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Decision Support Systems for Use of Phosphate Rocks and Organic Nutrient sources

Report of the FAO/IAEA Consultants Meeting held in Vienna, Austria on 25 – 27 August 2003

Scientific Secretary: Mr. Felipe Zapata

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JOINT FAO/IAEA DIVISION
OF NUCLEAR TECHNIQUES IN FOOD AND AGRICULTURE

INTERNATIONAL ATOMIC ENERGY AGENCY
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Decision Support Systems for Use of Phosphate Rocks and Organic Nutrient sources

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Soil and Water Management & Crop Nutrition Section

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EDITORIAL NOTE

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1. INTRODUCTION

Since its creation, the Joint FAO/IAEA Programme has conducted research and implemented field projects to increase crops' yields and the efficiency of applied fertilizers utilizing isotopes mainly ^{15}N and ^{32}P as tracers. The Programme has been also involved in the development of ^{15}N isotopic techniques to measure biological nitrogen fixation in field crops and implementation of projects aiming at increasing nitrogen fixation in grain, forage and tree legumes.

More recently, by adopting the integrated approach to soil, water and nutrient management in cropping systems, the development work focused on the cost-effective utilization of locally available nutrient sources, alternative to expensive and mostly imported chemical fertilizers. In this respect ^{15}N and ^{32}P techniques were used and developed to measure the nutrient (N and P) supply from these sources in a wide range of environments. Two CRPs on relevant topics, namely phosphate rocks and crop residues have been completed. Moreover national and regional Technical Co-operation projects have generated data on the best use of these local nutrient sources. The results from all these projects have been published targeting mainly the scientific community in several publications such as IAEA TECDOCs, special issues in peer-reviewed scientific journals and others. Thus, a wealth of information is available in many publications and reports from our and other international projects on these topics but it needs to be collated and properly consolidated into practical recommendations and guidelines directed to all stakeholders involved in sustainable agricultural development such as policy and decision makers, land use managers, environmental officers, high level; extension workers etc. to reach ultimately the end-users, i.e. the farmers.

A series of follow-up activities of the Phosphate CRP were initiated in 2001 and continued during the IAEA PWB 2002-2003. These activities include **the development of a Decision Support System for Phosphate Rock use (PR-DSS) and the construction of a website for Direct Application of Phosphate Rocks (DAPR).** They will continue during the next IAEA PWB 2004-2005. Furthermore, it is also planned during the next biennium 2004-2005 to start similar activities with the **Organic Nutrient Sources.**

To streamline the implementation of the activities related to the use of phosphate rocks and to plan better the activities on the use of organic nutrient sources (**ONS**), a consultants meeting was convened with the following objectives: a) to review the overall development and technical aspects of the PR tasks (**PR-DSS and DAPR website),** b) to assess progress made and plan the way ahead including requirements of resources, c) to develop a work plan for the development of the activities related to the use of **organic nutrient sources,** and d) to discuss other programmatic issues of common interest.

2. THE MEETING

A Consultants' Meeting on "Decision Support Systems of use of phosphate rock and organic nutrient sources" was held at the IAEA Headquarters, Vienna, Austria, from 25-27 August 2003. Four scientists were invited as consultants. In addition a staff from AGL, FAO and FAO/IAEA staff members attended the meeting. The list of participants is given in Annex A.

The meeting was formally opened by Mr. P.M. Chalk, Head of the Soil and Water Management and Crop Nutrition Section, who welcomed the participants and outlined the activities of the Joint FAO/IAEA Division, in particular those of the Soils subprogramme. Mr. F. Zapata, the scientific secretary provided background information and guidelines on the conduct of the meeting. The agenda of the meeting is included in Annex B.

The consultants together with the FAO/IAEA staff involved in this development work (Ian Ferris, Lee K. Heng and Felipe Zapata) reviewed the work done so far on the development of the PR-DSS and the interactive web-based DAPR resource as well as the available information on the use of Organic Resources (OR). A session on development of Environmental Decision Support Systems was also held. Abstracts of the presentations are given in Annex C. The participants identified a series of elements/issues needing discussion (Annex D). Thereafter, the panel developed independent proposals for further development of the PR-DSS including distance learning tools and initiating the development of the OR-DSS.

The overall aim of this work would be to disseminate the results obtained from PR and OR research conducted by the Joint FAO/IAEA Programme and other institutions by providing practical recommendations and guidelines to a wide audience comprising of policy and decision makers, scientific community, higher level extension workers, NGOs and other stakeholders involved in sustainable agricultural development at the local, national, regional and international levels.

During the final session the participants formulated conclusions and recommendations. Mr. P.M. Chalk closed the meeting with a word of thanks to the participants for their contributions.

3. THE PROPOSALS

The proposal for further development of the PR-DSS including distance learning tools is included in Annex E whereas the one for initiating the development of the OR-DSS is given in Annex F. Attached is a list of relevant references on the main topics (Annex G). Inputs for additional references are welcome.

4. CONCLUSIONS AND RECOMMENDATIONS

The consultants formulated the following conclusions and recommendations:

1. With regard to the review on-going PR and ONS activities, the objectives of the meeting were met.
2. The need for developing DSS was confirmed – a) to ensure inter-generational transfer of knowledge, b) to bring standalone systems into more sustainable corporate standards, c) to maximize synergies among information system existing between different institutions, d) to assist decision-makers in making policy-decision, and e) to provide different levels of information for different clients.
3. To implement the developed proposals for facilitating the dissemination of information.
4. The IFDC PR-DSS to be adopted and further developed, validated and incorporated into the FAO/IAEA/IFDC website, in accordance with the schedule of activities.
5. With regard to the Organic Nutrient Sources work, the group recommend that a consultants meeting be organized with AGL to define the way forward in regard to DSS and to formulate an associated CRP.

