitrous oxide (N_2O) emission because of minimal N inputs via chemical and organic fertilizers.

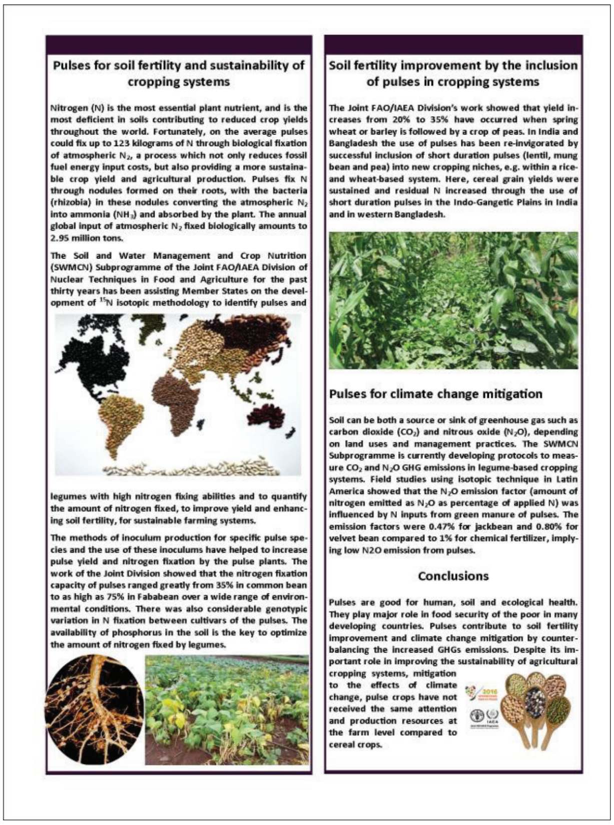
Pulses suport a large and diverse population f soil organisms (including microbial population) and therefore promote/enhance biodiversity in soil.

What are pulses?

Pulses are leguminous crops yielding between one and 12 seeds of variable size, shape and colour within a pod. They include dry broad beans, dry peas, lentils, pigeon peas, cowpeas, chickpeas, Bambara groundnut, vetch, lupins broad beans, lablab etc. They offer nutritional security and a major source of plant-based proteins/amino acids for large number of human populations. Thus, pulses are an important part of the general food basket globally. Recently there have been shifts in the pattern of consumption from meat-based diet to pulses in many developed countries, where they are increasingly considered as 'health' foods.

Pulses fix nitrogen in the soil and reduce the need for industrial nitrogen fertilizers and therefore boost soil fertility. When included as a rotation crop with cereals, it could save up to 88-350 kilograms of nitrogen per hectare, helps to control weeds and reduce disease and pest infestations. It is reported that pulses help to lower carbon and water food prints compared to cereals.

However, pulses crops have not received the same attention and production resources at the farm level compared to cereal crops.


Pulses for soil fertility and sustainability of cropping systems

Nitrogen (N) is the most essential plant nutrient, and is the most deficient in soils contributing to reduced crop yields throughout the world. Fortunately, on the average pulses could fix up to 123 kilograms of N through biological fixation of atmospheric N_2, a process which not only reduces fossil fuel energy input costs, but also providing a more sustainable crop yield and agricultural production. Pulses fix N through nodules formed on their roots, with the bacteria (rhizobia) in these nodules converting the atmospheric N_2 into ammonia (NH_3) and absorbed by the plant. The annual global input of atmospheric N_2 fixed biologically amounts to 2.95 million tons.

The Soil and Water Management and Crop Nutrition (SWMCN) Subprogramme of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture for the past thirty years has been assisting Member States on the development of ^{15}N isotopic methodology to identify pulses and legumes with high nitrogen fixing abilities and to quantify the amount of nitrogen fixed, to improve yield and enhancing soil fertility, for sustainable farming systems.

The methods of inoculum production for specific pulse species and the use of these inoculums have helped to increase pulse yield and nitrogen fixation by the pulse plants. The work of the Joint Division showed that the nitrogen fixation capacity of pulses ranged greatly from 35% in common bean to as high as 75% in Fababean over a wide range of environmental conditions. There was also considerable genotypic variation in N fixation between cultivars of the pulses. The availability of phosphorus in the soil is the key to optimize the amount of nitrogen fixed by legumes.

Soil fertility improvement by the inclusion of pulses in cropping systems

The Joint FAO/IAEA Division's work showed that yield increases from 20% to 35% have occurred when spring wheat or barley is followed by a crop of peas. In India and Bangladesh the use of pulses has been re-invigorated by successful inclusion of short duration pulses (lentil, mung bean and pea) into new cropping niches, e.g. within a rice- and wheat-based system. Here, cereal grain yields were sustained and residual N increased through the use of short duration pulses in the Indo-Gangetic Plains in India and in western Bangladesh.

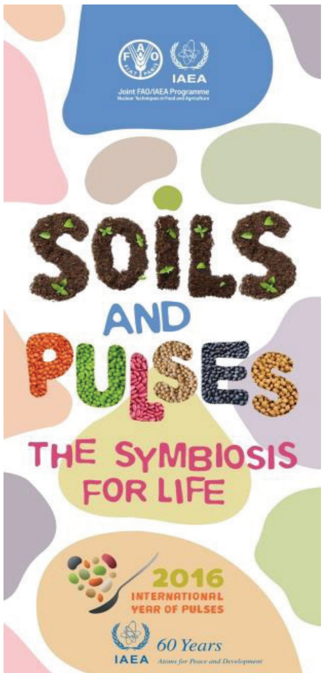
Pulses for climate change mitigation

Soil can be both a source or sink of greenhouse gas such as carbon dioxide (CO_2) and nitrous oxide (N_2O), depending on land uses and management practices. The SWMCN Subprogramme is currently developing protocols to measure CO_2 and N_2O GHG emissions in legume-based cropping systems. Field studies using isotopic technique in Latin America showed that the N_2O emission factor (amount of nitrogen emitted as N_2O as percentage of applied N) was influenced by N inputs from green manure of pulses. The emission factors were 0.47% for jackbean and 0.80% for velvet bean compared to 1% for chemical fertilizer, implying low N2O emission from pulses.

Conclusions

Pulses are good for human, soil and ecological health. They play major role in food security of the poor in many developing countries. Pulses contribute to soil fertility improvement and climate change mitigation by counterbalancing the increased GHGs emissions. Despite its important role in improving the sustainability of agricultural cropping systems, mitigation to the effects of climate change, pulse crops have not received the same attention and production resources at the farm level compared to cereal crops.

EXHIBITION: Celebrating the International Year of Pulses: 20 September 2016, IAEA HQ



The SWMCN Section together with the Plant Breeding and Genetics Section within the Joint FAO/IAEA Division of Nuclear techniques in Food and Agriculture will be celebrating the International Year of Pulses (IYP), as part of the global celebration of the 2016IYP events. Pulses will be presented as crops showing nodules for their ability to fix nitrogen to improve soil fertility which can be quantified through the use of ^{15}N stable isotope.

Technical Cooperation Field Projects

Operational Projects and Technical Officers Responsible for Implementation

Country/Region	TC Project	Description	Technical Officer(s)
Afghanistan	AFG5006	Developing and Implementing Soil and Water National Management System Using Nuclear Techniques	E. Fulajtar
Algeria	ALG5029	Improving Wheat and Legume Yield through Better Water and Fertilizer Management and Introduction of New Vegetal Material	M. Zaman
Bangladesh	BGD5029	Evaluating Promising Abiotic Stress Tolerant Crop Mutants/Varieties and Measuring the Suitable Management Practices for the Promotion of Sustainable Production at Saline, Submergence and Drought Prone Areas	A. Wahbi
Bolivia	BOL5021	Strengthening the Strategic Development Plan for Quinoa Production through Improved Use of Organic Manure, Soil and Crop Management	M. Zaman
Botswana	BOT5012	Improving Soil and Water Management Options to Optimize Yields of Selected Crops	J. Adu-Gyamfi
Brazil	BRA5059	Strengthening Strategies of Soil and Water Conservation at the Landscape Level in Natural and Agricultural Ecosystems	E. Fulajtar and G. Dercon
Burkina Faso	BKF5016	Using Nuclear Techniques for Improving Rice Yield and Quality	J. Adu-Gyamfi in collaboration with Plant Breeding and Genetics Section
Burundi	BDI5001	Improving Cassava Productivity through Mutation Breeding and Better Water and Nutrient Management Practices Using Nuclear Techniques	M. Zaman in collaboration with Plant Breeding and Genetics Section
Central African Republic	CAF5008	Cassava androgeneses culture and contribution to soil fertilization	M. Zaman
Cameroon	CMR5021	Developing Best Nutrient and Water Management Practices to Improve Soil Fertility and Productivity and Minimize Land Degradation Using Isotopic Techniques	J. Adu-Gyamfi
Chad	CHD5012	Using Nuclear Technology to Improve Knowledge and Sustainable Agricultural Production to Safeguard Lake Chad	J. Adu-Gyamfi

Country/Region	TC Project	Description	Technical Officer(s)
Costa Rica	COS5033	Assessing and Implementing Biochar Use in Climate Smart and Environmentally Friendly Pineapple Production Using Isotopic Techniques	M. Zaman in collaboration with Food and Environmental Protection Section
Cuba	CUB5019	Strengthening National Capacity for Monitoring Heavy Metals to Improve Soil and Food Quality Using Nuclear and Related Techniques	E. Fulajtar in collaboration with Food and Environmental Protection Section
Ecuador	ECU5028	Consolidating Food Security and Environmental Sustainability in Palm Oil Production Using Nuclear Applications	J. Adu-Gyamfi in collaboration with Food and Environmental Protection Section
Haiti	HAI5006	Increasing Productivity and Exportability in the Agricultural Sector through Soil and Water Management and Food Safety Monitoring	J. Adu-Gyamfi in collaboration with Food and Environmental Protection Section
Interregional project	INT5153	Assessing the Impact of Climate Change and its Effects on Soil and Water Resources in Polar and Mountainous Regions	G. Dercon
Iran	IRA5013	Investigating the Effects of Deforestation and Afforestation on Soil Redistribution	M. Zaman
Iraq	IRQ5020	Restoring Biomass Productivity of Range Land by Using Nuclear Techniques and Advanced Technology	A. Wahbi
Cambodia	KAM5001	Improving Soil Fertility and Crop Management Strategies in Diversified Rice Based Farming Systems	L. Heng
Jamaica	JAM5012	Optimizing Irrigation Water Management to Improve Crop Output and Water Quality Control	L. Heng
Kenya	KEN5036	Developing Soil Fertility and Water Management for Soil, Crop and Livestock Integration in Three Agro-Ecological Zones	J. Adu-Gyamfi
Kuwait	KUW5001	Improving Production and Water Use Efficiency of Forage Crops with Nuclear Techniques	A. Wahbi
Laos	LAO5002	Improving Soil Fertility and Water Use Efficiency in the Cassava-Rice-Soybean Production System under Smallholder Farming Systems	M. Zaman

Country/Region	TC Project	Description	Technical Officer(s)
Mauritania	MAU5006	Contributing to the Improvement of Rice Crop Yields through the Application of Nuclear Techniques To Water Management and Soil Fertility	M. Zaman in collaboration with Plant Breeding and Genetics Section
Myanmar	MYA5025	Monitoring and Assessment of Watershed Management Practices on Water Quality and Sedimentation Rate of Inle Lake	E. Fulajtar and L. Heng
Namibia	NAM5014	Evaluating Efficient Water and Nutrient Use, Molecular Characterization and Nutritional Composition of Mutant Germplasm Populations	J. Adu-Gyamfi in collaboration with Plant Breeding and Genetics Section
Nicaragua	NIC5009	Introducing Integrated Environmental Management in the Watershed of the Nicaraguan Great Lakes and the San Juan River: Responding to Future Challenges with Nuclear Techniques	E. Fulajtar
Niger	NER5019	Improving Sesame Plant Productivity by Obtaining High-Yielding Induced Mutants Adapted to Semi-Arid Conditions	J. Adu-Gyamfi in collaboration with Plant Breeding and Genetics Section
Niger	NER5021	Using Microbial Biotechnology to Improve Productivity and Adapt Cowpea to Climate Change	J. Adu-Gyamfi in collaboration with Plant Breeding and Genetics Section
Panama	PAN5023	Enhancing Rice Crop Yields by Improving Water and Nutrient Management Using Nuclear and Isotopic Techniques	M. Zaman
Sri Lanka	SRL5045	Establishing a National Centre for Nuclear Agriculture	M. Zaman
T.T.U.T.J of T. Palestinian A.	PAL5008	Reducing Soil Degradation by Improving Soil Conservation using Fallout Radionuclides (Phase I)	E. Fulajtar and.L. Mabit
Africa	RAF0038	Promoting Technical Cooperation Among Developing Countries (TCDC) in Africa through Triangular Partnerships (AFRA). [Bilateral TC project between Morocco and Côte d'Ivoire]	L. Mabit
Africa	RAF5071	Enhancing Crop Nutrition and Soil and Water Management and Technology Transfer in Irrigated Systems for Increased Food Production and Income Generation (AFRA)	L. Heng

