2003

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INTRODUCTION

Nuclear-based techniques are among the most effective for measuring the amount of nutrients absorbed by plants and monitoring nutrient movement in soil. They play an important role in developing more efficient soil nutrient and water management strategies for crop production and environmental preservation.

Sustainable agriculture depends on maintaining an appropriate balance between the use and conservation of soil nutrients and water resources for crop and fodder production. The main goal is to continuously provide the most favourable physical, chemical and biological conditions for sustainable crop production. Our current knowledge as to how this might be achieved in many diverse agro-ecological conditions is inadequate. In this context nuclear-based technologies provide valuable information on nutrient and water dynamics in soil and their effects on crop production. The Soil and Water Management and Crop Nutrition Section of the Joint FAO/IAEA Division and the Soil Science Unit of the FAO/IAEA Agriculture and Biotechnology Laboratory, Agency's Laboratories, Seibersdorf, assist in the development and transfer of nuclear techniques to Member States with the main objective of adopting these techniques for optimising soil, water and nutrient management practices in cropping systems, which support increased and sustainable crop production.

Nuclear techniques used in the field of Soil Fertility and Water Management complement conventional techniques, and provide unique information, which other techniques cannot, e.g.

- Quantitative information on the flow and fate of fertiliser in soils and uptake of nutrients by plants to identify efficient fertiliser management practices.
- Identification of sources of soil water and their availability to plants.
- Identification of sources of soil carbon and estimation of the contribution of organic sources to crop nutrition.
- Measurement of biological nitrogen fixation.

The Soil Science Unit works with the Soil and Water Management and Crop Nutrition Section in implementation of integrated projects in Member States on soil, water, crop and nutrient management focused on sustainable crop production through efficient use of natural resources. The Soils Newsletter provides further information on the present and future programmes.

Field experiment at the Seibersdorf Laboratory.

The main roles of the Soil Science Unit are to:

- Develop, adapt and validate nuclear methods for the use in Co-ordinated Research Programmes and Technical Co-operation Projects of the FAO/IAEA,
- Train technical staff and scientists from Member States in the analyses of stable isotopes and the use of nuclear and related techniques,
- Provide isotope analyses to projects where analytical facilities are not available,
- Provide quality assurance services to Member States.

Please visit the website of the Soil Science Unit:
www.iaea.org/programmes/naal/agri/pages/soilscience.htm.

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RESEARCH AND DEVELOPMENT ACTIVITIES

SOIL WATER

Lee Heng

Water is indispensable for life. It is critical for long-term economic development, human health and social welfare and environmental sustainability. It is also needed for broad-based agricultural and rural development to meet the Millennium Development Goals to improve food security and poverty alleviation.

Agriculture is by far the biggest user of freshwater, it accounts for 70% of the global water withdrawal. However, improper water management in many countries has resulted in severe shortage of water, which has reached a critical level for food production and is a major cause of poverty and hunger. As demands for food are non-negotiable, the only option for achieving food security is through better water management, and the only scope for doing so is to increase water productivity under existing agricultural systems, both rainfed and irrigated agriculture. The role of water in development and the implication of continued lack of access to safe drinking water have been a major discussion issue at various international forums such as The Earth Summit in Johannesburg, August 2002 and the Third World Water Forum in Kyoto, March 2003.

The key to efficient and improved soil water management is a good knowledge of both the amount of water in the soil profile that is available to the crop and the amount of water the crop needs. Poor irrigation and drainage practices lead to water-logging and salinization, which have affected the productivity of nearly 50 percent of the world's irrigated lands. Over and/or under irrigation also affects crop yield and quality, causing economic losses such as leaching of nutrients or agricultural chemicals and creating environment problems such as pollution of groundwater and degradation of surface waters with contaminated irrigation water.

Irrigators therefore have to manage water more prudently and efficiently, as a result, a range of equipment and techniques have been developed for measuring soil water status in recent years. Irrigation extension staff, consultants, equipment sales people and irrigation managers now face a huge task in choosing the right technology and be familiar with the features, advantages and limitations of each system.

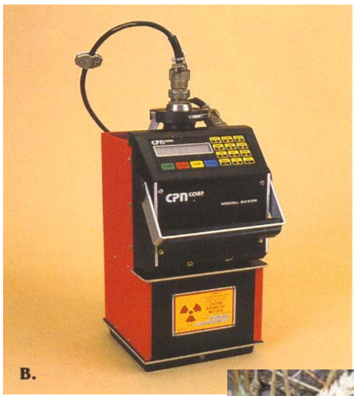
"Comparison of soil water measurement using the neutron scattering, time-domain reflectometry (TDR) and capacitance methods"

The Soil Science Unit co-ordinated and conducted a three-year study, on the "Comparison of soil water measurement using the neutron scattering, time-domain reflectometry and capacitance methods", to review the advances in the various soil water measuring techniques, and to consult on the procedures for adopting soil water measurement techniques in the Agency's future research and training programmes.

The study was undertaken in Seibersdorf as part of SSU fellowship training. Similar studies also took place concurrently with international collaborators. The soil moisture neutron probe (SMNP) which was the main technology for irrigation scheduling over the past 50 years, is radioactive and hence requires licensing for safe use and transportation, was compared with other non-nuclear techniques which were developed more recently.

The three-year results showed that the SMNP is still the most practical device for field measurement of soil profile water content for scientific purposes. It senses soil water content over a volume of soil that is an order of magnitude larger than that sensed by other devices. This offers substantial advantages over alternative technologies in dealing with the variability of soil water on the small scale near to the access tube; and it overcomes the problem of modification of the soil properties in the measured soil zone during the access tube installation process. It is also at least an order of magnitude less sensitive to salinity or temperature influences that cause large errors in capacitance or TDR systems used in access tubes. The SMNP is a stable technology that is reliable and easy to use effectively. It was felt that the SMNP was the technology most likely to provide the best measure of soil water content under 'common' field conditions in the hands of a novice user. While the alternative technologies could sometimes produce equivalent results without the problems presented by radiation safety laws, it was felt that reliable results could not be obtained without knowledge and experience beyond that likely in the average user. The technology is also mature, like all other methods, the SMNP is affected by a number of soil properties and installation problems. Unlike other technologies, these problems are well understood and documented widely enough to enable the conscientious user, even a novice, to read about them with little difficulty.

As result of this project a practical guideline on “Measuring Soil Water Content in the field: A beginners guide to water measurement: methods, instrumentation and sensor technology” is currently being written.



OPTIMIZING WHEAT PRODUCTIVITY UNDER EXTREME DRY RAINFED ENVIRONMENTS OF WEST ASIA NORTH AFRICA (WANA) USING CROP-SIMULATION MODEL APSIM

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The West Asia and North Africa (WANA) region is one of the driest places in the world, with frequent occurrence of droughts and precipitation is low and erratic. Water shortage is a major constraint to agricultural production. Cereal production is important in this region; in Morocco it represents more than 80 % of the total arable land (El Mejahed and Aouragh, 2004). However, yields of cereal crops in the rainfed areas are generally low; in Jordan it ranges from 0.2 - 1 Mg ha^{-1}. The unpredictability of the rainfall also makes it difficult to determine the level and timing of fertilizer needed to attain optimum yield, as it might result in over- or under-fertilization of N depending on the rainfall (Rusan *et al.*, 2004). Variation in the growing-season precipitation therefore has a strong impact on yield and utilization of applied N.

In order to develop suitable and appropriate crop production strategies for increased and sustained yields, and to understand the links between climate variability, water availability and use, and agricultural productivity, a crop simulation model, APSIM-N wheat (developed by APSRU in Australia), was used to evaluate the field experimental data collected in Morocco and Jordan between 1998-2002 (El Mejahed and Aouragh, 2004; Rusan *et al.*, 2004). Simulation models can be useful when appropriately used, as it allows one to study the outcomes over many seasons in parallel, with minimal computing time and with control over unwanted factors; it also allows the evaluation of alternative farm management options and overcomes the limitations of a field experiment, which is normally limited by the length of time, locations, soil types and management options and initial conditions. Using information from long-term simulation experiments and the characterization of production systems, it can be used to extrapolate the results from these experiments to other similar agro-ecological zones, and explore the potential implications of the various improved cropping systems in farmers' fields.

Materials and Methods

The experiments described were part of the "Management of Nutrients and Water in Rainfed Arid and Semi-Arid Areas for Increasing Crop Production" Co-ordinated Research Project, implemented between 1997 and 2002 with the overall objective of increasing crop production through improved management of nutrients and water in rainfed arid and semi-arid areas.

The field trial was conducted in Jemaa Riah (JR) at the Agricultural National Research Institute (INRA) experimental station, located 60 km south of Casablanca in the Chaouia region in Morocco; and at Maru Agricultural Research Station, 100 km north of Amman, Jordan.

