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ABSTRACTS

PROFICIENCY TESTING FOR SOIL AND PLANT ANALYSIS IN AUSTRALASIA. George E. Rayment¹ and Ken I. Peverill². ¹Department of Natural Resources and CRC for Sustainable Sugar Production, 80 Meiers Road, Indooroopilly, Queensland, Australia 4068. Fax: 61 7 38969622; E-mail: George.Rayment@dnr.qld.gov.au; ²KIP Consultancy Services Pty Ltd, 4 Collier Court, Wheelers Hill, Victoria, Australia 3150. Fax: 61 3 95451154; E-mail: ken.peverill@bigpond.com.au

The Australasian Soil and Plant Analysis Council Inc. (ASPAC) has coordinated regular inter-laboratory proficiency programs separately for soil and plant samples since the early 1990's. Certification of proficiency to perform specific tests depended on the demerit points accrued for the test in the particular program, without heed to historical performance. In addition to describing local ad hoc initiatives to enhance soil and plant analytical quality, this paper provides feedback on longer-term laboratory performance, based on reported results for eight tests in the four most recent ASPAC plant inter-laboratory proficiency programs (20 laboratories) and the three most recent ASPAC programs for soils (12 laboratories). Laboratories were subsequently rated as Category 1 through to Category 4 (best to least-well performed). None of the 20% of laboratories rated as Category 1 for plants received a similar rating for soils, although 4 laboratories achieved at least a Category 2 rating for their combined soil and plant analytical performance over several years.

Additionally, there was reasonable agreement between “as reported” median values for a selection of plant tests from five randomly selected Australasian laboratories (two from New Zealand and three from Australia) and “final” median values for the same samples and tests as documented in the 1999 Bi-monthly and the 2000 Quarterly International Plant Analytical Exchange Program reports from Wageningen. Similar international
comparisons were not undertaken for soils because of differences in much of the methodology.

NORTH AMERICAN PROFICIENCY TESTING (NAPT) PROGRAM FOR SOIL, PLANT, AND WATER ANALYSIS LABORATORIES. Robert O. Miller and Janice Kotuby-Amacher. 

The North American Proficiency Testing Program was developed in 1998 to serve and assist soil, plant and water testing laboratories in their performance through inter-laboratory sample exchanges and statistical evaluation of analytical data. It represents the amalgamation of two former regional proficiency programs and seven former state/provincial programs. It operates as an activity of the Soil Science Society of America and is directed by an oversight committee comprised of representatives of Regional Soil and Plant Analysis Workgroups, State/Provincial Departments of Agriculture, public analysis laboratories and private laboratories. Methods used in the program are based on regionally approved standard methods.

The 2000 program specified 84 soil analytical methods, 22 plant analysis methods and 15 water analysis methodologies and served 161 analysis laboratories. Samples are submitted quarterly and results are statistically compiled. Warning limits for each parameter are established based on the median plus or minus 2.5 times the median absolute deviation (MAD). Annually one sample of each material is replicated through the course of the exchanges and used to calculate the intra-precision level of each parameter for each participating laboratory. The NAPT program provides individual laboratory data to legislative mandated state/provincial certification programs. Reference materials generated through the program are offered for resale as reference standard quality control materials. The NAPT provides biannual regional laboratory workshops to program participants, which address quality assurance, instrumentation and laboratory technology innovation.

WORLD WIDE PROFICIENCY TESTING PROGRAMMES: WEPAL.

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A regular and independent assessment of the analytical performance of a laboratory is recommended as an important means of assuring the validity of analytical measurements. A common approach to this assessment is the participation in an independent proficiency testing scheme (PT). Participation in such a scheme is just one aspect of the overall quality strategy of the laboratory. Participation in a proficiency testing scheme is a system for objectively evaluating the performance of a laboratory by comparing its results with those of other laboratories at regular time intervals (preferably a minimum of four times a year). The Wageningen University in The Netherlands is organizing several of these world-wide laboratory evaluating programmes on chemical analysis of soils, plants, manure/refuses and sediments under the ‘umbrella’ organization called WEPAL: Wageningen Evaluating Programmes for Analytical Laboratories. WEPAL is accredited for the organization of Interlaboratory Studies by the Dutch Accreditation Board since April 16, 2000. In this contribution, an overview of the existing schemes is given. Attention is paid to the extra advantages of participation in an extensive international proficiency testing programme, e.g. availability of reference materials and exchange of experiences.

NITROGEN TRANSFORMATION FROM CROP RESIDUES IN A PACIFIC NORTHWEST IRRIGATED SANDY SOIL. A.K. Alva¹, H. Collins¹, R. Boydston¹, J. Davenport², and R.G. Stevens². ¹USDA-ARS and ²Washington State University, 24106 N. Bunn Rd., Prosser, WA, USA, 99350. Fax: (509)786-9277; E-mail: aalva@tricity.wsu.edu

Most potatoes (Solanum tuberosum L.) in the Pacific Northwest are produced in arid regions and rely on intensive irrigation to produce high tuber yield and quality. Potatoes are often grown in three to four year rotations with either corn (Zea mays L.), wheat (Triticum sativa L.), or alfalfa (Medicago sativa L.). The crop residue decomposition and mineralization of nitrogen provides a source of plant available N. In this study, in-situ column incubation technique was used to determine the N mineralization from corn, wheat, and potato crop residues. The dry weight of the crop residue in January soil samples taken at the top 30 cm depth ranged from 8.4 to 26.5 Mg ha⁻¹, but decreased to 4.6 to 12.7 Mg ha⁻¹ in late March, the beginning of potato growing season. Cumulative nitrogen mineralization during March through September from different crop residues varied from 39 to 85 kg N ha⁻¹, which represent approximately 45 to 65% of
potentially mineralizable N in the crop residue. The crop residue weight and the amount of N mineralized decreased in the order: corn > wheat > potato.

MEASUREMENT OF TRANSPERSION LOSS OF WATER FROM SOIL AND PLANT. Afros Sultana Chemon¹, Nadiruzzaman Mondol¹, Babuna Faiz², and S.M.A. Faiz². ¹Production officer, Aftab Biotech, Bhagalpur, Bajitpur, Bangladesh, ²Associate Professor & Professor, Department of Soil, Water, & Environment, University of Dhaka, Dhaka, Bangladesh.

A pot experiment was conducted in the shed house of Aftab Biotech at Bajitpur, Bhagalpur, Bangladesh with tomato plant under different water stress in order to investigate (a) water tolerance (b) ion uptake phenomenon (c) yield & dry matter production and (d) plant–water relationship to have quality Tomato. To evaluate the effect of different water stress level on the growth characteristics of tomato, it is indispensable to have a clear concept about the soil–water relation. This paper will give an account of this with respect to transpiration. The rate of water loss either by evaporation or by transpiration from the soils is determined basically by difference between the vapor pressure at the leaf of soil surface and that of the atmosphere. Sophisticated apparatus are required for direct measurement of vapor flux out of plant, but the inferential methods are widely used to measure the transpiration loss of water depending upon the weight change of the whole plant/soil unit or plant/water culture.

In our experiment, the transpirational loss of water by the tomato plants was determined by daily weighing the pots with and without plants. The pots were covered with aluminum foil to prevent evaporation loss. Relative water content were also determined by the following formula:

\[
\text{Relative water content (R.W.C) } \% = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Turgid weight} - \text{dry weight}} \times 100
\]

From the measured relative water content, the leaf water status may also be expressed conveniently by the index relative water deficit (WD) which is 100 RWC.

THE ESTABLISHMENT AND USE OF A REFERENCE MATERIAL AS A CONTROL SAMPLE. P.M. Chetty¹ and D. van Dijk². ¹Institute for Commercial Forestry Research, University of Natal, Pietermaritburg, KZN, S.
The production of reliable analytical data is dependent on a range of quality control procedures. One of the critical components of a robust quality assurance program is the ability to demonstrate the comparison of results achieved to a previously benchmarked sample. The use of a validated internal reference sample with a similar matrix as that of samples routinely analyzed is the preferred option. However, due to cost considerations and the commercial availability of suitable reference material, this is often not possible. This poster describes our experience in establishing a reference control sample \((Pinus patula)\) in collaboration with Wageningen Evaluating Programs for Analytical Laboratories (WEPAL) based at the University of Wageningen, Netherlands. The sample was analyzed for total concentrations of B, Fe, Cu, Zn, Mn, P, Ca, Mg, K, Na and N. The results achieved are presented in comparison to the consensus values achieved by the IPE program. The data was analyzed and the group statistics (means, standard deviation and coefficients of variation) were determined for each element. In general, standard deviation values for the intra laboratory analyses were lower than the inter laboratory values achieved. The wide range of analytical methods considered in the inter laboratory comparison will most likely account for this difference.
this program, in regard to their accuracy and precision. The program involves a quarterly exchange of 8 soil samples on which soil fertility analyses are conducted. Laboratories were characterized through a survey that consisted of a questionnaire about kind of analysis, facilities, methods, quality assurance, and management. In 2000, 79 laboratories from 23 Brazilian states took part in the program, which were responsible for 320,000 soil fertility analysis. Results indicate a significant improvement in the laboratories' quality analysis through the course of the nine-year program. Also, 82% of the laboratories attained an adequate performance. Laboratories' characteristics indicated capabilities and constraints that should be addressed to improve their future quality.

VARIABILITY OF IONIC CONCENTRATIONS IN SURFACE WATERS OF AN AGRICULTURAL CATCHMENT DURING STORM EVENTS. Antonio Diéguez, Antonio Paz, Mercedes Taboada and Teresa Taboada. Facultad de Ciencias, Universidad de A Coruña, A Zapateira, 15071 A Coruña, Spain. Fax: 34 981167065; E-mail: merche@mail2.udc.es

Agricultural pollutants are generally carried to water courses by storm flows and infiltration waters and their greatest impact on water quality usually occurs during intense rain events. This occurrence emphasizes the importance of water quality studies conducted on agricultural catchments during storm events. The report discusses analytical results (electrical conductivity (EC), Ca, Na, K, Cl, NH$_4$-N, and NO$_3$-N) for samples of runoff collected during five storm events from a small agricultural catchment receiving slurry applications. Generally, high concentrations were observed in the first stages of the events and were followed by a decrease that sometimes occurred before the stream reached its maximum flow rate. The most probable explanation for this behavior is the arrival of runoff containing materials from applied slurry. Transportation of these materials is promoted by formation of a surface crust on fallow land. This crust minimizes soil retention of slurry compounds. Later, increase in continuous flow promotes dilution, leading to a decrease in ion concentration. Exceptions to the trend were Na and Cl, concentrations of which were governed mostly by dilution effects. In these cases, measurements taken during high flows showed concentrations similar to, or lower than, those obtained from base flows.
A SIMPLE QUANTITATIVE CHEMICAL RECOVERY METHOD OF OXYFLUORFEN (2-CHLORO-1-(3-ETHOXY-4-NITROPHENOXY)-4-(TRIFLUOROMETHYL) (GOAL®) FROM LABORATORY FORTIFed SOIL AND WATER SAMPLES. D. Duseja and William Martindale. Department of Agricultural Sciences and Cooperative Agricultural Research Program, Tennessee State University, 3500 John Merritt Blvd., Nashville, TN, USA, 37209-1561. Fax: (615) 963-5319; E-mail: DDuseja@tnstate.edu

Oxyfluorfen (Goal®) herbicide chemical extraction and analyses techniques from both soil and water have been reported in the chemical literature. However, these techniques are time consuming or/and require the use of HPLC. Our paper reports the results of a simple method for the extraction and gas chromatographic (GC) analyses in laboratory oxyfluorfen fortified soil and water samples. Field samples from a Byler silt loam (Typic Fragiudalf) soil site were collected from the 0–10 cm depth, and appropriately dried and sieved to 2 mm size. They were fortified with 0.05 to 2.0 ug g⁻¹ levels of oxyfluorfen herbicide. The samples were extracted (1:5; soil:acetonitrile). The extracts were directly injected into the HP6890 gas chromatograph (µ-ECD detector). Water samples were spiked at the 0.1 and 1.0 ug g⁻¹ levels. The samples were intermittently shaken by hand with n-hexane for three minutes, and the supernatant directly analyzed by GC. Quantitative recoveries (97 to 101%) of the herbicide were obtained in both soil and water. Recovery percentage as well as GC response suggests that method detection limits (MDLs) of at least 0.005 ug g⁻¹ are achievable. Organic solvent/water ratio does not appear to affect the recovery of oxyfluorfen. However, the solvent exchange step in soil extraction can affect the oxyfluorfen recovery.

FERTILIZER RECOMMENDATION ON THE BASIS OF SOIL TEST VALUES FOR SUSTAINABLE PRODUCTIVITY IN BANGLADESH. A.T.M. Farid. Soil Science Division, Bangladesh Agriculture Research Institute, Gazipur, Bangladesh. E-mail: musa@bdcom.com

In Bangladesh, cropping intensity is 180%. To sustain such a high cropping intensity high and appropriate fertilization is essential. It is being done on the basis of soil and plant analytical data despite poor economic conditions of the farmers, insufficient laboratory facilities for regular soil analysis and fertilizer recommendations. High productivity rates of crops, e.g., rice @ 10–15 mt⁻¹·ha⁻¹·year has been possible partly due to soil test service and fertilizer
recommendation. The paper describes the method starting from soil analytical
data to the recommendation of fertilizers for rice and other crops. This method
will not match one required in developed countries. However, it may encourage
third world countries.

A SIMPLE METHOD FOR DETERMINATION OF TOTAL DISSOLVED
NITROGEN (TDN) IN SOIL WATER BY FLOW INJECTION ANALYSIS
IN COMBINATION WITH ON-LINE MICROWAVE-ASSISTED
DIGESTION. Preben Frederiksen and Thomas Dreyer. Danish Centre for
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Soil organic matter is characterized by a nitrogen content of 1–5% and very
low water solubility. The organic matter is further stabilised by formation of
complexes involving clay particles and polyvalent cations. In soils with low
content of clay and plant nutrients, organic bound nitrogen may, however,
contribute significantly to nitrogen leaching to the groundwater. In order to
evaluate the nitrogen balance in such ecosystems, it is important to measure
the content of total dissolved nitrogen (TDN) in the soil water.

Traditional methods for determination of TDN (total Kjeldahl digestion,
persulphate oxidation or UV-oxidation) are time consuming and difficult to
automate. For the purpose of screening large number of soil water samples
collected in Danish forests, a method was developed that involve automated
Flow Injection Analysis (FIA). The method is composed of an oxidation
reaction and a spectrophotometric determination of the oxidation product,
nitrate.

An aliquot of the water sample is injected and mixed with an oxidizing
peroxysulphate reagent and the mixture is passed through a reaction coil
placed in a focusing microwave oven. The reaction proceeds under pressure
induced by using larger i.d. on the entry pump tubing than on the exit tubing.
The pressure allows heating without bubble formation in the reaction coil.
Free and formed nitrate is measured spectrophotometrically in a flow cell at
215 nm. Calibration is performed by external calibration with NH4Cl
solutions. The method is applicable to water samples containing dissolved
organic carbon compounds up to 25 mg L⁻¹. The method was validated using
synthetic organic nitrogen containing compounds, reference standards of
humic acid (International Humic Substances Society), and a certified
wastewater standard.
USE OF POTASSIUM CHLORIDE TO INVESTIGATE THE EFFECT ON YIELD AND CHLORIDE BUILDUP IN SOIL IN A WHEAT–MAIZE ROTATION. Muhammad Ibrahim, Nisar Ahmad, and Khalid Mahmood. Soil Chemistry Section, Ayub Agricultural Research Institute, Faisalabad, Pakistan. Fax: 92 41 653874; E-mail: soilchem@fsd.paknet.com.pk; ibrahimwarriach@yahoo.com

Alluvial soil in the flood plains of Pakistan are rich in chloride (Cl). Therefore the use of muriate of potash (MOP) as a source of K is not recommended. Sulphate of potash (SOP) was used as an alternative source of K until its price increased in 1985, at which time a comparison with MOP was made. Soil and crops in a wheat–maize rotation received the following treatments, control (no fertilizer treatments), NP, NPK (K from SOP), and NPK (K from MOP). The recommended rates of NPK for wheat and maize were applied. Beginning in 1988, 12 crops each of wheat and maize fodder were harvested. The average yield of maize fodder was 23.5 t ha\(^{-1}\) for control, 41.7 t ha\(^{-1}\) for NP, 43.3 t ha\(^{-1}\) for NPK (SOP), and 45.6 t ha\(^{-1}\) for NPK (MOP). Similarly, the average wheat grain yield was 1.50 t ha\(^{-1}\) for control, 3.95 t ha\(^{-1}\) for NP, 4.03 t ha\(^{-1}\) for NPK (SOP), and 4.01 t ha\(^{-1}\) for NPK (MOP). Maize fodder responded to N and P application but the effect of K from either SOP or MOP was negligible. Wheat grain response to N and P application was similar to maize fodder. Wheat grain yield from either source showed no effect of K. The addition of Clin soil from SOP was 1.0 t ha\(^{-1}\), compared to the 0.6 t ha\(^{-1}\) removed by crops. The analysis of surface soil during 2000 showed that Cl contents were 74 mg Kg\(^{-1}\) for control, 77 mg Kg\(^{-1}\) for NP, 87 mg Kg\(^{-1}\) for NPK (SOP), and 84 mg Kg\(^{-1}\) for NPK (MOP). Results indicated no accumulation of Cl in the soil, perhaps due to leaching. It was concluded from the study that (1) there was a modest effect of K on maize fodder but no effect on wheat grain yield, and (2) there was no Cl accumulation in soil even after 12 years.

THE EFFECT OF TEMPERATURE ON THE IMPEDANCE PLASMA-TOGRAPHY OF HEMATITE, KAOLINITE AND KAOLINITE–HEMATITE SYSTEM. S. Kampiti, A. Ioannou, P. Papadopoulos, and A. Dimirkou. 1Department of Chemistry, University of Athens, Zografou, 15771, Athens, Greece; 2National Agricultural Research Foundation, Institute of Soil Science, 1 Sof. Venizelou St. 14123, Lykovrisi, Attiki, Greece. Postal address of the corresponding author: A. Ioannou, 14 Thermopilon St. 15351, Pallini, Attiki, Greece. Fax: 16031120; E-mail: aioannou@cc.uoa.gr

Impedance Spectroscopy is a relative new method of identifying many of the electrical properties of materials and their interfaces with electronically
conducting electrodes. The purpose of this study was to investigate the dielectric behavior and the spectroscopy of new materials. The materials studied were hematite, kaolinite and kaolinite–hematite system. The effect of temperature on the dielectric behavior is very interesting. For the reason one of us (A. I.) developed a certain measurement technique in temperature up to 1,000°C. The measurement equipment includes a high temperature dielectric cell, an impedance bridge covering a frequency range of 20 Hz–1 MHz and an oven. From the experiments we have found that for kaolinite an increase in the frequency results in decrease of the impedance. In the area of high frequencies, the material’s behavior at high temperatures (800°C) and at low temperatures (20°C) is alike but as the frequency decreases this kind of behavior degenerates. This kind of behavior is not typical of hematite. Furthermore the kaolinite–hematite system also shows a decline of impedance as the frequency increases. Of course the system acts as a mixture of the two materials, yet there is a clear dominance of kaolinite, at high temperatures as the frequency increases. Finally we have noticed a specific temperature area at 150°C–250°C where the abnormal behavior is attributed to the evaporation of the OH groups.

RESPONSE OF FOUR TYPES AND LEVELS OF ORGANIC MANURES ON GROWTH OF CYMBOPOGON WINTERIANUS AND CYMBOPOGON MARTINI IN MARGINAL ALKALINE SOIL. Tanu Kaur and Alok Adholeya. Centre For Mycorrhizal Research, Tata Energy Research Institute, Habitat Place, Lodhi Road, New Delhi, India, 110003.

A field experiment was conducted to study enhancement in soil fertility, increase in growth and yield of two crops Cymbopogon winterianus and Cymbopogon martini, grown in nutrient-deficient soil amended with four different organic manures. Vegetable compost, leaf compost, poultry manure and dried sewage sludge was applied @40 t ha\(^{-1}\), 80 t ha\(^{-1}\), 100 t ha\(^{-1}\) and 120 t ha\(^{-1}\) each. 64 treatments arranged as 4 × 4 × 4 factorial were examined for their effects on crop yield and soil chemical properties. Organic amendments resulted in significant increase in the soil macro and micronutrient levels.

INITIAL RESULTS OF AN INTER-LABORATORY COMPARISON OF NITROUS OXIDE ANALYSIS IN WESTERN CANADA. R. Lemke\(^1\), T. Goddard\(^2\), D. Burton\(^1\), B. Ellert\(^4\), R. Farrell\(^5\), M. Monreal\(^6\), D. Hahn\(^4\), and D.
Concern over the increasing concentration of nitrous oxide in the earth’s atmosphere has prompted a substantive effort to quantify its sources and sinks. A large number of laboratories are involved in the handling and analysis of trace gas samples in support of these efforts. It is of critical importance that the data generated from these various laboratories be consistent and comparable, however, sample handling and analysis procedures differ widely. In addition, the comparability of commercially prepared standard gases utilized by most laboratories for calibration procedures is uncertain. An inter-laboratory comparison study was initiated between six laboratories in western Canada. The objectives were to: (1) investigate the comparability of the commercially prepared standard gases currently used by the laboratories for calibration purposes, and, (2) investigate the comparability of the trace gas analysis conducted by the participating laboratories. Working standards from each laboratory were transported in pre-evacuated Exetainer® tubes to be analyzed at a single location. Similarly, a single working standard was transported via pre-evacuated Exetainer® tubes to each participating laboratory for analysis. Substantial discrepancies were noted between the commercially prepared standard gases used, and small but significant differences were also noted between analysis results reported. We can conclude that standardization of calibration materials is urgently needed, and that further work is required to understand the variation in analysis results reported by the participating laboratories.