Country/Region	TC Project	Description	Technical Officer(s)
Africa	RAF5075	Enhancing Regional Capacities for Assessing Soil Erosion and the Efficiency of Agricultural Soil Conservation Strategies through Fallout Radionuclides	E. Fulajtar and L. Mabit
Asia	RAS5069	Complementing Conventional Approaches with Nuclear Techniques towards Flood Risk Mitigation and Post-Flood Rehabilitation Efforts in Asia	E. Fulajtar in collaboration with Plant Breeding and Genetics, Animal Production and Health and Isotope Hydrology Sections
Asia	RAS5070	Developing Bioenergy Crops to Optimize Marginal Land Productivity through Mutation Breeding and Related Techniques (RCA)	M. Zaman in collaboration with Plant Breeding and Genetics,
Asia	RAS5072	Enhancing the Use of Salt Affected Soils and Saline Water for Crop and Biomass Production and Reducing Land and Water Quality Degradation in ARASIA states parties	A. Wahbi
Asia	RAS5073	Climate Proofing Rice Production Systems (CRiPS) Based on Nuclear Applications, Phase II	L. Heng in collaboration with Plant Breeding and Genetics Section
Asia	RAS5075	Improving Sustainable Cotton Production Through Enhanced Resilience to Climate Change	M. Zaman in collaboration with Plant Breeding and Genetics
Latin America	RLA5064	Strengthening Soil and Water Conservation Strategies at the Landscape Level by Using Innovative Radio and Stable Isotope and Related Techniques (ARCAL CXL)	G. Dercon
Latin America	RLA5065	Improving Agricultural Production Systems Through Resource Use Efficiency (ARCAL CXXXVI)	J. Adu-Gyamfi
Seychelles	SEY5007	Increasing Crop Production through Effective Management of Soil Salinity in the Coastal Area using Nuclear and Related Techniques	L. Heng
Sudan	SUD5037	Application of nuclear and related biotechnology techniques to improve of crop productivity and lively hood of small scale farmers drought prone areas of Sudan	M. Zaman in collaboration with Plant Breeding and Genetics Section
Uganda	UGA5037	Introducing Integrated Soil Fertility Management for Improved Crop Production and Food Security	E. Fulajtar and L. Mabit
Zimbabwe	ZIM5021	Assessing and Promoting Sustainable Agricultural Production in Communal and Newly Resettled Farms	L. Mabit in collaboration with Plant Breeding and Genetics Section

Forthcoming Events

FAO/IAEA Events

RAS 5070: Regional Training Course on Nutrient and Water Management for Bioenergy Crops in Marginal Lands, 11 -22 July 2016, Kathmandu, Nepal

Technical Officer: Mohammad Zaman

The purpose of this two weeks regional training course is to build knowledge on improving soil fertility, enhancing nutrient and water use efficiencies of marginal land using nuclear, isotopic and conventional techniques.

RLA5065: Mid-Term Review Meeting of RAS5065 on "Improving Agricultural Production Systems through Resource Use Efficiency (ARCAL CXXXVI)", 18-22 July 2016, San José, Costa Rica

Technical Officer: Joseph Adu-Gyamfi

The aim of the mid-term review meeting is to review and report the progress made under the project and to develop a work plan for the coming years including formulating the design and implementation of the field experiments for 2017.

First research coordination meeting (RCM) of the CRP D1.50.17 on "Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystems", 25-29 July 2016, Vienna, Austria

Technical Officers: Lionel Mabit and Lee Heng

This Coordinated Research Project (CRP) aims at developing combinations of nuclear techniques to assess changes in soil erosion, and distinguish and apportion impacts of climate variability and agricultural management on soil erosion in upland agro-ecosystems.

The purpose of the first research coordination meeting (RCM) is to discuss and review individual experimental plans of the CRP participants in line with the objectives of the CRP, and to provide them guidance for the next 18 months. It is expected that four research contractors, two technical contractors and seven agreement holders will attend the RCM.

Training course on "Nitrogen Management in Agro-Ecosystems", 25 July-5 August 2016, Seibersdorf, Austria

Technical Officer: Gerd Dercon

The Soil and Water Management & Crop Nutrition Laboratory with financial support of the IAEA Department of Technological Cooperation will host a training course on 25 July-5 August 2016 in Seibersdorf on the use of stable isotope nitrogen-15 techniques for improving nitrogen management in agro-ecosystems, as part of the celebration of the International Year of Pulses. This course will focus in particular on how to assess, with isotopes, the capacity of grain legume crops (pulses) to capture nitrogen from the atmosphere.

Joint event on "Enhancing pulses for food security by nuclear applications" at 60th anniversary of IAEA General Conference, September 2016, Vienna, Austria

Technical Officer: Lee Heng

In response to the 68th UN General Assembly declaration of 2016 as the International Year of Pulses (IYP), the Soil and Water Management and Crop Nutrition and the Plant Breeding and Genetic Subprogrammes within the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture will organize a joint event on "Pulses for Food Security: The role of nuclear techniques" in September 2016, during the 60th IAEA General Conference. The event is to heighten awareness of the contribution of soils and water management practices and plant mutation breeding using nuclear and isotopic techniques to improve pulse production for food security. The SWMCN Subprogramme produced several publications including a brochure on "Soils and Pulses: Managing soils for sustainable pulse production".

Technical workshop on "Remediation of Radioactive Contamination in Agriculture", 17-18 October 2016, Vienna, Austria

Technical Officer: Gerd Dercon

The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture will host a technical workshop on *Remediation of Radioactive Contamination in Agriculture*, from 17 to 18 October 2016 in Vienna. It is being planned and implemented in collaboration with the National Agricultural and Food Research Organization (NARO) of Japan. The aim of the workshop is to strengthen the global network for collaboration on remediation of radioactive contamination in food and agriculture. This event will highlight the experience gained in the remediation of radioactive contamination in agriculture and facilitate a broader understanding of the practical remediation methods. The Technical Workshop will serve to make the authorities and organizations responsible for food and agriculture aware of the danger of radioactive contamination for future policy development and research planning.

RAF5075: Regional Training Course on The Use of Short-lived Fallout Radionuclides (e.g. ^{7}Be) for Evaluating Soil Erosion/Sedimentation Magnitudes and the Effectiveness of Soil Conservation, 17-28 October 2016, SWMCN Laboratory, Seibersdorf, Austria

Technical Officer: Lionel Mabit

The main objective of this two weeks regional training course that will take place at the SWMCN Laboratory in Seibersdorf, is to equip the participants of RAF5075 with the knowledge and understanding on the use of short-lived fallout radionuclide (FRN) such as ^{7}Be (and to some extent ^{137}Cs). In the framework of RAF5075 i.e. "Enhancing Regional Capacities for Assessing Soil Erosion and the Efficiency of Agricultural Soil Conservation Strategies through Fallout Radionuclides", the use of ^{7}Be will allow the participants (i) to investigate erosion and sedimentation on short time scale processes and (ii) to assess the effectiveness of soil conservation strategies implemented in their respective countries.

Third RCM of the CRP D1.20.13 on "Landscape Salinity and Water Management for Improving Agricultural Water Productivity" 31 October-4 November 2016, Ho Chi Ming City, Viet Nam

Technical Officer: Joseph Adu-Gyamfi and Lee Heng

The purpose of the 3rd research coordination meeting (RCM) is to review and evaluate results obtained for the CRP since the previous RCM in October 2014, and to develop work plan for coming years.

Final RCM of the CRP D1.50.13 on "Approaches to Improvement of Crop Genotypes with High Water and Nutrient Use Efficiency for Water Scarce Environments" 7-11 November 2016, Vienna, Austria

Technical Officers: Joseph Adu-Gyamfi and Ljupcho Jankuloski

The purpose of the final research coordination meeting is to present and discuss the results obtained for the whole duration of the CRP, evaluate achievements in accordance with project objectives and expected outputs, and review manuscripts prepared for publication. Achievements with respect to (i) the total area covered by the improved/mutant variety (ii) the per cent increase in yield (iii) the contribution of good soil and water management practices to the yield increase will be discussed. It is expected that ten research contract, two agreement and one technical contract holders will be attending the meeting.

Final RCM of the CRP D1.50.12 on "Soil Quality and Nutrient Management for Sustainable Food Production in Mulch-Based Cropping Systems in Sub-Saharan Africa", 21-24 November 2016, Vienna, Austria

Technical Officers: Mohammad Zaman and Gerd Dercon

The aim of the final RCM is to present and discuss the results obtained since the beginning of the CRP, and evaluate progress report in the light of project objectives and expected outputs.

Non-FAO/IAEA Events

American Society of Agronomy, Crop Science Society of America, and Soil Science Annual Meeting, 6-9 November 2016, Phoenix, Arizona, USA.

FAO IYP Closing Event, 1 December 2016, FAO UN HQ, Rome, Italy.

7th International Nitrogen Initiative Conference, 4-8 December 2016, Melbourne, Australia. http://www.ini2016.com/

15th International Symposium Soil and Plant Analysis, 14-18 May 2017, Nanjing, China. http://isspa2017.csp.escience.cn/dct/page/1

Past Events

Meetings at the IAEA

RAS 5072: First Coordination meeting of the Regional Technical Cooperation on "Enhancing the Use of Salt-Affected Soils and Saline Water for Crop and Biomass Production and Reducing Land and Water Quality Degradation in ARASIA States Parties", 7-10 March 2016, Vienna, Austria

Technical Officer: Ammar Wahbi

The meeting was attended by 16 representatives from Iraq, Jordan, United Arab Emirates, Lebanon, Oman, Syrian Arab Republic, Saudi Arabia, Qatar, Kuwait and Yemen.

The purpose of this meeting was to provide an overview of the achievements under the previous project (RAS 5068) "Developing Effective Practices for Combating Desertification (ARASIA)", to present, discuss and design individual country work plan of the new regional project (RAS5072) and to schedule the future activities.

The nuclear and isotopic techniques in forthcoming field trials include neutron probe, ^{15}N and Carbon Isotope Discrimination (CID).

Two regional trainings have been planned as part of the capacity building which includes:

1. Two week training on "Water management and use of crop simulation model (AquaCrop) at the International Centre for Biosaline Agriculture, Dubai (U.A.E) in October 2016.

2. One week training on "Nitrogen use efficiency using ^{15}N and Carbon Isotope Discrimination (CID) at Kuwait Institute for Scientific Research (KISR). This training will be held either in December 2016 or January 2017.

RAS 5070: Coordination meeting to discuss the use of marginal land and resource use efficiency to improve soil fertility for growing crops including bioenergy crops, 15-18 March 2016, Vienna, Austria

Technical Officer: Mohammad Zaman

The coordination meeting was attended by participants from Bangladesh, China, Cambodia, Fiji, India, Indonesia, Malaysia, Myanmar, Mongolia, Nepal, Pakistan, Thailand, The Philippines, Sri Lanka and Vietnam. Mr. Oscar Acuna, Section Head of Asia and Pacific Division of IAEA Department of Technical Cooperation (TCPAP), welcome the participants, followed by presentations from Mr. Sinh Hoang, PMO and Mr. Mohammad Zaman, technical officer of RAS 5070. The PMO also informed the participants about the contribution of USD 200,000 for RAS 5070 by Japan. The purpose of the coordination meeting was to (a) review and finalizes the activities stipulated in the project work plan; (b) review the current status of soil and water management practices on marginal land and identify the roles of nuclear and isotopic techniques in the project; and (c) address the gaps and needs for the application of best soil and water management practices to improve soil fertility of marginal land to ensure growing a range of crops including corn, sugarcane, cassava, coconut, Kenaf and rapeseed in a sustainable and economical way. After individual country presentations, participants developed work plan for field activities of 2016-17

Participants of RAS 5070 at Vienna International Centre

Long Night of Research

More than 1300 visitors visited the IAEA Headquarters in Vienna on 22 April 2016 for the Long Night of Research.