ANNEXES

ANNEX A - LIST OF PARTICIPANTS

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Ms. Lee Heng, Soil Science Unit
Ms. Rebecca Hood-Nowotny, Soil Science Unit
Mr. Victor Mlambo, Animal Production Unit

ANNEX B - AGENDA

Monday, 25 August 2003

Session I	*Opening Session* Chairperson: P.M. Chalk
09:00-09:30	*Welcome Address* *Soil and Water Management & Crop Nutrition Subprogramme.* P.M. Chalk, Head
09:30-10:00	*Introductory remarks* by Scientific Secretary F. Zapata
10:00-10:15	Coffee break
Session II	*FAO and IAEA project activities on PRs and ONSs* Chairperson: P.M. Chalk
10:30-11:00	G. Keerthisinghe *Crop residues CRP*
11:00-11:30	F. Zapata *Phosphate CRP*
11:30-12:00	R.N. Roy *FAO PR activities*
12:00-13:30	Lunch break
Session III	*Phosphate rock activities* Chairperson: N. Sanginga
13:30-14:00	L. Hammond *Phosphate rock solubility database for a decision support System (PR-DSS*)
14:00-14:30	L Hammond *Development and evaluation of a decision support system for direct application of phosphate rock*
14:30-15:00	Lee K. Heng *Direct Application of Phosphate Rock, a Joint FAO/IAEA Division website*
15:00-15:30	Facilitator: R.N. Roy *General discussion on the progress made and integration of PR work and related activities*
15:30-16:00	Coffee break

Session IV	Development of environmental decision support systems Chairperson: N. Sanginga
16:00-16:30	Gabrielle Voigt *The application of Environmental Decision Support Systems in Radioecology*
16:30-17:00	Roberto Giaccio *Developing a web-based framework for integrated agricultural and environment management*
17:00-17:30	Ian Ferris *Distance learning and mapping tools for building capacity in sustainable agricultural and environmental development*

Tuesday, 26 August 2003

Session V	*Organic nutrient sources activities* Chairperson: L. Hammond
09:00-09:30	N. Sanginga *Sustainable resource management coupled to resilient germplasm to provide new intensive cereal-grain legume-livestock systems in the dry savanna*
09:30-10:00	G. Cadisch *Organic inputs for soil fertility management in tropical ecosystems: Applications and limitations of an organic resource database*
10:00-10:30	Coffee break
10:30-11:00	R. Hood *Isotope techniques in carbon and nitrogen dynamic studies*
11:00-12:00	Facilitator: G. Cadisch *General discussion on integration of activities related to Organic Nutrient Sources*
12:30-14:00	Lunch break
Session VI 14:00-17:00	*General discussion on issues and work plans related to the PR and OR-DSS*

Wednesday, 27 August 2003

Session VII	*Report of the meeting*

	Chairperson: L. Heng
09:00-10:30	*Discussion on proposal for development of PR-DSS*
10:30-11:00	Coffee break
11:00-12:00	*Discussion on proposal for development of DAPR website and Publications*
12:00-13:00	Lunch Break
Session VII	*Conclusions and recommendations* Chairperson: P.M. Chalk
14:00-15:00	*Discussion on proposal for OR-DSS*.
15:00-16:00	*Conclusions and Recommendations*
16:00	Closing
16:00-17:00	Other programmatic issues

ANNEX C – ABSTRACTS

Phosphate Rock Solubility Database for Decision Support System

S. H. Chien, U. Singh, J. Henao and L. L. Hammond

It is known that the major factors affecting the agronomic effectiveness of phosphate rock (PR) are PR reactivity, soil properties, and crop species. Use of a phosphate rock decision support system PRDSS is probably the most effective approach to integrate all these complex factors into a system that can effectively predict the agronomic value of directly applied PR. Assessment of the reactivity or solubility of apatite mineral in PR is generally the first essential step to determine the suitability of PR for direct application because PR solubility has been shown to closely relate to agronomic effectiveness. Therefore, a reliable and comprehensive of PR solubility database is essential for building a good PRDSS.

The main objective of the reported work, partially funded by IAEA, was to compile a reliable PR solubility database obtained from solubility measurements using IFDC standard procedures. The report presents solubility data of 77 selected PR samples (10 highly reactive, unground PR samples and 67 finely ground PR samples) varying widely in reactivity. These samples were collected by IFDC from different countries. Moreover, some general issues of problems for PR solubility measurements (first and second neutral ammonium citrate extractions, 2% citric acid, and 2% formic acid) and their proper interpretations will be discussed first using published and unpublished data in order to understand the complex issue of PR solubility for PRDSS development. It is suggested that the users of this PRDSS follow the recommended procedures as presented to have the proper input of PR solubility data when testing the PRDSS.

Development and Evaluation of a Decision Support System for Direct Application of Phosphate Rock

U. Singh, S. H. Chien, S. Smalberger, P. W. Wilkens, J. Henao, and L. L. Hammond

It is known that the direct application of phosphate rock (PR) can, under certain soil, climate, and crop conditions, be an effective alternative to the use of more expensive water-soluble P fertilizers such as SSP and TSP. However, the use of PR as a direct application P fertilizer is a very complex issue that needs to consider factors ranging from PR characteristics to agronomic effectiveness, size of the PR deposit, cost of mining, grinding, distribution, cost/benefit ratio, social, economic and environmental impact, and governmental policy. Use of a phosphate rock (PR) decision support system (PRDSS) is probably the most effective approach to integrate all these complex factors into a system for predicting the utility of using the PR for direct application.

This report presents an updated version of the PRDSS developed by IFDC and partially funded by IAEA. The developed program includes PR source, PR solubility (second neutral ammonium citrate extraction), crop species (rhizosphere effect), rainfall (P leaching), soil properties (pH, organic C, sand content, and P-fixing capacity). After the data input, the

program calculates the relative agronomic effectiveness (RAE) compared to water-soluble P such as SSP and TSP. Some examples were presented to show the sensitivity test of PRDSS and the actual and predicted RAE values of PR. Future version of PRDSS will include more variables such as soil available P, exchangeable Ca, CEC, Al saturation, residual effect from one-time PR application or annual PR application and economics of use.