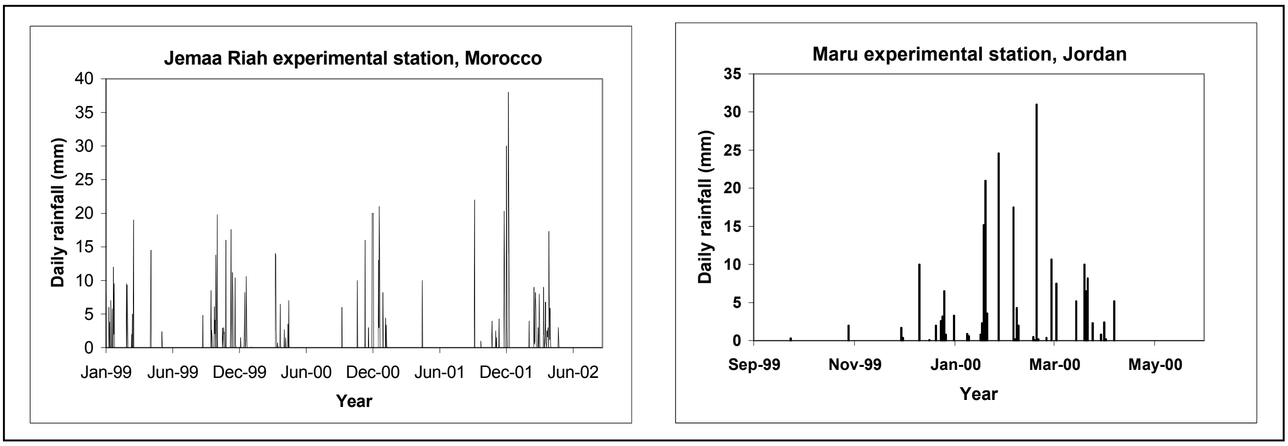


Fig.1. Daily rainfall for JR, Morocco (left) and Maru experimental station, Jordan (right) during the experimental period

Results and Discussion

Rainfall

The daily rainfall over the experimental period for JR, Morocco and Maru in Jordan is given in Fig. 1. The first two years (1999-2001) were dry in Morocco, the amount and the distribution of received rainfall during these years are an indication of the variation in climatic conditions prevail in semiarid regions of Morocco. The rainfall distribution in Jordan for the 98/99 growing season was also low, late rain in October to December resulted in delayed emergence and poor wheat growth.

Yields

The measured and simulated grain yields for Morocco and Jordan, plotted against the seasonal cumulative rainfall from October to April are shown in Figure 2. The measured grain yields were extremely low in both countries, with most values less than 1.5 t ha^{-1}. The results also showed that most of the yields fell below the French and Schultz (1984) 20 kg $ha^{-1}mm^{-1}$ potential line, which is commonly used by farmers in Australia to set a target for potential yield using growing season rainfall, after accounting for 110 mm of soil evaporation. This indicates that in the WANA region often the distribution rather than the total seasonal amount of rainfall determines potential grain yields.

Fig. 2 also shows that the model simulated the yield reasonably well in most seasons except for the Moroccan 01/02 cropping season, which had 270 mm. In that year, the model predicted yields of approximately 3 t ha^{-1} while the measured yields were only about 0.5 t ha^{-1}. The reason for these low yields was unknown. However, a parallel experiment carried out in another location Jemaa Shaim (JS) Agricultural National Research Institute (INRA) experimental stations, located in the Safi-Abda regions, with similar rainfall, produced grain yields close to model prediction for the JR site (Figure 2).

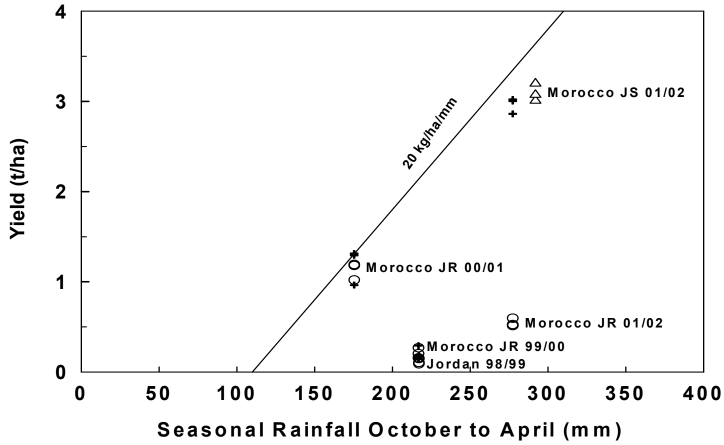


Figure 2. Measured (open symbols) and simulated (+) for Moroccan and Jordan wheat grain yields versus cumulative seasonal October to April rainfall. Also shown is the French and Schultz (1984) potential yield line of 20 kg $ha^{-1}mm^{-1}$.

The measured grain N is also reasonably well simulated, except for the 01/02 cropping season (Fig. 3).

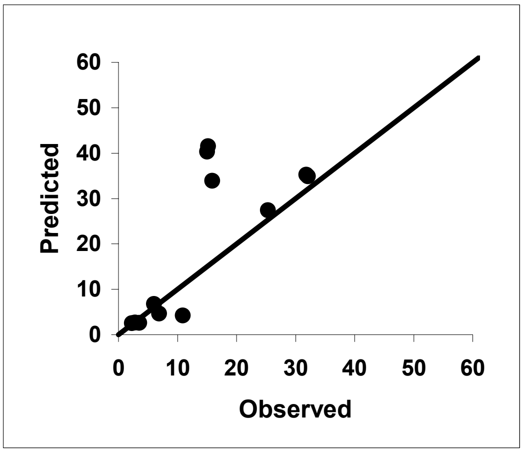


Fig. 3. Measured and predicted grain nitrogen (kg N ha^{-1}) for both Morocco and Jordan data

Long-term simulation

In order to better understand the cropping system and management options for the region, the model was run with a 20-year historical weather record from Morocco, to assess the effect of soil types, initial soil water and inorganic N profiles, cultivars, sowing date, on the probability of grain yield potential.

Simulated Results

The 20-year growing season (October to April) monthly rainfall pattern for JR in Morocco is given in Fig. 4. It varies markedly between and within seasons, from 124 mm in 94/95 to 439 mm in 87/88 seasons.

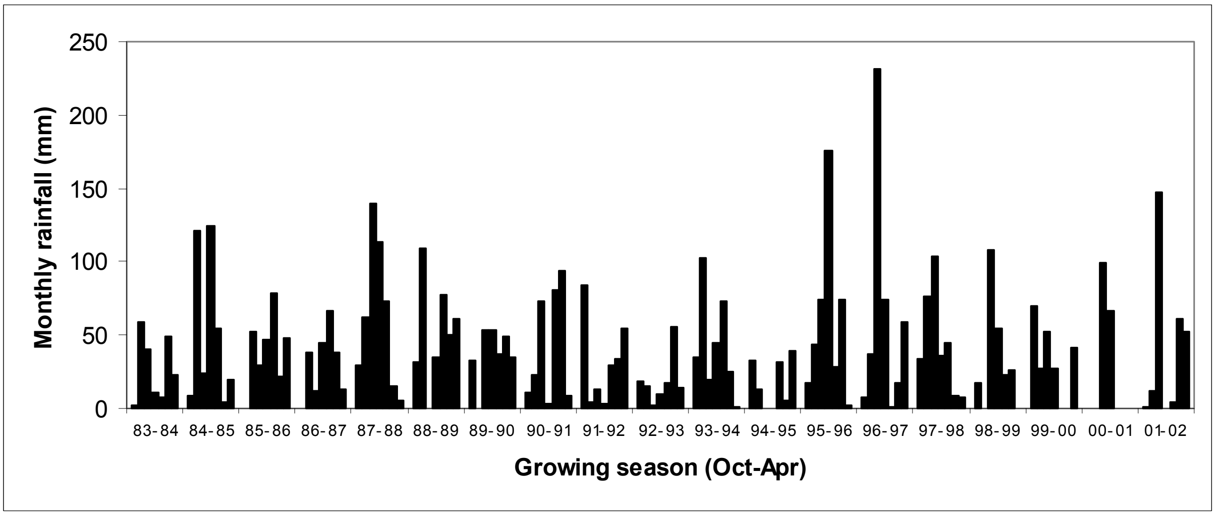


Fig. 4. The growing season (October-April) monthly rainfall for JR, Morocco between 1983-2002.

The highest simulated yield in the control no fertilizer treatment was close to 2.1 t ha^{-1} in 90/91 (Fig. 5), however, the application of 30 kg N ha^{-1} at sowing increased yield significantly to 3.2 t ha^{-1} for the same year, hence N fertilizer is needed to get an increase in yield. This was however, not always simulated, and in fact in some years applying fertilizer gave a negative yield response. In all these simulations, no yield was predicted in the three dry years (91/92, 92/93 and 94/95) indicating that water was the limiting factor.