GASEOUS LOSSES OF APPLIED NITROGEN FROM A MAIZE FIELD DETERMINED BY 15N ANALYSIS OF N₂ AND N₂O. Xinhui Li¹, T. Nishio², and Y. Uemiya³. ¹Faculty of Horticulture, Chiba University, Matsudo-Shi, Matsudo, Japan. Fax: 81 47 360 8078; E-mail: liliyan@yahoo.com; ²Department of Soils and Fertilizers, National Agriculture Research Center, Kannondai 3-1-1, Tsukuba, 305 Japan. Fax: 81 298 388837; E-mail: oibsin@narc.affrc.go.jp;
Denitrification is regarded as one of the major processes that are responsible for nitrogen loss from arable soils, through production of atmospheric N2O and NO. This study was carried out to estimate the amount of denitrification in a corn field where rape was incorporated as green manure. To measure the in situ emission of N2 and N2O from fertilizer N, micro-plots with plastic barriers (0.70 m £ 0.30 m) were set in triplicate, and \(^{15}\text{NH}_4\)\(_2\)SO\(_4\) (70.7 atom\% \(^{15}\text{N}\)) was mixed thoroughly with a 0–10 cm soil layer at the rate equivalent to 150 kg N ha\(^{-1}\) on 15 May 1998. The gas samples were taken periodically by using static chamber method. The N2O concentration was determined by GC equipped with ECD and \(^{15}\text{N}\) abundance in N2 and N2O was also measured by ANCA-MS. The N content and \(^{15}\text{N}\) abundance in the corn and soil in the micro-plots were determined after corn was harvested on 24 August.

The total amount of denitrified N was about 13.3% of the applied fertilizer N, and the total amount of N2O emission accounted for only 2.9% of the N loss. The average emission rates of N2 and N2O during the growing period were 13.4 and 0.041 mg N m\(^{-2}\) d\(^{-1}\) respectively. However, after 40 days, both the fluxes of N2 and N2O were very low. During the first week after fertilization, \(^{15}\text{N}\) abundance of N2O was as high as 34.3 atom\% \(^{15}\text{N}\) and then decreased quickly to the background level. These temporal changes in \(^{15}\text{N}\) abundance of N2O matched those in nitrification of the applied fertilizer N in the soil. At the end of the experiment, the recovery of the applied fertilizer N calculated from \(^{15}\text{N}\) mass balance was 82%, and 49% of the applied N still remained in soil as nitrate. This suggests that leaching loss of fertilizer N in this field was more significant than denitrification loss.
Laboratories seeking accreditation based on norm ISO 17025 are required to satisfy several requirements such as traceability of measurements, participation in interlaboratory comparison or proficiency testing programmes, and determination of the uncertainty of the measurements. The objective of the present work was to evaluate the accuracy of measurements and to establish traceability and proficiency tests in soil and plant analysis in Mexico and Guatemala, beginning in 1997 and 2000, respectively. In order to establish precision of the analyses, a set of WEPAL Program samples, previously analyzed by various laboratories, were used. To establish accuracy and traceability, the Program members received sample CRM 1515 (apple leaves) in 1999 and sample CRM 1570a (spinach leaves) in 2000. All members were asked to use the same methods to diminish variability in the results. The statistics used to evaluate the accuracy was the Mean Square Error as recommended by The Mexico’s Metrological National Center. Maximum allowed deviation for CRM 1515 and for CRM 1570a was $\pm 14\%$ and $\pm 11\%$, respectively. The following is the breakdown of the percentages of laboratories that reached the target level of accuracy for different elements. For CRM 1515: Mn 43%, Ca and Mg 38%, P and Cu 30%, K and Fe 19%, Zn 5%, and Na 0%. For CRM 1570a: P 50%, Mn 44%, Cu and Na 36%, Ca 31%, Zn 27%, and K 23%. These results show a tendency of laboratories to increase their performance only in the measurement of P, Zn, and Na. In order to learn how to get better quality data, Program members were invited to attend two quality control courses. Improving quality of analytical results of soil and plant analysis will take time. Members of the Program were encouraged to spend more time in improving their own quality assurance system.

MACRONUTRIENT AND MICRONUTRIENT CONCENTRATIONS OF SEEDED BERMUDAGRASSES. James N. McCrimmon. Department of Horticulture, 137 Julian C. Miller Hall, Louisiana State University. Baton Rouge, LA, USA 70803. Fax: (225) 388-1068; E-mail: jmccrimmon@agctr.lsu.edu

The development and utilization of seeded cultivars of bermudagrass [Cynodon dactylon (L.) Pers.] for use in turfgrass areas such as athletic fields and golf courses have increased in recent years. There is limited data concerning the fertility requirements and the resulting nutrient concentrations for these cultivars. A study was conducted to assess the nutrient content and
turfgrass quality of 14 seeded bermudagrasses and one vegetative cultivar, ‘Tifway’ (C. dactylon × C. transvaalensis). Turfgrass plots were established in 1996, maintained at a height of 2.54 cm, and fertilized at the rate of 454 g N m⁻² month⁻¹ from August through October. All other macronutrients and micronutrients were applied in equal amounts to all cultivars. The study was a randomized block design with three replications. Plant tissue samples were collected, dried, ground, and analyzed for both macronutrient and micronutrient concentration. The nutrient concentration for all the cultivars was within the sufficiency range for nitrogen (N) and phosphorus (P). There were differences for calcium (Ca), magnesium (Mg), sulfur (S), and potassium (K) concentration among cultivars. Although there were few differences among cultivars for macronutrient concentrations, the concentration of certain macronutrients varied widely among cultivars.

PERFORMANCE OF USGA ROOTZONE TESTING ANALYSIS
METHOD ASTM F1815-97. Robert O. Miller¹ and Janice Kotuby-Amacher². ¹Soil and Crop Sciences Dept, Colorado State University, Fort Collins, CO, USA 80523. Fax: (970) 491-0564; E-mail: rmiller@lamar.colostate.edu; ²Utah State University Analytical Laboratory, Utah State University, Logan, UT, USA 80433. Fax: (435) 797-7869; E-mail: jkotuby@mendel.usu.edu

In 1997 a proficiency testing program was established for United States Golf Association Root Zone Testing Laboratories in conjunction with A2LA laboratory accreditation. The program focus was on ASTM method F1815-97, which determines saturated hydraulic conductivity (SHC), bulk density, capillary moisture content, non-capillary moisture content and total porosity of root zone mixes used in the construction of golf putting greens. Twelve laboratories have participated in the program since 1997, each receiving three replicates of two root zone mixes quarterly. Results of the program indicate inter-laboratory SHC precision ranges from 15–35% across the 28 samples evaluated. Intra-laboratory precision for the SHC test ranges from 4–8%. The lack of inter-laboratory precision indicates that method as described is inherently unreproducible across laboratories. Further research has identified that three of the steps in the SHC method are sufficiently vague as to constitute most of the inter-laboratory variation. Results of individual lab evaluations indicate that sample loading, initial saturation and moisture tension lack homogeneity across laboratories. Research is in progress to develop a more robust method for determining SHC and will be described in the next revision of ASTM F1815-97.
INFLUENCE OF TOPOGRAPHICAL AND EDAPHIC FACTORS ON ROSE FLOWERING QUALITY AND QUANTITY. A. Misra, K. Kukarja, Anand Singh, and N.K. Patra. Central Institute of Medicinal and Aromatic Plants, Lucknow, India 226515; (CIMAP, Field Station, Pantnagar—263 145, CIMAP, Field Station, Purura, Almora—263 001).

Damask rose (Rosa damascena Mill.) clones were established on research farms at Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow and the CIMAP field station located at Purura, Almora and Pantnagar, India. Data for three consecutive years showed that flowering in Almora was observed in April, while in Lucknow and Pantnagar it was noticed in January–February. Greatest mean flower weight (5.67 g) and oil percentage (0.056%) were obtained in the semi-temperate climate of Almora. At Almora, gas liquid chromatography showed the following: 1.889% rose-oxide, 11.81% phenyl ethyl alcohol, 1.936% linalol, 23.758% 1-citronellol, 0.365% nerol, and 18.303% geraniol. The concentration of each constituent was higher than that in R. damascena grown in the tropical region. Highly significant association was found between low temperature and oil concentration ($r = -0.947$) in Almora-cultivated rose plants but the opposite correlation was obtained in clones grown at Pantanagar and Lucknow.

LEAF-NPK AND ITS RELATIONSHIP WITH GRAIN YIELD OF TRITICALE AS AFFECTED BY PROGRESSIVE APPLICATION RATES OF NITROGEN AND PHOSPHORUS FERTILIZER. Moinuddin1, K.N. Tiwari 2, and Shahid Umar 3. 1Potash Research Institute of India and 2Potash and Phosphate Institute of Canada (India Programme), Sector 19, Dundahera, Gurgaon—122 016, Haryana, India; 3Department of Environmental Botany, Jamia Hamdard, New Delhi—110 062, India.

Four triticales (TL-419, Tigre“S”, Musko“S” and Delfin) along with one check each of bread wheat (HD 1982) and rye (Russian Rye) were field grown with nine basal regimes, comprising three doses each of nitrogen (150, 200 and 250 Kg N ha$^{-1}$) and phosphorus (30, 40 and 50 Kg P ha$^{-1}$). Progressive application of nitrogen, irrespective of phosphorus, resulted in linear increase in leaf-NPK content. However, phosphorus, particularly with the highest N level, was equally effective. The data showed leaf-NPK values in the order: K > N > P at tillering > heading > milky grain stage. Triticales (Delfin and Tigre“S”), followed by wheat, gave highest contents, whereas rye gave poorest values. Interaction (nutrient $\times$ variety) was significant for leaf-N and -K only at one or
the other stage. There appeared significant quadratic relationship, determined either between grain yield and leaf-NPK content of individual triticales (p < 0.01, n = 9) or between individual yield of all triticales and the corresponding leaf-NPK content (p < 0.001, n = 36). The correlation between yield and leaf-NPK content of wheat and rye proved to be significant at p < 0.01 and p < 0.05 (n = 9) respectively. Among the growth stages, heading proved to be the best stage, particularly for triticales, to determine the leaf-NPK content so as to predict the grain yield.

A COMPARISON OF EXTRACTANTS FOR HEAVY METALS IN CONTAMINATED SOILS FROM SPAIN. R. Moral¹, R.J. Gilkes², and J. Moreno Caselles¹. ¹Dept. Agrochemistry and Environment, Miguel Hernandez University, EPS-Orihuela, Ctra Beniel Km 3.2, 03312—Orihuela (Alicante), Spain. Fax: 96 6749655; E-mail: raul.moral@umh.cs; ²Dept Soil Science and Plant Nutrition, University of Western Australia, Australia.

Many soils in industrialised countries are affected by acid deposition, mine wastes disposal and organic refuse including sewage sludge that are sources of pollutants and especially heavy metals. In Spain, the measurement of heavy metals in soils has encountered problems with the standardization of extraction procedures due to the wide diversity of soils, the low concentrations of these elements, and the scarcity of appropriate analytical instruments. In this research, the extractability of Cd, Ni, Pb, Co and Cr in eight contaminated soils from Spain was evaluated using ammonium chloride, calcium chloride, strontium chloride and DTPA extractants. These procedures have been used by earlier workers for assessing plant available metals. Each extraction procedure was performed in triplicate in 50 mL polycarbonate centrifuge tubes. All the extracting solutions were centrifuged for 10 min at 3000 rpm, and the supernatant filtered into volumetric flasks containing 10 μg In/Rh L⁻¹. All the extracts and standard solutions were acidified with 1% HNO₃. The amounts of metal extracted were related to total metal contents, determined following microwave digestion using HNO₃. Quantification of dissolved metals was by ICP-MS using matrix-matched standards. Results showed a high variability in metal extraction, depending on extracting procedure, source of pollution, and nature of the soil. We found that the extractability on calcareous soils seem to be better described by DTPA. Among chloride extractants, ammonium chloride was the most efficient in recovering heavy metals from soils.
STUDIES ON THE RELATIVE EFFICIENCIES OF DIFFERENT SULPHUR FERTILIZERS ON THE GROWTH AND YIELD OF GROUNDNUT AND PADDY CROPPING PATTERN. Shansun Noor and M.S. Islam. Agricultural Chemistry Section, Division of Soil Science, Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur, Bangladesh.

Large areas of southeast Asia have low organic matter content and as a result they are often sulphur deficient. Crop responses to sulphur have been reported and it is such a nutrient that plays a multiple role in the nutrition of crops. Therefore, two field experiments were conducted under the Grey Terrace Soils and Grey flood plains soils of Joydebpur and Jamalpur respectively on groundnut and paddy (transplanted aman) cropping pattern to evaluate the relative efficiencies of five sulphur materials: gypsum (GYP), ammonium sulphate (AS) elemental sulphur (ES), T-90 and pyrite (PYR). Sulphur material were added at the rate of 40 kg S ha\(^{-1}\). Recommended dose of N, P, K, Zn, B, Mo fertilizers were applied in the first crop of each cropping pattern. Only nitrogen was applied in the succeeding crop. Gypsum proved to be superior to other sources in the first crop of the cropping patent at both locations. In the succeeding crop of paddy significant yield increase were observe by the residual effect of ES and T-90 at Joydebpur but only beneficial affect were obtained with all sulphur source at Jamalpur. Sulphur application from PYR, T-90, AS + ES and ES + GYP produced significant yield increases for both crops in the third cropping year at both locations.

CULTURE OF MALT BARLEY, EXPERIENCES WITH MANGANESE QUELATE SUPPLEMENT. M.E. Palese\(^1\) and J.C. Landry\(^2\). \(^1\)N.V. Consultora, Cerrito 1136 Piso 9, Buenos Aires 1010, Argentina; \(^2\)Consultor privado, Arcos 1357, Piso 7, Buenos Aires 1426, Argentina.

Experiments were carried out during 1993–1996 to study the effects of Mn chelate on malt barley under different climatic conditions. The chelate was applied at seeding and different stages of growth: 40 days after emergence, tillering, and flag leaf. Manganese played a significant role in promoting photosynthetic activity, disease prevention, spike formation, and interaction with phosphorus.

“THE SPERMOSPHERE MODEL” IS A TOOL FOR MEASURING NITROGEN FIXATION. Mustafizur Rahman. Department of Soil, Water &
In 1982 Thomas Bauzon et al. reported the isolation of nitrogen fixing bacteria from the rhizosphere soil of a paddy field, using a germinating gnotobiotic model (“the spermosphere model”) as an enrichment step. The same model was used by several scientists to compare in the laboratory several plant genotypes and bacterial strains. In the present study “the spermosphere model” was used for measuring nitrogen fixation efficiency of some soils and plants of Bangladesh. For our study we have modified the Pankhurst tube. The lateral tube contains 1 M NaOH to trap CO₂ in the system. The system was incubated in the dark with 10% acetylene and the evolution of ethylene was measured at regular time interval. Ethylene production was measured after 3, 5 and 7 day, using a gas chromatograph equipped with a flame ionization detector. The ethylene content of individual tubes was measured over 3 different periods. The 3 rates were compared and each of the replicate tubes was characterized by its maximum rate of ethylene.

Adverse effects of long-term and excessive fertilization have been reported. A Review of fertilizing methodologies for efficient and sustainable resource management has become very important. The Diagnostic and Recommendation Integrated System (DRIS), based on indices from validated norms, was developed for rationalizing crop fertilization and has been applied successfully. Treatments of N, P, and K were applied to sugarcane, and dry matter yield was estimated at 6 months of age. Samples of 3a and 6a leaves were taken at 3 and 6 months and analysed for N, P, and K. Without fertilisation, diagnostic deficiencies were different in both sets of leaves but as fertiliser was supplied, nutrient concentration was similar in each. When a limiting element was applied, there was no response until it was accompanied by another element, indicating that the DRIS approach detects hidden hunger as well as nutritional interaction. When an element was indicated as deficient by the critical level, it was the most limiting according to DRIS. This has the advantage of indicating nutrient requirements, allowing application of the required amount of fertilizers to correct nutrient imbalances without overfertilization. The 3a leaf was useful as diagnostic tissue at three
months, but the 6th leaf was more stable at both ages. The methodology is capable of detecting nutrient imbalances throughout the growing period.

COMPARISON OF EXTRACTANTS USED FOR EVALUATING THE BIOAVAILABILITY OF SOIL P AND K. K. Sardi¹ and Gy. Füleky².

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Two extractants, hot water, and ammonium lactate (AL) were evaluated for estimating the bioavailability of soil P in four soil types. Nutrient uptake by plants on fertilized plots showed a dramatic increase, compared to control plots, and fertilizer application did not cause acid forming reactions in soils. Good correlation was found between the values of soil P and K obtained with the two extractants (r values ranged between 0.974 and 0.612 for P, and between 0.761 and 0.04 for K). Compared to K, a better relationship was found with soil P removed by either extractant. Similar tendencies were found when plant P and K uptakes were correlated with soil P and K extracted by the solutions. Plant removal of P showed better correlation with AL-extracted phosphorus. Among soils, the closest relationships were observed between plant removal and soil P contents on a Ramann brown forest soil (r = 0.925 and 0.932, respectively). On the other hand, a better correlation was obtained for K removal from lessivated brown forest soil. For a better understanding of the dominant factors influencing the effectiveness of these extractants, and their relationships with plant removal in a variety of soil types in Hungary, further studies are needed.

INORGANIC FERTILIZERS AND AGRICULTURAL PRACTICES: EFFECTS OF SOIL BIOLOGY. Reena Singh and Alok Adholeya. Centre for Mycorrhiza Research, Tata Energy Research Institute, New Delhi, India.

The effects of inorganic fertilizers and agricultural practices on mycorrhizal fungi and other beneficial microbes were investigated in wheat agricultural systems. Six fields, differing in past fertilizer input, wheat yields, and agricultural practices (zero tillage, ploughed/harrowed, raised-bed plantation) were studied. The soils were analyzed for chemical parameters (pH, EC, organic
carbon, organic matter, nitrogen, phosphorus, potassium), mycorrhizal
parameters (species diversity, population density, infectivity potential), and
microbial counts. The results showed that the field with low input of chemical
fertilizers contained more mycorrhiza and other beneficial microbes than the high
input field. Mycorrhizal population in the zero-till field (minimal soil
disturbance) was also higher than that in the harrowed field, where the soil was
disturbed by ploughing. The population of both mycorrhiza and beneficial
microbes, and species diversity of mycorrhizal fungi were found to be highest in
the field where plantation of wheat and rice was done on raised beds.

WATER SOLUBLE P AS AFFECTED BY FRESHLY APPLIED AND
RESIDUAL P AND P FRACTIONS OF SOIL. I. Sisák, K. Sardi, and M.
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From an environmental point of view, we need to know the amount of soil P
which is immediately soluble in water, and we need to understand the effect of
P application on the water soluble P content of soils in order to predict runoff
rates of dissolved P. Soils at two locations within a 28 yr old fertilization trial
were fertilized with P\textsubscript{2}O\textsubscript{5} at rates of 0, 50, 100, and 150 kg ha\textsuperscript{-1}. Some
samples were analysed by a modified P fractionation method, and others were
incubated for 10 wks after which they were analysed for water-soluble P.
Water-soluble P removal from unfertilized soils followed first order kinetics.
Removal rates from fertilized plots were decreased by the earlier P treatments.
Strongly bound inorganic fractions have shown the closest correlation with
removal rate. Freshly applied P affected water-soluble P similarly at both
locations but earlier P treatments promoted more P release in sandy soil than
in finer textured soil.

DEVELOPMENT OF A CRITICAL, MEHLICH 3 SOIL TEST ZN VALUE
FOR RICE IN ARKANSAS. N.A. Slaton, C.E. Wilson, Jr., R.J. Norman, and
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Zinc (Zn) fertilizer recommendations for rice (Oryza sativa L.) in Arkansas have been based solely on soil pH since the 1970s and have not accounted for the residual carryover of previous Zn fertilizer applications. Continuous application of Zn fertilizer to soil in some fields cropped to rice has resulted in very high Mehlich 3 extractable soil Zn (M3Zn) concentrations and illustrates the need to develop improved recommendations. The objective of this research was to develop a critical soil test M3Zn concentration for making Zn fertilizer recommendations in rice. The relationship between relative yield (RY), soil pH, and M3Zn concentration was determined from 36 Zn fertilizer studies conducted on silt loam soils between 1992 and 2000. Multiple regression analysis showed that soil pH, M3Zn concentration and their interaction best described rice yield response to Zn fertilization. When soil pH was >5.5, a yield response to Zn fertilization was possible, but depended on soil M3Zn concentration. The critical soil M3Zn concentration required to produce 90% RY, without Zn fertilizer application, for soils with pH values of 6.2, 7.0, and 7.8 was 1.3, 3.5, and 4.2 mg M3Zn Kg$^{-1}$ soil, respectively. Results suggest that soil pH and M3Zn concentration should be used together for making Zn fertilizer recommendations in rice to prevent yield loss from Zn deficiency and economic loss from needless Zn fertilizer application. Zinc fertilization is not needed on soils high in M3Zn concentration, regardless of soil pH, and yield could possibly be reduced by Zn fertilizer application to soil in these fields.