Organic inputs for soil fertility management in tropical ecosystems
Applications and limitations of an organic resource database

Georg Cadisch

Organic resources play a critical role in both short-term nutrient availability and longer-term maintenance of soil organic matter in most smallholding farming systems in the tropics. Despite this importance, there is still limited predictive understanding for the management of organic inputs in tropical agroecosystems while respective data and information is scattered. To compile and synthesize data on potential organic resources such as legume cover crops, tree prunings, green manures, cattle manure, and crop residues the Organic Resource Database (ORD) was set up as a collaborative project by Imperial College at Wye (formerly Wye College), UK, the Tropical Soil Biology and Fertility Programme (Kenya) and the KARI-Muguga Soil Chemistry Laboratory (Kenya). The ORD contains information on organic resource quality parameters including macronutrients, lignin and polyphenol contents of fresh leaves, litter, stems and/or roots in more than 2150 records, for at least 32 plant families, of which 1585 records refer to legumes mainly found in tropical agroecosystems. To provide a fair basis of comparisons between different datasets, methods for several key quality parameters, like polyphenols, are given. Each entry gives full credit to the origin by giving the reference from where the data have been obtained. Data on the soil and climate from where the material were obtained are also included, as are decomposition and nutrient release rates of many of the organic inputs. Examples of uses of ORD are (1) comparing nutrient contents and other resource quality parameters of farmyard manure and crop residues versus that of alternative nutrient sources such as different plant parts and plant types; (2) estimating nutrient stocks found in farm boundary hedges evaluation of their potential as a source of nutrients for soil fertility management; (3) testing of hypotheses regarding the indices and critical values of N, lignin, and polyphenol contents for predicting N release rates; (4) identification of suitability of organic materials for different soil fertility management experiments. This database, when coupled with models and decision support tools, will help advance organic matter management for soil fertility improvement from an empirical to a predictive practice. Examples are decision trees for recommendation of use of organic materials of different quality in practical applications based on our current understanding of the relationship between input quality parameters and nutrient supply patterns. The database is aimed at researchers, extensionists, NGO's and ultimately farmers. The challenge is to adopt such decision tools to the target clients. The database is freely available but in order to download the database you need to apply for a password from TSBF (tsbfinfo@cgiar.org).

Palm, C.A., Gachego, C., Delve, R., Cadisch, G. & Giller, K.E. (2001). Organic inputs for soil fertility management in tropical agroecosystems: Application of an organic resource database. *Agriculture, Ecosystems and Environment,* **83**, 27-42.

Sustainable resource management coupled to resilient germplasm to provide new intensive cereal–grain legume–livestock systems in the dry savanna

N. Sanginga

Sustainable resource management is the critical agricultural research and development challenge in sub-Saharan Africa. The accumulated knowledge on soil management gathered over the last 10 years, combined with solid crop improvement and plant health research at farmers' level, has brought us to a stage where we can now address with confidence the intensification of cereal–grain legume - based cropping systems in the dry savanna of West Africa in a sustainable and environmentally positive manner. The entry point for solving the problems of natural resource base deterioration has been the availability to farmers of resilient and adoptable germplasm of both cereals and legumes. The major hypothesis has been that adapting improved germplasm to soil problems will lead to resilient and sustainable cropping systems and be a starting point for the transformation of smallholder farmers earning 1$ a day into medium or commercial farmers with incomes above 10$ a day.

In recent years we have developed and implemented sustainable: (i) maize– promiscuous soybean rotations that combine high nitrogen fixation and the ability to kill large numbers of *S. hermonthica* seeds in the soil, and (ii) millet and dual-purpose cowpea that greatly enhance the productivity and sustainability of integrated livestock systems. The two systems are effectively used for the replenishment of soil nutrients and organic matter. In addition, the legume varieties have the traits that are most appreciated by farmers, such as high yields of grain and fodder that provide them with income. Economic analysis of these systems shows already an increase of 50–70% in the gross incomes of adopting farmers compared to those still following the current practices, mainly continuous maize cultivation. Furthermore, increases in legume areas of 10% in Nigeria (about 30,000 ha in the northern Guinea savanna,) and increases of 20% in yield have translated into additional fixed nitrogen valued annually at 44 million $. This reflects at the same time an equivalent increase in land-use productivity and with further spread of the improved crops there are excellent prospects for additional economic and environmental benefits from a very large recommendation domain across West Africa.

Improvement of the cropping systems in the dry savanna has been driven by the adoption of promiscuously nodulating soybean varieties (in particular TGx 1448–2E) and dual-purpose cowpea in Nigeria. Adoption is very high, even in the absence of an efficient seed distribution system. The number of farmers cultivating the improved varieties increased by 228% during the last 3 years. Increased production of promiscuous soybean has been stimulated by increased demand from industries and home utilization. Production in Nigeria has been estimated at 405,000 t in 1999 compared to less than 60,000 t in 1984. A good proof of the positive results achieved is the fact that the NGO Sasakawa Global 2000 that is extensively involved in the introduction of new agricultural technologies has decided to introduce the package among farmers in northern Nigeria, Bénin, and Ghana.

Most importantly these research results open new opportunities for the sustainable management of the soils in the savannas. Until now it has been generally accepted that currently in Africa it would be impossible to grow crops continuously on these soils without soil degradation or without the use of impractical or uneconomical quantities of inputs. It was considered that at all levels of farming there would still be a need for fallows. We are now at a stage where we are confident that continuous cropping with cereal – grain legume rotations can make agriculture much more attractive for the farmers in the dry savanna of West Africa. Indeed, it offers excellent opportunities for the sustainable management of natural resources, while at the same time providing better income opportunities. Working on these new technologies with farmers in the benchmark areas has clearly shown the environmental and economic benefits to be derived from these new cropping systems.

Developing a web-based framework for integrated agricultural and environmental management

Roberto Giaccio and Marco Marsella

When dealing with the problem of designing a web application with dynamic content, a typical solution consists of some Java Servlet engine connected via JDBC to a relational database. It adheres to Model-2 architecture for separation of processing and presentation and often uses XML. However, in the setting of UN agencies, such a response often does not solve the problem, since it does not take into account the specific issues involved with UN nations web sites.