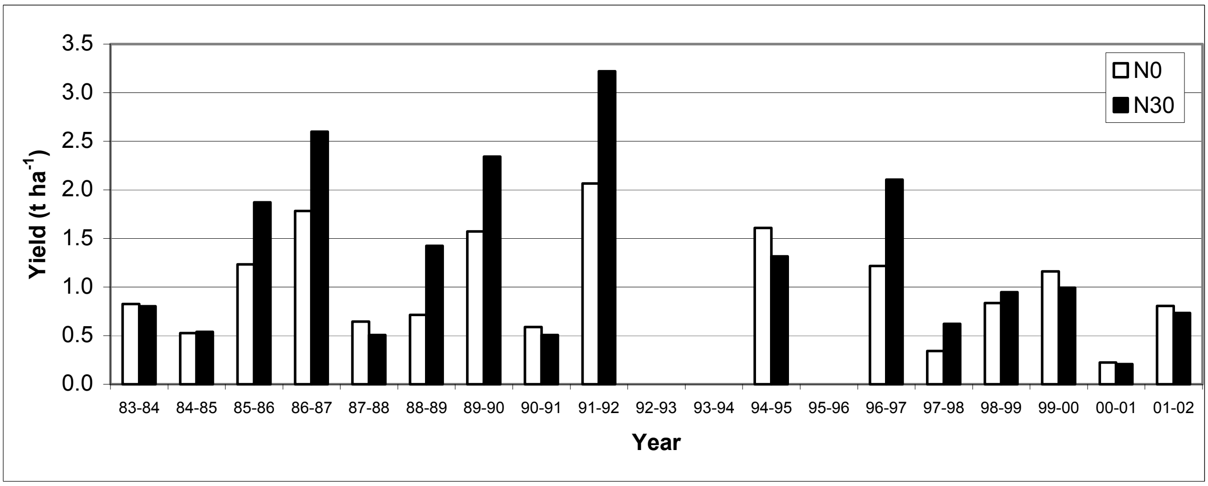


Fig. 5. The simulated wheat grain yield for JR, Morocco between 1983-2002 for zero and 30 kg N/ha fertilizer applied at sowing.

Fig. 6 shows that further increase in N application does not have a significant effect on increasing yield, although splitting it between sowing and tillering improved yields in many simulated seasons. Having initial stored soil moisture was beneficial in the dryer years but the effect was minimal in the wet years. Nevertheless, management practices, which enhance stored soil water, should be practiced. Similarly, having a better soil with a higher water-holding capacity increases the probability of obtaining higher yield, especially when there is stored soil moisture at the time of sowing, The benefit of having a better soil water-holding capacity out-weighs that of having 30 mm of initial stored soil moisture, it increases the probability of having higher yield. Having a late maturing cultivar often gave a negative yield response (data not shown); late wheat variety is not suitable for this environment because of the terminal drought often encountered at the end of the season.

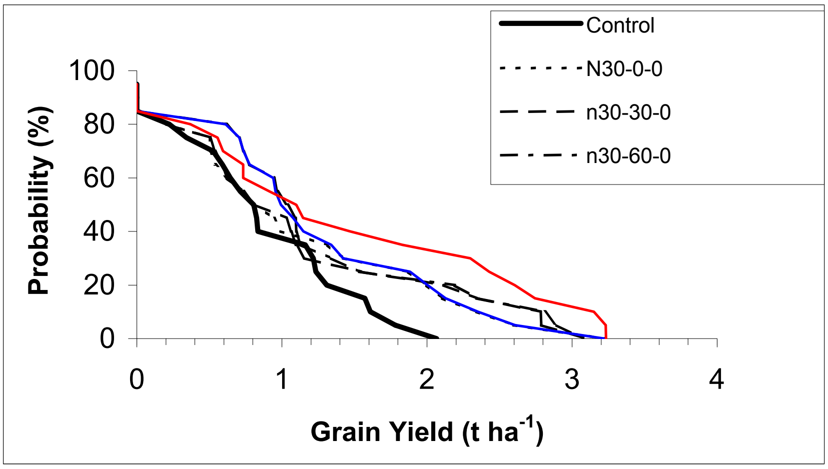


Fig. 6. Effect of different N treatments and soil type on Moroccan wheat grain yield

Conclusions

Grain yield in the arid and semi-arid rainfed environments such as the West Asia and North Africa region is highly dependent and sensitive to the amount and timing of rainfall during the growing season. Yield also varies markedly depending on the water-holding capacity of the soil, nitrogen management, and its interaction with stored soil moisture. All these parameters interact in a very complicated manner; to fully understand the processes involved by field experimentation alone is a costly and time-consuming task. Using a simulation model such as APSIM can help to integrate all these factors, and identify better nutrient and water management practices to increase crop production in rainfed arid and semi-arid areas, especially when it is combined with long-term climatic data and soil information.

References

El Mejahed, Khalil and Aouragh, L. 2004. Green manure and n fertilizer in soil quality and profitability of wheat based system in semiarid morocco using nuclear techniques. Manuscript submitted to the IAEA Tecdoc.

Rusan, Munir Mohammad, Battikhi, A. and Zuraiqi, S. 2004. Enhancement of nitrogen and water use efficiency by optimizing the combination of soil, crop and nitrogen management. Manuscript submitted to the IAEA Tecdoc.

POTENTIAL USE OF AN OPTICAL BREATH TEST ANALYSERS FOR ESTIMATING CARBON SEQUESTRATION

Rebecca Hood-Nowotny.
Studies carried out by: R, Syamsul, M. Khan, A. Haque, M. Khadir and J. P. Bonetto (FAO/IAEA fellows) under the supervision of R. C. Hood, L. Mayr and M. Heiling.

It may be possible within a short time frame to devise methods for estimating carbon sequestration under different agronomic management practices using NDIR (Non-dispersive Infrared Spectroscopy) breath test analysers in combination with simple ^{13}C-plant-labeling techniques. This requires that the technology is financially accessible, easy to use and appropriate. Base-line data is needed for a range of agro-ecological climates under a range of cropping systems to fuel the carbon models. The impact of new technologies such as conservation agriculture must be integrated into these models. The move from conventional to conservation agriculture has been suggested as one possible option to offset rising CO_2 levels. One of the three principles of conservation agriculture is that the crop residues are retained on the field surface at the end of the growing season and the following crop drilled into the residue layer. The other underlying principles are crop rotation and minimal soil disturbance. Under this remit FAO is engaged in the development of methodologies and tools to analyse win-win options for small farmers aiming at preventing land degradation, enhancing soil fertility, land productivity and carbon sequestration, which contribute to mitigating atmospheric CO_2 levels (FAO, 2004).

Here we describe experiments that were designed to develop and test simple protocols for estimating carbon sequestration using NDIR breath test analyzer. The experiments were set up in the greenhouse of the FAO/IAEA Agriculture and Biotechnology Laboratory, Seibersdorf, Austria. Cowpea plants were grown in the greenhouse and were watered daily with a Long Ashton solution labeled with ^{15}N. In addition they were pulse labeled with ^{13}C in a simple gas tight Perspex air-conditioned chamber containing $^{13}CO_2$ (IAEA 2001). The plants were harvested after 4 weeks and separated into shoots and roots, dried, ground and analysed for ^{13}C and ^{15}N. The dual labeling of the cowpeas was successful with leaves having 1.355 atom % ^{15}N excess and 2130 ‰ δ ^{13}C. The roots had 1.52 atom % ^{15}N excess and 2485 ‰ δ ^{13}C.

This material was used in the following treatments: 1. No residue added, soil only control; 2. Cowpea leaf residues added and 3. Cowpea root residues added. The sandy loam soil was packed into PVC incubation tubes. The soil samples were placed in gas tight Kilner jars with a CO_2 trap. The trap was changed at weekly intervals for three weeks and the jar aired. Strontium chloride was added to an aliquot of the NaOH trapping solution, which was back titrated with HCl and prepared for FANci analysis, the resultant $SrCO_3$ was added to a vacutainer, which was then evacuated and phosphoric acid added. CO_2 was sampled from the tube and later analysed by the FANci breath test analyser (FAN GmbH, Leipzig, Germany) (Hood, R, 2001).
Soil N analyses were done at each sampling using standard procedures (Hood et al, 2003). Net mineralisation rate and % nitrogen derived from residues as well as % carbon derived from residues were calculated.

Carbon mineralisation was rapid over the first 7 days (Figure 1) and fell exponentially in both leaf and root treatments in the following weeks. Nitrogen mineralisation was also rapid over the first 7 days, showing a similar pattern (data not shown). There was a significant linear relationship (r^2=1, $p<0.05$) between N derived from residue (Ndfr) and cumulative CO_2 respiration in the leaf treatments. Also there was a linear relationship observed in the root treatments, but it was not significant.

It was possible to measure carbon derived from residues using both the isotopic and non-isotopic methods. Both gave similar values suggesting that the techniques for measurement were appropriate. These data suggested that, in the first 21 days, only 15% and 8% of the added residues were mineralised from the leaf and root treatments, respectively. The data also showed that with isotope technique it would be possible to measure C derived from residue (Cdfr) over the following months if not years. This is not possible using the direct technique because of the small difference in CO_2 evolution in the treated and untreated sample.

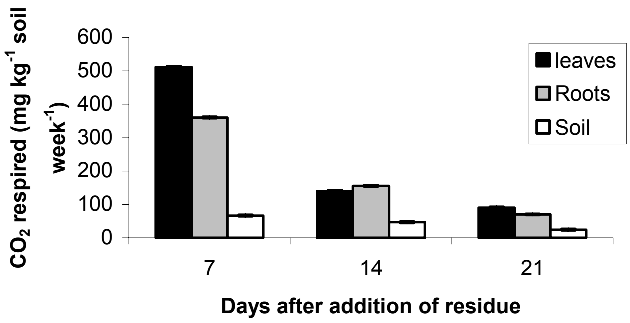


FIG. 1. Soil respiration following addition of residues.