CALIBRATION OF SOIL TEST METHODS FOR AVAILABLE PHOSPHORUS IN SWELL–SHRINK SOILS FOR WHEAT. Kashinath R. Sonar$^1$ and Chandrakant R. Palwe$^2$. Department of Agricultural Chemistry and Soil Science, Mahatma Phule Agricultural University Rahuri—413 722, India. $^1$Swastik Apartment, Dr. Bhide Hospital Road, Savedi, Ahmednagar—414 003, Maharashtra, India, Fax: 91 241 345963; E-mail: krsonar@rediffmail.com; $^2$Agril Research Station, Jalgaon 425 001, Maharashtra, India.

Eighteen surface soil samples (alkaline calcareous clay, low to high in Olsen-P) belonging to Vertisols, Inceptisols and Entisols were collected. Five Kg soil (<2 mm) was placed in plastic pots. Four levels of P$_2$O$_5$ (0, 50, 100 and 150 kg ha$^{-1}$) with constant rates of N and K$_2$O at 200, and 100 kg ha$^{-1}$, respectively, were applied. Wheat (cv. HD 2189) was grown, keeping four plants in each pot in a completely randomized design and three replications. Wheat yields were recorded and grain and straw samples analysed for P. Plant available P in soil was estimated with six extractants, A) 0.5 M NaHCO$_3$, B) 10% NaOAc, C) 0.03 NH$_4$F + 0.025 N HCl, D) 1 M NH$_4$HCO$_3$ + 0.005 M DTPA, E) 0.002 N
H₂SO₄, and F) 0.05 N HCl + 0.025 N H₂SO₄. Critical limits using scatter diagrams and per cent yield and P uptake were calculated. Soils containing high P produced higher percent grain yield indicating efficient utilization of applied P in low P soils than in medium and high P soils. Percent wheat yield showed significant correlation with P extracted by Solutions A, B, C, and D. The highest correlation coefficient values were observed between P in Solution A and percent wheat grain yield (r = 0.915), and percent P uptake (r = 0.894). The scatter diagram showed that the critical level of soil P was 28 Kg ha⁻¹, according to Solution A, and this extractant was considered most suitable for estimating available P in the swell–shrink soils of India.

**EFFECT OF SOIL USE AND AGRICULTURAL PRACTICES ON HEAVY METAL LEVELS IN SURFACE WATERS.** Teresa Taboada, Antonio Diéguez, Mercedes Taboada, and Antonio Paz. Facultad de Ciencias, Universidad de A Coruña, A Zapateira, 15071 A Coruña, Spain. Fax: 34 98 1167065; E-mail: teresat@udc.es

Dissolved Cu, Zn, Mn and Fe in surface waters of a small catchment (NW Spain) during 3 different periods of soil use and/or agricultural practices were determined. The aim of this study was to determine the influence of these factors on the soluble fraction of these metals in waters. These periods were characterized as: (1) agricultural catchment with application of slurries (bovine and porcine), mostly by means of cistern, (2) grassland and cultivated lands with massive contributions of slurries at the uppermost part of the catchment, and (3) forest land with no slurry application. Of the metals studied, Mn had the highest mean concentration (150 mg L⁻¹), ranging between 1.5 and 680 mg L⁻¹. Concentration of Fe ranged between 7 and 374 mg L⁻¹, Zn between 3 and 164.3 mg L⁻¹, and Cu between 1 and 121.6 mg L⁻¹. The soluble fraction of these metals permitted us to chemically differentiate between the three periods. Generally, highest concentrations of Cu and Mn in the waters appeared during the second period, which was related to slurry application and to solubilization of soil Mn and Cu. The distribution of Fe and Zn is not as clearly associated with slurry application.

**COMPARISON AND CO-OPERATION IN QUALITY CONTROL IN SOIL ANALYSIS: WEPAL, AGRILASA.** J.A.J. van Vuuren¹ and D. van Dijk². ¹Central Analytical Laboratories, Pty Ltd. Head Office, Building P3100,
ABSTRACTS

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Two acid soil samples from South Africa were sent to Wageningen. WEPAL took care of milling, homogenisation and splitting of the samples using their specialized equipment. Homogeneity tests were also performed. The one a buffered soil from Natal and the other an unbuffered soil from Pretoria University’s research farm. The unbuffered soil was sent through both WEPAL and AgriLASA’s proficiency schemes. A comparison of the two systems regarding analyses and statistical reporting is given. South Africa has gone a long way in standardization of methodology as well as extractants used. On the normal standard analyses e.g. pH, P (Bray-), Ammonium acetate Ca, Mg, K and Na there are sufficient laboratories reporting in order to do meaningful statistical analysis. On the other types of analysis, which are not frequently done e.g. micro nutrients, CEC, other extractants for P and Cations, the need exist to be able to compare with more laboratories. This is now possible where samples are sent through both schemes.

FARMING WITH ACIDITY. Malcolm E. Sumner¹ and Tsuioshi Yamada².
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In many parts of the world, soils have been limed to a particular target pH (H2O) of 6.5–7.0, according to the crop. Because plants do not directly respond to the activity of H⁺, it is pertinent to enquire why this approach to liming has enjoyed such widespread popularity. Among the reasons, the original near-neutral pH of many of the soils was no doubt a consideration and the use of acid-sensitive legumes to supply N in rotations, in the early stages of agricultural development, also played a part. The introduction of the pH meter, at about the same time as N fertilizers replaced legumes, facilitated the measurement of acidity and removed the focus from the real problems of soil acidity, namely, toxic levels of Al³⁺ and Mn²⁺ and deficiencies of nutrients such as Ca, Mg and MO. Even after legumes disappeared from the rotations, the high target pHs were retained. Liming experiments throughout the world reveal that, with very few exceptions, all crops including legumes
cease to respond to lime above pH (H₂O) = 5.5–5.8 provided that the factors (Ca, Mg, Mo, B, P, etc.) negatively impacted by soil acidity are optimized. In fact, on highly weathered soils, liming to near neutrality can have disastrous effects on yields of many crops. Many examples are presented as illustrations of the few benefits accruing to liming to neutrality and the many benefits of farming with levels of acidity somewhat more intense than has normally been the case. Among the latter benefits are increased profitability from higher nutrient efficiencies, reduced diseases and pests, slower nitrification with less pollution, improved soil tilth, and improved availability of many metals and P.

SOIL FERTILITY AND MANAGEMENT OF ACID COASTAL PLAIN SOILS FOR CROP PRODUCTION. Vincent A. Haby. Texas Agricultural Experiment Station, The Texas A&M University System, P.O. Box 200, Overton, TX, USA 75684. Fax: (903) 834-7140; E-mail: v-haby@tamu.edu

Management of soil acidity is the key to successful crop production on Coastal Plain Ultisols of the southern USA. Grasses and legumes are the primary crops grown on these sandy, acid, infertile, and leached soils. The dominant grasses are hybrid bermudagrasses (Cynodon dactylon) and annual ryegrasses (Lolium multiflorum). Bermudagrasses are tolerant to moderate levels of acidity and respond to N, P, and K fertilization. Ryegrasses respond to limestone, N, and P. High rates of N applied for grass production rapidly increase soil acidity on these low-buffer-capacity soils. Adjustment of soil pH is efficiently accomplished by application and incorporation of high effective calcium carbonate equivalence (ECCE) limestone. Research verified the improvement in P use efficiency and crop production as the pH of strongly acid soils was raised. Efficiency of fertilizer P for increasing soil test P was improved 38% by elevating soil pH from 4.5 to 6.2 in a Lilbert fine sandy loam (loamy, siliceous, thermic Arenic Plinthic Paleudults). Forage legume crops respond favorably to P, K, and B on limed Ultisols. Lime applied to strongly acid soils increased alfalfa yields greater than 6.2 t ha⁻¹. The critical 0–15 cm soil test P level is 20-mg Kg⁻¹ for alfalfa (Medicago sativa) using the NH₄OAc–EDTA extractant on several limed Coastal Plain soils. Estimated response to applied B was 3.9 t ha⁻¹ and was economical to 4.2 Kg ha⁻¹. As the level of soil B measured in the 5 to 15 cm depth increased from 0.3 to 0.7 mg Kg⁻¹, alfalfa production was raised an estimated 9 t ha⁻¹.
COMPARISON OF THE EFFECT OF EQUIVALENT NUTRIENTS GIVEN IN THE FORM OF FARMYARD MANURE OR FERTILIZERS IN HUNGARIAN LONG-TERM FIELD TRIALS. Tamás Árendás¹ and Péter Csathó². ¹Agricultural Research Institute of the Hungarian Academy of Sciences, H-2462 Martonvásár, Brunszvik u.2. Hungary. Fax: 36 22 569 556; E-mail: arendast@kukorica.mgki.hu; ²Research Institute for Soil Science and Agricultural Chemistry of the Hungarian Academy of Sciences, H-1022 Budapest, Herman O. út 15, Hungary.

The database of Hungarian field trials to compare the effects of farmyard manure and mineral fertilizers on the basis of NPK nutrient equivalence was compiled for the years 1955–1975. Among the various treatments, the yields of the absolute control, the farmyard manured treatment and the one with equivalent amounts of NPK in the form of mineral fertilizer were evaluated. In the experiments, grouped according to their soil texture—with the exception of extremely clayey soils, annual fertilization was more favourable in all cases than periodic manure application. Differences between yield surplus obtained per Kg of nutrient declined with increase of soil clay content. The efficiency of fertilization in both farmyard manured and fertilized treatments was the greatest on sandy soils, which have the poorest natural nutrient supplying capacity. The correlation between the changes in the organic matter (OM) content of control plots of the long-term field trials, and differences or ratio of the responses to farmyard manure (FYM) and fertilizer (FER), could be described by hyperbolic functions, using the data set of the 37 Hungarian long-term field trials found in the literature. A similar correlation was established between the ammonium lactate (AL)-soluble K contents and differences or ratio of the responses to farmyard manure (FYM) and fertilizer (FER). It was found that as the values of these two soil parameters rose, the advantage of the nutrients given in the form of fertilizer over farmyard manure declined. In the experiments reported, no correlation could be found between the AL-soluble P content and the yield differences.

DTPA AND MEHLICH-3 MICRONUTRIENT EXTRACTABILITY IN NATURAL SOILS. R. Caridad Cancela¹, C.A. Abreu², and A. Paz-González¹. ¹Facultad de Ciencias, Universidad de La Coruña, Campus de la Zapateira s/n, 15071 A Coruña, Spain. Fax: 34 981 167065; E-mail: rakel@mail2.udc.es; ²Centro de Solos e Recursos Agroambientais, Instituto Agronómico, Caixa Postal 28, 13001-970 Campinas (SP), Brazil.

Most soils of the humid area in the Iberian Peninsula are characterized by desaturated superficial organic-rich material developed under acid conditions. In
this study, micronutrients (Cu, Fe, Mn and Zn) were extracted using DTPA and Mehlich-3 and determined by ICP-AES. Seven natural soil profiles, representing major acid soil types and developed over a wide variety of parent materials, were collected. The pH range of this acid set of samples was between 4.47 and 6.79. Furthermore, three soil profiles containing carbonates and/or a high base saturation were also analyzed. The organic matter content of the samples as a whole ranged between 0.37 and 26.51%. For the acid set of samples, Mehlich-3 extractable concentrations of Cu, Fe, Mn and Zn were higher than contents released by DTPA. However, DTPA solution extracted higher concentrations of Cu, Fe and Mn than Mehlich-3 solution in soil samples with carbonates. When considering the acid set of samples, strong correlations were found between contents extracted by DTPA and Mehlich-3 solutions for Fe, Mn and Zn, in the range 0.85–0.97. However, taking into account acid and non-acid samples altogether, the correlation coefficients between micronutrients extracted by both solutions were not strong, except for Fe. This indicates a different response in availability between acid and non-acid soils. Interactions between micronutrient extractability, pH and organic matter content were evaluated. In all the natural soil profiles studied, surface horizons released more micronutrients than subsoil horizons.

AIR-FILLED POROSITY OF GOLF GREEN SAND MIXES. She-Kong Chong¹, Richard Boniak¹, and Chang-Ho Ok². ¹Plant, Soil and General Agriculture Department, Southern Illinois University Carbondale (SIUC) Carbondale, IL, USA 62901-4415. ²Department of Horticulture, University of Missouri, Columbia, MO, USA 6521 1-0001.

The air-filled porosity of sand mixes for greens as recommended by the United States Golf Association (USGA) is calculated from the difference between total porosity and water content retained in soil cores at 40 cm tension. However, the reason for using 40-cm tension was not explained in the recommendation. Recently, some researchers suggested measurement at 30 cm tension. The objective of this study was to determine the appropriate tension for the measurement. In the study, sand mixes amended with various organic amendments were tested. Each sand mix was packed in a core (7.9 cm in diameter and 10 cm long) with three replications following the USGA recommendation. Water retention characteristic of each core was measured using the hanging water column method. Results indicated that little water was released from the soil cores at 10 cm tension, but an abrupt drop in the retention curve occurred between tensions at 20 and 30 cm. As tension
increased to 40 cm or higher, water that retained in the soil core remained nearly unchanged. For all the soil cores, drainage completely ceased from 70 to 100 cm tension. The decreases in hydraulic conductivity and drainage at higher tensions indicated that water movement in the soil cores approached its steady condition at 40 cm tension. A Duncan Multiple Range Test revealed that the amount of water at 30 cm tension was not significantly different from water content at 40 cm tension. However, there was a significant difference for water contents between 40 and 50 cm tension. Therefore, it was concluded that using 40 cm tension for measuring sand mix air-filled porosity is reasonable.

EFFECTS OF MODES AND LEVELS OF MOLYBDENUM APPLICATION ON GRAIN YIELD PROTEIN CONTENT AND NODULATION OF CHICKPEA GROWN ON A LOAMY SAND SOIL. Chandra Deo and M.L. Kothari. Department of Soil Science and Agricultural Chemistry, Agricultural Research Station Durgapura, Jaipur 302018, Rajasthan, India. Fax: 91 141 550229; E-mail: ars-ipr@raj.nic.in

A field experiment was laid out during three consecutive years from 1997–98 to 1999–2000 on a loamy sand soil (typic ustipsamment) of the state of Rajasthan in India during rabi season to investigate the effects of modes of application and different levels of molybdenum on grain yield, protein content and number of nodules per plant of chickpea (Cicer arietinum L.; Variety RSG-44). Doses of Mo applied were: 0.5, 1.0 and 1.5 Kg ha$^{-1}$ as ammonium molybdate for soil application and 1.75, 3.5 and 5.25 g kg$^{-1}$ seed as sodium molybdate for seed treatment. The six treatments with one control were replicated thrice in a randomised block design. The physico-chemical characteristics of the soil were: pH 8.1, EC 0.11 dsm$^{-1}$ and organic carbon 0.12%. Available N, P$_2$O$_5$ and K$_2$O were 158, 45, 160 Kg ha$^{-1}$ respectively. The Mo status of soil was 0.06 mg Kg$^{-1}$.

Three years pooled data revealed that application of Mo either by soil application or through seed treatment has significantly increased the grain yield of chickpea. Soil application of 1.0 Kg Mo ha$^{-1}$ and seed treatment of 3.5 g sodium molybdate Kg$^{-1}$ seed increased the grain yield by 13.13 and 16.76% over their lower-dose yields (24.44 and 24.52 q ha$^{-1}$) respectively and it was at par with the yields at higher doses of Mo. Protein content of grain, number of nodules per plant and available nitrogen in soil also increased with the increasing doses of Mo under both modes of application.
ZINC SORPTION BY KAOLINITE: INFLUENCE OF PH, ELECTROLYTE AND INITIAL ZN CONCENTRATIONS WITH SIMULTANEOUS RELEASE OF MG, CA, MN, AND CU IONS. A. Dimirkou¹, A. Ioannou², and P. Papadopoulos¹. ¹National Agricultural Research Foundation, Institute of Soil Science, 1 Sof. Venizelou St. 14123, Lykovrisi, Attiki, Greece. ²Department of Chemistry, University of Athens, Zografou, 15711, Athens, Greece; Postal address of the corresponding author: A. Dimirkou, 14 Thermopilon St. 15351, Pallini, Attiki, Greece. Fax: 16031120; E-mail: aioannou@cc.uoa.gr

Sorption of Zn by kaolinite, and the simultaneous release of Mg, Ca, Mn, and Cu during the sorption process were studied. Experiments were carried out, using five initial Zn concentrations (from $4.05 \times 10^{-2}$ to $5.17 \times 10^{-4}$ M Zn) in the presence of $10^{-2}$ and $10^{-3}$ M KNO₃, at different pH values between 3.5 to 8.5. Generally, the results showed an increase in Zn sorption as pH and initial Zn concentrations increased, with a simultaneous decrease in electrolyte concentration. The sorption of Zn followed Langmuir equation better at pH 4.5 and 7.5 in the presence of $10^{-2}$ and $10^{-3}$ M KNO₃, at different pH values between 3.5 to 8.5. At constant initial Zn concentration, as pH and molarity of the Zn solution increased, there was a decrease in the amount of Mg, Ca, Mn, and Cu released. When the initial concentration increased, between pH values 4.0 and 8.0 and with constant KNO₃ concentration ($10^{-3}$ M), there was an overall increase in ion concentration (Mg, Ca, Mn, and Cu). In the presence of $10^{-2}$ M KNO₃ and between pH 4.0 and 8.0, Zn sorption influenced, differentially, adsorption and desorption of Mg, Ca, Mn, and Cu. These observations should be taken into account when plant availability of these ions is studied.

THE SOIL ACIDITY IN AND HEALTH CONDITION OF CONIFEROUS FOREST PLANTATIONS IN THE WESTERN BALKAN MOUNTAINS IN BULGARIA. Vania Doichinova. Forest Research Institute, Blvd. Sv. Kliment Ohridski, No 1321756 Sofia, Bulgaria. E-mail: vdoichinova@hotmail.com

This article presents preliminary results of studying the changes in soil acidity caused by pollution of different kinds, and considers the influences of these changes upon the growth and development of forest plantations of different
species in the Western Balkan Mountains, the longest range on the Balkan Peninsula. The sample plots are near industrial centers. The changes in the texture and physical properties of the soils have been followed, and the general chemical characterization has been made with respect to acidity, organic-matter contents, and macro- and trace-element concentrations. Changes of acidity status and Zn, Cu and Pb pollution of the sample plot soils were observed. General comprehensive assessment of the tree species health condition has been made on the basis of defoliation, and change in the color of the needles in tree crowns. Changes of the state of the tree crowns were observed, which correlate with the data on the chemical soil analyses for the availability of heavy metal pollution related to the alkaline or acidic response of the different sample plots soils.

THE EFFECT OF TILLAGE AND LIME RATE ON SOIL ACIDITY AND GRAIN YIELDS OF A CORN–SOYBEAN ROTATION. S. A. Ebelhar1, E. C. Varsa2, and A. H. Anderson3. 1Department of Crop Sciences, University of Illinois, Dixon Springs Agricultural Center, Route 1, Box 256, Simpson, IL, USA 62985-9615. Fax: (618) 695-2492; E-mail: sebelhar@uiuc.edu; 2Department of Plant, Soil and General Agriculture, Southern Illinois University, Carbondale, IL, USA 62901-4415. Fax: (618) 453-7457; E-mail: evars@siu.edu; 3Department of Crop Sciences, University of Illinois, Brownstown Agronomy Research Center, Brownstown, IL, USA 62418. Fax: (618) 427-3650; E-mail: ahanders@uiuc.edu

Modern tillage systems, such as reduced tillage and no-tillage systems, provide shallow incorporation of surface applied materials at best. Because of concern of over-liming the surface few cm depth of agricultural soils, producers either reduce lime rates (and apply more often) or perform some sort of soil inversion to mix the lime deeper into the soil profile. The objective of this field study was to evaluate the effects of tillage, lime rate and time of limestone application on corn and soybean growth, and assess the changes in soil acidity to an already acidic soil. Treatments consisted of a no lime check, two no-tillage systems with either a 4.5 t ha\(^{-1}\) lime application every two years or an annual application of 450 Kg pelleted lime ha\(^{-1}\), a continuous annual chisel tillage system with a 9.0 t ha\(^{-1}\) lime application every four years, and two inversion systems utilizing a Howard Rotovator where 9.0 t lime ha\(^{-1}\) was mixed into the soil followed by either continuous chisel tillage or continuous no-tillage. Soil samples were collected annually in increments of 5 cm to a 30 cm depth for pH determinations. The inversion of the soil the initial year resulted in reduced corn grain due to reduced
moisture conservation compared to the no-tillage systems. The continuous chisel system increased soil pH in the top 10 cm and had grain yields comparable to the no-tillage system. The no-tillage system had only a slight increase in pH in the surface 5 cm of soil. The inversion treatments mixed the lime more thoroughly in the top 15 cm which diluted the lime effect on soil acidity and pH changes in the surface were less than with chisel tillage but to a deeper depth. The pelleted lime had no effect on soil acidity.