The large rotunda of the Vienna International Centre was transformed for one night in an interactive exhibition space to showcase nuclear sciences and applications for peace and development. IAEA scientists highlighted more than a dozen scientific fields, with special attention for the smallest and youngest and very junior "scientists" under us.

The Soil and Water Management & Crop Nutrition Subprogramme presented the use of innovative and state-of-the-art stable isotope techniques for monitoring greenhouse gases from agriculture. Visitors to the Long Night of Research were also learning about the reasons soil management matters to climate change through a keynote given by Mr. Gerd Dercon, Head of the Soil and Water Management & Crop Nutrition Laboratory.

Duty travel

Ecuador: Technical support to Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP) of Ecuador for supporting the National Irrigation Plan, 4 - 5 January 2016, Quito, Ecuador

Technical Officer: Gerd Dercon

Mr. Gerd Dercon travelled to Quito to visit the Sub-Secretariat of Irrigation and Drainage of the Ministry of Agriculture, Livestock, Aquaculture and Fisheries (MAGAP) of Ecuador, for giving advice on the National Irrigation Plan, which targets a large-scale implementation or improvement of irrigation systems in the coastal and Andes region of Ecuador. Through this visit, the technical officer also explored opportunities for collaboration between the Soil and Water Management & Crop Nutrition Subprogramme of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and the MAGAP.

This mission took place, upon the request of the Permanent Mission of Ecuador to the IAEA. Mr. Dercon met stakeholders from the MAGAP, one NGO (Central Ecuatoriana de Servicios Agrícolas) and farmer organizations, and visited three irrigation schemes in the provinces of Pichincha and Tungurahua of Ecuador.

Mexico: To participate as Technical Officer in the Final Coordination Meeting of project RLA5064 on "Strengthening Soil and Water Conservation Strategies at the Landscape Level by Using Innovative Radio and Stable Isotope and Related Techniques", 20-24 January 2016, Mexico City, Mexico

Technical Officer: Gerd Dercon

Mr. Gerd Dercon travelled to Mexico to participate as Technical Officer in the final coordination meeting for assessing implementation of project activities and interpretation of combined data sets of project RLA5064.

The RLA5064 project team has achieved the general and specific objectives of the project and reached additional goals beyond those planned. The regional network, started under the related RLA5051 project with the focus on fallout radionuclides (FRNs) for soil erosion assessment. It has been further strengthened by focusing more on the combined use of isotopic, nuclear and complementary techniques for soil conservation. The network includes now 18 countries across the Latin American and Caribbean region. At least 165 technicians have been trained through the project RLA5064. Collaboration and cooperation have been established with different stakeholders including public and private sectors. In all participating countries, the project members have obtained additional funding (including in kind support) from the private and/or public sector.

Expert missions conducted by members of the RLA5064 project team were essential in levelling and training Member States which could not attend the first meeting and training course or had not acquired the necessary skills in previous related projects. Expert missions and support from outside the Latin American and Caribbean region (USA, Germany and New Zealand) also further enhanced the capabilities of the leading countries of the RLA5064 project.

Equipment has been installed and put in operation in three countries (Brazil, Chile and Venezuela) for providing analytical services to the project countries, i.e. equipment for sample preparation for Compound-Specific Stable Isotope (CSSI) and Mid-Infrared Spectroscopy (MIRS) analysis at cost-sharing or donation. Further, RLA5064 project Member States received support with the preparation of analytical facilities in the field of FRNs (13 countries), CSSI (6), MIRS (5) and X-Ray Fluorescence (XRF) (5).

The combined use of isotope, nuclear and complementary techniques has shown the potential to improve soil conservation strategies in the Latin American and Caribbean regions, and proven to be able to reduce analytical costs of soil samples for identifying and quantifying soil erosion. The project has created a database compiling all carried out CSSI and MIRS analysis of more than 400 points distributed over the participating countries. Success stories are now being prepared.

Kuwait: To participate in the IAEA Symposium on Nuclear Applications for Sustainable Development in GCC Member States, 14-16 February 2016, Kuwait City, Kuwait

Technical Officer: Gerd Dercon

The objective of the symposium was to foster dialogue among relevant stakeholders in GCC states and bring together national decision makers, scientific and research institutions and foundations with an interest in science, technology and innovation for sustainable development. The IAEA DG, Mr Amano emphasized the importance of such a dialogue in his keynote address.

To achieve this objective, IAEA staff members made presentations about the work of the IAEA in different areas of non-power applications of nuclear technology and the partnership with GCC states. An emphasis was placed on the role of the NA laboratories in meeting current as well as future Member States' needs. Presentations of the representatives of the GCC states focused on the priorities and concerns for the region as well as on past and current support received from IAEA. The sustainable development goals framework provided a strong linkage with the main thematic areas of IAEA's activities that assist Member States in responding to various challenges, including the impacts of climate change, improving agriculture productivity, supporting environmental assessment, both marine and terrestrial, improving human health, and promoting other applications of socioeconomic significance, relevant to the priorities and needs of GCC states.

With more than 80 participants, the two-day symposium resulted in increased awareness of the IAEA's work in the areas of priority for GCC states as well as better understanding of the needs of the participating Member States. A draft summary of the recommendations was prepared to summarize the discussions on how the IAEA can better assist GCC states to respond to 21st century challenges in sustainable development. The symposium proved to be a useful platform for further promoting regional cooperation among the GCC states and with the IAEA.

One of the main recommendations was to have similar events organized on regular basis with rotating host GCC states. Another important outcome of this symposium was a better understanding of the important role that the NA laboratories play in supporting Member States, which could lead to additional contributions towards the ReNuAL project in the near future.

Haiti: To develop work plan and establish partnership and collaboration for TC project HAI5006 on "Increasing Productivity and Exportability in the Agricultural Sector through Soil and Water Management and Food Safety Monitoring", 15-19 February 2016, Port-au-Prince, Haiti

Technical Officer: Karuppan Sakadevan

The main purpose of this duty travel by the Technical Officer was to develop the work plan, design field studies, identify logistics and human resource development needs, and establish partnership and collaboration with Harvest Plus, AKOSAA and Ministere de l'Agriculture, des Ressources Naturelles et du Developpement Rural (MARNDR). During the visit, the Technical Officer carried out activities that included (1) identifying appropriate locations for establishing field studies, (2) human resource development needs, (3) laboratory consumable and other logistic support, and (4) partnership/collaboration between AKOSAA, HarvestPlus, MARNDR and IAEA. The Technical Officer along with the expert team visited Kenskoff, the main vegetable production area to explore the possibility of establishing field studies to improve the production, water and nutrient use efficiencies of cash crops at the Artebonite Valley, the main crop production area in Haiti. During the visit, Mr Patrice Dion provided an overview of the AKOSAA project including improving nutritional quality of beans and sweet potato in Haiti. After the presentation, the team visited Saint Marc (Atrebonite Valley) farm area and identified experimental sites for the project. The team also visited the MARNDR experimental site in Moujer and identified another experimental site for the project. The FAO national office was also appraised of the project.

A detailed work plan for the project was developed in consultation with the counterpart. It was decided to establish field studies in three locations namely (1) Saint Marc, (2) Moujer, and (3) Plain Torbec. In all three locations, rice based cropping systems will be established with rotations involving (1) rice-bean/cowpea-sweet potato, and (2) rice-maize rotation. N-15 labelled fertilizer will be used to quantify fertilizer use efficiency and N uptake by grain under different rotational systems. The human resource capacity development requirements including fellowships and scientific visits, laboratory needs and logistic support for field studies were identified.

Argentina: To organize the third research coordination meeting (RCM) of the coordinated research project (CRP) D1.20.12 on "Optimizing Soil, Water and Nutrient Use Efficiency in Integrated

Cropping-Livestock Production Systems", 14-18 March 2016, Buenos Aires, Argentina

Technical Officer: Karuppan Sakadevan

The Technical Officer visited INTA in Buenos Aires to organize the third Research Coordination Meeting to review progress made for the CRP since July 2013, identify project constraints and gaps, and to develop work plan and activities for the next two years. During the meeting, the participants he (1) discussed and analyzed data collected from field studies in relation to soil, water, crop and livestock management under integrated crop-livestock production systems, (2) identified constraints for the project implementation, and (3) refined the existing work plan to meet the objectives of the CRP. Nine research contract holders from Argentina, Brazil (two participants), China, India, Indonesia, Kenya, Uganda and Uruguay, and one research agreement holder from USA attended the meeting. Five participants involved in the project from Argentina also attended the meeting.

All participants presented data and information obtained from field studies to evaluate different soil, crop and livestock management practices on crop and livestock production, soil characteristics, carbon sequestration, greenhouse gas emissions and soil erosion. During the presentation, the counterparts informed the meeting participants about the need for opportunities to integrate crop with livestock for a sustainable and profitable crop and livestock system. Most field studies used crop rotation and conservation tillage practices that enhance soil fertility, quality and crop yield and livestock production.

As part of meeting the participant visited two farmer field sites in the wet Pampas that involve cropping systems (maize-alfalafa-soybean) and practices (tillage-mulching-fallow) within the integrated crop-livestock production systems. The participants also developed a revised work plan and activities for 2016-2018. Technical support and guidance were provided by the Technical Officer and the agreement holder (thanks to Alan Franzluebber, USDA-ARS) to counterparts for refining the work plan and project activities.

Sudan: **To review the project work plan and to provide technical assistance in setting up future field trials to enhance nutrient use efficiency on a range of crops (Wad Madani, SUD 5037) combined with unplanned travel under RAF5071, 30 March to 8 April, Khartoum, Sudan**

Technical Officer: Mohammad Zaman

During the first part of this mission, the Technical Officer (TO) discussed the activities of the national Technical Cooperation (TC) project (SUD 5037) with the counterpart (CP) and his team members in Madani. These include: (1) revised work plan for 2016, (2) experimental design of the field trials at three locations, soil, plant and environmental data collection, (3) a field protocol that the TO wrote for measuring nitrogen use efficiency using N-15 technique, (4) procurement of the glassware, chemicals and equipment (5) group national training on nutrient and water management and conservation agriculture (6) and visit to the field site and laboratories to assess the need for procuring new equipment, chemicals and glassware.

During the second part of the mission, the TO travelled to Khartoum, Kassala and Madani to provide technical support to Ms Nicole Jawerth and the CP to discuss the successful results and dissemination of drip irrigation technology of the RAF5071 project with the key stake holders including Federal State Minister for Agriculture and Forestry, Kassala State Minister of Agriculture and Forestry, Director General of Agriculture and Forestry, representatives of Sudanese Red Crescent, NGOs, UNDPs, and local farmers. The TO also briefed the National Liaison Assistant (NLA) about the national and regional project activities. Local farmers and researchers were shown how to enhance vegetable production further using best drip irrigation and nutrient management system.

Female farmers harvesting onion crops in Kassala

Philippines: RAS/5/073 Regional Training Course on "Integrated Good Agricultural Practices/Technology Packages Based on Innovative Soil, Water and Nutrient Management", 11-20 April 2016, Los Banos & Manila, Philippines

Technical Officer: Lee Heng

The Technical Officer Lee Heng travelled to the Philippines under RAS/5/073 project on "Supporting Climate-Proofing Rice Production Systems (CRiPS) based on Nuclear Applications-Phase II", for the first week of the above 10-day regional training course. The course was held in the International Rice Research Institute (IRRI), Los Banos (11-13 April) and the Philippines Nuclear Research Institute (PNRI), Manila (14-20 April). The purpose of the course was to receive training on good agricultural practices and technology package for rice production from IRRI and to standardize methodologies and protocols on the use of nitrogen-15 isotopic technique for determining nitrogen fertilizer use efficiency under flooded rice conditions; as well as establishing studies on alternate wetting and drying (AWD) water-saving technology, set up greenhouse gas (GHG) emission study and on the use of oxygen-18 to separate evaporation (E) and transpiration (T) for improving water use efficiency. Twenty participants from ten Member States of this project (Bangladesh, Cambodia, Indonesia, Lao P.D.R., Malaysia, Mongolia, Myanmar, Philippines, Thailand and Viet Nam) attended the course. During the three days at IRRI, theory and demonstration on the following topics were given: AWD technology, setting up GHG study, high precision mapping drone, soil EC mapping, nutrient management and drought phenotyping. Mr Steve Klassen and Ms Achu Arboleda were the IRRI resource persons in the training.