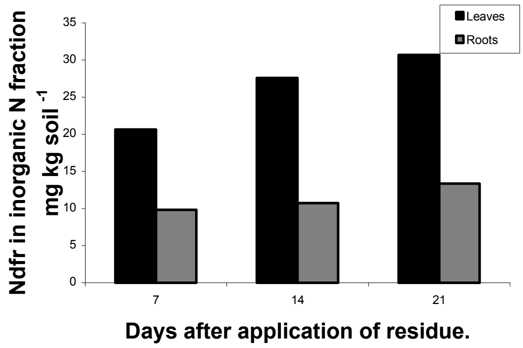


FIG. 2. Nitrogen derived from residue in organic N pool.

It was possible using these data to construct very rough carbon budgets for an equivalent inorganic N fertiliser system. The mineral N release from the organic residue was equivalent to approximately 60 kg ha^{-1} over the three week period, which may be a slight underestimate due to nitrate accumulation feedback mechanisms. It was assumed that in the conventional inorganic fertilizer system, to achieve a similar level of fertilization 100 kg ha^{-1} would have to be applied assuming an optimistic fertiliser use efficiency of 60%. It was estimated that 118 kg CO_2 was required for inorganic N production based on published data. The carbon sequestration was calculated by subtracting the respired carbon from the original input value using the isotopic data. From this perspective the cowpea residue treatment had significant benefits in terms of C sequestration, if it is assumed that residues are stabilised in the soil. This assumption is not necessarily true. Using the techniques described and measuring the ^{13}C remaining in the soil it would be possible to quantify this over many years.

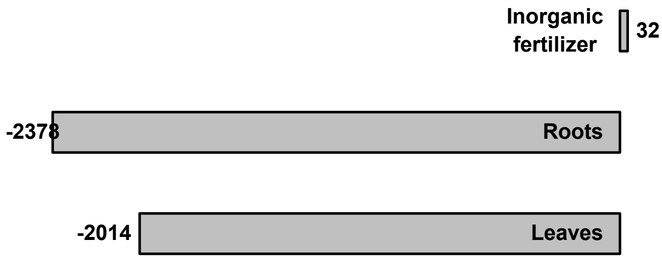


FIG. 3 Carbon budget for inorganic fertiliser and residue system in kg ha[1].

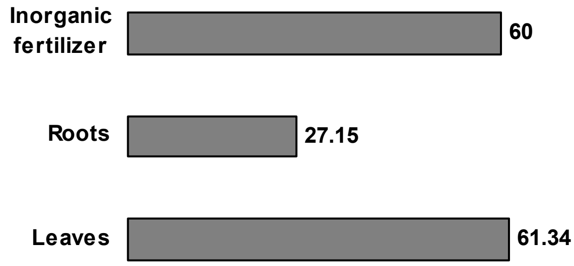


FIG. 4 Nitrogen budget for inorganic fertiliser and residue system, in kg ha^{-1}.

Figures 3 and 4 show that addition of leaf residues would lead to the "win win" scenario of N release and carbon sequestration. However, it is recognised that there needs to be synchronization of the residue N release and crop N uptake. Although these were pot experiments they allow a reasonable estimation of carbon sequestration and enable us to compare different soil management scenarios. Further experiments will have to be done under field conditions.

These experiments demonstrate how a simple ^{13}C labelling procedure used in conjunction with a simple breath test analyser could be used to get a range of values for C sequestration under different cropping systems in range of agro-ecological zones.

This work was presented at the International Conference on Isotopic and Nuclear Analytical Techniques for Health and Environment, Vienna 2003 and is currently In Press in Analytical and Bioanalytical Chemistry.

References

FAO (2004) www.fao.org/landandwater/agll/

Hood, R., (2001) The effect of temperature and moisture on organic matter decomposition and plant growth. Stable Isotopes in Health and Environmental Studies 37, 25-41.

Hood, R. C., Khan, M, Haque A, Khadir M, Bonetto J P, Mayr L and Heiling M (2003) Development of preparation methods for 13/12C analysis of soil and plant samples using optical breath test analysers. Communications in Soil Science and Plant Analysis. Vol 34, 15 & 16, 2219-2227.

IAEA (2001) Use of Isotope and Radiation Methods in Soil and Water Management and Crop Nutrition. Training Course Series No.14, IAEA Vienna, 2001. Available free from IAEA on request.

PREPARATION OF AMMONIUM-^{15}N AND NITRATE-^{15}N SAMPLES BY MICRO-DIFFUSION FOR ISOTOPE-RATIO ANALYSIS BY OPTICAL EMISSION SPECTROMETRY

Heiling M, X. Videla, Arrillaga J L, Mayr L and Hood-Nowotny R

The routine use of ^{15}N as a tracer of N transformations in the soil-plant-atmosphere continuum has been restricted by time-consuming sample preparation methods, such as steam distillation, and limited access to isotope-ratio mass spectrometers. Process studies such as measurement of gross N mineralization or nitrification provide a unique insight into biological N transformations, which are not possible using non-isotopic techniques. However, extensive and repeated sampling of the nitrate and ammonium pools is required to determine N concentration and ^{15}N enrichment. Diffusion preparation methods that have been adopted in the last 15 years have proved invaluable, allowing in excess of 200 samples to be prepared for analysis per day as compared to 24 or so using steam distillation procedures. The limiting step still remains access to isotope ratio mass spectrometers.

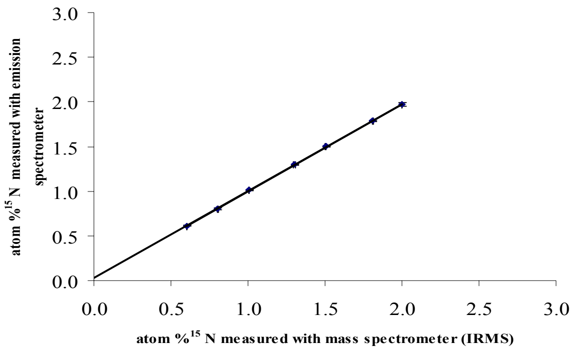
Optical emission spectrometry (OES) has proved to be an appropriate technology for measurement of ^{15}N abundance in plant and soil samples, worldwide. The comparative simplicity and lower cost of emission spectrometers have been major factors in enabling laboratories in developing countries to be equipped for ^{15}N analyses. In addition, the annual external quality assurance exercise for total N and ^{15}N analysis of plant materials run by the Soil Science Unit has provided confidence in the results obtained.

In the laboratory the micro-diffusion procedure as a concentration step preceding the analysis of inorganic ^{15}N in KCl extracts of soil using optical emission spectrometry was validated, by comparison with results obtained using standard Dumas combustion and isotope-ratio analysis by mass spectrometry.

^{15}N solutions in which a range of enrichments were prepared and made up with 1M KCl. Triplicate samples were prepared for analysis with the isotope ratio mass spectrometer (IRMS) or the emission spectrometer (ES) using the diffusion technique. The principle of the diffusion technique is that ammonia is liberated from the KCl extract by increasing the pH of the solution by adding magnesium oxide, and is then collected on an acidified quartz or glass fibre filter disc enclosed in a PTFE (polytetrafluoroethylene) envelope. The disc is then analysed either by conventional Dumas combustion with IRMS or ES. Nitrate is sequentially analysed from the same sample; by reduction to ammonium using Devarda's alloy.

In these experiments the ^{15}N enrichments were determined using a semi-automatic NOI 7 emission spectrometer [Fisher Analysen Instrumente GmbH (FAN)]. The acidified discs were placed in 1-ml Ependorf tubes, 200µl of distilled water was added to give a concentration of 1µg N μl^{-1}. The tubes were vortexed for approximately 10 seconds to ensure complete dissolution, and a 25µl aliquot was pipetted into the micro test tubes, and the samples measured with the NOI 7C.

Regression analysis showed a highly significant ($P < 5x10^{-12}$) correlation between the values obtained using the IRMS and the emission spectrometer for the ammonium sulphate solutions (Fig. 1). The r^2 was 1.000, and the 95% confidence limit of the slope included the value 1 and the intercept included the value 0.



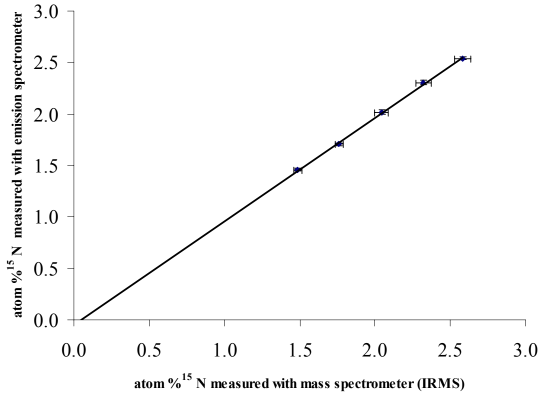


Fig.1 Ammonium sulphate solution.

Fig. 2 Potassium nitrate solution.