LIMESTONE QUALITY AND EFFECTIVENESS FOR NEUTRALIZING SOIL ACIDITY. V. A. Haby, A. T. Leonard, and M. L. McFarland. Texas Agricultural Experiment Station, P.O. Box 200, Overton, TX, USA 75684. Fax: (903) 834-7140; E-mail: v-haby@tamu.edu

Slow reactivity of coarse-grade limestone surface applied on soils established to perennial grass meadows led to studies of the effectiveness of finer-ground limestone. Limestone is analyzed for neutralizing value or calcium carbonate equivalence (CCE) and screened to determine particle-size ranges. The efficiency factor for each particle-size range multiplied by the percentage of limestone in each range gives an efficiency rating. The sum of efficiency ratings multiplied by CCE describes the effective calcium carbonate equivalence (ECCE) that can range from <30% to >100%. Research verified the greater efficiency of ECCE 100% limestone compared to ECCE 62% for forage legume production. Four years after application, annual ryegrass yields were similar for the ECCE 62% and 100% lime treatments. Seven years after application, the ECCE 100% limestone, averaged over rates, maintained soil pH 0.3 unit above pH due to ECCE 62% limestone. At this same sampling time, soil pH due to application of 6.7 Mg of ECCE 100% limestone ha⁻¹ maintained soil pH only 0.18 unit lower than pH due to 13.5 Mg of ECCE 62% limestone. We propose calculation of the effective liming material (ELM) in each Mg or short ton of limestone where

\[
ELM = (ECCE \% \div 100) \times 1000 \text{ kg Mg}^{-1} \quad \text{or} \quad (ECCE \% \div 100) \times 2000 \text{ lb ton}^{-1}.
\]

More simply, ELM may be computed as ECCE % × 10 for kg Mg⁻¹ and ECCE % × 20 for lb ton⁻¹. Limestone with an ECCE of 62% would have 620 kg of ELM Mg⁻¹ or 1240 lb of ELM ton⁻¹. The ECCE 62% limestone would contain 380 kg or 760 lb of relatively ineffective limestone per Mg or short ton, respectively. Publication of ELM enables consumers to easily determine the purchase value of limestone.
GROWTH AND YIELD OF A PINEAPPLE CV. JOSAPINE ON SANDY TIN TAILINGS. M.M. Hanafi and A. Halimah. Department of Land Management, Faculty of Agriculture, 43400 UPM, Serdang, Selangor, Malaysia. Fax: 603 89434419; E-mail: mmhanafi@agri.upm.edu.my

The physical and chemical properties of sandy tin tailings are unsuitable for agriculture without proper fertilizer and crop management practices. Malaysia has a vast area (200,000 ha) of abandoned barren sandy tailings. An attempt was made to convert these lands to sustainable agricultural production by planting pineapple, using fertilization and irrigation techniques. The objective of the study was to determine the optimum rate of fertilizer for growth and production of pineapple cv. Josapine for consumption. The fertilizers used were prepared from a mixture of N (urea), P₂O₅ (triple superphosphate), K₂O (muriate of potash), CaO (calcium sulfate), MgO (gypsum) and CuSO₄ (copper sulfate), and the respective rates of fertilizers in Kg ha⁻¹ were (i) Plot 1L: 872, 24,400, 108, 24, and 2, (ii) Plot 2L: 750, 48, 266, 84, 36, and 3, and (iii) Plot 3L: 600, 72, 798, 108, 24, and 3.2. The same quantity of Fe, B, Mn, Zn, and Mo was used for each plot, i.e. 0.1, 0.023, 0.0045, 0.0015, and 0.0001 Kg plot⁻¹. There were 32 plants in each sub-unit (for the three classes of ground suckers used—A, B, and C) in each treatment. The plant parameters, soil and plant analyses were determined during this period. There were significant differences (p = 0.01) in plant height, number of leaves, and ‘D’—leaf area for each sub-unit with time. The fruits in sub-unit ‘A’ showed significant (p = 0.05) increase in fruit diameter, fruit length, and total acidity. The highest proportion of biomass was in the leaf (40–50%). The optimum rate of fertilizer used for growth and production of pineapple cv. Josapine on sandy tin tailings was for plot 1L.

MATCHING SPATIAL VARIABILITY OF SOIL ACIDITY WITH VARIABLE RATE LIME APPLICATIONS. S. Haneklaus and E. Schnug. Institute of Plant Nutrition and Soil Science, Federal Agricultural Research Centre, Bundesallee 50, Germany D-38116. E-mail: pb@fal.de

Plant production requires inputs of different origins and most of them are maintained according to certain soil parameters. The variability of soil fertility features together with the uniform treatment of fields causes an inefficient factor utilisation and unnecessary environmental burdens. In case of soil acidity this would imply, for instance, that with a surplus of lime amendments this may cause the immobilization of trace elements such as manganese or zinc in more sandy soil zones and that an under-supply may cause an unfavourable soil structure on
more clayey soil zones. Precision agriculture technologies—DGPS (Differential Global Positioning System), GIS (Geographical Information System) and VRT (Variable Rate Technology)—enable farmers to determine and match the fine-scale variability of soil characteristics for a variable rate application of fertilizers. In this paper, aspects of the spatial variability of soil acidity and new production technologies will be discussed comprehensively.

EVALUATION OF SIDE EFFECTS OF FLUE GAS DESULPHURISATION PRODUCTS. S. Haneklaus, H.M. Paulsen and E. Schnug. Institute of Plant Nutrition and Soil Science, Federal Agricultural Research Centre (FAL), Bundesallee 50, Germany D-38116. E-mail: pb@fal.de

Gypsum from flue gas desulphurisation of German coal-fired power plants is recycled 100% while spray dry absorption (SDA) products are only partly re-utilised. Sulphur fertilisation with these residues may be a suitable form to recycle the released and re-bound fossil plant nutrient sulphur. Further residual lime in the products from the flue gas desulphurisation (FGD) process can add qualities as alkaline amendments to agricultural soils. SDA products contain considerable amounts of Ca bound to SO$_3$, SO$_4$, Cl, F, CO$_3$, O, or OH. The liming potential of the products depends on the basic reaction of Mg and Ca carbonates, oxides and hydroxides while Ca-sulphite and Ca-sulphate do not affect soil pH but contribute to the calcium saturation of clay minerals in soil. Thus soil aggregation is promoted without increasing soil pH which may be an important factor on heavy soils where a high Ca saturation of clay minerals is required for flocculation of soil aggregates and for avoiding an immobilisation of micronutrients induced by too high pH values. Undesired, environmentally relevant elements may accumulate in soils and enhance uptake by plants when SDA products are applied. The heavy metal content of SDA products was proportional to their fly ash content. The Se content of all SDA products is so high that they are not suitable for use on grassland. The paper evaluated FGD products as liming agents and provided a risk assessment of heavy metal contamination.

EFFECT OF MG AND CA ADDITION SUPPLIED IN LIMING AND NON-LIMING MATERIALS ON THE GROWTH OF CAMELLIA JAPONICA GROWN IN AN ACID SOIL, ITS NUTRIENT UPTAKE AND AVAILABILITY. L.S.K. Hettiarachchi$^1$ and A.H. Sinclair$^2$. $^1$Tea
Long-term effects of applying locally mined crushed crystalline dolomitic-limestone, to tea (*Camellia sinensis* L) are being investigated in field trials in Sri Lanka. From these trials, it appeared that an understanding of the roles of both Mg and Ca during liming was necessary to understand the nutrition of the tea plant. A pot experiment was carried out in the glasshouse, to investigate the effect of raising Mg status of soils of differing soil pH and Ca availability using a *Camellia* species, in particular concern to the Sri Lankan tea industry. To address this concern, treatments that supplied Mg and/or Ca in the presence or absence of liming materials were used. Leaves of plants were harvested after 6, 12 and 24 months, and analyzed for P, K, Mg, Ca, S, Al, Mn, Fe, Cu, Zn and B using Inductively Coupled Plasma-Atomic Emission Spectrophotometer. Total N contents were obtained by combusting dried material in a NC analyzer. Soils in the pots were removed and dismantled from the roots lump, determined the soil pH levels and analyzed for exchangeable cations including Al, using 1M ammonium acetate solution at soil pH level and a recently developed mixed resin method. Leaf yield of *Camellia japonica* was unaffected either due to higher Mg and/or Ca levels in soil or due to increased soil pH. *Camellia* plants in preference to Ca took up Mg when Mg and Ca were added. Uptake of K was reduced by the addition of Mg. Increase in soil pH caused a reduction of leaf Al, Mn and B in *Camellia* plants whereas Fe, Zn and Cu concentrations were unaffected. The amounts of soil nutrients extracted with mixed resin and ammonium acetate solution were compared with their uptake by *Camellia* plants. Both methods extracted similar amounts of Mg and Ca but in limed soil the amount of Al taken up by plants was more closely correlated to resin Al values than those in ammonium acetate solution adjusted to soil pH level.

**INFLUENCE OF SOME EDAPHIC FACTORS ON THE TRANSPORT OF SULPHATE IONS TO PLANT ROOTS IN SOILS.** A.S. Josan and M.S. Bajwa. Department of Soils, Punjab Agricultural University, Ludhiana, India.

The objectives of the study were, to 1) evaluate soil and plant parameters that affect the movement of sulphate ions to the roots of oil seed crops that are known to respond to sulphur application, and 2) to compute the net S influx and compare it with measured net S uptake by mustard and rape crops under field and
greenhouse conditions. The measured soil and plant parameters included volumetric soil water content, soil hydraulic conductivity, diffusivity, transpiration rate, porous diffusion coefficient of SO$_4^{2-}$, average macroscopic velocity of water at the root surface, radius of the root, plant root length, concentration of SO$_4^{2-}$–S in soil solution surrounding the root, and plant tissue net S uptake between two successive harvests. These parameters were recorded 40, 70, 100 and 140 days after sowing in mustard, (field) and 30, 50 and 70 days after sowing in rape (field), and 20, 30, 40 and 50 days after sowing in rape (greenhouse) crops. The recorded parameters were affected markedly by sulphur status of the soil, soil water regime, and soil bulk density. A theoretical model based on the assumption that the flux of SO$_4^{2-}$–S in the soil solution surrounding the root was proportional to the concentration of SO$_4^{2-}$–S in the soil surrounding the root was tested. The constant of proportionality relating these two qualities has been considered to be the root uptake coefficient. It decreased with time and/or age of the plant. The predicted uptake and measured net accumulation was highly correlated in all the three crops with coefficient of correlation, as 0.92, 0.93, and 0.94 for mustard (field), rape (field) and rape (greenhouse) crops, respectively.

EFFECT OF SOIL AND VARIETY ON MORPHOLOGICAL AND PHYSICO-CHEMICAL CHARACTERISTICS OF TOMATOES AND CHILLIES. Rajneesh Kalra. Britannia Industries, 16 Jawahar Nagar, PO—Sahamatganj—243005, Bareilly (U.P.) India. Fax: 91 522 438041. E-mail: rajneeshkalra@usa.net, rajneeshkalra@rediffmail.com

In tomatoes and chillies, post-harvest losses are high. Therefore, suitable varieties are used for processing. Five tomato varieties (pant bahar, pusa ruby, pant $T = 3$, pant $T = 4$, and pant $T = 5$) and ten chilli varieties (CA-206, CA-586, DPLC-1, KCS-1, PANT C-1, pusa jwala, selection-1, TC-1, TC-3, and X-235) were screened for processing quality on the basis of their physico-chemical characteristics. Twelve physical and five chemical characteristics of chillies were evaluated. All tomato varieties had a symmetrical shape but their colour and surface appearances were different. Average percentages (on moisture-free basis) of total and reducing sugars, ascorbic acid, lycopene and pectins were 33.82, 3.02, 2.17, 20.6, 1.41, and 0.31 respectively. Total sugar content exhibited negative correlation with ascorbic acid and juice yield. These results showed pusa ruby and pant—5 to be good for processing. The mean length and diameter of ten chilli varieties were 3.74 and 1.02 cm, respectively. Mean percentages (on moisture-free basis) of protein, ash, total and reducing sugars, ascorbic acid, and
tannin were 15.86, 11.48, 7.83, 3.04, 54.6, and 0.48, respectively. A positive correlation existed between ascorbic acid and tannin content. ASTA colour value (9.0–17.5) and total pigment (29.89–61.46 μg g⁻¹ chilli solids) also varied within varieties. Lycopene, beta-carotene, cryptoxanthin, luteoxanthin, and capsanthin were the important carotenoids affecting the visual colour of chillies. ASTA colour value of chillies increased with lycopene, betacarotene, and cryptoxanthin content but there was no relationship between this colour value and capsanthin content. Capsaicin contents (0.12–0.35%) was negatively correlated with capsanthin and positively correlated with tannins and sugars.

WATER RETENTION CHARACTERISTICS OF SOME COTTON GROWING SOILS OF NORTH WEST INDIA. M.S. Kuhad, R.R. Dahiya, and K.S. Grewal. Department of Soil Science, CCS Haryana Agriculture University, Hisar, India 125004. Fax: 91 1662 34613; E-mail: mskuhad@lycos.com

Studies on water retention characteristics of eleven pedons representing cotton growing areas of north-west India were carried out. The studied soils were classified as Typic Ustorthents, Typic Camborthids and Typic Ustipsamments. The Typic Ustipsamments were having more moisture content in their horizons as compare to other great groups. The results indicated that the variations in moisture retention and available storage capacity were associated with changes in texture. The amount and nature of clay was also found to influence the moisture retention properties of soils at all the tensions. The cation exchange capacity, clay, silt, organic carbon and exchangeable Mg and Na had significant positive relationship with the available water content and also with the water retained at 0.03 and 1.5 MPa, while the sand had shown negative correlation with all the four parameters studied.

A SIMPLIFIED APPROACH TO LIMING AND ITS EVALUATION. Jiri Matula. Research Institute of Crop Production, Drnovska Rd 507, 161 06 Prague 6—Ruzyné, Czech Republic. Fax: 42 2 33310636; E-mail: matula@hb.vurv.cz

Liming requirement is based on determination of soil acidity, CEC, buffering capacity, depth, bulk density and texture. To evaluate a liming model function, 15-week incubation experiments with differentiated doses of CaCO₃ and CaO
(equivalents of 1.5 to 9 t ha\(^{-1}\) CaCO\(_3\)) were carried out on seven soils with naturally low pH. The goal of these observations was to determine changes in soil acidity (\(pH (H_2O)\), 0.01 M CaCl\(_2\), 0.2 M KCl and 1 M KCl), concentrations of extractable aluminium, accumulation of mineral nitrogen forms (NH\(_4^+\) and NO\(_3^-\)), organic solutes in soil, and availability of nutrients from the soil, using test plants (barley and mustard). The liming doses providing for the lower suitable pH value were fully sufficient with respect to the appropriate depression of aluminium. Liming also considerably decreased manganese availability, but not below the limit of induction of Mn-deficiency. There was a large depression of boron availability in all soils when low liming doses below the lower pH value were applied; it increased the level of its common deficit in some soils. Liming exceeding the suitable pH range was connected with an increase in nitrification, which was especially high in soils with extremely low starting pH values.

Rice growth in wetlands or paddy soils is economically important in Latin America, where lime amendment is becoming a conventional practice. A field study was conducted to compare changes induced by liming a rice soil in Corrientes (Argentina). Three different treatments were used: control (with no lime addition) and two applications of dolomite at rates of 625 kg ha\(^{-1}\) and 1250 kg ha\(^{-1}\). Physico-chemical parameters (Eh, pH) and nutrients (NH\(_4^+\)-N, Olsen-P, and extractable Mn and Fe) were measured just before flooding and during a ten week period after flooding. At the beginning of the study, pH varied between 4.0 and 4.4 and in all the treatments a sharp pH rise was observed from week two to week four after inundation. These initial differences in pH between the control plot and plots amended with dolomite vanished at the end of the ten week period, when pH conditions were near neutrality. Before flooding, high NH\(_4^+\)-N differences between treatments were obtained; during anaerobiosis the trend was to increase the low initial NH\(_4^+\)-H level of the control plot, whereas the high initial level in the amended plots decreased during waterlogging. Olsen-P was also initially higher in the amended plots than in the control plot and after flooding no unique trend was observed in the three treatments. Concentration of Mn and Fe increased as the
IMPROVING THE MICRONUTRIENT AVAILABILITY IN CALCAREOUS SOILS BY SEWAGE SLUDGE AMENDMENT. R. Moral, J. Moreno-Caselles, M.D. Perez-Murcia, and A. Perez-Espinosa. Department of Agrochemistry and Environment, Miguel Hernandez University, EPS-Orihuela, Ctra Beniel Km 3.2, 03312—Orihuela (Alicante), Spain. Fax: 96 6749655; E-mail: raul.moral@umh.es

The pollution associated with the presence of heavy metals in sewage sludges is a hazard. Elements that may be essential for plants are sometimes present in toxic quantities. However, calcareous soils are deficient in elements like Fe and Zn. In this experiment, we analyzed the contribution of sewage sludge application to the input and availability of Fe, Mn, Cu and Zn in amended soils. In order to study the dynamics of these essential elements, the experimental design was based on incubation of two calcareous soils with different textures (loamy and sandy soils), after amendment with composted and non-composted sewage sludges. Sewage sludge applications to soils were 30 and 50 g Kg\(^{-1}\) soil. Each set of treatments included a control treatment with no organic amendment. Seven samples were taken periodically (0, 15, 30, 60, 90, 120 and 150 days). A significant increment of available Fe, Cu, Mn and Zn was observed. The influence of soil texture was negligible. Availability of Fe, Cu, Mn and Zn increased throughout the incubation period. This fact indicates that mineralization of the organic material in the soil could mobilize trace elements.

NUTRIENT VALUE OF ANIMAL MANURES IN FRONT OF ENVIRONMENTAL HAZARDS. J. Moreno-Caselles, R. Moral, M.D. Perez-Murcia, A. Perez-Espinosa, and B. Rufete. Department of Agrochemistry and Environment, Miguel Hernandez University, EPS-Orihuela, Ctra Beniel Km 3.2, 03312—Orihuela (Alicante), Spain. Fax: 96 6749655. E-mail: raul.moral@umh.es

Animal manure application to soils in arid and semiarid areas was a traditional source of nutrients and organic matter for soil–plant systems but the scarcity of these biosolids in the second part of the century reduced their use in the Southeast of Spain. But now, the increasing number of industrial farms without soil nearby
represents a new opportunity to reuse these materials for agricultural purposes. However, a certain risk of contamination exists in incorporating this type of residual in soils because there are diverse components that make them potentially dangerous for the environment and humans. In this experiment, 48 different types of manure (from horse, cow, calf, pig, sheep, goat, rabbit, chicken, ostrich, turkey and earthworm) were evaluated for total nutrient content, especially N and P, and physical, chemical and biological properties. Salt content and the presence of the heavy metals Cd, Ni, Pb, Cr, and Hg as main environmental hazards for agricultural soils were also monitored.

MICRONUTRIENTS RELEASED FROM SLAG IN HAPLORTHOX SOIL. Renato M. Prado¹, William Natale¹, and Francisco M. Fernandes². ¹Departamento de Solos e Adubos, Universidade Estadual Paulista, FCAV, Jaboticabal, São Paulo, Brazil. E-mail: rmprado@fcav.unesp.br; ²Departamento de Ciência do Solo e Engenharia Rural, Universidade Estadual Paulista, FEIS, Ilha Solteira, São Paulo, Brazil. E-mail: maximino@agr.feis.unesp.br

Basic metallurgical slag is predominantly a mixture of Ca and Mg silicates, but it also contains other nutrient elements such as P, S and K. It can be used as a soil amendment in correcting acidity as well as a fertilizer. With the objective of evaluating the slag application on a cultivated sugar cane Haplorthox soil, a field experiment was conducted between December 1997 and January 2000. Slag (at levels of 0, 3.0, 6.1, and 9.3 t ha⁻¹ and CaCO₃ at 0, 1.23, 2.52, and 3.80 t ha⁻¹) were incorporated in the 0–20 cm layer of the soil. The micronutrients Fe, Mn, Cu, Zn and B in soil were determined at 12 and 24 months. The application of slag increased residual levels of Fe, Mn, Cu, Zn and B in soil were determined at 12 and 24 months. The application of slag increased residual levels of Fe, Mn, Cu, B and Zn in the soil. The concentration of Fe, Mn, Cu and Zn in the soil showed a quadratic response to slag rate, whereas B concentration increased linearly. Except for Fe, the quadratic response was associated with pH and base saturation of 6.0 and 72%, respectively. In using the slag to correct soil acidity and supply micronutrients, base saturation of the soil may approach 70–80%.

THE MECHANISM OF OSCILLATORY TRANSPORT PROCESSES AT THE INTERFACE BETWEEN TWO PHASES: MAIZE ROOT-EXTERNAL SOLUTION. C. Radenovic, Z. Jovanovic, and M. Veskovic. Maize Research Institute, Zemun Polje, Belgrade, Yugoslavia.
The excitation of maize root occur under unfavorable conditions, i.e., with the pre-stress state. The root with such a state does not perform transport functions with common processes of passive and active mechanisms. Furthermore, intensity, direction and kinetics of transport processes are modified under such conditions. In order to prove the above stated hypothesis we have measured oscillations of the membrane potential. These observations indicated that there were several classes of oscillations of the membrane potential, within which, single impulses and, in certain cases, local impulses were registered. The analysis of oscillations of the membrane potential and single impulses reveals information on a mechanism of oscillatory transport processes at the interface between two phases: maize root-external solution.