Field visit during training course

The PNRI Director Ms Alumanda Dela Rosa gave a welcoming address. The technical officer gave a presentation on the application of isotopic and nuclear techniques for soil, water and nutrient management; a lecture on ‘Evaporation and transpiration partition using nuclear and isotopic techniques’, and summarising the work on N-15 carried out in the project and showed the needs to standardize methodology and protocol. Lectures were also given by experts from PNRI (Mr Roland Rallos) and from PhilRice on GHG sampling, AWD set up and demonstration on the use oxygen-18 isotopic technique for E and T study. At the end of the training course, standardized protocols on N-15 for flooded rice and AWD were developed. Procedures on GHG emission measurement for rice were also established.

The Netherlands: Orientation and fact-finding mission Greenhouse Construction under ReNuAL, 20-21 April 2016, Bleiswijk – Wageningen, The Netherlands

Technical Officer: Gerd Dercon

Mr. Gerd Dercon travelled to the Netherlands on behalf of the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture to participate in the Fact-Finding Mission on Greenhouse Construction under the ReNuAL project, to Bleiswijk, Netherlands, from 19 to 21 April 2016.

The purposes of the mission were: (i) To represent the ReNuAL project to the various companies through which the Netherlands might be in a position to finance some of the new greenhouses, (ii) To ensure the requirements for the greenhouses within the ReNuAL project are clearly defined and communicated to specialized companies that deal with greenhouse construction and climate control, and (iii) To explore opportunities for collaboration between the Joint FAO/IAEA Division and the University of Wageningen and greenhouse construction companies. The arrangements were determined together with the Permanent Mission of the Netherlands.

Italy: To participate in the 4th Global Soil Partnership Plenary Assembly, 23-25 May 2016, FAO Rome, Italy

Technical Officer: Lee Heng

The technical officer travelled to FAO, Rome to participate in the 4th Global Soil Partnership Plenary (GSP) Assembly at the request of FAO AGL Director Mr Eduardo Mansur to strengthen the collaboration between FAO AGL and the SWMCN Subprogramme in the Joint Division. The Assembly was opened and welcomed by the Assistant Director-General of Agriculture and Consumer Protection Department Mr Ren Wang. The technical officer gave a presentation on the use of nuclear and isotopic techniques for climate-smart agriculture illustrated how these techniques can be used to enhance agricultural productivity, conserve soil and water resources, improve soil quality and soil resilience against impacts of climate change and variability and to reduce greenhouse gas emissions and increase soil carbon sequestration in both productive and marginal lands. The roles and activities of the SWMCN Laboratory were also highlighted in the presentation. The Assembly endorsed a set of voluntary guidelines for sustainable soil management, marking a step towards coordinated actions to assure that the earth remains fertile. The Voluntary Guidelines for Sustainable Soil Management are meant to serve as a reference of sustainable soil management principles for audience ranging from government officials and policy makers to farmers and pastoralists as well as development practitioners. During the GSP Assembly, the Glinka World Soil Prize was established to honour individuals or organizations which contribute towards sustainable soil management. During the visit to FAO, the technical officer also met with the DG of International Center of Biosaline Agriculture (ICBA) Ms Ismahane Elouafi and the Director of AGL to discuss possible joint ICBA/FAO/IAEA collaboration.

Germany: To facilitate the second research coordination meeting (RCM) of the coordinated research project (CRP) D1.50.16 on “Minimizing Farming Impacts on Climate Change by Enhancing

Carbon and Nitrogen Capture and Storage in Agro-Ecosystems", 23-27 May 2016, Giessen, Germany

Technical Officer: Mohammad Zaman

The Technical Officer visited Justus-Liebig University Giessen to participate in the second Research Coordination Meeting (RCM) of the above CRP. The aim of the RCM was to review progress made by CRP participants since November 2014, and to develop work plan and activities for 2016-17. The RCM was hosted by Justus-Liebig University Giessen with Mr Christoph Muller as the local coordinator. In addition to our counterpart from Germany and his team, seven research contract holders from Brazil, China, Chile, Costa Rica, Ethiopia, Iran and Pakistan, and one research agreement holder from Spain attended the RCM to review each participant's project progress to ensure the accomplishment of the CRP objective. The Technical Officer presented the objectives of the CRP and the work plan developed during the first RCM. During the five-day meeting, each CRP research contract holder presented results obtained since the first RCM held in Vienna, from 3 to 7 November 2014, followed by feedback from the meeting participants. The 2 year results indicated that N_2O emissions across arable and pastoral system were greatly influenced by soil and environmental factors. Co-application of urea fertilizer with N process inhibitors such as urease and nitrification inhibitors has the most potential to enhance fertilizer use efficiency, minimize N_2O emissions and increase crop productivity. Land use changes had a significant impact on carbon sequestration and soil quality. All participants visited the Free Air Carbon dioxide Enrichment (FACE) study on permanent grassland at Giessen University. This study started in 1998 and is currently the longest running CO_2 free-air study in the world. Results from this study demonstrate that climate change has a stimulatory effect on biomass growth but also on N_2O emissions which highlights the urgency to develop techniques that enhance soil carbon sequestration.

Participants of the CRP D1.50.16 at the FACE experiment site at Justus-Liebig University Giessen

Kenya: RAF5071 To evaluate the implementation of the mobile phone information, communication technology driven irrigation management software for Maasai pastoral community, 30 May to 2 June, 2016, Nairobi, Kenya

Technical Officer: Lee Heng

The objective of the travel was to evaluate the feedback on the implementation of the mobile phone technology pilot project developed for irrigation and nutrient management (sending of SMS on when and how much of irrigation water and fertilizer needed by the crops, verified using nuclear and isotopic techniques) for small-holder farmers, pilot-tested with Maasai pastoral community practising vegetable growing in the Kajiado region east of Nairobi. The evaluation was jointly carried out with the project managing officer Mr Abdou Ndiath and five experts from RAF5071 project (Mr Mohammed Semaini from Algeria, Mr Felix Gbaguidi from Benin, Mr Ahmed Hegazi from Egypt, Mr Hamid Marah from Morocco and Mr Imad-eldin Ahmed Ali Babiker from Sudan), together with the Kenya counterpart (Mr Isaya Sijali) from Kenya Agricultural and Livestock Research Organization (KARLO) and the developer of the web-based Smart Irrigator software Mr Peter Okoth from Fibrelink Communications Ltd based in Nairobi. The group went to the pilot test sites and met the twelve Maasai farmers and community if the messages received were helpful and beneficial and the reply was unanimous that this information has helped them regarding when and how much to irrigate, which helps to safeguard the little water available. Also for the first time, this community was able to grow vegetables from their farms to feed their families and to sell the surplus which generated income. However, water accessibility and availability are major problems and challenges these people are facing, the Kenya project counterpart and KALRO are currently working with local government, NGO to source funding to improve the situation. The opportunity is therefore huge to multiply the benefit to many more farmers in the area, in Kenya and in Africa. The travel was also to update project work plan and agreed on strategies for the dissemination of the pilot project to other countries within RAF5071 project. The technical officer, the PMO and the five experts from RAF5071 also met with the DG of KALRO Mr Eliud Kireger who assured his support for extending this mobile phone ICT project in Kenya.

Lee Heng with Maasai farmers

Algeria: RAS/5/073 To review the project work plan for 2016 and to provide technical assistance in setting up future field trials to crop productivity of wheat, legumes and vegetables (ALG5029) May 30-3 June 2016, Algiers, Algeria

Technical Officer: Mohammad Zaman

The Technical Officer, Mohammad Zaman travelled to Algier under ALG 5029 project on "Improving wheat and legume yield through better water and fertilizer management and introduction of new vegetal material". The Technical Officer met Ms Hamana Korichi Malika, Central Director, of Algerian Ministry of Agriculture, Fisheries and Rural Development and the national liaison officer (NLO) to discuss forthcoming project activities. The Technical Officer along with the CP visited the ongoing field trials on wheat and legumes at the National Institute of Agronomic Research of Algeria and provided technical support on the design and layout of the forthcoming trials. The Technical Officer then had meetings with counterpart and his team members at INRAA to revise work plan for 2016-17, arranging a group national training on nutrient and water management, provided technical inputs to the design of the field trials of wheat and legumes, data collection, and measuring fertilizer use efficiency through N-15 technique. The Technical Officer also visited the laboratories at INRAA, and talked to the lab staff to assess their need for procuring new equipment, chemicals and glassware. Finally the technical officer gave a presentation on the application of isotopic and nuclear techniques for soil, water and nutrient management to the project team members in INRA and also at the Soil Irrigation and drainage National Institute.

Scientific Visitors

- Mr. Ali Abbas Mohammed AL-HASANI (IRQ 5019), visited SWMCN Laboratory 11-15 April 2016 to discuss the work plan and to explore how isotope and nuclear techniques can help in improving soil and water management.
- Mr Amadou Tidiane Dia from Ministry of Agriculture and Livestock Development Directorate of Animal Disease and Mr Baba Ahmed Naghra, Director CNRADA- Mauritania visited SWMCN Subprogramme, from 17 to 20 May to discuss project activities of Mauritania national TC (MAU5006) for 2016-17.

Coordinated Research Projects

Project Number	Ongoing CRPs	Scientific Secretary
D1.20.12	Optimizing Soil, Water and Nutrient Use Efficiency in Integrated Cropping-Livestock Production Systems	Mohammad Zaman
D1.20.13	Landscape Salinity and Water Management for Improving Agricultural Productivity	Lee Heng and Joseph Adu-Gyamfi
D1.50.12	Soil Quality and Nutrient Management for Sustainable Food Production in Mulch-Based Cropping Systems in Sub-Saharan Africa	Mohammad Zaman and Gerd Dercon
D1.50.13	Approaches to Improvement of Crop Genotypes with High Water and Nutrient Use Efficiency for Water Scarce Environments	Joseph Adu-Gyamfi and Pierre Lagoda
D1.50.15	Response to Nuclear Emergencies Affecting Food and Agriculture	Gerd Dercon and Lee Heng
D1.50.16	Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agro-Ecosystems	Mohammad Zaman and Lee Heng
D1.50.17	Nuclear Techniques for a Better Understanding of the Impact of Climate Change on Soil Erosion in Upland Agro-ecosystems	Lionel Mabit and Lee Heng

Optimizing Soil, Water and Nutrient Use Efficiency in Integrated Cropping-Livestock Production Systems (D1.20.12)

Technical Officer: Mohammad Zaman

This CRP is in its third year and the third renewals for all national projects will be completed in July 2016. The main objective of the project is to enhance food security and rural livelihoods by improving resource use efficiency and sustainability of integrated crop-livestock systems under a changing climate. The specific objectives are to: (1) optimize water and nutrient use efficiency in integrated crop-livestock production systems, (2) identify the potential for improving soil quality and fertility in integrated crop-livestock systems, (3) assess the influence of crop - livestock systems on GHG emissions, soil carbon sequestration and water quality, (4) assess socio-economic and environmental benefits of crop-livestock systems, (5) strengthen the capacity of Member States to use isotopic and nuclear techniques as tools for improving the management of crop-livestock systems, and (6) develop soil, water and nutrient management options in integrated crop-livestock systems for potential adoption by farmers. The CRP was started in July 2013 with nine research contract holders from eight countries (Argentina, Brazil (two), China, India, Indonesia, Kenya, Uganda and Uruguay) and three agreement holders from France, Nigeria and United States of America. The third RCM was held in Buenos Aires, Argentina from 14-18 March 2016 to review project progress and develop work plan for the remaining two years. The mid-term review for the project was completed and was approved by the CCRA.

1. The soil organic carbon (SOC) accumulation of no-tillage summer crops and integrated crop-livestock system (ICLS) with a history of seven years and involving the same productions system in wet pampas of Argentina was assessed. Preliminary results showed that in the top 20 cm of the soil, continuous cropping system (CCS) accumulated less organic carbon (1.25%) compared to 1.55% in the ICLS.
2. Small (6 ha) scale ICLS involving soybean/maize rotation and large (22 ha) scale ICLS with soybean/pasture rotation were compared to conventional cropping systems (continuous maize and soybean) for maize and soybean yield. Preliminary results showed that soybean and maize yield under rotational grazing were greater than that in continuous mono maize or soybean cropping. The potential of integrated crop-livestock systems for minimizing emissions of methane and nitrous oxide (N_2O) were assessed for Rio Grande do Sul and Parana States in Brazil and the results showed that ICLS reduced N_2O emission by 50% compared to continuous cropping systems.
3. The effect of three types of land use practices including (1) wheat and maize rotation with conventional tillage, (2) grassland with grazing and (3) without grazing in Loess Plateau, China on soil quality and soil carbon sequestration were studied in small holding farms. Preliminary results indicated that controlled durational grazing (with a grass cover of 20 cm, and stocking rate of 10 sheep per ha for 1 hour daily with 3 to 4 grazing per month) reduced soil erosion by 77% and SOC content losses by 80%

during the growing period compared to continuous cropping.