The correlation between the IRMS and emission spectrometer was again excellent for the potassium nitrate solution $r^2 = 0.999$ and again there was a highly significant ($P < 5x10^{-5}$) correlation. The 95% confidence limit of the slope included the value 1 and the intercept included the value 0. This suggests that the results of the two methods for ammonium sulphate and potassium nitrate did not differ significantly and there is no evidence for proportional systematic error. These results suggest that in principle emission spectrometry in combination with the micro-diffusion technique could be used as an alternative to mass spectrometry in the range of 0.6 to 2.6 atom % ^{15}N.

This work has been submitted for publication in Communications in Plant and Soil Analysis. The development and dissemination of these techniques through training and publication will enable scientists in Member States to confidently undertake N transformation studies and apply that knowledge to their cropping systems thus improving nitrogen management.

BELOW-GROUND NITROGEN IN SOYBEAN

M. Aigner, M. Heiling and G.Hardarson

Most studies using ^{15}N isotope dilution methodology on biological nitrogen fixation (BNF) have concentrated on the above ground plant parts and below ground N (BGN) have been largely ignored. One might consider this a major limitation to the previous BNF work. However, it all depends on the objectives of each study. It is certainly not necessary to measure below ground N if one is screening for BNF potential in various crops or when the effect of various agronomic practices on BNF is being investigated. If one is only interested in the measurement of %N derived from atmosphere (%Ndfa) then sampling of below ground N is of limited importance. The reason is that the % ^{15}N atom excess in the above and below ground plant parts are usually similar and the %Ndfa will be similar whether or not below ground material are used. For enhancing BNF in various grain legumes it is certainly not necessary to include measurements of below ground N. However, if the objective is to measure total amount of N fixed or N balance then it will be necessary to measure below ground N, both in the roots and in the substrate, if rhizodeposition is occurring.

Due to the lack of measurements of BGN the N contribution of leguminous crops in cropping systems have been largely underestimated with the N balance often being reported negative after legume growth when it should have been positive had the BGN be considered.

Several scientists have recently published data on BGN measurements using ^{15}N foliar labelling methodologies. These papers have revealed large proportions of legume N or legume-derived N below-ground in roots and adjacent soil. As an example the data of Khan et al 2002 is presented in Table 1.

Table 1. Below ground recovered ^{15}N in several legumes (Khan et al. 2002)

Crop	**Below ground recovered ^{15}N (% of total recovered ^{15}N in crop)**
Fababean	32
Chickpea	35
Mungbean	11
Pigeonpea	42
Wheat	5

Greenhouse experiments were conducted at the Seibersdorf laboratory to quantify the amount of N below ground. The stem ^{15}N labeling technique of McNeil (1999) was used to label the soybean plants including root systems (Fig. 1). The soybeans were grown under greenhouse conditions in pots with 1 kg of soil. Stem labelling was performed 14 days after sowing by inserting a thread connected to a vial through the stem. The vials contained 2 ml of 0.075M urea solution having 94 atom % ^{15}N excess. 4.23 mg ^{15}N was applied to soybean and the ^{15}N recovery measured in shoots, roots and soil (Table 2). Parallel experiments were conducted to quantify biological nitrogen fixation by the soybean using the ^{15}N isotope dilution method.

Figure 1. Experimental set-up.

Figure 2. ^{15}N stem labeling

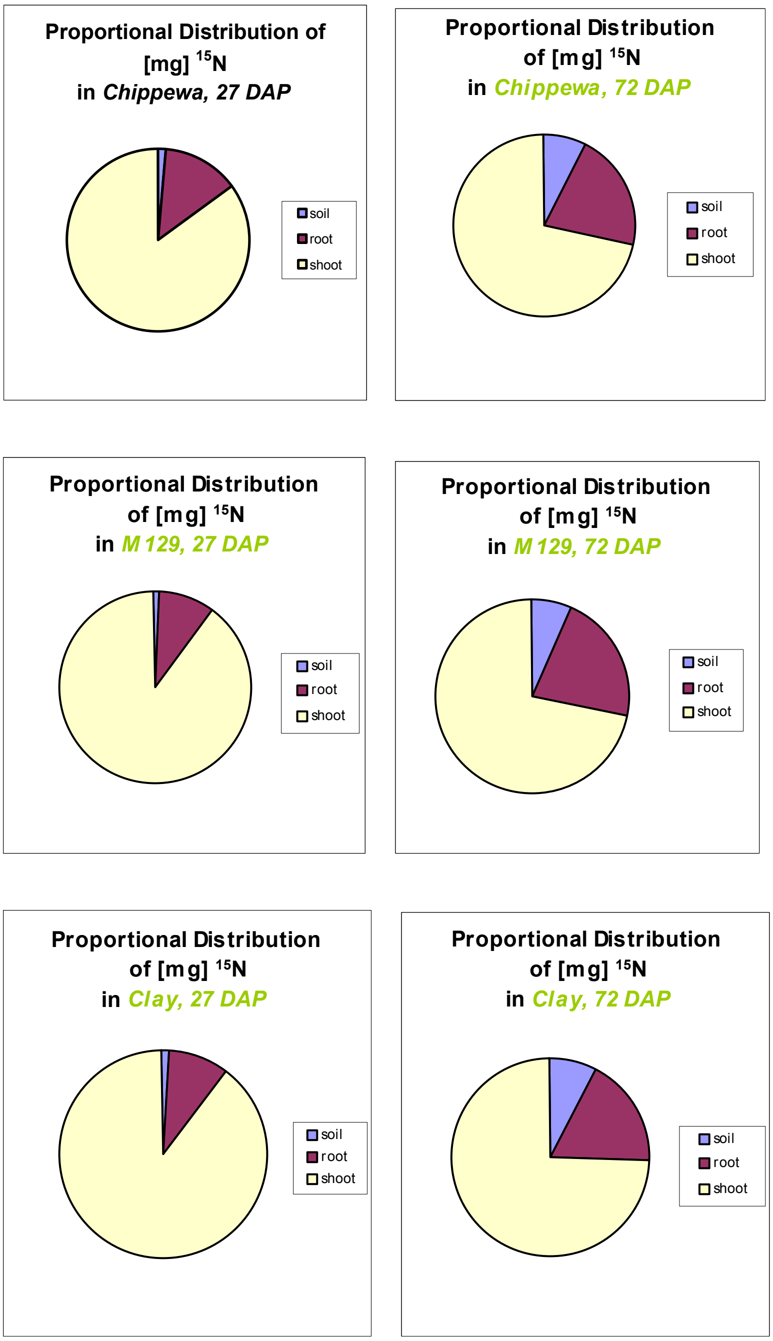
Table 2. ^{15}N recovery in the various plant parts of three soybean cultivars as well as soil when the ^{15}N was applied through stem labeling.

		[mg]^{15}N (% recovery)					
variety	Harvest (DAP)	applied	straw	pods	roots	soil	total
Chippewa	1 (27)	4.23	2.95 (69.7)	-	0.47 (11.2)	0.045 (1.1)	3.47 (82.0)
	2 (44)		2.75 (64.9)	-	0.66 (15.6)	0.158 (3.7)	3.56 (84.2)
	3 (58)		1.86 (44.0)	0.30 (7.1)	0.67 (15.8)	0.206 (4.9)	3.04 (71.8)
	4 (72)		1.04 (24.6)	1.07 (25.3)	0.61 (14.5)	0.225 (5.3)	2.95 (69.7)
M129	1 (27)	4.23	3.42 (80.9)	-	0.36 (8.5)	0.038 (0.9)	3.82 (90.3)
	2 (44)		2.87 (67.9)	-	0.73 (17.3)	0.097 (2.3)	3.71 (87.6)
	3 (58)		2.36 (55.7)	0.18 (4.3)	0.65 (15.4)	0.146 (3.5)	3.34 (78.8)
	4 (72)		1.60 (37.8)	0.59 (13.9)	0.67 (15.8)	0.199 (4.7)	3.05 (72.2)
Clay	1 (27)	4.23	3.33 (78.6)	-	0.35 (8.3)	0.054 (1.3)	3.73 (88.1)
	2 (44)		2.94 (69.4)	-	0.65 (15.3)	0.132 (3.1)	3.72 (87.9)
	3 (58)		1.72 (40.6)	0.71 (16.7)	0.52 (12.2)	0.176 (4.2)	3.12 (73.7)
	4 (72)		0.63 (14.8)	1.58 (37.4)	0.53 (12.6)	0.232 (5.5)	2.98 (70.3)

Table 2 illustrates good total recovery of the applied ^{15}N. The time course shows that at 27 DAP most of the ^{15}N was found in the straw and roots. Only about 1% of the applied ^{15}N was found in the soil at that time. At 44 DAP the ^{15}N in roots had already reached maximum level. Later in the growing season there was translocation of N from the straw to pods in the above ground plant parts. During the growing season there was a continuous increase of ^{15}N in the soil from approximately 1 to 5 % of the applied ^{15}N.

Previous greenhouse experiments have shown that approximately 10-11% of dry matter or total N of soybean is in the recoverable roots. This is significantly lower than the below ground $\%^{15}N$ recovery in the present experiment which was approximately 25–27 %, i.e. 17 – 21 in the roots and the attached soil and 6 – 8% in the soil (Figure 3). This is a much higher figure than the amount of dry matter or total N in soybean root.