Some specific aspects for instance, are that the web site has to be multilingual, either just in the user interface or in the content itself, that data quality is critical, so access control and logging are required, that some sort of revision process is often needed, and that user interface has to be coherent with other sites at least in the same department or agency.

Furthermore, from the experience on the EcoPort site, there exists a set of modules that can be easily shared among different web sites, like the glossary, the bibliographic references database, and modules for multimedia content, document revision and annotations. In the case of IAEA, two other important modules are a generic rule based ranking system, used for the DAPR site, and distance learning facilities.

Hence, the solution adopted so far for IAEA has been to design and implement a set of reusable multilingual modules providing integrated access control and user interface coherency. Then, for each new site we only add the services needed to handle it's core data. In this case, we could use this solution since we have driven the specifications of each site and we owned all the core data, so we could use a centralized database.

In different settings this is not true; for instance, if we had to integrate data from different heterogeneous sites within a UN agency, or among different UN agencies, the data could be spread in several databases and pages from each site would have different appearance. In this case we have to go for a different solution, along the middleware/business objects concept. Namely, we define a software architecture that strongly divides the two phases of working with the data and interacting with the user into two different layers.

The lower layer provides applicative services, like database access view/update functions; applicative services are located and are in charge of the organizational unit that owns their core data. The upper layer provides presentation services, by accessing the underlying applicative service, possibly merging information from different core data and presenting them to the user in a uniform way.

The benefits of this solution are the detachment of presentation user interface from data sources, the possibility for each application to use different core data sources and to use common service modules; also, we are able to disseminate information on service level.

We currently fully support the first solution, with several integrated applications like Infocris, Ididas, DAPR, and others. We have a set of reusable modules for glossaries, bibliographic references, remote learning. Furthermore, DAPR has been built using the Jeeves presentation/service engine, an open source product promoted by FAO, which is XML/XSL based, multilingual and enabled for interoperability with other systems.

The next steps along the outlined direction consists of defining a reference protocol and a documentation structure for applicative services (XML, SOAP, Web services), and to implement a set of reusable modules in Jeeves to be used as building blocks for future inter-operational applications.

Distance learning & mapping: A recipe for accelerated capacity building

Ian Ferris[*], Jason Besky[‡], Nikolay Douchev-Schachner[‡], Roberto Giaccio[§], Kerstin Gross[*] Marco Marsella[§], Martin Kiff[‡], Cihay Wirawan[‡]

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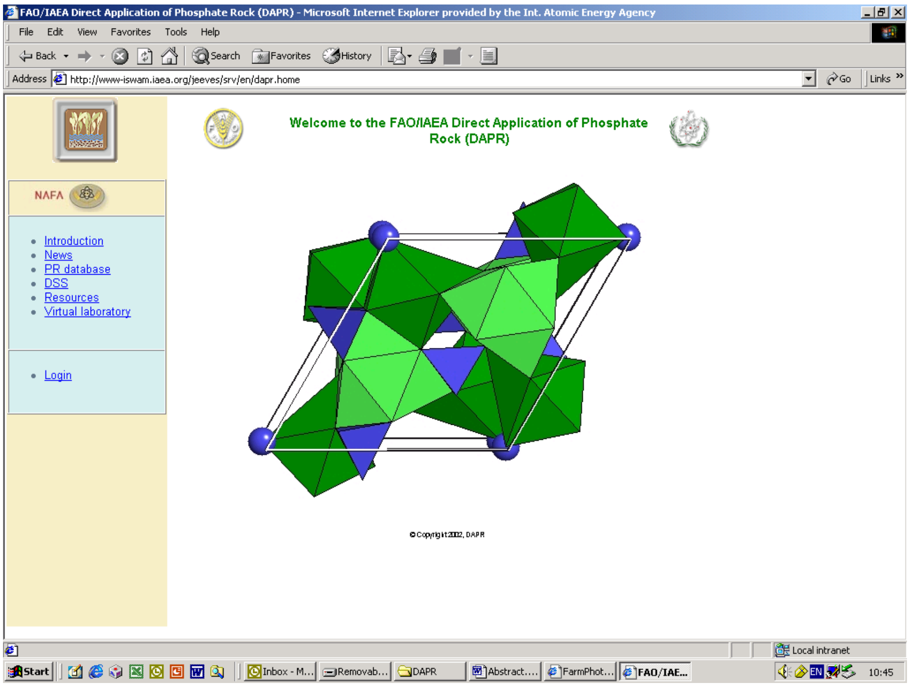
In partnership with staff from central computing services, the Joint FAO/IAEA Agriculture programme used an evolutionary prototyping strategy to port standalone databases and fragmented information on nuclear and related techniques to a more secure electronic knowledge commons. The system uses a Client Server architecture and TCP/IP to communication information between the user's browser. On the server side ITK provides TCP/IP connectivity and 4th Dimension manages the data repository, including HTML templates. Technical information is available freely to users via the Web and on CD-ROM because the task of acquiring and maintaining up-to-date information is distributed globally with low transaction costs. Typically, information is associated with the contributing author or editor and entered directly over the Web under a system of password protection. A powerful toolset simplifies adding hyperlinks and updating of web pages while global peer review maintains the quality of the information.
The system is entity based with records displayed in a compendium multi-media format according to system style sheets. Sharing code and resources have kept system's development on budget and on time. Common system resources include glossary, reference and news database. In addition, specialized tools or "sandboxes" are available for editors including method validation (MVRS) collaborative editing (DocMaster) discussion groups (bulletin board) and visualization of complex data sets (mapping). Methodologies, FAQ and especially slide shows provide overarching utilities that enable editors to define linkages among entities. Key benefits include browser access for cross-platform compatibility, reduced data duplication, more coherent data and more efficient maintenance.
More recently, a learning management system was added to aggregate data into distance learning modules that are more thematic, for example nuclear preparedness and response in the event of a nuclear accident or radiological emergency affecting food and agriculture. The development of a new Java application (Jeeves) added new functionalities such as handling HTML and XML requests and providing rule based decision support. The Jeeves engine unleashes the full potential of the open source community and emerging metadata standards such as SCORM that improve interoperability with university partners. This presentation examines advances in information technology and communication (ITC) and suggests a new paradigm to accelerate capacity building in developing countries. Likely outcomes include: adoption of a more holistic farm-to-fork approach where nuclear and related technologies help fill the gaps needed for sustainable agricultural development, the harnessing of local assets and establishing continuous education and self-reliance. In concert, these developments would help countries achieve their Millennium targets.