4. The impact of integrated crop-livestock systems that involved rice and two forage crops (a legume and grass) were assessed for crop and livestock production and soil quality in four different agro-eco regions in southern state of Tamil Nadu, India. Results to date showed that SOC under paddy, which received animal manure increased, from 0.68 to 0.79%.
5. Soil physical and chemical characteristics of the three agricultural rotational practices that involved soybean/maize, soybean/maize fed with manure and maize/gliricidia legume fed with manure were assessed in Bogor, Indonesia. Preliminary data showed that there was an increasing trend in cation exchange capacity, total N and total C contents. The isotopic signature data of N-15 and C-13 in soil and plants-are currently being analyzed.
6. Two tillage practices (tied ridges and flat cultivation) and five cropping systems (sole maize, sole cowpea, sole lablab, maize/cowpea and maize/lablab intercrop systems) were tested for yield of maize and lablab. Combination of 2.5 tons farm yard manure and inorganic fertilizers at 20 kg N and 8.73 kg P per ha gave higher grain and biomass yield. Maize lablab intercrop provided higher maize grain yield than the maize/cowpea intercrop system.
7. The effect of crop-livestock integration on maize yield and soil properties (pH, soil organic matter, nitrogen, potassium, phosphorous and texture) were assessed at the Mukona district, northeast of Kampala, Uganda. Preliminary results showed that soil organic matter was negatively affected by continuous maize cultivation and maize-grazing rotation.
8. Agronomic and environmental effects of integrated crop-livestock production systems (continuous agriculture under no till (CC-NT), pastures–crop rotation under no till (CP-NT) and pastures–crop rotation under conventional tillage (CP-CT)) on yield and nitrogen fixation of legume based cropping systems in Uruguay were assessed. The results are currently being analyzed.

Landscape Salinity and Water Management for Improving Agricultural Productivity (D1.20.13)

Technical Officers: Lee Heng and Joseph Adu-Gyamfi

This project started in July 2013 with the aims to: a) identify ways to improve crop productivity and sustainability through water and salinity management, b) define approaches and technologies to assess and monitor soil water content and salinity at field and area-wide scales, c) reduce the impacts of climate change and variability on the widespread increase in landscape. The first RCM was held from 15 to 19 July 2013 in Vienna, Austria with seven research contract holders (Bangladesh, China (two participants), Iran, Pakistan and Vietnam (two participants)), two agreement holders (Spain and USA) and two technical contract holders (Czech republic and USA) participating in the project. The second RCM was held in Beijing, China in September 2014 where results from the first year's findings were presented. The research contracts are currently being evaluated for renewal. Meanwhile the mid-term review is also coming up in the coming weeks. Both AquaCrop and HYDRUS-1D models are being used to simulate the yield response of crop to salinity stress. This was successfully carried out for Pakistan and Bangladesh, where good simulation of rice field studies using AquaCrop model was obtained and the output from AquaCrop was used as input to HYDRUS to assess the potential impacts of sea-level rise and the consequent increase in water and soil salinity and other climatic parameters on rice yield in the coastal region of the country. The third RCM is planned in November 2016 in Ho-Chi Minh City in Viet Nam.

Status of the Coordinated Research Projects (CRP) - Soil Quality and Nutrient Management for Sustainable Food Production in Mulch-Based Cropping Systems in Sub-Saharan Africa (D1.50.12)

Technical Officers: Mohammad Zaman and Gerd Dercon

This Coordinated Research Project (CRP) is already in its 4rth year of implementation. The CRP aims to improve the livelihoods of farmers with a low level of socio-economic development in rural communities in Sub-Saharan Africa through restoration of degraded soils and ecosystems and the development of productive and resilient agricultural practices. There were 15 participants, including seven research contract holders from Benin, Kenya, Madagascar, Mauritius, Mozambique, Pakistan and Zimbabwe, three technical contract holders from China, the Czech Republic and the United Kingdom, and five agreement holders from Austria, Belgium, Kenya, New Zealand and United States of America. These participants had attended three Research Coordination Meetings (RCM), including the first RCM at the IAEA's headquarters in Vienna, Austria, from 30 January to 3 February 2012, the second RCM, held in Antananarivo, Madagascar, from 14 to 18 October 2013 and the third RCM held on 4 to 8 May, 2015 in Harare, Zimbabwe. Seven research contracts have been renewed based on their project progress report and renewal proposals in October 2015. The three year field data indicated that applying mulch under Sub-Saharan soil and climate conditions have the potential to improve soil quality through accumulation of C, retain nutrients and moisture, and stimulate microbial activity which can then lead to increased crop productivity. In the Sub-Sahara countries, low soil fertility and soil acidity, residue removal, and mono-culture cropping system were the main factors resulting in low crop productivity. When lime and animal manure were applied to correct soil pH (acidic) and lift soil fertility level respectively, mulch application started to show improvement in crop yield. Other steps such as enhancing biological N fixation by *Rhizobium* inoculation and practicing mixed cropping rotation also led to soil fertility enhancement.

The SWMCN Laboratory team has further followed up research activities in order to support this CRP. Based on samples collected from several long-term experiments in Austria, Belgium, Kenya, Senegal and China, a protocol has been produced to assess soil organic carbon stability using ^{13}C and ^{15}N stable isotope techniques. These results of three years of intensive research also led to the publication of a research paper in Soil Biology and Biochemistry Journal. The final RCM will be held from 21 to 24 November 2016 in Vienna, Austria to present and discuss the results obtained since the beginning of the CRP, and evaluate progress report in the light of project objectives and expected outputs.

Approaches to Improvement of Crop Genotypes with High Water and Nutrient Use Efficiency for Water Scarce Environments (D1.50.13)

Technical Officers: Joseph Adu-Gyamfi and Ljupcho Jankuloski,

This CRP is in its final year. Ten research contract holders (Bangladesh, China, Kenya, and Malaysia (two participants), Mexico, Pakistan, Peru, South Africa, Uganda and Vietnam), one technical contract holder (Peru) and one agreement holder (South Africa) are participating in the CRP. The research project was started in December 2011 and three RCMs have been carried out so far to review project progress and present preliminary results. The overall objective of this CRP is to increase crop productivity and food security by developing improved crop varieties and soil, water, nutrient and crop management technologies and making them available to farmers, and ensure their cropping systems are resilient to biotic and abiotic stresses in water scarce environment.

Key outputs of the CRP to date include:

1. The total area covered by ratooning rice cultivars (one planting and two harvests) from 2012-2015 is 42,000 ha in China with yield up to 14,500 kg/ha over two harvests.
2. 20-30 % yield increase of two elite potatoes with high fertilizer use efficiency at 4 locations (Njoro, Kabiana, Marigat and Molo) using a combination of animal manure and nitrogen fertilizer have been recorded by farmers.
3. Three genotypes of wheat with high water and nutrient use efficiencies are being tested in 25 farmers field (0.5 ha per farmer) in 6 districts (Peshawar, Nowshera, Charsadda, Lakki- Marwat, Swabi and Dir) in Pakistan
4. Three varieties and one advanced mutant line of barley, and five improved genotypes of quinoa suitable for high altitude have been identified and are being tested in the high altitude mountains and coastal areas of Peru.

The final RCM will be held in Vienna, Austria during 7-11 November 2016.

Response to Nuclear Emergencies Affecting Food and Agriculture (D1.50.15)

Technical Officers: Gerd Dercon and Lee Heng

This CRP aims to develop and assess systems of innovative data collection, management and geovisualization platforms that can be used for both routine monitoring and also in emergency response to nuclear and radiological incidents that could affect food and agriculture. Through this CRP network, institutions and governments involved in nuclear emergency response for food and agriculture will be strengthened. The CRP will also assist in compiling Standard Operating Protocols (SOPs) for actions required in case of a nuclear emergency affecting food and agriculture, as well as sampling analytical SOPs for activity measurements.

The objectives of the CRP are:

1. To identify sampling and analytical strategies in nuclear emergencies affecting food and agriculture
2. To determine how online geo-visualization tools can influence emergency response strategies, approaches to learning from nuclear accidents, and end-users ability to generate future short-term and long-term scenarios about the impact of nuclear accidents on food and agriculture
3. To ensure that systems use common or standardized protocols that can be shared across different software platforms.
4. To produce low-cost computer-based platforms that are robust and can be used both routinely to monitor everyday sampling as well as in nuclear emergency situations.
5. To produce decision support tools that will help rapid analysis of the situation in radionuclide contamination of food stuffs.

Four research contract holders from China, Morocco, the Russian Federation and Ukraine, four technical contract holders from France, Japan (2) and Macedonia and four agreement holders from Belgium, European Commission, India and Japan participate in this CRP. To date, protocols for supporting sampling and radionuclide concentration analysis of foodstuffs are being prepared, and an advanced prototype of the online information system to support decision-making in food safety in case of a nuclear emergency is available. This information system is currently being further improved based on comments from the CRP participants. Major efforts are being made to integrate the data management and visualization part of the system, and to establish the algorithm for decision-support with regards to the implementation of food restrictions. Further significant progress has been made as well to link this system with existing data exchange platforms of the IAEA, such as the Unified System for Information Exchange on Incidents and Emergencies (USIE) and International Radiation Monitoring Information System (IRMIS) managed by IEC. The second RCM was held from 28 September to 2 October 2015 in Fukushima, Japan to review progress made and plan for the second phase of the CRP. The third RCM is planned for the first trimester of 2017.

Minimizing Farming Impacts on Climate Change by Enhancing Carbon and Nitrogen Capture and Storage in Agro-Ecosystems (D1.50.16)

Technical Officers: Mohammad Zaman and Lee Heng

The objective of this CRP is to mitigate nitrous oxide (N_2O) emissions and minimize nitrogen (N) losses from agricultural systems, whilst enhancing agricultural productivity and sequestering soil carbon (C). The first Research Coordination Meeting (RCM) was held in Vienna, Austria from 3 to 7 November 2014 to review individual experimental plans of the research contractors in line with the objectives of the CRP, and to provide the contractors with suggestions for the next 18 months. Ten participants, with seven research contract holders from Brazil, Chile, China, Costa Rica, Ethiopia and Pakistan, two agreement holders from Estonia and Spain, and one technical contract holder from Germany attended the first RCM. Since the first RCM, all CRP participants have established field trials to assess the effects of nitrogen process inhibitors on N_2O emission and also on C sequestration under different agro-climatic condition. Detailed results were presented in the 2nd RCM which was held on 23-27 May in Justus-Liebig University Giessen, Germany. The CRP is expected to continue for five years (2014–2019).

Key outputs of the CRP to date include:

1. Urea applied with nitrification inhibitor (nitrapyrin and DMPP) to arable soil led to significant N_2O reduction as well as increase in crop yield in China, Iran, Pakistan, and Spain; while no such effect was observed when Nitrapyrin with cow urine was applied to grassland in Costa Rica.
2. In China, biochar significantly reduced annual N_2O emission from maize and wheat crops by 28 to 35%.
3. In Brazil, N_2O emissions varied significantly with the type of green manure and were in the order of: velvet bean > sunnhemp > jack bean > maize. The fraction of N from green manure lost as N_2O was lower than the default value indicated by IPCC, being 0.47% for jack bean, 0.86% for velvet bean, 0.67% for sunnhemp and 0.35% for maize residues.
4. ^{15}N technique identified two more microbial processes (Co-denitrification and conversion of organic N to mineral N).