ACTUAL AND POTENTIAL PYRITIC ACIDITY OF NSW CANELANDS. George E. Rayment. 1CRC for Sustainable Sugar Production and Department of Natural Resources, 80 Meiers Road Indooroopilly, Queensland, Australia 4068. Fax: 61 7 38969622; E-mail: George.Rayment@dnr.qld.gov.au

A peroxide oxidation combined acidity and sulfate method (POCAS test) for confirming actual and potential acidity of acid sulfate soils (ASS) has national endorsement in Australia. Analytical outputs include total actual acidity (TAA), and sulfate–S (% SCI). Outputs following treatment of the soil with hydrogen peroxide include total potential acidity (TPA) and total potential sulfate–S (% Sox). All can be expressed as moles H⁺ t⁻¹. This paper reports POCAS test results from an interactive, 1996–1999 survey of low-lying areas of 446 NSW cane farms (soil profile depths of 0.25, 0.25–0.5, 0.5–0.8, 0.8–1.2, 1.2–1.5 m). The survey covered the Condong, Broadwater and Harwood mill regions. The grand median level of TAA at Condong (independent of depth) was 2.96 moles H⁺ t⁻¹ almost three times higher than the grand median for Broadwater (1.04 moles H⁺ t⁻¹) and over six times higher than the grand median for Harwood (0.46 moles H⁺ t⁻¹). Corresponding grand median levels of TPA were highest at Condong (9.24 moles H⁺ t⁻¹). This was around 2.1 and 3.9 times higher than at Broadwater and Harwood. The difference between TAA and corresponding TPA values, expressed as a percentage of TPA, increased with increasing profile depth, particularly beyond 0.8 m. At 0.25–0.5 m, the percentage differences were 45, 56 and 60 for Condong, Broadwater and Harwood, respectively. Corresponding percentages at 1.2–1.5 m were 98, 96 and 98. The data for SCI and Sox confirmed the presence of a considerable potential
ASS hazard below 0.8 m relative to soil-profile segments nearer the surface. Implications for the management of ASS in the region are discussed.

STUDIES ON THE PHOSPHORUS DYNAMICS IN POT EXPERIMENTS WITH DIFFERENT SOIL TYPES. K. Sardi¹ and P. Csathó². ¹Veszprém University, Georgikon Faculty, Keszthely, Deák F. str 16, H-8361, Keszthely, Hungary. E-mail: sardi@georgikon.hu; ²Research Institute for Soil Science and Agricultural Chemistry, Herman O. Str. 15, H-1022 Budapest, Hungary.

Effectiveness of residual and freshly applied phosphorus fertilizers was studied in pot experiments, using soil from long-term trials involving 9 sites, and differing in pH, texture, organic matter content, and P status. Soil samples were taken after 20 years from the unfertilized controls, and from plots annually fertilized with P₂O₅ at 200 kg ha⁻¹. Effects of long-term fertilization as well as that of freshly applied phosphorus were studied in our experiments. Perennial ryegrass (Lolium perenne L.) was used as a test plant. Amounts of P removed by plants during 5 cuts were correlated with dry matter (DM) production of plants as well as with the available phosphorus extracted at pH 3.7 by ammonium lactate. Highly significant differences were found between DM production of plants in unfertilized controls and fertilized plots. Good correlations were found between DM production of plants and amounts of P taken up by plants during the five cuts. Among soils, correlation coefficients ranged between 0.911 and 0.64, and similar tendencies were observed for relationships between soil-P and P uptake by plants (r = 0.906 and 0.597). Differences in correlation were related mainly to soil pH and texture. Residual soil P influenced the effects of freshly applied P.

ACID SOILS OF LOWER AND MIDDLE HIMALAYAS. Avdhesh K. Sharma¹, H.N. Singh¹, and J.R. Murthy². ¹Department of Agrometeorology and Soil Science, G.B. Pant University of Agriculture & Technology, Pantnagar—263 145, Uttaranchal, India. Fax: 915944 33473; E-mail: ag@gbpuat.ernet.in; ²National Remote Sensing Agency, Balanagar, Hyderabad A.P., India.

Twenty four representative pedons of acid soils under cultivated, grazing and forest lands of the lower and middle Himalayan region in north west India were studied for their characteristics and classification according to USDA Soil Taxonomy. Cultivated soils (six) were located between 1,050 and 2,100 M
elevation on 2 to 47% slopes, the grazing land soils (six) were between 850 and 2,100 M elevation on 1.75 to 58% slopes, and the forest soils (twelve) were between 1,525 and 2,075 M elevation on 25 to 70% slopes. The cultivated soils under poorly managed terraces were shallow to deep (45 to 68 cm), while those on well managed terraces were deep to very deep (72 to 105 cm). All the soils were coarse textured and weakly developed. They were low in CEC and exchangeable bases and were acidic in reaction. All were high in organic matter content except those on poorly maintained terraces. Soils on poorly managed terraces were classified as Typic Dystrudepts and Typic Udorthents while those of well managed terraces were classified as Typic Argiuudolls, Ultic Hapludalfs and Typic Eutrudepts. The grazing lands were shallow to deep (22 to 78 cm), coarse textured and weakly developed except one on newly opened grazing lands which was deep, silty loam and well developed. The soils were acidic in reaction, high in organic matter and low in base status. They were classified as Lithic Ustorthents, Udic Ustochrept, and Typic, Aquic and Lithic Dystrochrepts. The forest soils were shallow to very deep (19 to 100 cm) and were well drained. Textures of surface soils were silty loam or silty clay loam while those of subsoil were somewhat heavier being silty clay loam and silty clay. pH of both surface and subsoil were in the slightly acidic to neutral range. The soils were classified as Typic Hapludolls, Lithic Udorthents, Dystric Eutrochrepts and Typic Argiudolls. Generally northern slopes at high altitudes were mollisols.

GROWTH AND YIELD OF CYMBOPOGON MARTINII AS INFLUENCED BY FLY ASH, AM FUNGI INOCULATION AND FARMYARD MANURE APPLICATION. Mahaveer P. Sharma, Tanu Kaur, and Alok Adholeya. Centre for mycorrhizal research, Tata Energy Research Institute, Habitat Place Lodhi Road, New Delhi—110003, India.

An experiment was conducted in a fly ash pond to study the effect of fly ash (FA), AM inoculation and farmyard manure (FYM) application on the growth and yield of *Cymbopogon martinii* (Palmarosa grass). The experiment comprised of 6 treatments viz., T1 (FA alone, control), T2 (FYM @10 t ha\(^{-1}\)), T3 (FYM @20 t ha\(^{-1}\)), T4 (FYM @10 t ha\(^{-1}\) and AM), T5 (FYM @20 t ha\(^{-1}\) and AM) and T6 (AM alone). The study evaluated the influence of the various treatments on the absorption of heavy metals (Cr, Co, Ni, Zn, Mn, Fe and Cu) by the plant and its availability in fly ash. A significant difference in the levels of each element was observed for all the treatments tested. The chemical properties of fly ash also altered significantly. Mycorrhiza inoculated and FYM amended treatments produced significantly higher biomass over T1. Amongst the inoculated-amended
treatments (at both the FYM levels), higher biomass yield was recorded over plants grown in T2. However, the yield in inoculated treatments did not differ significantly. AM infectious propagules varied significantly with maximum production in T5.

SODIUM BICARBONATE EXTRACTABLE PHOSPHORUS IN RELATION TO VARIOUS FORMS OF SOIL PHOSPHORUS AND CROP RESPONSE. O.P. Srivastava. Department of Soil Science and Agricultural Chemistry, Institute of Agricultural Science, Banaras Hindu University, Varanasi, India.

In soils belonging to order Entisol, Inceptisol and Vertisol having average values of pH 7.4 and organic carbon 0.52%, available soil phosphorus extracted with sodium bicarbonate (Olsen’s method) was found to be significantly correlated with adsorbed phosphate and aluminium phosphate in linear correlation and with adsorbed phosphate, aluminium phosphate and iron phosphate in multiple correlation. Calcium phosphate, organic phosphorus, pH and clay content did not influence phosphorus availability significantly. Sodium bicarbonate extractable phosphorus correlated well with yield response of paddy and its phosphorus uptake. Critical limits of available phosphorus showing definite yield response under upland and low land conditions of paddy were found to be 12.5 and 9.5 Kg ha$^{-1}$ respectively. Water logging lowered the critical limit. After harvesting of the crop, appreciable reduction was also recorded in adsorbed phosphate aluminium phosphate and iron phosphate contents of soil while calcium phosphate fraction remained almost unchanged.

ACCURATE LIME RECOMMENDATIONS IN SOUTH AFRICAN CONDITIONS. J.H. van der Waals and A.S. Claassens. Department of Plant Production and Soil Science, University of Pretoria, Pretoria, 0001, South Africa. Fax: 27 12 420 3221; E-mail: jvdwaals@postino.up.ac.za, andries.claassens@bioagric.up.ac.za

In a trial to test the bioavailability of certain heavy metals from slags, twelve liming materials (including different slags) were applied at three different rates to an acrisol (pH (water) of 5.2 and CEC of 4 cmol kg$^{-1}$ soil) from the South African Eastern Highveld. Two Ca(OH)$_2$ incubations were done on the specific
soil—one in a soil to solution ratio of 1:1 before the trial and another in a soil to solution ratio of 2:5 on the control treatment soil after the trial. The Calcium Carbonate Equivalent (CCE) in HCl and RH-value (Resin Suspension Method) were determined for each liming material before the trial. After an incubation period of three months, the pH(water) and pH(KCl) of each of the four replicates for every treatment were measured. From the average pH values, an incubation curve and regression equation were derived for each material. Using the CCE in HCl and the RH-values, as well as the values from the two Ca(OH)2 incubations, lime recommendations required for target pH-values of 5.8, 6.8, and 7.8 were modeled. The soil to solution ratio of 2:5 and the RH-value gave an accurate indication of the lime required for the specified targets of 5.8 and 6.8. As expected, all the methods underestimated the lime required for the target of 7.8. The CCE in HCl value overestimated lime reactivity, especially in the case of coarser materials. The RH-value, on the other hand, gave a more accurate indication of the reactivity of the lime throughout.

LONG-TERM TILLAGE AND FERTILITY EFFECTS ON SOIL ACIDIFICATION, ORGANIC MATTER AND NUTRIENT DISTRIBUTION, AND CROP RESPONSE.

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A continuous experiment has been conducted since 1970 in southern Illinois to determine the long term effects of fertilizer application and tillage practices on soil acidity, organic matter and nutrient distribution, and crop responses. Four tillage treatments were evaluated: continuous conventional; alternate till (two years no-till: one year conventional); continuous chisel till; and continuous no-till. Five fertilizer treatments were also evaluated (kg ha\(^{-1}\) N–P–K): control, 0–0–0; 196–0–0 broadcast; 180–0–0 broadcast plus 16–39–100 row banded at planting; 196–39–167 broadcast; and 180–24–139 broadcast 16–15–28 row banded at planting. From 1970 to 1990 the fertilizer treatments were applied annually to continuous corn. During the final 10 years, the fertilizers were applied only in alternating years to corn which was in rotation with soybean. Tillage treatments were unaltered from the inception.

Soil pH levels were reduced significantly on all fertilizer treatments compared to the control. For all tillages, irrespective of the fertilizer treatment, the most acidic soil was always in the surface 0 to 5 cm depth and the acidity was found to decrease in intensity to a depth of about 20 cm or to the extent of
tillage. Soil levels of P and K increased dramatically over the 30 years of the study where P and K fertilizers were applied in the treatment. Soil depletion of P and K occurred to the point of observable plant deficiency symptoms in the N only treatment and the depletion was most obvious in continuous no-till. Organic matter levels increased most rapidly under no-till and was enhanced by complete fertilization.

Yields increased steadily over the years. Under high fertility management very few differences in yield were observed among the four tillage methods. No-till yields tended to be somewhat lower in the initial 10 year period of the study but that trend changed such that no-till yields were comparable to the other tillage methods in later years. There was not any substantial yield benefit resulting from alternate tillage compared to continuous no-tillage.

SODIUM CHLORIDE AND LIME EFFECTS ON ELEMENTAL COMPOSITION OF ASPARAGUS FERN. Darryl D. Warneke, Taylor Reid, and Mary Hausbeck. Michigan State University, East Lansing, MI, USA 48824-1325.

Studies have shown the potential for sodium chloride (NaCl) to reduce the incidence or severity of fusarium root and crown rots in asparagus. With annual applications of NaCl there is concern about possible adverse effects on the availability and uptake of the essential plant elements, especially calcium and magnesium. Studies were established in two commercial asparagus fields in west central Michigan. Soil in both fields is a Spinks loamy fine sand (Sandy, mixed, mesic Psammentic Hapludalfs). In April 1998, NaCl was applied at 0, 560, or 1120 Kg ha\(^{-1}\) with or without the addition of 6.7 Mg ha\(^{-1}\) pelletized dolomitic lime. The NaCl treatments were applied again in April of 1999 and 2000. Soil samples were collected from 0 to 15 and 15 to 30 cm prior to NaCl application each year and 5 to 6 months later. The top 20-cm of asparagus fern was collected from 12 plants in each plot in August of 1999 and 2000. Soil analyses show the movement of sodium downward over time. Lime application had no effect on the elemental composition of asparagus fern. Soil application of NaCl increased the Na concentration in the asparagus fern two to three fold and significantly decreased the Ca and Mg concentrations. The adverse effects of Na on Ca and Mg concentrations in the asparagus were more marked in 2000 than in 1999. This reflects the increasing sodium concentration in the active rooting zone of the asparagus resulting from annual NaCl application.
ACID SOILS OF INDIA AND THEIR MANAGEMENT. R. Yamdagni and R.B. Sharma. N.D. University of Agriculture and Technology, Kumarganj, Faiyabad—224229, India. Fax: 91 5270 62023, 62480; E-mail: nduat@up.nic.in

The productive capacity of soil can be impaired through chemical degradation leading to the development of soil acidity. Processes leading to very high $H^+$ activity in soils result in toxic levels of $Al^{3+}$ and $Mn^{2+}$. This also restricts the availability of essential plant nutrients such as Ca, Mg, P and Mo. A separate category of soils, acid sulphate soils, develops as a result of oxidation of pyrites. An earlier rough estimate indicated that in India there are about 48 million hectares of acid soils of which about 25 million hectare have pH values below 5.5 while about 23 million hectares have pH values between 5.5 and 6.5. Based on an actual survey, information from different sources, and extrapolation, 40% of the land in India may be categorized as being in the Acid Soil Region (ASR). This paper discusses the various aspects of the problem of soil acidity and its corrective measures.

RATIONALE OF THE ECONOMY OF SOIL TESTING. Bernardo van Raij¹, Heitor Cantarella², and J.A. Quaggio². ¹Embrapa Environment, Caixa Postal 69, 13820-000 Jaguariúna (SP), Brazil. E-mail: bvanraij@cnpm.embrapa.br; ²Institute Agronômico, Caixa Postal 28, 13001-970 Campinas (SP), Brazil. E-mail: jquaggio@barao.iac.br; heantare@barao.iac.br

Soil testing is probably the cheapest and most widely used chemical analysis used in agriculture. Even then its proper use is often neglected, probably because the economical benefits are not clearly recognized. The main objective of soil analysis is the identification of unfavorable soil reaction and nutrient deficiencies and excesses that affect plant growth. In São Paulo State, Brazil, soil testing is used for the diagnosis of soil acidity and P, K, Mg, B, Zn, Mu and Cu deficiencies. Liming rates based on the elevation of the base saturation of the cation exchange at pH 7 can result in economic returns higher than 10 to 1 in a period of some years. Surface application of gypsum to soils with low calcium or high aluminum saturation in the subsoil is often also economically advantageous, although returns are much smaller than those obtained by liming. The more effective method of soil analysis for P based on the extraction with ion exchange resin allows for saving in expenditure with P fertilizers in the case of some clayey soils and in limed soils, and prevents the loss of productivity in soils treated with rock phosphates. In general, largest profits obtained by the provision of nutrients to deficient soils are due to yield increases and not to savings in fertilizers.
QUALITY OF ANIMAL AND HUMAN LIFE AS AFFECTED BY SELENIUM MANAGEMENT OF SOILS AND CROPS. Umesh C. Gupta¹ and Subhas C. Gupta². ¹Agriculture and Agri-Food Canada, Crops and Livestock Research Centre, Charlottetown, PEI, Canada C1A 4N6. Fax: (902) 566-6821; E-mail: guptau@cm.agr.ca; ²Division of Plastic Surgery, CP 2116, 11175 Campus Street, Loma Linda, CA, USA 92354. Fax: (909) 558-4175; E-mail: sgupta@ahs.llume.edu

Nutrient management of soils and crops affects the quality of crops with respect to their selenium (Se) and other mineral composition. A number of world regions are deficient in Se to meet the needs of animals and humans. In general, soils containing less than 0.6 mg Se Kg⁻¹ and crops containing less than 0.1 mg Kg⁻¹ are considered deficient for animals and humans. Areas receiving sulfur fertilization contain low Se because sulfur interferes with Se uptake by plants. Principal Se responsive diseases in animals include white muscle disease, neonatal weakness, retained placentae, abortions, diarrhea, ill thrift and immune system deficits. Specific immune, reproductive, neurologic, and cardiac disorders are found in humans deficient in Se. Additionally, certain cancers and chronic diseases appear to be related to Se in the human diet. A higher Se status in humans has proven beneficial in specific disease states such as pediatric cardiomyopathy and viral hepatitis. Selenium fertilization of soil, Se application as a foliar spray or seed treatment with Se at 10 g Se ha⁻¹ applied as selenate results in crops sufficiently enriched with Se to protect against Se deficiency. There are other methods of overcoming Se deficiency, but crop enrichment and consumption of crop products containing Se in organic form are more bioavailable.

PROFITABLE AND SUSTAINABLE SOIL-TEST-BASED NUTRIENT MANAGEMENT. Parviz N. Soltanpour¹, Robert O. Miller¹, and Jorge A. Delgado². ¹Department of Soil and Crop Sciences, Colorado State University, Fort Collins, CO, USA 80523; ²USDA-ARS—Soil Plant Nutrient Research Unit, 301 S. Howes, Fort Collins, CO, USA 80522.

The hypoxia in the Gulf of Mexico is caused by eutrophication due mainly to the transport of farmland NO₃-N and P into the Gulf by the Mississippi River. This scenario is not uncommon on a global scale. Soil-test-based nutrient management will be a key factor in increasing nutrient use efficiencies of pre-plant and/or pre-sidedress nutrient applications. Use of soil P index, pre-sidedress soil NO₃-N test with quick test kits (or tissue N index utilizing a portable chlorophyll meter or remote sensing), multi-element soil extracting solutions coupled with multi-
element analyzers, global positioning system (GPS), geographic information system (GIS), and variable rate technology will contribute to better nutrient management for profit, environment and food quality. Advances in genetic engineering and plant breeding to develop varieties with higher nutrient uptake and use efficiencies will further significantly reduce the optimal rate of fertilizers and their environmental impact. Field calibrated cultivar-specific response functions and response indexes for soil-test, fertilizer, manure and sewage-sludge nutrients form the foundation of profitable and sustainable fertilizer recommendations. Adoption of conservation practices such as no-till cropping, contour planting, grass buffer strips, inter-cropping, agro-forestry, slash and mulch cultivation and others can further reduce soil erosion and surface transport of nutrients into water bodies in addition to boosting the yields. Some examples of the above will be presented and potential economical and environmental benefits will be discussed.

CORRELATION BETWEEN SOIL P AND CORN LEAF P CONTENTS IN A NETWORK OF HUNGARIAN LONG-TERM FIELD TRIALS. Péter Csathó1, Marianna Magyar1, Katalin Debreczeni2, and Katalin Sárdi2. 1Research Institute for Soil Science and Agricultural Chemistry, H-1022, Herman O. út 15, Budapest, Hungary. Fax: 36 1 356 4980; E-mail: csatho@rissac.hu; 2Veszpréms University, Georgikon Faculty, Keszthely, Déak F. str 16, H-8361 Keszthely, Hungary.

The correlation between soil available P, flowering stage corn leaf P contents, and dry weight of leaves taken from a network of Hungarian long-term field trials at 9 sites was evaluated. The fertilizer treatments were equal at all sites. Corn leaf weight and P content at flowering, 0.01 M CaCl2-P, ammonium acetate–acetic acid P, and ammonium-lactate-soluble soil P were determined. Correlation was found between the soil and plant P contents and P leaf weights, depending on the soil properties (mainly soil texture and reaction status), and P levels applied. Correlation between soil available P, corn leaf P contents, and weight is evaluated in the presentation.

CORRELATION BETWEEN SOIL ACIDITY AND RESPONSES TO LIME APPLICATION IN THE DATASET OF HUNGARIAN LONG-TERM FIELD TRIALS, 1950–1998. Péter Csathó. Research Institute for Soil Science and Agricultural Chemistry, H-1022 Budapest, Herman O. út 15, H-1525 Budapest, Hungary. Fax: 36 1 356 4980; E-mail: csatho@rissac.hu
When considering the quantity of liming materials to be applied to agricultural soils in Hungary, soil texture and hydrolytic acidity ($\gamma_1$) are taken into account. Generally, soils with higher clay content and $\gamma_1$ values require higher doses of lime. The database was compiled and evaluated for 46 published field trials involving lime applications made between 1950 and 1998. The trials were grouped according to the pH in H$_2$O, pH in KCl, $\gamma_1$ values of the unlimed plots, as well as according to the soil texture, soil organic matter content and soil type. When the pH in H$_2$O values were below 5.5 and the pH in KCl values were below 4.5, responses to lime application were doubled, compared with the other pH groups. At higher $\gamma_1$ values, both the advised lime doses and responses to lime application increased. Responses to lime application were tripled in soils in which $\gamma_1$ was greater than 16, compared to soils in which $\gamma_1$ was less than 8. According to the soil textural groups, recommended lime doses increased with clay content. The most economic applications of lime occurred on light sandy to sandy loam soils.