Direct application of phosphate rock, a Joint FAO/IAEA Division website

Lee Heng

Follow-up activities from the past Phosphate coordinated research project on "The Use of Nuclear and Related Techniques for Evaluating the Agronomic Effectiveness of Phosphatic Fertilizers, in Particular Rock Phosphates" (1993-98) were the construction of a website for direct application of phosphate rocks (DAPR) and the development of a Decision Support System for phosphate rock use (PR-DSS). These tasks started implementation in 2002 and will be continuing through 2003 within the IAEA PWB and Budget 2002-2003 (Task 10, project E1.01).

The website is an interactive resource for direct application of phosphate rock, it contains a database on the characteristics of phosphate rocks, a comprehensive list of glossary terms on PR and bibliography references, and a simple decision-support system for PR application. A prototype has been developed according to IAEA standards. In future, more resources such as eLearning, slide show etc will be added.



Influence of residue quality characteristics on plant N uptake from organic residue as determined using ^{15}N labelled techniques

Rebecca Hood, Willis Atie, Sri Harti, Rizal Syambusul, Mirta Matijevic, Martina Aigner, Champa Kularatne, M`hamed El Khadir, Md. Azizul Haque and Maria Heiling.

A series of experiments were conducted to determine the influence of plant quality characteristics on plant N uptake from a series of organic residues.

An initial experiment set out to determine whether drying material influenced N mineralisation. Fresh ^{15}N labelled leaf material was collected from 4 tree (albizia, eucalyptus, gliricidia, and accacia) and chopped into 2cm lengths, samples were either stored in the cold store at 4°C or oven dried at 70°C for 48 hours. Residues were mixed with Seibersdorf soil at a rate of 100 mg N kg soil^{-1}. A no N control and a 100 mg N kg $^{-1}$ as $(NH_4)_2SO_4$, treatment, were also set up. All 10 treatments (3 replicates) were sown to ryegrass, which was harvested from the pots after 30, 50, 72, 93, 114 and 135 days. Dry weight, % N and ^{15}N abundance of grass samples were measured. There was no significant differences in ryegrass dry weight, % N or nitrogen derived from residue, whether tree residues had been added fresh or dry to the soil.

Labelling of trees with ^{15}N can be an expensive and difficult operation, therefore labelling of tree residues with a ^{15}N tree injection technique was tested and the influence of quality characteristics on subsequent plant N uptake from the residues investigated. Three tree species Casuarina, acacia, and gliricidia were injected with highly labelled ^{15}N, six weeks after injection leaf samples were taken dried at 70°C and ground and plant quality characteristics of the residues were determined. Residues were added to soil at a rate of 100 mg N kg soil $^{-1}$ (3 replicates). Soils were sown with ryegrass and harvested after 67 days. Dry weight, % N and ^{15}N abundance of grass samples were measured. Results showed that plant N uptake from the residue was highly correlated with the total extractable phenol of the residue.

Plant N uptake from organic residues under non-N limiting conditions was determined from organic residues labelled with ^{15}N. Once again results showed that plant N uptake from the residues was most highly correlated to total extractable phenol concentration of the residues added.

Experiments to determine plant N uptake from organic residues under wetland rice conditions were also conducted. Results showed that although total extractable phenol concentration of the residue was the main controlling factor of plant N uptake, the correlations were not so strong suggesting influence of the oxygen constraints on phenol oxidase activity.

The application of Environmental Decision Support Systems in Radioecology

Gabriele Voigt

The Agency's Laboratories in Seibersdorf have been established to contribute to different fields covered within the department of Nuclear Sciences and Applications such as Food and Agriculture, Human Health, Physical-Chemical Sciences, and also programmes of other departments in Nuclear Safety and Security, Safeguards and Technical Co-operation. The protection of the environment is a field requiring strong (radio-) ecological expertise, which

is presently strengthened in the laboratories in Seibersdorf in the field of terrestrial environments.
Environmental decision support systems are valuable tools for land management since these provide measures to identify sensitive or resilient areas where any protection or remediation activities might be implemented. Appropriately constructed not only spatial and temporal environmental changes can be included but also social, economic and ethical constraints. EDSSs use a Geographical Information System (GIS), which can be combined with any models e.g. erosion or food chain models. In the presentation as an example for such an EDSS, the RESTORE and SAVE EDSS developed for remediation strategies after the Chernobyl accident are presented. A further example of their adaptation for Chilean conditions to evaluate and assess nuclear weapon's fallout is given.