Developments at the Soil and Water Management and Crop Nutrition Laboratory

In situ Determination of CO_2 and N_2O Emissions and Isotopic Composition in Agricultural Soils Following a Precipitation Pulse - The Use of Real-Time CO_2 and N_2O Isotope Analysers

Janet Chen, Christian Resch, Leopold Mayr, Maria Heiling, Gerd Dercon

Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Seibersdorf, Austria

Agricultural soils cover 12.6% of the Earth's surface and are essential in food production. Agricultural land can either serve as a reservoir of greenhouse gases (GHGs) in the soil, or release them into the atmosphere. Accurately estimating GHG fluxes from agricultural soils is difficult, however, due to the dynamic pattern of emissions that are largely driven by environmental factors such as water availability. Farming practices, such as mulch application, also influence soil GHG emissions. We measured effects of mulch application on emissions and isotopic composition of two GHGs, CO_2 and N_2O, in agricultural soils by using greenhouse "mesocosms" (soil sample columns 70 cm deep and 50 cm diameter that have been subjected to a soybean-maize crop rotation since 2012). Following a small artificial rain event, we used a novel closed-loop method in real-time to collect and measure the two GHGs. Both CO_2 and N_2O emissions increased in mulch-covered soils immediately after the rain event, while N_2O emissions were reduced in bare soils and CO_2 gas was absorbed into bare soils. Response of CO_2 and N_2O emissions in bare and mulch-covered soils to the artificial rain event was rapid and quickly returned to the background level of emissions prior to the watering event. Only CO_2 emissions from mulch-covered soils exhibited a change in isotopic composition after the precipitation pulse, that was indicative of an increase in respiration of a C source that was relatively depleted in ^{13}C, e.g., from a C source that has a larger proportion of CO_2 fixed via C3 photosynthesis relative to a source fixed by the C4 pathway of photosynthesis. The high temporal resolution of our continuous CO_2 and N_2O gas measurements allowed us to more accurately measure GHG gas flux and isotopic composition than intermittent gas sampling that resulted in overestimation of GHG gas fluxes. Our results indicate that CO_2 emissions are predominant in agricultural soils and that bare soils can temporarily serve as a sink for CO_2 following a precipitation event. In contrast, mulch-covered soils function as a source of CO_2.

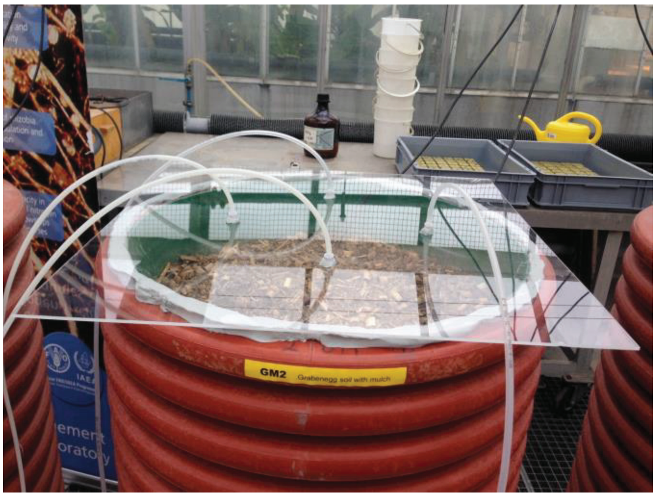


Figure 1. Closed-loop chamber method on top of a greenhouse mesocosm with mulch application. The two inlet and two outlet tubes allow for simultaneous analysis of buildup of CO_2 and N_2O greenhouse gases within the closed-loop system.

Determining Isotopic Composition of Dissolved Nitrate Using Bacterial Denitrification Followed by Laser Spectroscopy

Tiezhu Yan, Amelia Lee Zhi Yi, Maria Heiling, Georg Weltin, Arsenio Toloza and Christian Resch

Nitrate (NO_3^-) pollution is a prevalent problem that can cause water quality degradation and eutrophication of water bodies. Quantifying the nitrogen and oxygen isotopic composition of nitrates will allow for better identification of their potential sources, which in turn will assist in remediation of contaminated water and the designing of future water management practices. In this research bacterial denitrification followed by laser spectroscopy are used to determine isotopic composition of $\delta^{15}N$ and $\delta^{18}O$ of dissolved nitrates. The objective of the project is to establish a standard operating procedure (SOP) that outlines the best practices for both methods in sequence and designed to be used as a technical guideline.

Preudomonas aureofaciens is a naturally occurring bacterium that lacks nitrous oxide (N_2O) reductase enzyme which reduces N_2O to non-greenhouse gas N_2. While it is able to convert NO_3^- to N_2O in the classical denitrification pathway, the final conversion to N_2 is inhibited due to the lack of the reductase enzyme. The *Preudomonas aureofaciens* strain, that is utilized in the research, thus allows for determination of both nitrogen and oxygen isotopic composition in the NO_3^- ion. The subsequent laser spectroscopy is performed using the Los Gatos Research Isotopic N_2O Laser Analyzer and there is no need to be concerned with interference by CO_2 and H_2O.

The advantages of using the bacterial NO_3^- reduction prior to laser spectroscopy are that this technique works well for a small sample of low NO_3^- concentration with no extra addition of toxic chemicals. The laser spectroscopy method provides robust analysis and can be customized to accommodate a large sample through-put. Using both methods in sequence forms an experimental procedure that is economical, both in time and sample requirements.

Initial set up and standardization of experimental methods are currently being performed. Experiments with varying conditions have been carried out to determine ideal conditions for *Preudomonas aureofaciens*' inoculation and growth. Components that have been studied include differing autoclave times of medium, medium-bacteria concentration, utilization of starter, and availability of oxygen during the rapid growth phase. Future work will include analysis with the N_2O Laser Analyzer and sample collection from watershed scale locales affected by NO_3^- pollution.

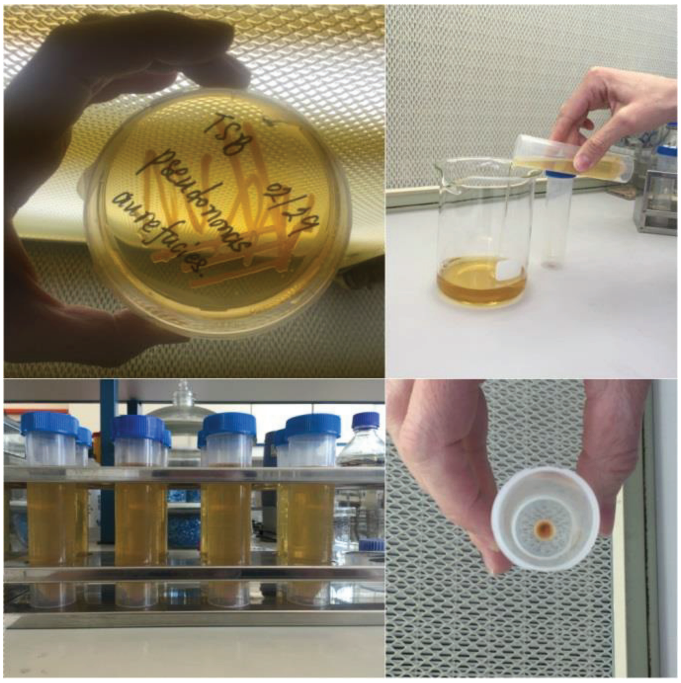


Figure 2. Clockwise from top left: (1) Bacterial growth on Tryptic Soy Agar (2) Inoculation of bacteria into growth medium (3) Concentrated bacterial pellet after centrifugation (4) Growth of bacteria in medium after 5-7 days

Latest development in using CSSI - Carbon-13 natural abundance signatures of long-chain fatty acids - case study of Mistelbach

Lionel Mabit[1], Christian Resch[1], Arsenio Toloza[1], Katrin Meusburger[2], Max Gibbs[3], Andreas Klik[4], Christine Alewell[2]

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[2]Environmental Geosciences, Department of Environmental Sciences, University of Basel, Basel, Switzerland
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[4]Institute of Hydraulics and Rural Water Management, University of Natural Resources and Life Sciences, Vienna, Austria

In our January 2016 Soils Newsletter (see Mabit et al., 2016), we presented an innovative study conducted in the sub-catchment of Mistelbach for testing and validating the use of compound-specific stable isotope (CSSI) techniques to determine the origin of the eroded soil. The experimental design and the sampling strategy, the CSSI determination, the selection of the best suitable fatty acid fingerprints (i.e. Behenic Acid [C22:0] and Lignoceric Acid [C24:0]) as well as the preliminary data analysis have been carried out according to the protocol of Gibbs (2013).

Our quantitative assessment obtained with the mixing model IsoSources (see January 2016 Soils Newsletter) was reinforced by the results from SIAR (i.e. Stable isotope analysis in R), a mixing model within a Bayesian framework running on R that allows detailed statistical information to be obtained. Indeed as highlighted by Parnell et al. (2010), IsoSources do not incorporate uncertainty and variation and its outputs deliver only a range of feasible solutions with no quantification. More information on both models i.e Iso-Sources and SIAR can be found in Phillips and Gregg (2003) and Parnell et al. (2008, 2010), respectively.

For our case study, the IsoSources results are within the range of the SIAR values, confirming the main contribution of around 50% to the deposition area (at the outlet of the sub-catchment) of the sediment originating from the main grassed waterway i.e. the source 4 (see Figure 1).

Our next investigation will focus on a better understanding of the soil redistribution and its linkage with the historical land use(s) of the four agricultural sources of the study area.

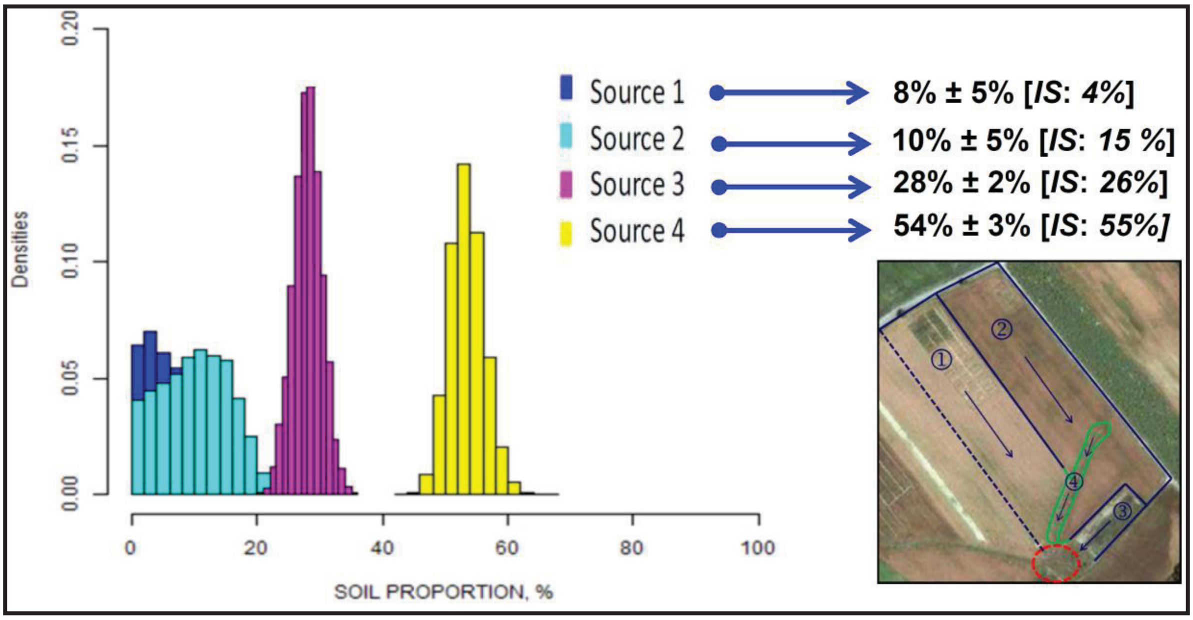

Figure 1. Soil/sediment contribution from each agricultural sources using SIAR (IS being the results provided by the mixing model Iso-Sources)

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Using artificial soil sediment mixtures for calibrating fingerprinting techniques at catchment scale

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Soil erosion and related sediment transportation and deposition are key environmental problems in Central Argentina. Certain land use practices, such as intensive grazing, are considered particularly harmful in causing erosion and sediment mobilization. In our studied catchment, Sub Catchment Estancia Grande (630 hectares), 23 km north east from San Luis, characterized by erosive loess soils, we tested sediment source fingerprinting techniques to identify critical hot spots of land degradation, based on the concentration of 43 elements determined by Energy Dispersive X Ray Fluorescence (EDXRF). To validate the used fingerprinting techniques, we created artificial mixtures using the most representative sediment sources of the studied catchment. The artificial mixtures were also measured as regular samples by EDXRF. Using known proportions of these sources in the mixture, we tested which algorithms and measured elements would allow re-establishing the source sediment proportion of the artificial mixture. Elements including Ca, Fe, Na, P and V were identified as the most effective fingerprints for our studied catchment. These fingerprints could be linked mainly to land management practice, such as cattle grazing and feedlot cattle, and to geomorphological units in the landscape such as gullies. These preliminary results, which will be presented during the Tropentag "Solidarity in a competing world - fair use of resources", Vienna, Austria (September 19-21), will contribute to a much wider research project including additional fingerprinting approaches such as Compound Specific Stable Isotopes Analysis (CSSI) and Mid Infrared Spectroscopy (MIRS), in addition to soil erosion quantification techniques through the use of Fallout Radionuclides (FRNs) and Environmental Radionuclides (ERN).