EVALUATION OF THE AL (AMMONIUM LACTATE)–P TEST CORRECTION MODEL ON THE DATABASE OF HUNGARIAN LONG-TERM FIELD P TRIALS WITH CORN. Péter Csathó. Research Institute for Soil Science and Agricultural Chemistry, H-1022 Budapest, Herman O. út 15, H-1525 Budapest, Hungary. Fax: 36 1 356 4980; E-mail: csatho@rissac.hu

The objective of the study was to evaluate the database of 43 P-fertilization long-term field trials with corn, was the objective of the study. Correlation between AL–P values on the P control plots, and P responses expressed as $(\text{NPK} – \text{NK}, \text{in t ha}^{-1})$, showed a hyperbolic function, while between AL–P values and P responses expressed in relative yields $(\text{NK/NPK}, \%)$ formed a saturation (Mitscherlich) curve. Calcareous and acid soils formed two separate groups. When using the corrected AL–P values, as suggested by the AL–P correction model, the differences between acid and calcareous soils diminished significantly, and a stronger correlation was found between the soil corrected AL–P test values in the P control plots and the P responses of corn, than in the case of the original AL–P values. In the model, the AL–P values were transformed to standard soil properties (soil texture: loam; pH (in KCl) 6.8; CaCO$_3$ 0.1%). Soil P supply, expressed by the corrected AL–P values, strongly influenced the responses of corn to P fertilization. On soils with corrected AL–P values $< 50$ mg kg$^{-1}$, surplus yield varied between 0.6 and 0.8 t/h. When AL–P was between 50 and 150 mg kg$^{-1}$, the surplus yield was between 0.1 and 0.2 t ha$^{-1}$. At AL–P levels greater than 150 mg Kg$^{-1}$, there was no response to fertilization. Corn showed moderate P responses in the database.
of the Hungarian field trials, and proved to be less demanding of P fertilization than small grain crops (wheat, barley and oats).

THE RESIDUAL EFFECT OF K FERTILIZATION IN A HUNGARIAN CORN MONOCULTURE LONG-TERM FIELD TRIAL, 1990–1999. Péter Csathó. Research Institute for Soil Science and Agricultural Chemistry, H-1022 Budapest, Herman O. út 15, H-1525 Budapest, Hungary. Fax: 36 1 356 4980; E-mail: csatho@rissac.hu

Agricultural crops in Hungary depend on residues of soil K and P, but these reserves are decreasing. It is essential to know, how long the previous K application provides adequate K for crop as a function of residual effects. A K-exhaustion field trial with 0, 240, 480, 960 and 1440 Kg ha\(^{-1}\) of K\textsubscript{2}O was established in the autumn of 1989, on a light loam calcareous chernozem soil, containing 2.5–3% soil organic matter, 5% CaCO\(_3\), originally poorly to moderately supplied by K (ammonium lactate-soluble K\textsubscript{2}O = 100–140 mg kg\(^{-1}\)) moderately supplied with N, and poorly supplied with P. Yearly application of 150 Kg ha\(^{-1}\) N and 50 kg ha\(^{-1}\) P\textsubscript{2}O\(_5\), provided adequate NP supplies for the crops and did not hinder the appearance of maximum effects and residual effects of initial K doses. In the trials, Pioneer SC 3732 was sown in the first 8 years, and Stira since that time. Plant density has been 70,000 plants ha\(^{-1}\).

Residual effects of initial K application were investigated on the changes in the available soil K levels, as indicated by ammonium lactate-soluble K values, as well as on the grain yields. The tenth year residual effect of previous K application is still significant on both the soil K test and on grain yields. Weather conditions, i.e., the amount and distribution of rainfall during the vegetation period, strongly affected the residual effect of K.

EVALUATING SALT-AFFECTED SOILS FOR SUSTAINABLE AGRICULTURE PRODUCTIVITY. S. El-Demerdashe. Water Research and Desert Soils Division, Desert Research Centre, Mataria, Cairo, Egypt. E-mail: saademerdashe@hotmail.com

Salt-affected soils occupy vast areas of Egypt. The efficiency of soil reclamation, and soil and water management were studied on a 42-ha irrigated site, east of the Nile Delta. A total of 357 soil samples representing 93 soil profiles, and six water samples collected from two sources of irrigation water and four drains were analyzed. The
results indicated that the soils were derived from alluvial and lacustrine deposits, and their salinity levels were classified as slightly saline, moderately saline, saline, and extremely saline. The cationic composition is dominated by Na\(^+\) followed by Ca\(^{++}\) or Mg\(^{++}\) and the anionic composition is dominated by Cl\(^-\) followed by SO\(_4^{2-}\) and HCO\(_3^-\). Soil reaction is mildly alkaline. DTPA-extractable Fe, Mn, Zn, Cu, and Ni indicate deficiency while chemically extractable Co, Pb, and Cd are below permissible levels. Irrigation water was low in sodium, very highly saline, and neutral with low concentration of trace elements and heavy metals. Drainage water was medium to very high Na, very saline, and low in trace elements and heavy metals. The main agricultural constraints were defined; soil salinity, seasonal water logging, and land utilization maps were prepared. Scenarios for optimum use of soil, water, cropping pattern, and rotation were developed.

TRACE ELEMENTS IN WESTERN CANADIAN HARD RED SPRING WHEAT. Eugene J. Gawalko¹, Robert G. Garrett², and Thomas W. Nowicki¹.
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A monitoring program for trace elements in Western Canadian hard red spring wheat (Triticum aestivum L.) is described. Samples were selected from producer submitted harvest survey samples received from crop districts in Manitoba, Saskatchewan, and Alberta for the 1996, 1997 and 1998 crops. The analytical quality control measures employed in these surveys are described along with the results for Cd, Cu, Fe, Mn, Se and Zn. Accuracy and precision for the analyses fall within acceptable control limits. Year-to-year variations in grain chemistry are small for Cd, Mn, Se and Zn, but Cu and Fe contents show 12 and 9% decreases, respectively over the three years. The overall variability for the plant-essential trace elements, Cu, Fe, Mn and Zn, is low in comparison with Cd and Se. It is demonstrated that the spatial variation in crop chemistry across the Canadian Prairie wheat producing region is greater than the year-to-year variations, and that soil properties are major factors controlling Cd and Se levels in grain.

NEW TOOLS FOR ANALYSIS AND CHARACTERIZATION OF SLOW RELEASE FERTILIZERS. William L. Hall¹ and Jerry B. Sartain². ¹IMC Global, 3095 County Road West, Mulberry, FL, USA 33860. Fax: (863) 428-
Slow release fertilizer materials are used to provide nutrients to crops, turf and
ornamentals. There is an increasing need to provide efficient delivery of these
nutrients to maximize their use while avoiding waste and loss to the environment.
New regulatory initiatives may require use of these products in best management
systems. The ability to regulate slow release products will be tested as nutrient
criterion open new markets.

Methodology is needed to assess the release of nutrients under controlled
systems. New laboratory systems designed to evaluate nutrient release are
studied. Two methodologies are tested that evaluate all slow release materials
under controlled conditions. An accelerated non-biological system is tested that
evaluates materials within a four-day test protocol. Additionally, a biological
system is evaluated that uses a standardized soil environment, including bacterial
inoculums. This system can be managed under controlled conditions for 128 days
to evaluate materials with extended release characteristics.

EFFECT OF MULCHING ON SOIL CHEMICAL PROPERTIES AND
ENZYME ACTIVITIES IN BAMBOO PLANTATION OF PHYLLOSTACHY PRAECOX.
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Phyllostachy praecox is a major producer of small bamboo shoots, one of the
delicious forest vegetables in China. Emergence of bamboo shoots of
Phyllostachy praecox usually begins in late January to early February, and
lasts till April. Mulching in winter is commonly adopted to achieve early
emergence of the bamboo shoots. However, plantations of bamboo trees
exhibit early senescence. This may result born ‘disordered’ changes of soil
chemical and/or biochemical properties. A field experiment was conducted to
understand the mechanism of senescence. Three commonly used mulching
materials, rice straw (RS), mixture of rice straw and rice grain hulls (RH) and
leaves of bamboo trees (BL), and the control (without covering, CK) were
applied in December. Dynamic changes of soil chemical properties and soil enzymatic activities were monitored through winter into spring by collecting soil samples at 25-day intervals. The results showed that changes of soil organic matter (OM), total nitrogen (N) and available phosphorus (P) were similar from winter to early spring in March. The contents of soil OM and N decreased slowly but soil available P showed little change. In contrast, net losses of soil OM, N and P were much greater in spring when it was warm. This coincided with the output of bamboo shoot production. After 100 days (April), the RL and CK treatments resulted in the least net loss of soil OM, N, and P, in comparison with 0 days, whereas RS and RH showed the greatest loss. Enzymatic activity of hydrogen peroxidase, sucrase, phosphatese, urase and protease was generally higher in mulched soils, and enzyme activity in BL-treated soils was highest.

VIRTUAL CROP GROWING—IT IS POSSIBLE? Doug Keyes and John Ashworth. Norwest Soil Research Ltd.; 9938-67 Ave., Edmonton, AB, Canada T6E 0P5. Fax (780) 434-8586; E-mail: johna@norwestlabs.com

Soil testing laboratories analyze samples from many kinds of farms and give fertilizer recommendations for a wide range of crops under differing sets of soil, climatic and economic conditions. Rates of fertilizer application given on laboratory reports are used as the basis for deciding on rates that are affordable for the producer, reasonable to the agriculturist and practical for the supplier. Laboratory systems for deciding on fertilizer recommendations first of all need validation through being based on agronomic trials done with current crop varieties in the region of interest. Systems also need to be flexible enough to be able to satisfy a likely cross-section of users. These two distinct goals are met by the system currently in use at Norwest Labs and described in this display. Nitrogen (N) is viewed as the key nutrient in terms of the economics of (non-legume) crop production. The interaction of moisture with N is taken into account by separately considering typical yields under both average and excellent growing conditions. Recommendations for other major nutrients are essentially a maximum rate, offset by an amount proportional to the soil test result for that element, in line again with results of cropping trials. Micronutrient applications at rates currently recommended by Alberta Agriculture are suggested only when the available amounts in the soil are less than agronomically determined threshold values. Norwest Labs’ system, as well as operating in-house, also runs from a website, allowing clients to grow “virtual crops” on the basis of their actual soil test results. In
this way a client can log on and fine-tune the economics of the coming
growing season, using current fertilizer costs and prices for a range of crops,
before deciding on which crop to seed or how much fertilizer to apply.

CONNECTIONS OF YIELD PRODUCTION AND MACRONUTRIENTS
IN GRAPE ROOTSTOCK–SCION COMBINATIONS UNDER DRY
CLIMATIC CONDITIONS. László Kocsis and Eva Lehoczky. Veszprém
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A field experiment was set up at Cserzetomaj, in western Hungary in 2000. The
age of the vines was 8 years, the vineyard was on Eutric cambisol soil. The mean
annual temperature and rainfall of the area are 10.4°C and 650 mm. The
experiment was a randomized block design, with four repetitions, 10–10 stocks
per rootstock variety. The rootstocks used in the trial were Berlandieri × Riparia
T. 5C (5C), Berlandieri × Riparia T. K. 5BB (5BB), 140 Ruggeri (140 Ru),
Fercal, Berlandieri × Riparia T.8B GK10 (8BGK10), Georgikon 28 (G28). As
scions, Vinitor, Hungarian Riesling and Italian Riesling were grafted on the six
rootstocks. Leaf samples for analysis were collected from above the grape
cluster, and concentrations of N, P, and K were determined. Yield and sugar
content of the juice were determined at harvest. The level of P differed according
to rootstock varieties. Statistically verified differences occurred in rootstock–
scion combinations for all the measured parameters. Of the six rootstocks, Italian
Riesling was most sensitive to drought but gave reasonable results in combination
with Fercal. Hungarian Riesling contained less sugar but produced good yield in
all combinations. Although Vinitor grafted on 140 Ruggeri was highest in N, it
gave the lowest yield. On the basis of the comparison, it was determined that P
level is important under drought conditions and can be strongly affected by
rootstock–scion combinations.

CADMIUM AND LEAD UPTAKE BY WHITE MUSTARD (SINAPIS
ALBA L.) GROWN IN DIFFERENT SOILS. Eva Lehoczky and László
Eckmann. Veszprém University, Georgikon Faculty of Agricultural Sciences, PO
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A pot experiment was set up with different soils having different Cd and Pb
contents. White mustard (Sinapis alba L.) was used as the test plant. Plants were
grown under greenhouse conditions for 29 days. Fresh and dry weight of plant biomass (root, stem and leaves) were measured. Concentrations of Cd and Pb of separate plant parts were determined by atomic absorption spectrometry. The total (HNO₃-soluble) and available (KCl + EDTA extraction) Cd and Pb contents of the soils were determined. Correlation was determined between Cd and Pb contents of soils and plant uptake. Positive linear regression was found between the total and available Cd and Pb contents of the soils. Statistically significant correlation could be found between the Cd content of the soil and Cd concentration of different plant parts. In the case of Pb, there was correlation with the root, but not for stem and leaves. The highest concentration of Pb was measured in the roots. The results show that Cd can be translocated to the shoots, and the highest concentration was observed in the leaves.

CADMIUM AND ZINC UPTAKE BY RYEGRASS (LOLIUM PERENNIE L.) IN RELATION TO SOIL METALS. Eva Lehoczky and Zsanett Kiss. Veszprém University, Georgikon Faculty of Agricultural Sciences, PO Box 71, H-8361, Keszthely, Hungary. E-mail: lehoczky@georgikon.hu

A greenhouse pot experiment was set up in four replications to study the Cd and Zn uptake of ryegrass from soils with different Cd and Zn content. Ryegrass was grown for 4 weeks and the plants were cut above the soil. The cutting was repeated in 4-week periods to study uptake dynamics as well. This paper deals with the results of the first cut. Fresh and dry biomass weight, and Cd, and Zn concentrations were measured. The uptake of Cd and Zn was calculated as well. The experiment was carried out with various soil types that had not only different Cd and Zn concentrations but other characteristics (pH, C, hydraulic acidity, etc.) as well. Regression and variance analysis were used. Results show that the Zn content of the soils determined plant uptake as well. In the case of Cd, the correlation with plant uptake was higher for total Cd concentration of the soils than available Cd. Plant uptake of Zn, and concentrations of total and available soil Zn were described by positive linear correlation. Our results demonstrate that in ryegrass shoots there was no accumulation of Cd and Zn, compared to the concentration of soil Cd and Zn.

LOW-LEVEL PHOSPHATE ANALYSIS IN THE PRESENCE OF SILICATE. Rao Mylavarapu¹ and Elizabeth Kennelley². ¹Department of Soil and Water Science, University of Florida, Gainesville, FL, USA 32611. Fax: (352)
Concerns over anthropogenic contributions to phosphate in the environment have led to a demand for the development of new and more sensitive methods of phosphate detection. We have recently succeeded in reconfiguring a standard Alpkem Flow Solution IV system to analyze low-level (less than 10 μg Kg\(^{-1}\)) phosphate samples using a modified version of EPA Method 365.1. By using a higher reaction temperature, longer instrument residence time and modified color-development reagents, instrument responses can be increased significantly allowing for reliable detection of extremely low levels of phosphate. However, many “real-world” environmental samples contain appreciable amounts of silicate, which is chemically analogous to phosphate. Under the conditions described above, silicate also forms a blue-colored complex that causes a strong positive interference in phosphate analysis even at relatively low concentrations of silicate. It was, therefore, necessary to further modify our method in order to analyze low-level phosphate in the presence of silicate. Careful examination of a variety of parameters including instrument configuration, reagent ratios, temperature and flow-rate has led to the development of a phosphate analysis method that maximizes the phosphate signal and maintains peak integrity while at the same time minimizes the signal input from silicate interference.

**EFFECT OF DIFFERENT ORGANIC MATERIALS AND LEAD LEVELS ON GROWTH AND HEAVY METAL CONTENT OF CORN.** R.P. Narwal\(^1\), A.S. Sidhu\(^2\), and R.S. Antil\(^1\). \(^1\)Department of Soil Science, CCS Haryana Agricultural University Hisar—125004, India. Fax: 91 1662 34952; E-mail: coag@hau.hry.nic.in, narwalrp@rediffmail.com; \(^2\)Punjab Agriculture University, Regional Research Station, Bathinda, India.

A greenhouse study was conducted to evaluate the effect of four levels of organic carbon (0, 0.125, 0.25 and 0.5%) applied through different organic materials (farmyard manure, pressmud, pig manure, and sewage sludge) on plant growth and heavy metal content of corn grown on a sandy loam (Typic Ustochrepts) soil amended with different levels of Pb (0, 25, 50, 100 and 200 mg Pb Kg\(^{-1}\) soil). Dry matter yield was recorded and plant samples were analysed for Pb, Zn, Cu, Fe and Mn. Low level of Pb has stimulatory effect on plant growth and increased the dry matter yield at 25 mg Pb Kg\(^{-1}\) soil and decreased thereafter with increasing levels of Pb. Application of organic carbon counteracted the adverse
effect of Pb on plant growth and significantly increased the dry matter yield. The dry matter yield increased by 48.7, 57.9, 60.3 and 94.2% with 0.5% organic carbon over control in soil amended with sewage sludge, pressmud, farmyard manure and pig manure, respectively. The application of Pb significantly increased the Pb, Fe and Mn content and decreased the Zn and Cu content of plants with increasing levels of Pb. Whereas the addition of organic carbon through any source significantly reduced the Pb, Cu and Mn content and increased the Zn and Fe content. Generally, the heavy metal content of plants was found higher in sewage sludge amended soils than other organic materials. These results suggest that the application of organic carbon may reduce the harmful effect of Pb on plants and improve the quality of the corn crop.

RESIDUAL EFFECT OF PHOSPHATE FERTILIZER AND ITS RELATIONSHIP TO THE CHANGES IN SOIL PHOSPHORUS FRACTIONS IN A SANDY RAINFED LOWLAND SOIL OF CAMBODIA. Sovuthy Pheav1,2, Richard W. Bell1, Peter F. White3, and Guy J.D. Kirk4. 1School of Environmental Science, Murdoch University, Murdoch, Perth 6150, Western Australia. Fax: 61 8 9310 4997; E-mail: spheav@central.murdoch.edu.au; 2Cambodian Agricultural Research and Development Institute (CARDI), Ministry of Agriculture, Forestry and Fisheries, PO Box 01, Phnom Penh, Cambodia. Fax: 855 23 219 800; 3Agriculture Western Australia, Baron-Hay Court, South Perth 6151, Western Australia. Fax: 61 8 9367 5232; E-mail: pfwhite@agric.wa.gov.au; 4Soil and Water Sciences Division, International Rice Research Institute (IRRI), Manila, Philippines. Fax: 63 2 845 0606; E-mail: g.kirk@cgiar.org

Rice plants, generally, acquire less than 50% of the phosphorus fertilizer applied to the first crop. P fertilizer that is not taken up by plants either remains in the soil and/or is lost through leaching or erosion. The fate of the P remaining in the soil and its availability to following crops is important for P fertilizer management strategies. The present study was conducted to determine the residual value of P fertilizer on a sandy soil (Plinthustalf) of the rainfed lowland rice ecosystems of Cambodia and the mechanisms underlying the decline in residual value of P caused by long-term reactions of P with the soil and changes of soil P fractions over four consecutive rice crops. Soil P fractions were extracted from air-dried soils using a sequential P fractionation technique. With P fertilizer application at 16.5 Kg ha\(^{-1}\), there were substantial increases in amounts of both the labile organic P (NaOH–Po) and occluded P (Residual-P), which averaged 12.4 and 13.9 mg Kg\(^{-1}\) soil, respectively. By contrast, low amounts of resin-extractable P
(Resin-P) and H₂SO₄-P (about 0.2 mg kg⁻¹ soil) were recovered, suggesting that these are not major pools for supplying plant requirements. All P fractions were significantly increased with a freshly applied P fertilizer, whereas the amounts recovered in succeeding crops from the residual P fertilizer declined. After two crops, the amount of P in all fractions in the soil decreased, but remained higher than in plots with no applied P fertilizer. By contrast, yields dropped dramatically in the third and fourth crops reliant on the residual P fertilizer. Indeed, crop four produced the same as plants in the nil fertilizer treatment, even though soil P fractions remained higher from residual P applied than the nil treatment. The amounts of P in all fractions were on average 5 to 20% lower than those indicated in literature reports with different soils. The reason why levels of P in the various fractions after crop two did not reflect the decline in rice yields needs further investigation.