Management of Crop Residues for Sustainable Crop Production

Gamini Keerthisinghe

It is well recognized that the organic matter content of a soil is a key attribute of fertility. The beneficial effects of organic matter on the physical, chemical, and biological properties of soil are well documented. Decline in organic matter content in intensive cropping systems is considered to be the major problem in maintaining agricultural productivity in the tropics. Additions of organic materials such as crop residues play an important role in the recycling of nutrients. More than one half of all dry matter in the global harvest is in the form of residues, and in most developing countries the amounts of nutrients in residues are often several orders of magnitude higher than the quantities applied as fertilizers. Thus, proper management of crop residues for the maintenance of soil fertility cannot be overstressed. This report summarize the main achievements of a Co-ordinated Research Project (CRP) initiated by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture on "The Use of Isotope Techniques in Studies on the Management of Organic Matter and Nutrient Turnover for Increased Sustainable Agricultural Production and Environmental Preservation." The overall objective of the CRP was to increase crop production through better management of soil organic matter and nutrient inputs and it was implemented between 1996 and 2001. Ten contract holders from Bangladesh, Brazil, Chile, China, Egypt, Malaysia, Morocco, Mexico, Sri Lanka and Viet Nam, and five agreement holders from Australia, Belgium, ICRISAT-India, the United States and the United Kingdom participated in the project.
The field experiments of this CRP covered a wide range of soils (Oxisols to Vertisols), climatic regions (semi-arid to humid tropics), and cropping systems (e.g. wheat-maize, maize-bean, faba bean-wheat, maize/mucuna, rice-wheat, etc.). Various options for the recycling of crop residues that are sustainable and economically attractive to farmers were examined using isotopic techniques. All experiments were conducted according to an agreed protocol, but the design allowed flexibility to adjust treatments and management practices to suit the conditions and cropping systems. Some counterparts included additional treatments such as different tillage systems (Mexico) and addition of animal manure (Malaysia), and some extended the experiments to more than one location (Morocco and Viet Nam). The nitrogen (N) added to soil as ^{15}N-labelled fertilizer, which ranged from 35 to 300 kg N ha^{-1}, and the residue additions ranged from 12 to 160 kg N ha^{-1}. The fate of applied N was followed through the following treatments: (i) ^{15}N-labelled fertilizer with unlabelled crop residues, (ii) unlabelled fertilizer with ^{15}N-labelled crop residues, and (iii) ^{15}N-labelled fertilizer without residues.
A simple mathematical model, descriptive in nature, was developed to synthesize information collected from all experimental sites, allowing comparisons between treatments and sites.

The descriptive model generated curves representing the fate of fertilizer N in soil and crop under various management practices. In synthesis, the results obtained under varying cropping systems and agro-climatic conditions over a period of five years showed that only about 35% of the applied fertilizer N was recovered by the crops during the first season. During subsequent seasons, insignificant amounts of N (<4%) were recovered from the residual fertilizer. Application of residue had no significant effect on N uptake by crops. Experiments conducted using labelled crop residues showed high variability in availability of residue N to crops. The availability was rather low, less than 10% during the first season, and declined rapidly during subsequent seasons. The slow release of N from residues and lack of synchrony between N demand by the crop and N release resulted in poor recovery of residue N.

Most of the fertilizer N was lost during the first cropping season and only insignificant losses occurred in the following seasons. The losses of N from applied fertilizer ranged from 45 to 85% irrespective of crop-residue management practice. More than 30% of N was lost from crop residues. When N was applied as crop residues, its retention in the soil was higher than for fertilizer N, but its recovery by plants was poor, as mentioned above. These results highlight the importance of investigating fertilizer-management practices to minimize the losses, especially during the early part of the cropping season.

Application of straw resulted in increases in grain yields of rice and wheat of about 10% in experiments conducted in China. However, in general, addition of straw did not increase crop yields in other locations. This is encouraging, as initial immobilization of N due to application of high inputs of carbon through residues did not exhibit negative effects on crop yields.

The experiments in India demonstrated simple practices, using wheat and rice residues, to produce compost as an alternative to stubble burning. Such practices can have important implications apart from the desired maintenance of soil organic matter and improving plant growth. For example, approximately 12 million tonnes of rice and wheat straw are burnt annually in Punjab, India, causing atmospheric pollution and producing over 28 million tonnes of carbon dioxide, a greenhouse gas. In addition, various gaseous forms of N are emitted during burning, representing a loss of $17 million in fertilizer equivalents and significant pollution of the environment by nitrous oxide.

The results obtained from crop-residue application studies are of importance for residue-management practices. There is an increasing need for such information as in many countries new legislation has been introduced to ban the on-site burning of crop residues, for environmental reasons.

Evaluating the Agronomic Effectiveness of Phosphatic Fertilizers, in Particular Rock Phosphates

Felipe Zapata

Phosphorus (P) is an essential plant nutrient and its deficiency severely restricts crops yields. Tropical and subtropical soils are predominantly acidic, and often extremely P-deficient with high P-sorption (fixation) capacities. Therefore, substantial P inputs are required for optimum plant growth and adequate food and fiber production. Manufactured water-soluble P fertilizers such as superphosphates are commonly recommended to correct P deficiencies but most developing countries import these fertilizers, which are often in limited supply and represent a major outlay for resource-poor farmers. In addition, sustainable intensification of agricultural production in these regions necessitates the addition of P inputs not only to increase crop production but also to improve soil P status to avoid further soil degradation. Therefore, it is imperative to explore alternative P inputs. In this context, under certain soil and climatic conditions the direct application of phosphate rocks (PR) is an agronomic and economically sound alternative to the more expensive superphosphates.

The idea of a project on PR evaluation was first conceived in 1991, prompted by developments in promising technologies to enhance the agronomic effectiveness of PRs, which needed to be properly evaluated and tested in a research network. The Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture convened a Consultants Meeting in May 1993 in Vienna to formulate a Co-ordinated Research Project (CRP) on "The Use of Nuclear and Related Techniques for Evaluating the Agronomic Effectiveness of Phosphatic Fertilizers, in Particular Rock Phosphates", which was implemented from 1993 through 1998 and terminated in 1999. The main objectives of the project were: a) To assess the initial available soil P status and its fertilizer-induced changes when amended with PR products and water-soluble P fertilizers in a variety of agro-ecosystems using conventional and isotopic techniques; b) to quantitatively evaluate P uptake and utilization of P fertilizers, in particular PR products by crops grown under a variety of soil and climatic conditions, and c) to obtain agronomic and economic recommendations on the use of P fertilizers, in particular PR products in acid soils.

The Joint FAO/IAEA Division co-ordinated the research network in close collaboration with scientists from National Agricultural Research Systems (NARS) in Brazil, Chile, China, Cuba, Ghana, Indonesia, Kenya, Malaysia, Romania, Thailand, Venezuela and Vietnam and from advanced research organizations in Australia, France, Spain and the USA. The IAEA provided the core funding for the project, while financial support from the Government of France enabled inclusion of participants from Belarus, Hungary, Lithuania, Poland, and the Russian Federation. The project also received financial support from the "Institut Mondiale du Phosphate" (IMPHOS) to carry out standard characterization of the soils and PRs utilized and to conduct field-testing of PRs of known reactivity.