Sharing our research progress and connecting with international researchers through the European Geosciences Union (EGU) General Assembly 2016, Vienna, Austria

Lionel Mabit[1], Johanna Slaets[1], Janet Chen[1], Maria Heiling[1], Arsenio Toloza[1], Tiezhu Yan[1], Christian Resch [1], Georg Weltin[1], Roman Gruber[1], Mohammad Zaman[2], Gerd Dercon[1]

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The European Geosciences Union (EGU) 2016 Programme Committee announced a very successful 2016 EGU General Assembly, with 4863 oral, 10320 poster and 947 PICO (i.e. Presenting Interactive COntent™) presentations. Approximately 13650 scientists from 109 countries attended this event in Vienna and the Soil System Science division had more than 1400 scientific contributions.

This year at the EGU, the SWMCN Subprogramme activities were reported in 16 presentations (oral, poster and/or PICO) covering carbon and nitrogen cycling, soil erosion, soil conservation and climate change.

All details about the contributions from the SWMCN Subprogramme can be found in our list of publications at the end of this Newsletter and more information regarding EGU 2016 can be found at: http://www.egu2016.eu

We would like to inform our readers that the next EGU General Assembly will take place again in Vienna from 23 to 28 April 2017.

Johanna Slaets reports about the effectiveness of rice terraces (Northwest Vietnam) to trap sediments and protect downstream water resources during an EGU PICO presentation

Using Cosmic-Ray Neutron Probes to Monitor Landscape Scale Soil Water Content in Mixed Land Use Agricultural Systems

Trenton E. Franz[1] AmmarWahbi[2] Mariette Vreugdenhi[3] GeorgWeltin[2] Lee Heng[2]
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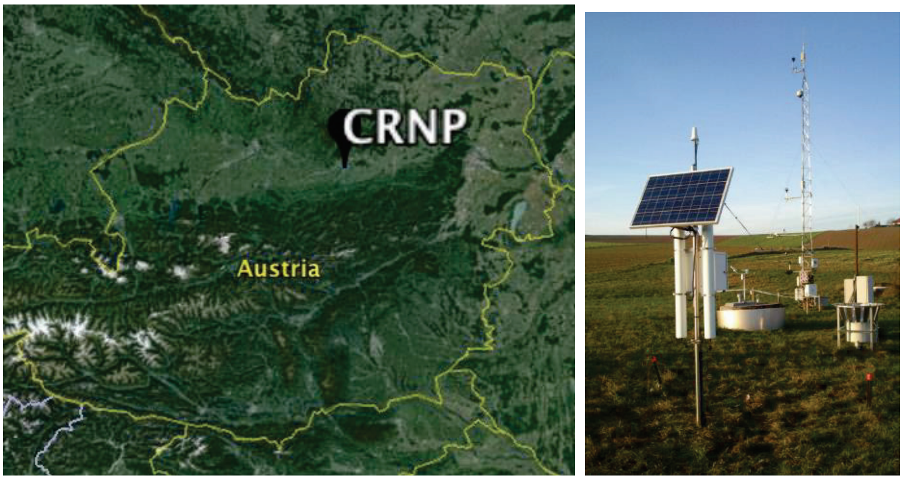
With an ever-increasing demand for natural resources and the societal need to understand and predict natural disasters such as flood, soil water content (SWC) observations remain a critical variable to monitor in order to optimally allocate resources, establish early warning systems, and improve weather forecasts. However, routine agricultural production practices of soil cultivation, planting, and harvest make the operation and maintenance of direct contact point sensors for long-term monitoring a challenging task. In this work (Franz et al., 2016), we used Cosmic-Ray Neutron Probe (CRNP) to monitor landscape average SWC in a mixed agricultural land use system in northeast Austria (Figure 1) since December 2013. The study site, Hydrological Open Air Laboratory (HOAL), jointly run project between the Federal Agency for Water Management (BAW Petzenkirchen) and the Technical University Vienna (TU Vienna), is located in Petzenkirchen, about 100 km west of Vienna and receives an annual average rainfall of 823 mm, which is mostly distributed between April and September. The calibrated CRNP landscape SWC values compared well against an independent in situ SWC probe network of Time Domain Transmission (TDT) sensors (MAE = 0.0286m^3/m^3), thus posing the challenge of continuous in situ monitoring from probes across a heterogeneous agricultural landscape (Figure 2). The ability of the CRNP to provide real-time and accurate landscape SWC measurements makes it an ideal method for long-term monitoring of SWC under different agricultural ecosystems. Such long-term monitoring of SWC helps agricultural water and nutrient management decisions at small and large land scale.



(a) (b)

Figure 1: (a) Location of the Cosmic-Ray Neutron Probe (CRNP) (48.1547°N, 15.1483°E) within a mixed agricultural land use area in northeast Austria. (b) CRNP located at study site with weather station.

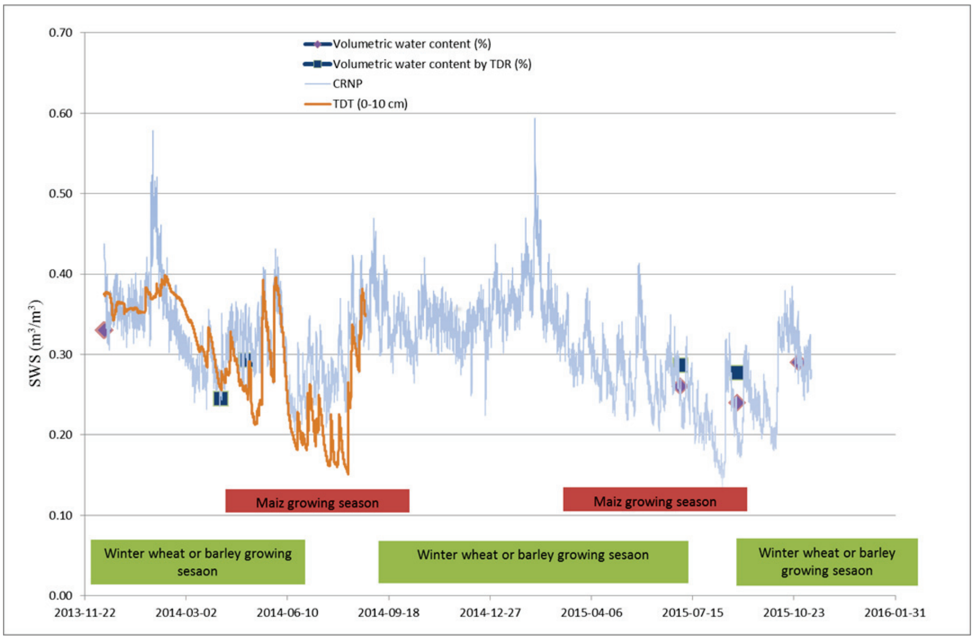


Figure 2. Time series of site average soil water content (SWC) of Time Domain Transmissivity (TDT) values by depth, SWC from the Cosmic-Ray Neutron Probe (CRNP), and independent gravimetric (12 December 2013, and 3 July, 28 August and 28 October 2015) and Time Dain Reflectometry (TDR) sampling campaigns (5 and 30 April 2014 and 3 July and 28 August 2015) at Petzenkirchen research station.

Protocol development for continuous nitrogen-15 measurement of N_2O and its isotopomers for real-time greenhouse gas tracing

Slaets, J., Mayr, L., Heiling, M., Zaman, M., Resch, C., Weltin, G., Gruber, R., Dercon, G.

Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Seibersdorf, Austria

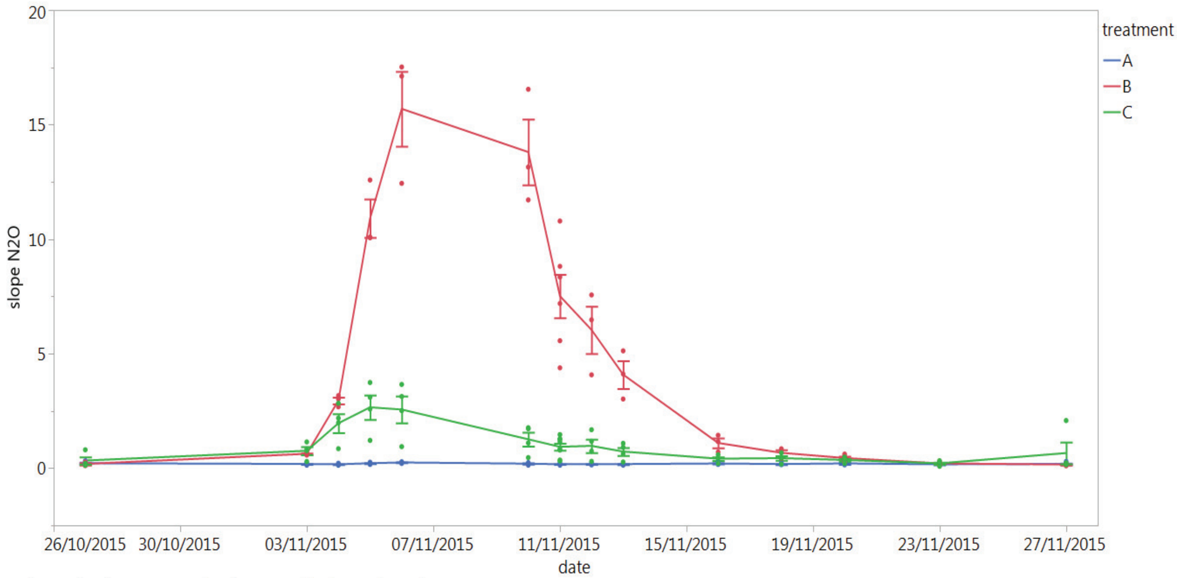
Quantifying sources of nitrous oxide (N_2O) (soil-N and applied N) is essential to improve our understanding of the global N cycle and to develop climate-smart agriculture, as N_2O has a global warming potential that is 300 times higher than that of CO_2. The isotopic signature and the intramolecular distribution (site preference) of ^{15}N are powerful tools to identify N_2O sources.

We have developed a protocol for continuous (closed-loop), real time measurement of the N_2O flux, the isotopic signature and the intramolecular distribution of ^{15}N by using off-axis integrated cavity output spectroscopy (ICOS, Los Gatos Research). The method was applied in a fertilizer inhibitor experiment, in which N_2O emissions were measured on undisturbed soil cores for three weeks. The treatments consisted of enriched ^{15}N labelled urea (5 atom %) applied at a rate equivalent to 100 kg N/ha), ^{15}N labelled urea with the nitrification inhibitor (NI) nitrapyrin (375 g/100 kg urea), and controls (no fertilizer or NI).

Measuring the isotopic signature of ^{15}N helps to distinguish N_2O emissions from soil and applied fertilizer. Characterization of site preference could additionally provide a tool to identify different microbial processes leading to N_2O emissions. Furthermore, the closed-loop approach enables direct measurement on-site and does not require removal of CO_2 and H_2O.

Results showed that cores with urea alone resulted in a total emission of 11 345 µg N_2O N/m^2, of which 75% originated from the fertilizer and 25% from the soil. Urea with nitrapyrin treatment yielded a total emission of 2 450 µg N_2O N/m^2, with 55% originating from urea. In the controls, the average emission amounted to 529 µg N_2O N/m^2 – corresponding to only 40% of the size of the corresponding pool from the fertilized cores. This difference shows the importance of using the isotopic signature, rather than relying non-treated cores to estimate soil emission rates. The latter method would have introduced bias in our dataset, as it would have resulted in an underestimation of the soil emission in fertilized soils.

The site preference of ^{15}N in N_2O (defined as the numeric difference between $\delta^{15}N\alpha$ and $\delta^{15}N\beta$) increased linearly over time for urea alone and urea with nitrapyrin. During the first 10 days, urea alone showed a more negative site preference than urea with nitrapyrin. This trend changed during the last 10 days of the measurements, when urea alone treatment showed a more positive site preference than urea with nitrapyrin. Our results suggest that site preference of ^{15}N may provide insights on the contribution of N_2O from different microbial processes. Low enrichment levels (5% atomic excess in this study) sufficed in order to separate N_2O emissions from soil and applied urea, making the proposed closed-loop approach a cost-effective and practical tool to obtain a continuous, in situ characterization of N_2O sources.