ASSESSMENT OF SOILS TEST BASED RECOMMENDATION TECHNOLOGY ON WHEAT IN MEDIUM BLACK SOIL OF CENTRAL INDIA. Girish Puri. Department of Soil Science, J.N. Agricultural University, Jabalpur 482004, India. Fax: 91 761 397117; E-mail: girish_puri@yahoo.co

The quantitative refinements in the fertilizer recommendations based on soil and plant analysis are being made through the All India Coordinated Research Project for Investigations on Soil Test Crop Response (STCR) correlation, Indian Council of Agricultural Research (ICAR), and New Delhi, India. In view to create an awareness among the farmers about the technology developed in STCR project for balanced use of fertilizers based on soil tests, Front Line Demonstrations (FDL) on soil test based crop response on wheat have been launched since rabi 1996 and are going on in medium black soils in central India. The fertilizer adjustment equations have been used to ascertain the fertilizer doses for desired yield targets of wheat. The results of fourteen FLDs on wheat revealed that in a majority of cases the yield targets were achieved +/−10% variation. The benefit:cost ratio, sustainable yield index and sustainable value index were 5.76, 0.66 and 0.61, respectively in STCR technology.

HEAVY METALS IN AUSTRALIAN SUGARCANE. George E. Rayment, Alan Jeffrey, and Glenn Barry. CRC for Sustainable Sugar Production and Department of Natural Resources, 80 Meiers Road, Indooroopilly, Queensland,
Twelve cane varieties and their different parts were screened in eastern Australia for plant-mobile heavy metals to assess whether genetic differences were of greater significance than the soil/environment for uptake and within plant distribution. Soil pH (1:5 soil/water) ranged from 4.5 to 6.4 and all breeding-trial sites contained relatively low levels of extractable Cd, Hg and Pb and variable levels of Cu and Zn. Internal concentrations of Cd and Zn were more influenced by soil/environment than by variety, while the distribution of metals in plant parts was quite consistent. About 70% of the Cd and 50% of the Zn were contained in the stem, which relocates to the mill following harvest. There was very little Hg in all plant parts (concentrations < 0.05 mg Kg\(^{-1}\)). From a predictive viewpoint, correlations between extractable heavy metals such as Cd in soils and corresponding plant concentrations were inconsistent, with the narrow range in soil concentrations seen as a contributing factor. On present evidence, the uptake of heavy metals by sugarcane can be adequately managed by manipulating soil properties rather than by varietal selection. It is also clear that for each 100 tonnes of fresh mature cane, about 0.3 g of Cd and 170 g of Zn will relocate to the soil surface with the trash. Corresponding quantities moved to the mill are 0.6 g of Cd and 200 g of Zn, with amounts expected to be higher for cane grown in strongly acidic soils with above average levels of heavy metals.

ROLE OF INTERNATIONAL RESEARCH CENTERS’ SOIL LABORATORIES IN AGRICULTURAL DEVELOPMENT. John Ryan\(^1\), Paul Smithson\(^2\), Bernadita Mandac\(^3\), and Joseph Uponi\(^4\). \(^1\)International Center for Agricultural Research in the Dry Areas (ICARDA), PO Box 5466, Aleppo, Syria. E-mail: J.Ryan@cgiar.org; \(^2\)International Center for Research in Agroforestry (ICRAF), PO Box 30677, Nairobi, Kenya. E-mail: P.Smithson@cgiar.org; \(^3\)International Rice Research Institute (IRRI), PO Box 3127, Makati City, The Philippines. E-mail: B.Mandac@cgiar.org; \(^4\)International Institute of Tropical Agriculture (IITA), PO Box 5320, Ibadan, Nigeria. E-mail: J.Uponi@cgiar.org

The worldwide network of 16 research centers of the Consultative Group for International Agricultural Research (CGIAR) focuses on research, training, education, capacity-building, with the goal of poverty alleviation, economic development, and environmental protection in the poorer countries of the world. The centers work in partnership with the National Agricultural
ABSTRACTS

Research Systems (NARS) as well as advanced institutions. The pillars of its research are germplasm enhancement and natural resource management. The soil laboratory is fundamental to such research endeavors, involving analysis of soils as a basis for soil characterization, identifying nutrient constraints, and establishing criteria for fertilizer application, along with water, plant, and fertilizer analysis. The soil laboratory backstops both basic and applied research. Most CGIAR centers’ laboratories have a training function for their region’s national programs, and are involved in networks to upgrade analytical standards and maintain quality output. Many laboratories also host students from regional universities for their graduate research. This presentation gives an overview of CGIAR soil laboratories and focus on their organization, management, constraints, future challenges, and development potential.

EFFECTS OF CHLORIDE AND SULFATE SOURCES OF POTASSIUM AND ZINC FERTILISERS AND LEACHING ON THE UPTAKE OF CADMIUM AND OTHER ELEMENTS BY POTATO (SOLANUM TUBEROSUM L. CV RUSSET BURBANK). Ali. A. Salardini and Leigh A. Sparrow. Tasmanian Institute of Agricultural Research, University of Tasmania, Northwest Centre, PO Box 447 Burnie, Tasmania, Australia 7320. Fax: 613 64304953; E-mail: ali.salardini@utas.edu.au

The effects of adding K2SO4, KCl, ZnSO4, and ZnCl2 to a ferrosol (ultisol) on the Cd, P, K, Ca, Mg, Na, S, Fe, Zn, Cu, Mn and B concentrations in potato shoots and tubers in the presence or absence of leaching were studied in a glasshouse trial. The highest tuber and shoot Cd concentration, double that of the control, was found in the KCl treatment. Tuber Cd concentrations were reduced significantly (P < 0.001) with both ZnSO4 and K2SO4 treatments. Leaching reduced shoot Cd concentrations significantly only in the KCl treatment. Shoot and tuber Mn increased (P < 0.001) with both chloride fertilizers, but unchanged with the others. There was a strong correlation between tuber and shoot Cd concentrations (R² = 0.83). KCl increased shoot K, Mn, Zn and Cu more, and reduced shoot P, B, S and Mg less than K2SO4. The results suggest that the Cl-ion mobilizes Cd and metallic trace elements in soil more than the SO4-ion. In soils where Cd contamination may be a problem, use of K2SO4 may give lower Cd uptake than would use of KCl. However, leaching may remove Cd from the root zone when chloride forms of fertilizers are used.
PHYSIOLOGICAL TESTS TO MEASURE IMPACTS OF GASEOUS POLYCYCLIC AROMATIC HYDROCARBONS (PAHS) ON CULTIVATED PLANTS. Jan J. Slaski, Daniel J. Archambault, and Xiaomei Li. Climate Change Technologies, Alberta Research Council, Vegreville, AB, Canada. E-mail: slaski@arc.ab.ca

Polycyclic aromatic hydrocarbons (PAHs) are important airborne pollutants that accumulate at increased concentrations in vegetation surrounding PAH emitters such as smelters, roadways, runways, oil and gas operations. Terrestrial plants are at risk of injury from potentially toxic PAHs. The objective of this study was to measure the effects of gaseous PAHs on performance of crop plants using a combination of destructive and non-destructive methods. Experiments were carried out in a gas exposure system on five crop species: canola, barley, field pea, alfalfa and lettuce. Plants at two developmental stages (7 and 21 days old) were exposed to naphthalene and creosote (a substance containing 90% PAHs). Chlorophyll fluorescence was measured daily using a portable screening chlorophyll fluorometer and compared with readings taken from control plants. At the end of the experiments, chlorophyll content in leaves was measured with a portable OS 660 chlorophyll meter. A rapid, sensitive seedling-based bioassay was used to evaluate the relative toxicity of water extracts from plants exposed to PAHs. Using this method, it is possible to use percent germination, root and shoot growth as parameters. Our results suggest that measurements of photosynthetic parameters of plants exposed to gaseous PAHs using portable devices accurately reflect detrimental effects of these compounds. The bioassay used in these experiments allowed for the indirect determination of the accumulation of PAHs in/on plant tissues. Simple, non-destructive physiological measurements and bioassays are practical diagnostic tools for the monitoring of PAH exposure and injury.

EVALUATION OF FUNCTIONAL DIVERSITY OF MICROBIAL COMMUNITIES IN SOILS USING THE BIOLOG SYSTEM. Jan J. Slaski, Daniel J. Archambault, Xiaomei Li, and Terry Macyk. Climate Change Technologies, Alberta Research Council, Vegreville, AB, Canada. E-mail: slaski@arc.ab.ca

Soil microorganisms play a vital role in the function of terrestrial ecosystems. Changes in the structure or function of soil microbial communities have substantial effects on ecosystem activity. We investigated functional diversity of microbial communities in manured, reclaimed and amended soils using the
BIOLOG system based on sole-carbon-source utilization analysis. Eco MicroPlates that include 31 carbon sources similar to those commonly found in soils were used. Extracts were prepared from field-moist soils and the extracts containing soil microorganisms were injected into each of the 96 wells on the BIOLOG plates. Following incubation, reduction of tetrazolium dyes by respiring microorganisms was detected and quantified spectrophotometrically on an Emax microplate reader. The data obtained were analyzed using community analysis techniques such as cluster analysis from community coefficients and ordination. Analysis of substrate richness, as demonstrated by percentage of substrates utilized on BIOLOG Eco MicroPlates, revealed significant differences in functional diversity of soil microorganisms among manure treatments on three agricultural sites in central Alberta, in peat-amended tailings and forest soils amended with pulp and paper sludges. This method appears to be suitable for monitoring of changes in microbial diversity in soils with time.

APPLICATION OF MITSCHERLICH–BRAY EQUATION FOR FERTILIZER USE IN WHEAT. Kashinath R. Sonar¹ and Vipin P. Babhulkar². Department of Agricultural Chemistry and Soil Science, Mahatma Phule Agricultural University, Rahuri 413 722, India. ¹4 Swastik Apartment, Dr. Bhide Hospital Road, Savedi, Ahmednagar 414 003, Maharashtra, India. Fax: 91 0241 345963; E-mail: krsonar@rediffmail.com; ²54 Kotwal Nagar, Nagpur 440 022, Maharashtra, India.

A field experiment was conducted for formulating N, P and K requirements of wheat (cv. HD 2189) based on the Mitscherlich–Bray equation in a Vertic Ustropepts soil. There were 60 treatment combinations consist of 5 × 4 × 3 levels of N, P₂O₅, and K₂O fertilizers, respectively. Available N, P and K were estimated and wheat yields recorded. The data were substituted into the Mitscherlich–Bray equation: \( \log(A - y) = \log A - c_1b - cx \) where \( A = \% \) theoretical maximum yield, \( y = \) yield obtained in t ha⁻¹, \( b = \) native soil test value in Kg ha⁻¹, \( x = \) fertilizer nutrient applied in Kg ha⁻¹, and \( c_1 \) and \( c \) = constants for efficiency of soil and fertilizer nutrients, respectively. The constants \( A, c, \) and \( c_1 \) values were calculated. The validity of results was tested by conducting two field verification trials on wheat in two soils (Vertic Ustropepts and Typic Chromusterts). The results showed that 85% of the theoretical maximum yield treatment gave the highest wheat yields of 5.6 and 5.8 t ha⁻¹ with monetary returns of Rs. 42,000 and 43,500 ha⁻¹, while highest returns/rupee invested on fertilizers (15.45 and 10.44) and lowest nutrient requirements of 37.9 and 38.4 Kg t⁻¹ were obtained respectively in two soils under 75%
theoretical maximum yield treatment. The Mitscherlich–Bray equation was found to be superior to fertilizer recommendations made only on the basis of soil testing.

VARIATION IN SOIL CARBON AND CROP YIELD ON SLOPING LAND IN TASMANIA, AUSTRALIA. Leigh Sparrow1, Bill Cotching2, and Kerri Hawkins3. 1Tasmanian Institute of Agricultural Research, Mount Pleasant Laboratories, Launceston, Tasmania, Australia 7250. Fax: 61 3 6336 5395; E-mail: Leigh.Sparrow@dpiwe.tas.gov.au; 2Department of Primary Industry, Water and Environment, Stoney Rise Centre, Devonport, Tasmania, Australia 7310. Fax: 61 3 6424 5142; E-mail: Bill.Cotching@dpiwe.tas.gov.au; 3Department of Primary Industry, Water and Environment, Mount Pleasant Laboratories, Launceston, Tasmania, Australia 7250. Fax: 61 3 6336 5395; E-mail: Kerri.Hawkins@dpiwe.tas.gov.au

Concern exists about the impact of intensive vegetable and other cropping on Tasmanian soils, particularly on sloping land. Water erosion can be substantial because soils are left bare between crops, and because many row crops are planted up and down slopes, rather than on the contour, to accommodate harvesters. Soil organic carbon (OC) is often suggested as an appropriate measure of the impact of cropping, but there is little data showing any relationship of OC to crop yield in Tasmania. In this study, crop yields and associated OC concentrations were measured in 5 paddocks on undulating ferrosols (humic eutrudox) in north west Tasmania. In each paddock, transects on contours were selected in each of the following land slope classes: Class 1: <5% slope; Class 2: 5–12%; Class 3: 13–18%; Class 4: 19–30%. We have previously observed variation in crop growth in steeper versus flatter parts of paddocks, and we wanted to quantify this variation and see if it was related to variation in OC. Yield and OC were measured at up to 15 points along each transect. The crops grown were poppy (Papaver somniferum), onion (Allium cepa), pyrethrum (Tanacetum cinerariifolium), and carrot (Daucus carota). Crop yields in each paddock were expressed as a percentage of the maximum yielding sample point in that paddock to allow data to be combined across paddocks. A one-way analysis of variance was conducted on the combined data. Average relative yields on transects of slope Class 4 were about 15% less than those on Classes 1, 2 or 3 ($P < 0.001$). There was also a progressive decrease in OC (0–150 mm) from Class 1 (4.1% OC) to Class 4 (3.3% OC) ($P < 0.001$). However, while slope class could explain variation in both yield and OC, there was no significant relationship between relative yield and OC ($P = 0.41$). This suggests that other factors associated with slope are affecting crop growth. These may
include aspect, irrigation efficiency, rainfall effectiveness, and soil depth. All of these factors might influence water availability and disease incidence, although we found no evidence that this was the case. We conclude that OC is not a good indicator of potential crop productivity over the range of OC (3–4%) and crop management encountered in our study.

THE AVAILABLE MICROELEMENT CONTENT OF THE SOIL IN A LONG-TERM NUTRIENT SUPPLY EXPERIMENT. Tamás Szalai¹, Ferenc Nyárai¹, Eva Lehoczyk², Sándor Holló¹, and Péter Csathó³. ¹Szent István University Gödöll, Páter K. u. 1. H-2100 Gödöll, Hungary. E-mail: tszalai@fau.gau.hu; ²Veszprém University, Georgikon Faculty of Agricultural Sciences, P.O. Box 71, H-8361, Keszthely, Hungary. E-mail: lehoczyk@georgikon.hu; ³Research Institute for Soil Science and Agricultural Chemistry, H-1022 Budapest, Herman O. út 15.H-1525 Budapest, Hungary. Fax: 36 1 356 4980; E-mail: csatho@rissac.hu

In a long-term nutrient supply trial, the essential micronutrients (Fe, Cu, Zn, Mn, B and MO) and toxic elements (Cd, Pb, Sr and Co) were studied in the 0–20 cm soil layer. Soil samples were taken in the 30th year of the experiment from the most important fertilization treatments in four replications. Soil samples were analyzed according to the Lakanen–Ervio method (AAc + EDTA) by ICP. The long-term trial had two different cropping patterns as well, thus samples were taken from the rotations as follows: (1) corn–corn–w. wheat–w. wheat, and (2) corn–s. barley–pea–w. wheat. These two crop sequences were analysed separately. Within the fertilization treatments, there were various levels of N–P–K and farmyard manure. The results show that, compared to unfertilized control plots, fertilization treatments had different effects on micronutrients and toxic elements. In some cases (e.g. Cu, Cr and Cd), there was no significant difference with the AAc + EDTA extractant but in most cases (Fe, Mn, Sr, etc.) the differences were significant.

ERGOSTEROL DETECTION IN A VARIETY OF ENVIRONMENTAL MATRICES USING LC/UV AND OFF-LINE LC/MS/MS. Brij Verma, Richard D. Robarts, and John V. Headley. National Water Research Institute, 11 Innovation Boulevard, Saskatoon, SK, Canada S7N 3H5. Fax: (306) 975-5143; E-mail: john.headley@ec.gc.ca
Ergosterol, a sterol constituent of fungal cell walls, is used as a measure of living fungal biomass. Ergosterol occurs in a broad range of fungi and is believed to undergo rapid degradation after cell death. Most research has focused on fungal biomass in decaying plant litter or on forest soils where there is a high detrital content. Little work, however, has been reported for the detection of ergosterol in environmental matrices other than the two noted. As part of an investigation of Prairie wetlands, near St. Denis, Saskatchewan, we have applied a conventional LC/UV method to the analysis of sediments, and a variety of plant matrices. Samples (0.2–1 g dry weight) were subjected to alkaline saponification and extracted serially using pentane (3 $\times$ 10 mL). Instrumental analysis utilized a reversed phased column (Supelcosil LC-18 5 m 15 cm $\times$ 4.6 mm HPLC). Extractions efficiencies were generally in the range 70–90% with detection limits in the low ug g$^{-1}$ for LC/UV analyses, detection at 282 nm. Confirmations utilized electrospray ionization tandem mass spectrometry, performed on a Micromass Quattro Utima. Ergosterol was observed to be prevalent at ug g$^{-1}$ levels throughout the wetland, and was confirmed in *scirpus* leaves and *scirpus* stems, (living and dead), wetland water, and sediment collected at the water sediment interface.

IMPROVEMENT IN SITE SPECIFIC FERTILIZER RECOMMENDATIONS BY CO-KRIGING OF SOIL FERTILITY TESTS WITH OTHER DENSE DATA. Nathan A. Wright. Geophyta Inc., 2685 C.R. 254, Vickery, OH, USA 43464. Fax: (419) 547-8538; E-mail: geophyta@nwonline.net

Many site-specific fertilizer recommendations are derived from soil sampling patterns that result in one composite sample every 1.0 ha. Inaccurate fertility maps are the result because the density of data does not permit proper use of geostatistical procedures such as Kriging. The purpose of this research is to explore the use of surrogate soil data collected at high density for use in co-Kriging techniques. This densely collected data may improve the sparsely collected soil nutrient information and result in improved soil fertility maps with more precise fertilizer recommendations. Two 13 + ha fields were used to collect hue point samples at three different intensities. The coarse level involved soil sampling on a diamond pattern grid measuring 20m $\times$ 20m. Two of these grids were sub-sampled on a 1m $\times$ 1m grid. Finally, three of these sub-grids were sub-sub-sampled on a 0.1m $\times$ 0.1m grid. All samples were analyzed for pH, phosphorus, potassium, calcium, magnesium, rubidium, and organic matter. Electrical conductivity (EC) readings were collected over each entire field and over the sub-sampled grids. This presentation will explore the correlations, variograms, and nutrient maps resulting
from co-Kriging of coarsely collected soil samples with densely collected EC, organic matter, rubidium, and cation exchange capacity.

ANALYSIS ABOUT SOIL WATER SOLUBLE ORGANIC MATTER UNDER CHINESE FIR AND PINUS MASSONIANA FOREST. Qiufang Xu¹, Peikun Jiang¹, Jianming Xu², Zhengqian Ye², and Yuanxin Teng³. ¹Department of Resources and Environment, Zhejiang Forestry College, Lin-an 311300, Zhejiang, China; ²Department of Resources Science, College of Environmental and Resources Sciences, Zhejiang University, Huajiachi Campus, Hangzhou 310029, Zhejiang, China; ³Department of Forest Soils and Environmental Science, Faculty of Forestry, The University of Toronto, Toronto, ON, Canada. E-mail: yezhengq@mail.hz.zj.cn

In order to understand the behavior of soil water soluble organic matter (WSOM) under different types of forest, soil samples from twenty sites were collected and analyzed for each forest in the area of Huzhou, China. Each sample was extracted with both hot water (100°C) and cool water (25°C). Chinese fir forest soil contains both more cool water soluble organic carbon (CWSOM) and hot water soluble organic carbon (HWSOM) than Pinus massoniana forest soil does, CWSOM ratio of two types of forest was 1.49, HWSOM ratio was 1.34. Without exception, HWSOM was more than CWSOM. Chinese fir forest soil CWSOM accounted for 1.11% of total SOC, HWSOM account for 1.6%; 0.71% and 1.15% are the rates of Pinus massoniana forest soil. Chinese fir forest soil CWSOM has a good relationship to total SOC, microbial C, total N and hydrolysable N; correlation coefficient are respective 0.4739*, 0.4817*, 0.5815**, and 0.5761**. Pinus massoniana forest soil HWSOM was closely related to total SOC, total N, hydrolysable N and sucrase activity; correlation coefficient are 0.5106*, 0.6750**, 0.6234** and 0.5406*, respectively. The regression equation between Chinese fir forest soil CWSOM (Y) and total SOC (X) was Y = 0.0895 + 0.00184X; the regression equation between Pinus massoniana forest soil HWSOM (Y) and total SOC (X) was Y = 0.0962 + 0.00222X. There was a similar tendency of vertical distribution in soil profile about WSOM under these two types of forests.