Figure 3. Proportional distribution of recovered ^{15}N in three soybean cultivars, when harvested 27 and 72 days after planting (DAP).



Also it could be observed that below ground N increased with time. At 27 DAP below ground N was 10-14 %, at 44 DAP 20-22 %, at 58 DAP 22- 29 % and at 72 DAP 25 – 27%.

References

Khan D F, Peoples M B, Chalk P M and Herridge D F 2002 Quantifying below-ground nitrogen in legumens. 2. A comparison of 15N and non isotopic methods. Plant and Soil 239: 277-289.

McNeil A (1999) Enriched stable isotope techniques to study soil organic matter accumulation and decomposition in agricultural systems. In Application of Stable Isotope Techniques to Study Plant Physiology, Plant Water Uptake and Nutrient Cycling in Terrestrial Ecosystems. CLIMA, 105 – 119p. Nedlands, Australia

TRAINING

INTERREGIONAL FAO/IAEA TRAINING COURSE ON "THE USE OF NUCLEAR AND RELATED TECHNIQUES TO INCREASE WATER USE EFFICIENCY IN RAINFED AND IRRIGATED AGRICULTURE", 1 – 29 JULY 2003, SEIBERSDORF, AUSTRIA

The Soil Science Unit of the FAO/IAEA Agriculture and Biotechnology Laboratory, Seibersdorf, organized an Interregional FAO/IAEA Training Course on the Use of Nuclear and Related Techniques to Increase Water Use Efficiency in Rainfed and Irrigated Agriculture from 1 - 29 July 2003. The objective of the course was to give scientists from developing countries a sound working knowledge of strategies, approaches and applications of nuclear and related techniques to monitor soil water status and improve the use of water resources, particularly in arid and semi-arid areas for increased and sustainable agricultural productivity.

A total of nineteen participants attended this training course, including an observer and three scientists from developing countries already at Seibersdorf receiving practical training in soil water measurement under the IAEA Technical Co-operation fellowship programme.

Interregional FAO/IAEA Training Course, Participants and staff

Participants of Training Course:

Mr. Samson Bekele, Ethiopia
Mr. Daniel Asare, Ghana
Mr. Joseph Miriti, Kenya
Mr. Lav Bhushan India
Mr. Haithem Al-Adaileh, Jordan
Ms. Gulmira Sariyeva, Kazakhstan

Mr. Abdul Rahman Shyful Azizi, Malaysia
Mr. Fayyaz Hussain, Pakistan
Mr. Jalal Al Attar, Syria
Mr. M. Onur Özbas, Turkey
Mr. Bruno J.R. Alves, Brazil
Ms. Clover La Guerre, Jamaica
Ms. Mariana León Lárraga, Venezuela
Ms. Vesna Zupanc, Slovenia
Mr. Matej Knapic, Slovenia

Fellows who attend the Training Course:

Mr. Onesimus Semalulu, Uganda
Mr. Richard Max Kpange, Sierra Leone
Mr. Augustine Bundu Rashid-Noah, Sierra Leone

Observer:

Mr. Seung Oh Hur, Korea

FELLOWSHIPS

Mr. Onesimus Semalulu from Uganda (UGA/03010P) attended a two-month training in soil water including the Inter-regional Training Course. He carried out a field experiment comparing the soil moisture content of mulched and bare plots using nuclear, capacitance and time domain reflectometry techniques. Lee Heng supervised him.

Mr. A. B. Rashid-Noah (SIL/01004P) and **Mr. Richard Max Kpange** (SIL/ 02003P), both from Sierra Leone came for a three and half month fellowship. They also participated in the Inter-regional Training Course. They carried out field experiments comparing traditional and drip methods of irrigation using nuclear and related techniques. Lee Heng supervised them.

Mr. A. Dumbuya (SIL/02001P) was trained in the use of ^{15}N methodology to quantify biological nitrogen fixation. He conducted a greenhouse experiment to study early nodulation and nitrogen fixation in soybean cultivars with the objective to observed differences in the early establishment of this crop. He has also participated in the group training on total N and ^{15}N analyses.

GROUP TRAINING ON TOTAL N AND N-15 ANALYSES BY OPTICAL EMISSION SPECTROMETRY

Mr. T. Alam (BGD/02037R) and **Mr. S. Faye** (SEN/02017R) received eight weeks isotope analytical training under the overall supervision of Mr. Leo Mayr from 23 October to 05 December 2003. Sample preparation (plant material and soil) using Kjeldahl method for total nitrogen determination, measurement of $^{14}N/^{15}N$ ratio using NOI 7 emission spectrometer and quality assurance of the analysis were the main topics of the training. One week of troubleshooting of the OES system was also included in the programme.

Mr. A. Dumbuya (SIL/02001P) participated on the total nitrogen analysis sessions.

SUPPORTIVE SERVICES

ISOTOPE ANALYSES

Analytical services 2003

The Soil Science Unit performed more than 10,000 stable isotope analyses during 2003. Of these analyses approximately 55% were at natural abundance level.

Samples received:

CRP	3,436	74.8%
TC	165	3.6%
Seibersdorf	994	21.6%
Total	4,595	100.0%

Requested analysis:

^{15}N enriched level	3,671	63.0%
^{15}N nat. ab.	233	4.0%
^{13}C nat. ab.	1,374	23.6%
^{18}O nat. ab.	546	9.4%
Total	5,709	100.0%

Measurements carried out:

^{15}N enriched level	4,705	45.2%
^{15}N nat. ab.	1,569	15.1%
^{13}C nat. ab.	2,754	26.5%
^{18}O nat. ab.	1,378	13.2%
Total	10,406	100.0%

Number of samples analysed by the Soil Science Unit in previous years:

Year		**2002**	**2001**	**2000**	**1999**
	CRP	5019	4923	5048	5624
	TC	402	752	413	498
	Seibersdorf research	1006	3409	5109	3832
Requested analysis:	^{15}N enriched	2801	6176	7512	7686
	^{13}C nat.ab.	502	147	389	260
	^{13}C nat.ab.+^{15}N enriched	2866	2699	2564	2008
	^{13}C nat.ab.+^{15}N nat.ab.	39	-	-	-
	^{18}O nat.ab.	219	62	105	-
Total number of samples		**6427**	**9084**	**10570**	**9954**

The above table shows a significant reduction in the number of samples received where just ^{15}N analysis at an enriched level is requested from more than 6000 samples in the last years to 2800 in the year 2002 and 3700 in 2003. These types of samples can be measured by an emission spectrometer like the NOI7. A mass spectrometer is not necessarily need and therefore with the benefit of external quality assurance many Member States are now doing their own analyses of this type of samples. However, requests for analysis at natural abundance level have increased over the past years, i.e. $^{15}N/^{14}N$, $^{13}C/^{12}C$, $^{18}O/^{16}O$ and are now 55% of the samples analysed. These analyses can only be performed by mass spectrometer and many Member States lack facilities for such analyses.

PROFICIENCY TESTING EXERCISE "EQA2003"

Martina Aigner

The seventh round of proficiency testing exercise in ^{15}N and total N- analysis of plant materials has been conducted during the period January to October 2003.

As in the previous years a test panel containing of three different plant materials with unknown ^{15}N atom abundance and total N- contents including instructions for result reporting was sent to each participating laboratory for analysis. Five months time (April to August 2003) was given to submit the results. The choice of the instruments and methods was up to the participant. A certificate covering the period of the year 2003 and stating the successful participation in the exercise is provided to those labs that submitted "class I results", i.e. fully within the accepted control limits set by the Soil Science Unit.

Thirty-five applicants were provided with the test panel, twenty-three laboratories (i.e. 66 %) reported within the deadline (Table 1). Four laboratories reported technical problems, one did not receive the test panel, one lab sent a technician for training and will do the analysis afterwards, six laboratories were provided with the test panel, but neither did they report nor did they give any explanation. An increasing number of laboratories (namely labs in Belgium, Brazil, China, Kazakhstan, Thailand, New Zealand and Pakistan) are using a mass spectrometer for ^{15}N atom abundance determination the rest uses emission spectrometers.

Eleven laboratories (Argentina (2 labs), Belgium, Chile, Cote d'Ivoire, Iran, Mauritius, Poland, Syria, Turkey and Uzbekistan) received a certificate.

Table 1.: Summary of response:

Region	Number of participating laboratories	Number of laboratories receiving the certificate	Number of laboratories producing satisfactory results	Number of laboratories producing results outside control limits	Number of laboratories not submitting results
Africa	10	2	1	2	5
Latin America	7	3	2	0	2
East Asia & The Pacific	9	0	3	2	4
West Asia	5	3	1	1	0
Europe	4	3	0	0	1
TOTAL	**35**	**11**	**7**	**5**	**12**

Iran Islamic Republic is a newcomer in the EQA-project and the laboratory showed an outstanding performance in the first proficiency testing exercise.