Each error bar is constructed using 1 standard error from the mean.

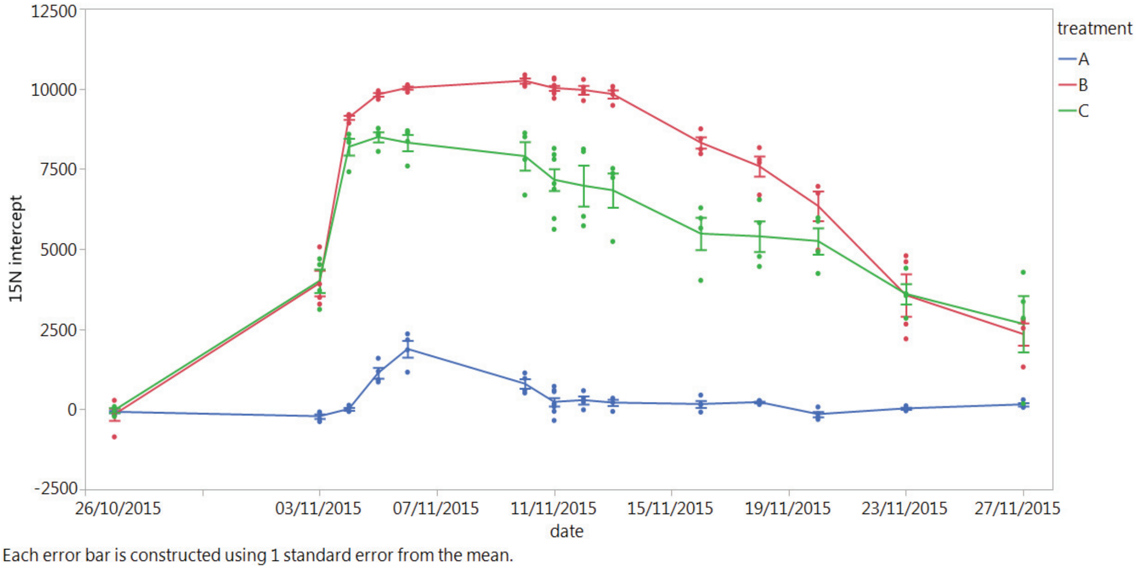


FIGURE 1. (top) Total N_2O emissions (ppm) and (bottom) ^{15}N-N_2O signature (‰) over time from undisturbed soil cores as influenced by ^{15}N labelled urea applied with or without nitrification inhibitor (nitrapyrin).

Treatment legends-A: Control, B: urea alone, C: urea with nitrapyrin

This research was conducted within the context of CRP D1.50.16 on "Minimizing farming impacts on climate change by enhancing carbon and nitrogen capture and storage in agro-ecosystems".

Can we screen phosphorus movement in the landscape through the analysis of $\delta^{18}O$ isotopic abundance in phosphate?

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The SWMCNL explored the possibility of using $\delta^{18}O$ isotopic signature in phosphate for screening phosphorus (P) movement in the landscape. Phosphorus is essential for crop production, but extensive use of P fertilizer and animal manure can lead to eutrophication of rivers and lakes. To study these effects, numerous studies on P movement in the soil plant system and P transformation processes have been performed in the past decades. Assessing losses of P through erosion processes, however, is challenging – particularly at the landscape level and on a longer timescale. Using the isotopic signature of stable oxygen isotope (^{18}O) in the phosphate ion as a tracer could be a cost-effective way to study P movements. This approach is already applied as a paleo-temperature proxy (the fractionation between phosphate and water is temperature dependent) and can be used for quantifying P losses through leaching into surface and groundwater, as oxygen exchange between phosphate and water is slow in the absence of biological activity.

The aim of this study was to test if $\delta^{18}O$ signatures in phosphate could be used as tracers to screen P movements from uplands to lowlands. As several biochemical reactions lead to a shift of $\delta^{18}O$ in phosphate, this could lead to a limitation of the applicability of oxygen isotopes as tracers. Supposedly microorganisms preferentially take up lighter isotopologues of phosphate, leading to an enrichment of heavier isotopologues in the residual phosphate. Several enzymatic processes, which are necessary for living organisms to avoid phosphate toxication, lead to oxygen exchange from the surrounding water.

The silver phosphate method was applied in Petzenkirchen in the foothills of the Alps in Lower Austria and in Rauris, located in the national park Hohe Tauern in the Alps. Manure and soil samples of different altitudes were collected and processed for silver phosphate analyses.

The $\delta^{18}O$ in phosphate values had very similar signature in Petzenkirchen (14.69-15.09‰ $\delta^{18}O$ in soil and 13.77-15.23‰ $\delta^{18}O$ in manure samples), with no significant difference between different locations within Petzenkirchen. While the number of replicates was too small to show significant differences between the different soils at the Rauris site, at this location a depletion of ^{18}O of 2‰ $\delta^{18}O$ was observed with increasing altitude (Figure. 2). This decrease could be due to different isotopic oxygen composition of snow compared to that of rain water or because of different microbial communities and/or different microbial activities. Therefore, the silver phosphate method could be an important tool to study biological processes influencing the P cycle. While the $\delta^{18}O$ value of phosphate itself cannot be used to trace phosphate sources within sites, the results indicate additional potential for distinguishing processes that differ with altitude and climatic factors, which could be important when quantifying the effects of climate change on phosphorus cycling.

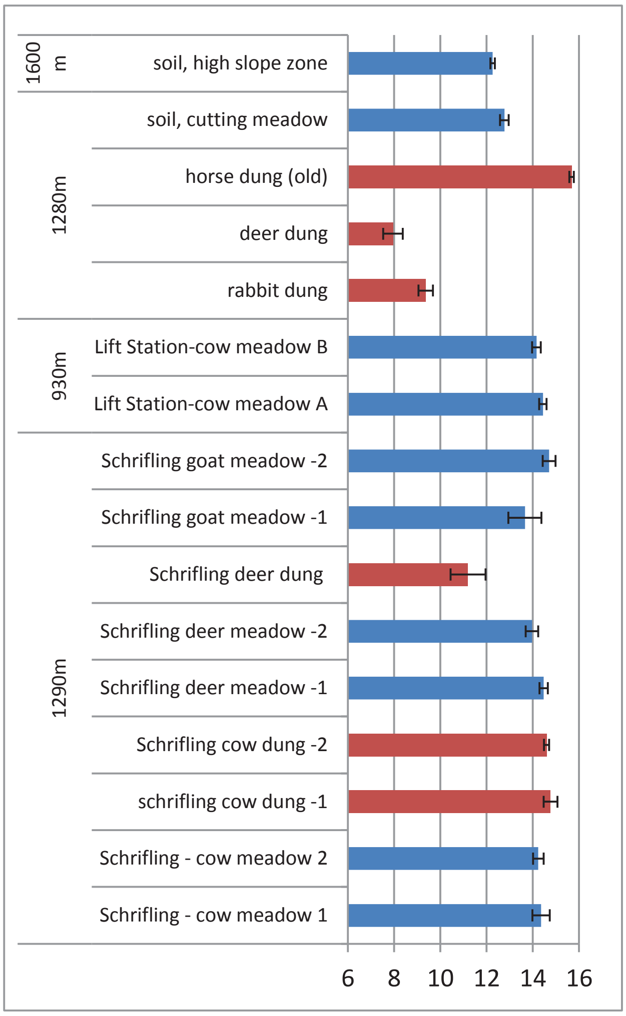

FIG. 2: $\delta^{18}O$ (‰) in phosphate values in manure and soil samples of different altitudes at Rauris, Austria

This research was conducted under CRP D1.20.12 on "Optimizing Soil, Water and Nutrient Use Efficiency in Integrated Cropping-Livestock Production Systems".

Publication of the TECDOC for Cosmic Ray Neutron Probe: Use, Calibration and Validation (IAEA TECDOC No.)

Technical Officer: Ammar Wahbi

The TECDOC consists of three chapters, including, overview of the cosmic ray technique, measurement principles and calculations, field installation of a cosmic ray soil moisture sensor, and field calibration and validation of a cosmic ray soil moisture sensor.

A cosmic ray soil neutron probe (CRNP) can be used to monitor soil water content over a footprint (the area covered by the probe) diameter of 600 m (approximately 30 hectares in area) and to an integrated depth varying from 0.1 to 0.6 m, depending on soil water content. The cosmic ray technique is a fairly recent soil moisture monitoring technology, having developed out of research performed mainly over the past decade. The technique is applicable to a number of disciplines, including ecology, agronomy, atmospheric science, and remote sensing which require a robust, readily deployable field instrument for automatic monitoring of near surface and area wide moisture conditions. These applications take advantage of the large footprint, which provides spatial representativeness, and the non-invasive nature of the probe, which facilitates installation and avoids disturbing the hydrologic properties of the soil being measured.

In this publication the key characteristics of the technique are described, recent literature related to its use and field validation is reviewed, and procedures for installation, calibration and validation are provided. The data processing procedure is also described. This includes corrections based on ancillary measurements of air temperature, relative humidity and barometric pressure and corrections derived from publicly available data on solar activity. To aid the readers and users of the CRNP, this publication is complemented by an Excel spreadsheet which implements the raw and the processed data after the correction using weather data.

High-throughput and homogeneous ^{13}C-labelling of plant material for fair carbon accounting

Slaets, J.I.F., Resch, C., Mayr, L., Weltin, G., Heiling, M., Gruber, R., Dercon, G.

Soil and Water Management & Crop Nutrition Laboratory, Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Department of Nuclear Sciences and Applications, International Atomic Energy Agency, Vienna, Austria

With growing political acknowledgement of the anthropogenic drivers and consequences of climate change, the development of carbon accounting mechanisms is essential for fair greenhouse gas emission mitigation policies. Therefore, carbon storage and emission must be accurately quantified. Plant material labelled with ^{13}C can be used to measure carbon storage in soil and carbon losses via CO_2 emission to the atmosphere from various cropping practices through in situ and incubation experiments.

Such an approach, however, is only useful when plant material is labelled homogeneously, cost-effectively and in sufficient quantity. Current pulse labelling methods often result in heterogeneous signatures and produce only limited amounts of plant material. We developed a high-throughput method in a walk-in growth chamber of 12 m^3, where ambient CO_2 concentration and isotopic composition are continuously monitored by an off-axis integrated cavity output spectroscope (Los Gatos Research), and are held at a $\delta^{13}C$ value between 350 and 400‰ (Figure 3). Maize was chosen as a first test crop because of its global importance as cash crop and animal fodder, as well as the possibility to produce considerable amounts of biomass, yielding one kilogram dry matter of plant material per run.

The resulting material showed a homogeneous isotopic labelling and variability in isotopic signature decreased with leaf age (Figure 4 and 5). Bottom leaves had an average $\delta^{13}C$ value of 277‰, with a 95% confidence interval of [247, 307] whereas top leaves showed an average $\delta^{13}C$ value of 366‰, the 95% confidence interval equalling [362, 370]. As C uptake by the plants in the initial growing phase is low, the effects of chamber leaking, although limited, were larger during this stage, which could be compensated for by having higher ^{13}C concentrations during early growth stages.

Future steps of high-throughput ^{13}C labelling will focus on legumes and other cereal crops, opening research avenues for better understanding C dynamics in existing crop rotation systems. Furthermore, dual labelling with ^{13}C and ^{15}N would enable simultaneous accounting of not only CO_2 but also CO_2-equivalent emissions, such as N_2O. Additional need exists for labelled edible fiber crops, pasture species, and material covering wide ranges of C/N ratios. High-throughput isotopic labelling of plant material can thus provide accurate and cost-effective methods for C and N tracing in agricultural systems.

Figure 3: Growing maize in a walk-in growth chamber under constant atmospheric $\delta^{13}C$ signature

Figure 4 and 5: Sampling plant leaves for analysis with isotope ratio mass spectrometer to check homogeneity of isotopic labelling

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Impressum

Soils Newsletter Vol. 39, No. 1, July 2016

The Soils Newsletter is prepared twice per year by the
Soil and Water Management & Crop Nutrition Section,
Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture and
FAO/IAEA Agriculture & Biotechnology Laboratory, Seibersdorf.

International Atomic Energy Agency
Vienna International Centre, PO Box 100, 1400 Vienna, Austria
Printed by the IAEA in Austria, July 2016

16-27781