In addition to conventional techniques, the radioisotope ^{32}P was employed as a tracer to gather quantitative and precise information on the dynamics of P in soils amended with PRs and water-soluble P fertilizers, and the value of management practices utilized to enhance the agronomic effectiveness of PRs in greenhouse and field studies. The application of these techniques required trained technical staff and adequate laboratory facilities for handling and measuring the radioisotope. The FAO/IAEA Agriculture and Biotechnology Laboratory, Seibersdorf, Austria, and the "Centre d'Etudes Nucleaires", Cadarache, France, provided the required technical support for the implementation of these activities. The report summarizes the results obtained in the project providing new information on the chemistry of soil P, tests for available soil P, phosphate nutrition of crops, agronomic effectiveness of PR products, and P fertilizer recommendations with particular emphasis on the use of PRs. Over 40 papers containing valuable information that should aid developing countries utilize local PR deposits with optimum economic return have been published in the IAEA TECDOC-1272 "Assessment of soil P status and management of phopshatic fertilizers to optimize crop production" and the special issue of Nutrient Cycling in Agroecosystems 63(1): Utilization of phosphate rocks to improve soil P status for sustainable crop production in acid soils.

This project promoted various follow-up activities such as the joint FAO/IAEA-IFDC collaborative work on developing a decision support system for PR application, the production of an FAO Technical Bulletin, and the initiation of a new CRP on Tropical Acid Soils, which will promote research within the broader context of integrated soil, crop, water and nutrient management and towards the ultimate goal of achieving sustainable agricultural production in the savannahs of Africa and Latin America.

ANNEX D - GENERAL DISCUSSION POINTS

- Objectives? Clients?
- Information-database? DSS? Website?

PR-related issues

a) Assessment of actual status

- The PR-DSS is at a more advance stage than the OR-DSS.
- A PR-DSS is possible and useful. How to proceed?
- Currently 3 groups involved on DSS: IAEA, IFDC and Univ. Hawaii. -Who should take charge?
- IAEA and IFDC should share data and develop one PR-DSS.
- US $30 are earmarked from IAEA for further work on PR-DSS.

b) Needs

- The need for an integrated approach to the development work: database-DSS/publications/references/IT tools

For the PR-DSS

- Checking of meta-data on the web.
- More field data than greenhouse data will be helpful in further developing the IFDC PR-DSS.
- Availability of field data from Eastern block countries.
- Soil info- FAO map is too crude for purpose in most cases. The scale issue should not be ignored.
- Should we have a web-based system or a CD version? We need to define standards
- A simple preliminary version where we classify a rock in terms of its suitability for direct application versus a more comprehensive version.

For the website

- The website as a collector of information? Parallel efforts should be carried out by the groups towards collecting this info.
- A circular letter to all who work on PR, to gather info and publications by each of these people.

For Training: requirements and materials for the PR-DSS

- IFDC: Focus on end-users: trainers of end-users, fertilizer dealers.
- IAEA: train the trainers.
- Training ICS in Senegal next year. Information to be put on-line?
- Joint collaboration is important, with FAO/IAEA put in resources. Difficulty in attending training in US.
- Proposed sequence for operational strategy: 1. decide what effort in terms of time, resources, 2. a joint-activity between institutions for quality-cross checking, inventory should be shared. 3. How to further develop, 4. a temporary CD-ROM version, 5. actual DSS on the web only. Structure and input requirements

Conclusion:

The group decision was it is not in the remit of the Joint FAO/IAEA Division to develop its own decision support but to support IFDC in its efforts. We should work together under the umbrella of the existing MoU's.

Organic Nutrient Sources(ONS) or Organic Resources(OR)-related issues

- ONS- who is target audience?

- What is lacking is info on the interaction between chemical fertilizer nutrient and organic nutrient source. Review paper by Bernard Vanlauwe summarizes a lot of information on the interaction of the different sources.
- Interaction info is available with conflicting results. Developing a DSS on this will be a long-term task, 8-10 yrs? What is achievable is the info on the contribution of nutrients from organic sources.
- The added inputs/benefits from organic sources are not only nitrogen supply but also improvement of soil water status. Extensive research has been carried out on interaction and role of water in Africa. Where should information on water to be kept?

Conclusion:

A new CRP with well-defined objectives starting in 2006 is the entry point.

ANNEX E – PROPOSAL FOR A JOINT IFDC/FAO/IAEA PR-DSS AND DAPR WEBSITE

Overall objective:

To effect the means to support, consolidate and disseminate the development of PR-data-bases and decision support systems for target clients and training purposes.

Specific objectives:

1. To assist decision makers in determining how to manage phosphate resources.

2. To synthesize information to assist in sustaining institutional memory.

3. To further develop systems to be used as training materials with the objective of reaching the maximum number of end users.

4. To facilitate integration of FAO climate, agroecological and soils databases with the DSS under development with the proviso that there will be an open source possibility

Target groups (Clients):

Policy and decision makers, scientists, high-level extension workers, fertilizer dealers and students. There will be different target groups, those that will take advantage of initial stage of the internet pages, later there may be different end users as the systems evolve.

Beneficiaries of PR-DSS:

1. decision-makers – should PR be use?
   Gross economic can be included at this level but not detail specific to each site.
2. middle decision-makers, researchers - Potential areas of PR, gaps of research?
3. extension workers/farmers – can the PR be applied & amount?
4. dealer – chart-type of DSS.

Work plan:

PR-DSS Development (IFDC to take the lead)

1. Joint FAO/IAEA Division (AGE) to bring together current groups, which work on data bases and decision support systems on phosphate rocks and to define a common way forward. Joint IFDC/FAO/IAEA PR-DSS

2. Development of meta data sets so clear documentation of what information available. Together with institutional effort which has been made.