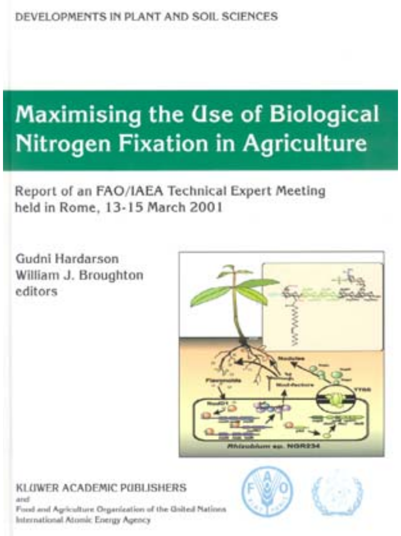
Laboratories in Argentina-1, Argentina-2, Brazil, Chile, Cote d'Ivoire, Syria, Turkey, and Uzbekistan showed a sustainable and good performance in the last three to seven years.

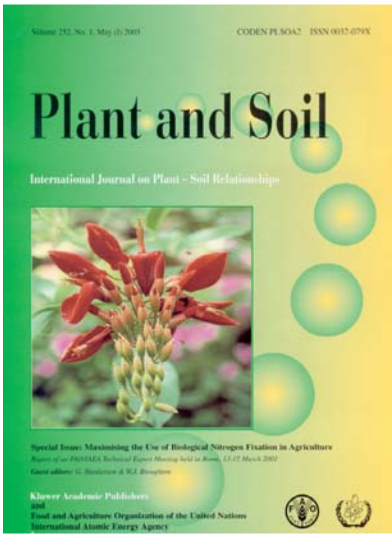
The Department of Agriculture in Thailand has started with ^{13}C measurements at the natural abundance level and received a standard material for testing from the Soil Science Unit. It will be the first lab to start with a proficiency testing exercise on ^{13}C abundance and total carbon analysis in plant materials next year in the frame of EQA2004.

It is also planned to produce a ^{15}N labeled soil reference material in 2004 and include analysis of ^{15}N abundance and total N in soil in future proficiency testing exercises.

APPENDIXES

PUBLICATIONS





Maximising the Use of Biological Nitrogen Fixation in Agriculture, Report of an FAO/IAEA Technical Expert Meeting held in Rome, 13-15 March 2001, Eds Gudni Hardarson and William J. Broughton, Development in Plant and Soil Sciences, Partly reprinted from Plant and Soil, Vol 252, No. 1 (2003) Kluwer Academic Publishers and FAO/IAEA.

Incorporating contributions from microbiologists, molecular biologists, plant breeders and soil scientists this volume reports the results and recommendations of an FAO/IAEA meeting of twelve experts on biological nitrogen fixation. This volume will be invaluable to scientists working on nitrogen fixation, soil microbiology, agronomy and crop production as well as farm advisers and extension specialists.

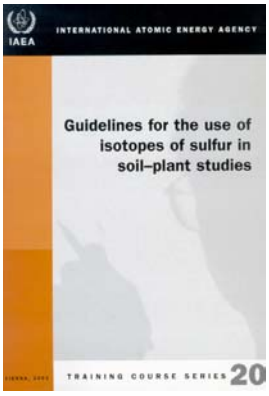
Maximising the Use of Biological Nitrogen Fixation in Agriculture is unique in that it

- Reviews the latest thinking on the various aspects of biological nitrogen fixation technology and applications
- Reviews the possibilities in enhancing nitrogen fixation in various cropping systems
- Shows ways how biological nitrogen fixation can be used to enhance crop production
- Consider the application of these technologies to small framers in developing countries

Contents

The hard cover book is available from Kluwer Academic Publishers (US$ 69). Limited number of copies is available from the Soil Science Unit for scientists in developing countries.

Guidelines for the use of isotopes of sulfur in soil/plant studies



These guidelines are being published in the Training Course Series of the IAEA and they will be available in December 2003.

Written by G Blair and R Till
Edited by P Chalk and G Hardarson

Contents:

1. The sulfur cycle and the advantages of using S isotopes in soil/plant studies
2. Measurement of S in soils and fertilisers and isotopes of S
3. Safety procedures when using ^{35}S
4. Preparation of labelled sulfur fertilisers and plant material
5. Estimating the quantity of isotope to add to experiments
6. Applications using ^{35}S AND ^{34}S

Production of Interactive CD, Electronic manual on the Use of Isotopes and Radiation Methods in Soil and Water Management and Crop Nutrition.

Compiler: *Rebecca Hood-Nowotny*
Contributers: *Maria Heiling, Gudni Hardarson, Felipe Zapata, Gamini Keerthisinghe, Leopold Mayr, José Luis Arrilaga, L K. Heng and Martina Aigner, Nelly Blair and Dan Murnick.*

Aim and scope

- To provide an electronic version of the Manual entitled Use of Isotope and Radiation Methods in Soil and Water Management and Crop Nutrition, Training Course Series No 14, with ready made presentations which could be used as learning tools and teaching aids by scientists in Member States.
- To provide short video presentations of techniques which are difficult to convey using other media.
- To provide an interesting and stimulating learning environment.

Text

PDF version of the Laboratory Manual

Power Point presentations.

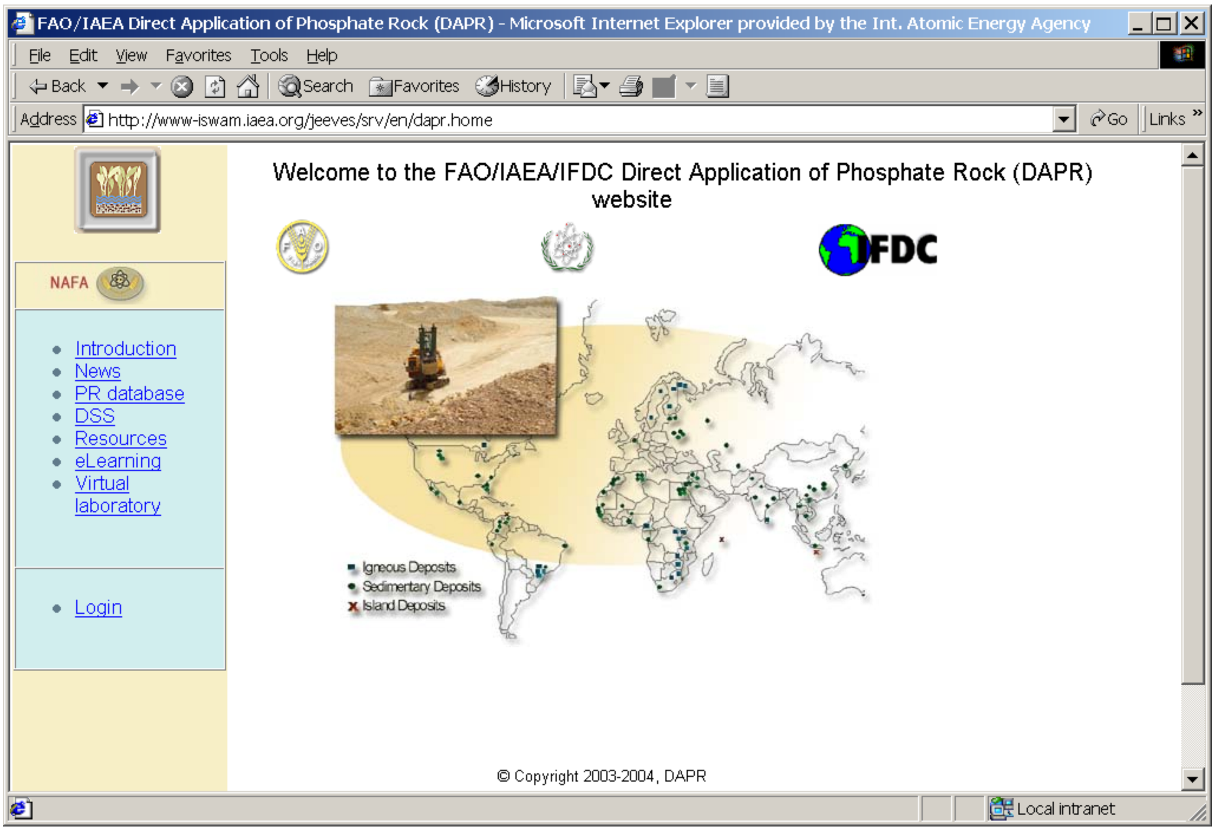
1. Introduction to the use of Nuclear Techniques in Agriculture
2. The principles of nitrogen isotope studies.
3. Mass spectrometry
4. Emission spectrometry
5. Optical methods of measuring ^{13}C
6. Laser method LARA
7. Integrated soil water nutrient management (SWNM)
8. The use of stable isotope techniques for fertilizer studies
9. The use of stable isotopes in measuring N fixation
10. Isotope techniques for measuring plant N uptake from organic materials
11. The use of stable isotopes in measuring N losses
12. Nuclear techniques for measuring plant water relations
13. Use of stable isotopes for carbon studies.