3. Expand existing agronomic PR database: a) contact researchers to get information, and b) using existing publications

4. Completing PR-DSS version 1, including residual effect

5. Preparation of the corresponding PR-DSS users manual

6. Future model PR-DSS will include more variables: soil available P, exch Ca, CEC, residual values, etc

7. Field calibration of emerging decision support systems. Establish a research network for field validation of the decision support system. Identify people to test and validate PR-DSS. When to go to have field trials to validate the model? Experimental protocols.

Direct Application of phosphate rocks (DAPR) website (FAO/IAEA to take the lead)

1. IFDC and FAO (AGE and AGL) are to negotiate a proposal on how to proceed, then define areas of joint collaboration and areas of complimentarity. Agreement on website and define benefits of added value. Also on inter-operability standards.

2. Continuation of compilation of bibliography and reference list with abstracts for inclusion in the website. Upload references into website

3. Upload PR-DSS version 1 and future versions into website. CD-ROM production of version 1.

4. Linking training materials (users manual, FAO PR Bulletin) produced to web page to make-work more effective.

5. To identify users for different levels of information on the website.

6. To develop and agree on training programme, identify the targets groups, to be involved in training and to assist in the preparation of suitable training materials.

7. To translate the resources of the system into French and Spanish.

8. Field verification

Assumptions:

- Acknowledge that it is difficult to transfer from CD to web. However it is easy to move from web to CD format. Problem is that IFDC's-DSS system is a CD based system.
- Property and patent rights issues. Who is owner?
- Legal framework before DSS system is put into a public domain.

PR-Publications

1. Translation of FAO PR Bulletin into several languages
2. Production of an abbreviated bulletin based on the FAO PR Bulletin for extension purposes, in several languages

SCHEDULE OF ACTIVITIES

ACTIVITY	2003	2004	2005	2006	2007
Technical Group Meeting *		X (AGE) Convene Meeting			
PR agronomic database	X (AGE) Contract funding	X (IFDC) Version 1, incl. guidelines	X	X (IFDC) Version 2 expanded	X
Joint IFDC/AGE PR-DSS	X (AGE) Contract funding	X (IFDC) Version 1 initial	X (IFDC) Version 1 residual	X (IFDC) Preparation version 2	X (IFDC) Version 2
PR-DSS users manual	X (AGE) Contract funding	X (IFDC) Version 1	X Version 1		
Field validation trials		X(AGE/IFDC) Crop 1 First cycle	X(AGE/IFDC) Crop 2 First cycle	X(AGE/IFDC) Crop 1 Second cycle	X(AGE/IFDC) Crop 2 Second cycle
Website development	X(AGE/IFDC) Compilation of bibliography and reference list with abstracts	X(AGE/IFDC) Upload PR-DSS, version 1 SSA contract	X(AGE/IFDC)	X(AGE/IFDC)	X(AGE/IFDC)

ACTIVITY	2003	2004	2005	2006	2007
CD production		X (AGL) FAO PR Bulletin	X (IFDC) PR-DSS version 1	X	X
Distance learning Tools		X(AGE/IFDC) SSA contract	X(AGE/IFDC) Preparation Modules	X(AGE/IFDC) SSA contract	X(AGE/IFDC) Internet-based training course
FAO PR Bulletin	X (AGL) Pub. English	X (AGL) Translation Pub. Spanish/ French Contract funding			
FAO Abbreviated bulletin		X(AGL) Pub. English Contract funding	X (AGL) Translation Pub. Spanish/ French Contract funding		

* Joint activity between team leaders of working groups PR-DSS, website and publications to decide a common way forward.

ANNEX F – PROPOSAL FOR A JOINT TSBF-IC-FAO/IAEA OR-DSS

Main objective:
- Improve existing OR-DSS to assist clients to best use their natural organic resources in combination with mineral fertilizers

Additional objective:
- Use of organic resources to improve water use efficiency in cropping systems

Outputs:
- Recommendations of organic resource use to improve farmers capability to face water shortages in a global climate change environment.

Clients:

Policy makers:
- what are potential environmental implications
- how much fertilizer saving can be created
- can we convert to organic agriculture

Scientists:
- summarizing current understanding of underlying principles of regulator of N, P, K release,
- identification of knowledge gaps

Extension workers:
- principles of OR suitability (potential use for ….
- Effectiveness of OR (potential N benefit (t increase/crop) per ton of OR)
- Best practice to use OR (application method, timing)
- Fertilizer substitution value (t OR equiv. xx kg urea)
- How best to combine with mineral fertilizer (ratio, timing,

Farmers:
- where best to apply (in which field?.
- How much OR do I have (can produce on my farm?)/do I need
- How best/much to apply

What do we have? Assessment of available information
- Database on plant/animal OR quality (TSBF/IC-Wye)
- Data on plant OR quality and effectiveness (IAEA)
- Database on plant/animal/wastes/sewage sludge OR quality (minimal dataset?) and quantity in certain regions
- DSS for plant/animal of mainly tropical resources to guide potential use

What needs to be done? Tentative work plan

1. Link IC/TSBF, IAEA and FAO databases on resource quality
2. Complement databases where minimal dataset not available
3. Upload/convert or link DB to web, add statistics capability

4. Literature data search/analyses on effectiveness of OR compared to urea (RAE), establish main factors affecting the relationships of OR and RAE (e.g. timing, quality, method of application, climate, cropping system etc.
5. Add organic – fertilizer interaction relative to RAE
6. Consultants meeting 2004 to formulate CRP
7. Field validation within a new CRP-IAEA Org x fert programme (2006-2010)
8. New CRP-IAEA Org x fert programme should have focus on added interactions, e.g. water, soil structure, soil biodiversity, etc.
9. Update DSS-ORD
10. Add quantity relationship and crop specificity
11. Link to FAO soil, climate, cropping system database
12. Update DSS-ORD and make web available

Outputs:
- Improved and tested isotope methodologies to determine org x fert interactions
- Training in methodology and NR methods
- Web based DSS

Add output: Recommendations of organic resource use to improve farmers capability to face water shortages in a global climate change environment.

ANNEX G – REFERENCES

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