Videos

1. The diffusion technique
2. The stem injection technique
3. Field labelling using solutions
4. Field labelling using dry fertilizer

Developments on the FAO/IAEA/IFDC Direct Application of Phosphate Rock (DAPR) Website
Lee Heng

Phosphorus deficiency is widespread and a major constraint to crop production in tropical acid soils. However, the high cost and limited availability of manufactured water-soluble phosphate fertilizers farmers have prevented resource-poor farmers in many developing countries in Africa, Asia and Latin America from using it. Direct application of phosphate rock (DAPR) to acid soils is an attractive alternative compared with the more expensive water-soluble P-fertilizers. However, the effectiveness of PR as a source of P to plants depends on a host of factors. Using information obtained through research and technical cooperation projects, a database of the chemical and physical properties of 135 phosphate rocks from all regions was made. The first version of a FAO/IAEA/IFDC decision support system, which integrates phosphate rock properties with measurable soil and climatic variables to predict the effectiveness of phosphate rocks compared with water-soluble super phosphate fertilizer, was placed on the web in 2003. The DAPR website is an interactive resource of information on the use of phosphatic fertilizers, in particular phosphates rock (PR). It also includes a simple decision support system integrating the above factors to predict their effective and economic utilization, so that valuable information can be provided to resource managers including policy makers and farmers.



Articles

Kamilov, Bakhtiyor; Ibragimov, Nazirbay; Esanbekov, Yusupbek; Evett, Steven; and Heng, Lee. 2003. Drip Irrigated Cotton: Irrigation Scheduling Study by use of Soil Moisture Neutron Probe. International Water and Irrigation. Vol. 23. No. 1. pp. 38-41.

Rebecca Hood, Elvira Bautista and Maria Heiling. 2003. Gross mineralization and plant N uptake from animal manures under non-N limiting conditions, measured using ^{15}N isotope dilution techniques. Phytochemistry Reviews. Vol 2, 113-119.

Hood, R. C., Khan, M, Haque A, Khadir M, Bonetto J P, Mayr L and Heiling M, 2003. Development of preparation methods for $^{13/12}C$ analysis of soil and plant samples using optical breath test analysers. Communications in Soil Science and Plant Analysis. Vol. 34, 15 & 16, 2219-2227.

R. C. Hood, M. Khan, A. Haque M. Khadira,, J. P. Bonetto, R, Syamsul L. Mayr and M. Heiling. (2004) Carbon sequestration and estimated carbon credit values as measured using ^{13}C labeling and analysis by an optical breath test analyser. Analytical and Biochemical Chemistry. In press

Posters

Carbon sequestration and estimated carbon credit values as measured using ^{13}C labeling and analysis by an optical breath test analyser (2003) R. C. Hood, M. Khan, A. Haque, M. Khadir, J. P. Bonetto R, Syamsul L. Mayr and M. Heiling. International Conference on Isotopic and Nuclear Analytical Techniques for Health and Environment

TRAVEL

Busteni, Romania - Final Meeting

Lee Heng conducted the Final Co-ordination Meeting, 22 – 25 September 2003 of the FAO/IAEA Regional TCP for Europe on "Fertigation for Improved Crop Production and Environmental Protection" (RER/5/011) held in Busteni, Romania. Mr. Mihail Dumitru from the Research Institute for Soil Science and Agrochemistry in Bucharest was the local organizer. The following nine countries are involved in this regional project: Bulgaria, Cyprus, Greece, Hungary, Romania, Serbia and Montenegro, Slovenia, The Frmr.Yug.Rep. of Macedonia and Turkey.

The objectives of the project are to increase water-use efficiency, improve crop production and reduce environmental damage through fertigation, using nuclear techniques to monitor fertilizer and water dynamics.

In general, the group observed higher crop yields and a considerable increase in the efficiency of water and fertilizer use with fertigation compared with conventional practices, while reducing the risk of nitrate leaching to groundwater. The study also helped to establish scientific basis for fertigation and drip-irrigation scheduling for a range of soils, crops and environments in the participating countries. The results also highlighted the need for policy and decision makers to formulate strategies to assist farmers to adopt best management practices.

Hanoi and Ho Chi Minh City, Vietnam

Gudni Hardarson attended the Joint Workshop on the FNCA Biofertilizer Project and the JSPS Cooperative Multilateral Project, which was held in Hanoi and Ho Chi Minh City, Vietnam during 20 to 24 October, 2003.

Developing countries use more than 53 million metric tonnes of N fertilizers annually worth more than 16 billion US$. 88% of this fertilizer is used in Asia with China and India consuming 22 and 10 million metric tonnes, respectively. Studies using ^{15}N labelled fertilizer have shown that, unless fertilizer application is managed properly, only 30 – 40 % of the applied N fertilizer is taken up by crops and the rest is lost to the atmosphere and groundwater. With the objective to reduce the economical burden of N fertilizer use and furthermore to reduce tremendous environmental pollution scientists in the East Asia region have formed networks to find and promote alternatives technologies to the use of mineral fertilizer for crop production. Two of these networks, FNCA Biofertilizer Project and JSPS Cooperative Multilateral Project, have worked on biofertilizer in the East Asia region for several years with the objective to establish biofertilizer production in the participating countries and to promote their use.

The Joint Workshop on the FNCA Biofertilizer Project and the JSPS Cooperative Multilateral Project was sponsored by FNCA and JSPS (Ministry of Science, Technology and Environment and Ministry of Education, Culture, Sports, Science and Technology, Japan) and was locally organised by Vietnam Atomic Energy Commission, Vietnam Agriculture Science Institute and Cantho University.

The group of scientist working with FNCA have completed several years of research work to test and promote biofertilizer production and use in the East Asia region. This group will now need assistance in the use of nuclear technology (^{15}N for the quantification of biological nitrogen fixation and radiation for the sterilization of carrier) to complete the work.

Leipzig, Germany

Maria Heiling traveled to Leipzig Germany 3 – 5 November. The purpose of travel was to undergo detailed technical training on the ^{13}C analyser and to discuss the modified new software of the FANci-2 analyser with the developer of the equipment.

The FANci breath test analyser is an instrument developed to determine $^{13/12}CO_2$ in breath samples. The principle of measurements is based upon the specific absorption of infrared light (NDIR: Non-depressive Infrared Spectroscopy) and the main field of application is human medicine, in particular diagnosis of *Heliobacter pylori* and liver function disorders. In conjunction with methods developed in the Seibersdorf laboratory this equipment could be a useful tool in soil carbon research particularly in developing Member States.

The training on the FANci 2 breath test analyser was focused on the new software developed by the company for easier use of the equipment.

Lanzhou, People's Republic of China,

Gudni Hardarson travelled to Lanzhou, People's Republic of China, 21 November to 28 November 2003. The purpose of travel was to review Technical Cooperation project No. CPR/5/014 as new Technical Officer; plan future work of the project and to introduce the Counterpart to the use of nuclear techniques in crop nutrition.

Brazil

Rebecca Hood travelled to Brazil, to attend the Second World Congress on Conservation Agriculture (WCCA), and the FAO/IAEA consultants meeting on Integrated Soil, Water and Nutrient Management in Conservation Agriculture. Conservation Agriculture is seen to be the next big agricultural revolution, especially in developing countries. FAO is fully committed to promoting and assisting the spread of CA practices globally to provide win-win scenarios in terms of sustainability and production. At present it is estimated that 5% of the global cultivated land is under minimum or zero tillage, a concept which lies at the heart of the CA philosophy. It is interesting to note that adoption of CA has been extremely rapid in certain areas such as Paraña, Brazil where 80% of the area is under conservation agriculture and that its adoption and development has been driven by farmers. CA is based on the three main principles of:

- Minimal soil disturbance (minimal tillage)
- Permanent soil cover,
- Crop rotation

The benefits of CA are reduced labour inputs, fuel bills, and soil erosion, providing more resilient cropping systems, which can be more easily managed by women, leading to greater food security and improved environmental management. CA is non prescriptive, providing a basket of technologies appropriate for adoption, however it must be stressed that much of the success of CA is based on effective weed management using systemic broad spectrum herbicides such as glyphosate.

The WCCA attracted approximately 1000 participants from all regions, including stakeholders from Government, NARS, international donors (GTZ, CIRAD, World Bank, IICA), intergovernmental organizations (FAO, IAEA), the CGIAR (CIMMYT, IRRI), NGOs, farmers and manufacturers of direct-drill equipment. Topics covered at the WCCA were adoption, impact of CA practices, farmer experiences; socio-economic and political impacts, barriers to adoption, etc.

The Congress provided a good forum to publicise the activities of the FAO/IAEA Programme including the Soil Science Unit in the field of Conservation Agriculture. Five posters were displayed. Many requests were made for publications from the Unit and there was an excellent response to the scientific approach adopted by the Unit. From the discussions it was clear that knowledge gained using stable isotope and nuclear techniques will play a key role in the understanding and management of conservation agricultural systems worldwide.

The conference provided an excellent opportunity to network and discuss issues with near and far stakeholders from researchers in the national agricultural research institutes to farmers adopting CA technologies.

At the FAO/IAEA Consultants' Meeting Rebecca presented a talk entitled "The use of stable isotopes for the assessment and optimisation of conservation agriculture practices" which summarised the research, which has been carried out at the Seibersdorf laboratory. The presentation concentrated on the method developed to measure plant N uptake from complex organic residues and the development of low cost technologies for doing ^{13}C analysis and carbon sequestration studies.