KINETIC STUDIES OF PHOTODEGRADATION OF THIFEN-SULFURON-METHYL. Xu, Xiangrong, J.V. Headley, K.M. Peru, and Jing-Long Du. National Water Research Institute National, Hydrology Research
The fate of sulfonylurea herbicides in Prairie environments is of particular interest in the agricultural region of Saskatchewan. Despite this interest, there has been little research conducted on the photodegradation of this class of herbicides in Prairie natural waters. For example, it is not established whether photodegradation is a major fate process for the commonly used sulfonylurea herbicide, thifensulfuron-methyl (Harmony) in Saskatchewan. An investigation was, therefore, conducted to measure rates of degradation of thifensulfuron-methyl in aqueous solutions using 254 nm irradiation. The pseudo first-order rate constants determined for Difenbaker Lake, Candle Lake, Saskatchewan River and Millipore water were 9.94, 8.68, 9.00 and $8.55 \times 10^{-5}$ (s$^{-1}$), respectively. The quantum yields in these waters were 0.0135, 0.0167, 0.0215 and 0.0148, respectively. In general, there was no significant difference in degradation rates for both natural and Millipore waters. However, the photodegradation rate constant was enhanced relative to neutral waters (pH = 7; $0.366 \times 10^{-4}$ (s$^{-1}$)) for strongly acidic (pH = 2.7) or alkaline environments (pH = 11.3) with rate constants of 1.65 and $1.69 \times 10^{-4}$ (s$^{-1}$). Degradation was also enhanced when either Fe$^{3+}$ or H$_2$O$_2$ was added to the system, with rate constants of 1.24 (Fe$^{3+}$) and $1.12 \times 10^{-4}$ (s$^{-1}$) (H$_2$O$_2$). In view of the rapid rates observed in these laboratory studies, it is proposed that the photodegradation will be a major pathway for degradation of thifensulfuron-methyl in Saskatchewan natural waters.

COMPARISON STUDY OF SEASONAL CHANGES OF SOIL CHEMICAL PROPERTIES AND ENZYME ACTIVITY IN BAMBOO (PHYLLOSTACHY PUBECENS) FORESTS WITH HIGH AND LOW PRODUCTIVITY. Zhengqian Ye$^1$, Peikun Jiang$^2$, Qiufang Xu$^2$, Yiwu Yu$^2$, and Yuanxin Teng$^3$. $^1$Department of Resources Science, College of Environmental and Resources Sciences, Zhejiang University, Huajiachi Campus, Hangzhou 310029, Zhejiang, China. E-mail: zhqye@zju.edu.cn; $^2$Department of Resources and Environment, Zhejiang Forestry College, Lin-an 311300, Zhejiang, China; $^3$Department of Forest Soils and Environmental Science, Faculty of Forestry, The University of Toronto, Toronto, ON, Canada.

Phyllostachy pubecens is a major bamboo species and has its very important economic values in forestry industry in China. However, productivity of the bamboo forests varies greatly. Soil properties are the key factors that affect the productivity. This study was carried out to understand differences of soil
chemical properties and enzyme activity between bamboo forests with high and low productivity (HP and LP) forests. The two contrasting types of forests that located nearby were selected. Dynamic changes of soil properties were analyzed for one year. Results showed that levels of soil organic matter (OM), total nitrogen (N), hydrolysable N and available phosphorus (P) and enzymatic activities of hydrogen peroxidase, sucrase, and protease were always higher, especially in soils at depth of 0–20 cm, in HP forest than that in LP forest. By contrast, activity of soil phosphatase maintained lower in HP forest. Soil OM, N, P and potassium (K) decreased from spring to summer, and started to recover from autumn. These changes were consistent with growth activity of newly growing bamboo and the change of weather. The emergence of bamboo shoots and their growth to bamboo trees to near full size were during the period from spring to autumn, and soil nutrients were consumed greatly. Soil enzymatic activities of hydrogen peroxidase, phosphatase and protease increased with warming up climate and reached maximum in summer, then started to decrease from autumn. Levels of their activities in winter were similar to that in the spring. Change of soil sucrase activity in LP forest was similar too. In contrast, it maintained at high level in winter in HP forest.

Thallium (Tl) is a rare and dispersed element which occurs mainly in sulphur containing ores and potassium minerals. Tl and its compounds are toxic to all organisms. Geopedochemical levels of Tl in some areas of the Czech Republic were found to be relatively high. The contents of Tl $> 2 \text{mg Kg}^{-1}$ in aqua regia soil extracts were found in soils derived from melanocratic porphyric hornblende–biotite granite or from hornblende–biotite granodiorite. The contents of Tl in the range 0.45–1 mg Kg$^{-1}$ occurred mainly on soils derived from paragneiss. A detailed study of some of these sites has been done. Content of Tl in soils was determined after extraction with aqua regia, 2 M HNO$_3$, DTPA-TEA and 1 M NH$_4$NO$_3$. Plant samples (whole rapeseed kernels) were wet ashed.
and the total content of Tl was determined by ICP-MS. The soil extractants were evaluated according to their ability to predict bioavailability of Tl.

**DIAGNOSTIC METHODS TO EVALUATE NUTRIENT STATUS OF GARLIC, ONION AND BROCCOLI.** Gabriel Alcantar G.¹, Manuel Sandoval V.¹, Javier Z. Castellanos², Fernando Mendez G.¹, Prometeo Sánchez G.¹, and Ma. Nieves Rodríguez M.¹. ¹Edafología, Instituto de Recursos Naturales, Colegio de Postgraduados, 56230 Montecillo, Edo. de México, México. Fax: 52 5951 0198; E-mail: smanuel@colpos.colpos.mx; ²Instituto Nacional de Investigaciones Forestales Agrícolas y Pecuarias, Departamento de Suelos y Fertirrigación, Km 6 carretera Calaya-San Miguel Allende, Apartado postal 112, 38110 Celaya, Guanajuato, México. Fax: 52 46 11 5262; E-mail: casteja@ibm.net

Field experiments with garlic (*Allium sativum* L.), onion (*Allium cepa* L.) and broccoli (*Brassica oleracea* L. var. *italica* Plenk.) were established in the previous four years using fertigation, drip irrigation, and different treatments of plant density, soil moisture levels as well as nitrogen rates and nitrogen forms to test diagnostic nutrient status methods and their correlation to crop yield. Plant samples from fresh roots and bulbs (garlic and onion), stems and leaves were collected at different growing stages to conduct quick field tests for NO₃-N, N-reduced in plant sap, and total N according to the conventional micro-kjeldahl method. It was found that the NO₃-N sap test in fresh stems, fresh roots, and dried roots of garlic were good indicators of its nitrogen status, and the three methods had acceptable correlation with crop yield (r > 0.8). Fertilization with ammonium nitrate as compared to urea increased root growth and fresh weight of bulbs. In onion, only NO₃-N determined in sap derived from the bulb maintained a consistent linear relationship with total N (r = 0.84). In the shoot, NO₃-N concentration was higher than reduced N until 130 days after sowing and in the bulb, the concentration of reduced N was always higher than that of NO₃-N. Sufficiency levels of NO₃-N for broccoli were established in whole leaves and peduncles for six growing stages.

**VIRTUAL SOIL TESTING™. IS IT POSSIBLE?** Rigas E. Karamanos. Western Cooperative Fertilizers Limited, P.O. Box 2500, Calgary, AB, Canada T2P 2N1. Fax: (403) 279-1127; E-mail: re.karamanos@westcoag.com
Currently only 10% at best of the total arable land in western Canada is soil tested. The percentage of farmers testing soil on a yearly basis is even lower. Providing recommendations to the farming community for the non-tested land presents both a challenge and an opportunity. Virtual soil testing (or VST™) is in essence a modeling technique that reverses the soil testing process, i.e., utilizes crop production characteristics in association with chemical tests that assess long-term agronomic practices. In particular, a Health-of-the-Land™ test has been developed that includes such parameters as hot KCl-extractable N, a Q/I relationship for P and K, CEC, organic C, and is employed in establishing the core parameters of a field’s VST. A “traditional” soil test may also serve as a basis for generating virtual soil tests for a land.

A number of field experiments have been conducted to assess the ability of VST to predict crop requirements that are within the requirements generated by laboratories operating in western Canada. Thus, samples from each experimental site were split into six sub-samples and submitted to six different laboratories operating in the region. The recommendations from each laboratory and those generated by VST were replicated twelve times. Both recommendations and resulted yields by utilizing VST were within 95% control limits of the population. Large-scale field data are also presented.

EFFICIENCY OF MULTINUTRIENT EXTRACTANTS FOR THE DETERMINATION OF AVAILABLE ZINC IN SOILS. C.A. Abreu¹, U. Gabe¹, B. van Raij², M.F. Abreu¹, and A. Paz González ³. ¹Centro de Solos e Recursos Agroambientais, Instituto Agronômico, Caixa Postal 28, 13001-970 Campinas (SP), Brazil. Fax: 55 19 32369119; E-mail: caabreu@barao.iac.br; ²Embrapa Meio Ambiente, Caixa Postal 69, 13820-000, Jaguariúna (SP), Brazil. E-mail: bvanraij@zaz.com.br; ³Facultade de Ciências, Universidade da Coruña, Campus da Zapatcira s/n, 15071 A Coruña (Espanha). Fax: 34 981 104129; E-mail: tucho@udc.es

The increasing use of the ICP-AES as a multielement analytical technique has stressed the preference for the use of multinutrient extractants in routine soil analysis. However, few studies relating the extraction of zinc from soil and the absorption of the element by plants have been published. Two experiments under greenhouse conditions were carried out in order to determine the efficiency of some multinutrient extractants on the determination of available zinc in 44 soils from the State of São Paulo, Brazil, for corn and soybean. All soil samples were limed to elevate the base saturation of the CEC at pH 7 to 70%. Twenty two soil samples with DTPA extractable zinc contents lower than or equal to 60 mg Kg⁻¹
received either the application of B, Cu, Mn and Zn or of these micronutrients excluding Zn. The remaining 22 soil samples, with Zn contents above 60 mg Kg$^{-1}$, received applications of the three micronutrients (B, Cu and Mn). Macronutrients were applied to all pots as needed for crop development. Zinc was extracted from the soils before each planting using the extracting solutions DTPA, Mehlich-1, Mehlich-3 and ABDTPA and determined by ICP-AES. The results showed significant correlations between Zn uptake by plant and soil contents. The correlation values between soil-Zn and plant-Zn were 0.74 (M-3), 0.73 (DTPA), 0.62 (ABDTPA) and 0.61 (M-1) for corn and 0.71 (DTPA), 0.63 (M-1), 0.58 (M-3) and 0.46 (ABDTPA) for soybean. Thus the DTPA solution was the most efficient extractant for the determination of bioavailable Zn, if both crops are considered together.

COMPARISON OF WATER EXTRACTION PROCEDURES FOR CHEMICAL ANALYSIS OF SUBSTRATES. M.F. Abreu, C.A. Abreu, O.C. Bataglia, and I. Sazi. Centro de Solos e Recursos Agroambientais, Instituto Agronômico, Caixa Postal 28, 13001-970 Campinas (SP), Brazil. Fax: 55 19 32369119; E-mail: monica@barao.iac.br

The use of substrates for container grown plants is rapidly expanding in Brazil. However, there is no accepted method for physico-chemical evaluation of these materials. The objective of this research was to test different water extraction procedures to evaluate physico-chemical characteristics of substrates. Ten commercial substrates and the most used components (composted pinus bark, rice hulls, peat vermiculite, coconut fiber and others) were used in the tests. EC, pH, NO$_3$, NH$_4$, P, K, Ca, Mg, S, B, Cu, Fe, Mn and Zn were measured in the aqueous extracts. The following procedures were tested: (A) saturation extract; water-extraction based on volumes: (B)1:1.5, (C)1:2 and (D)1:5—using 100 cm$^3$ of substrate added by 150, 200 and 500 mL of water respectively. Extract (E) was prepared by weight, 20 g of substrate and 200 mL of water. Variation of volume relations (F) 1:2 and (G) 1:5 were prepared by adding the substrate or components to volumes of 200 or 250 mL of water to bring the final volume to 300 mL. All samples were analyzed three times for each method. Generally, the coefficients of variation for most of the analyses were high for the extract 1:1.5 (values from 30 to 70%). The lowest values (less than 20%) were observed for the saturation, 1:2 and 1:5 extracts. Correlation coefficients between extraction procedures were always higher than 0.900 for all chemical characteristics. The only exception was obtained with the 1:10 method.
NUTRIENT INDEXING TO MONITOR NUTRIENT STATUS AND RESPONSES OF CROPS IN INTENSIVELY CULTIVATED INDO-GANGETIC PLAINS OF INDIA. C. L. Arora, M. S. Brar, and H. S. Hundal. Department of Soils, Punjab Agricultural University, Ludhiana, India. Fax: 91 161 400945; E-mail: brarms@glide.net.in, brarms@yahoo.co.in

The Indo-Gangetic plains of India are the most intensively cultivated areas with as high as 184% cropping intensity in Punjab. The soils are generally light textured, low to medium in organic matter and alkaline in reaction. Periodic nutrient indexing surveys of crop areas were conducted on benchmark sites on farmers’ fields to determine the extent of nutrient deficiencies and changes in the status of different nutrients under the prevailing cultivation practices. Samples of representative plant parts at the recommended stages of growth were analyzed for P, K, Ca, Mg, S, Zn, Cu, Fe, Mn and B. Results of nine field crops (wheat, rice, groundnut, Egyptian clover, cotton, gram, sugarcane, maize and sunflower), seven fruit crops (grapes, kinnow, guava, peach, pear, litchi and mango) and four vegetable crops (potato, tomato, cauliflower and peas) have been compiled. The data were evaluated for deficiencies on the basis of critical levels available in the literature. Major yield limiting nutrients were phosphorus in groundnut and guava, potassium in sugarcane, guava, litchi and peas, sulphur in sugarcane, sunflower, litchi and mango, zinc in wheat, rice, groundnut, gram, kinnow, grapes, mango, tomato and peas, copper in mango and peas, manganese in groundnut and litchi, and boron in groundnut, mango and peas. Periodic surveys show no change in the concentration of P, K, Ca and Mg. While Zn and Fe increased appreciably in almost all the crops, the concentration of copper and manganese had variable trends. Consequently the most widespread deficiency of zinc during the 1970s has been completely alleviated due to regular application of zinc sulphate by the farmers. Follow up field studies were conducted in farmers’ fields to verify the actual responses to applied nutrients and to estimate the improvement in crop yields. Modified critical levels have been suggested for a few crops. Results suggested that plant analysis could be used as a diagnostic tool to identify and correct the yield-limiting nutrients in crops.

ANALYTICAL METHODS OF SOILS FOR FERTILITY FROM THE OCCIDENTAL REGION OF VENEZUELA. Isabel Arrieche and Mora Orlando. Instituto Nacional de Investigaciones Agrícolas-Yaracuy. Km 3. El Rodeo, Yaritagua. Edo. Yaracuy. Venezuela. E-mail: bibliciae@softome.net
The UNIA-CIAEY Soil Laboratory has been providing services to farmers and researchers of the occidental region of Venezuela (Yaracuy, Lara and Falcon States) for the last 20 years. During that time, the laboratory has analyzed close to 40,000 soil samples. The entire process of soil analysis includes several steps: 1) Field Sample, 2) Drying, grinding and sieving and 3) Physical, and chemical analysis. The analysis involves the following determinations: A) pH in 1:2.5 soil–water, B) Electric Conductivity in 1:5 soil–water, C) Organic matter using the Walkley–Black method, D) Texture analysis using the Bouyoucos method, E) Phosphorus and Potassium using a sodium bicarbonate 0.5 M solution at pH 8.5 (Olsen) and F) Calcium and Magnesium extracted by a sodium acetate solution at pH 4.5 (Morgan). After considering the soil texture, the analytical results are grouped as follows: very low, low, medium, high and very high. The laboratory soil results allow the extension workers to formulate the best doses of fertilizer for the crops of the region (corn, sugarcane and horticultural crops).

CADMIUM ACCUMULATION IN WHEAT AND DURUM WHEAT IN RELATION TO CD EXTRACTED FROM THE SOIL AND CD IN THE SOIL SOLUTION. Håkan Asp, Susanna Hultin, and Patrik Stolt. Department of Crop Science, The Swedish University of Agricultural Sciences, Box 44, S-230 53 Alnarp, Sweden. Fax: 46 40 464590; E-mail: hakan.asp@vv.slu.se, susanna.hultin@vv.slu.se, patrik.stolt@vv.slu.se

The main source of Cd in humans is intake of food, primarily cereals. Thus, it is important to decrease Cd accumulation in cereals aimed for food consumption. Cereal grains generally contain low amounts of Cd, but our large intake of cereal products amounts to a critical intake of Cd. The objectives of this study were to determine the Cd accumulation of high- and low Cd accumulating varieties of wheat, and how this varied with Cd in the soil and soil solution during the growing season. The genetic variation of Cd accumulation in the different cultivars was consistent throughout the growing period and at different sites. Cadmium concentration in the shoots decreased during growth probably due to dilution and possibly by translocation to the seeds. The Cd concentration in the seeds increased during the time of development. Soil Cd content was estimated by extraction with HNO\(_3\), ammonium lactate, and by lysimeter extraction of the soil solution. The pattern of uptake did not relate directly to the estimation of soil Cd content. The results will be discussed in relation to pH, Cd species, clay and organic matter content.
DEVELOPMENT AND VALIDATION OF METHOD FOR COLLECTION AND CHARACTERIZATION OF RICE ROOT EXUDATES. M. S. Aulakh1,2, R. Wassmann1,3, C. Bueno1, J. Kreuzwieser4, and H. Rennenberg4. 1International Rice Research Institute, PO Box 3127, 1271 Makati City, Philippines; 2Present address: Department of Soils, Punjab Agricultural University, Ludhiana 141004, Punjab, India; 3Fraunhofer Institute for Atmospheric Environmental Research, Kreuzeckbahnstrasse 19 D-82467 Garmisch-Partenkirchen, Germany; 4Institute for Forest Botany and Tree Physiology, Albert-Ludwigs University, Freiburg, Germany.

Plant root exudates play several important roles in the rhizosphere; however, a reliable and practicable method of collecting rice root exudates is not available. We used three media (deionized water, nutrient culture solution and 0.01 M CaSO4) for three periods (2, 4, and 6 h) to collect and quantify root exudates of rice plants of IR72, a high yielding dwarf cultivar, at two physiological growth stages in order to develop, optimize and validate a method of collecting root exudates of soil-grown rice plants under submerged conditions. Nutrient culture solution, which would be a logical choice for simulating ambient soil solution surrounding rice roots, created complications in the analyses of exudates for total organic C by wet-digestion method, and organic acids by HPLC due to the interference by its components. Deionized water excluded the possibility of such interferences in analysis but perhaps affected the osmotic behavior of plants as roots released 20 to 60% more total organic C (TOC) than in 0.01 M CaSO4. Further, the proportion of carbohydrates in TOC was also enhanced. On the other hand, 0.01 M CaSO4 maintained the osmotic environment for root cells and did not interfere in analytical procedures. The method was further validated by collecting and comparing the root exudates of rice plants of four widely different rice cultivars. Our results clearly illustrate that short-term collection for 2 h is better to minimize an underestimation of TOC and individual compounds exuded by rice roots. This method for collecting root exudates of rice plants was proven to be a useful tool for obtaining information on the rate and composition of root exudates with increasing plant growth.

ASSESSING POTASSIUM RELEASE IN BENCHMARK SOIL SERIES OF INDIA HAVING SIMILAR NH4OAC-K CONTENT BUT DISSIMILAR IN MINERALOGY. S.K. Bansal1, Shivali Datta1, N.S. Pasricha2, and Patricia Imas2. 1Potash Research Institute of India, Sector-19, Gurgaon-122001, Haryana, India. Fax: 91 124 6341792; E-mail: priiin@bol.net.in; 2International Potash Institute—India Coordinator, c/o DSW, Beer Sheva, Israel.
Potassium release behavior of 20 selected benchmark soil series representing agriculturally important areas of India, with similar NH₄OAc-K content but dissimilar in non-exchangeable K and clay mineralogy was assessed. K release was studied in surface soil samples (0–0.15 m) representing inceptisols (alluvial), vertisols (black) and alfisols (red and laterite) with 40, 80, 120 and 200 (!2) mg kg⁻¹ of neutral 1 N NH₄OAc-K by using 0.01 M CaCl₂ up to a total of 10 extractions. Potassium release data with time was fitted to three mathematical models to describe K release kinetics in these soils.

In the 40 mg kg⁻¹ NH₄OAc-K group, cumulative K release ranged between 64.1 mg Kg⁻¹ in Kumbhave (laterite) to 97.7 mg kg⁻¹ soil in Balisahi soil series (alluvial). In general, the illitic inceptisols had higher cumulative K release than kaolinitic red and laterite alfisols. This trend was also evident in soils having 80, 120 and 200 mg kg⁻¹ NH₄OAc-K. Higher K release was observed in smectitic Kalathur and Kamalikheri soils and the lowest in Tymagondalu and Nedumangad soils containing 15 to 20% of amorphous material besides kaolinite. Smectitic soils, in general, had a fast exchange rate and thus could release high amount of K. However, the dominance of illite in alluvial soils resulted in a more sustained K release over a long time than smectite or kaolinite soils. This is important for nutrient management of agricultural soils of varying mineralogical make-up.

Plots of cumulative K released to CaCl₂, in each case showed curves consisting of two parts, an initial linear part representing a rapid K release from planer surfaces, edges and wedges zone (external K) and second part representing a constant slower K release from the inter-lattice positions (internal K). The external K release rate ranged from 1.25 to 5.00, 2.90 to 5.00 and 2.96 to 5.64 × 10⁻³ cmol K⁺ Kg⁻¹ soil hr⁻¹ in kaolinite, smectite and illite dominant soils, respectively.
relate amounts of heavy metals extracted from the soils to their levels in plant tissue. Results showed that metal concentrations, in general, tend to increase in soil with increasing number of years of irrigation management. Correlation coefficient was poor between EDTA-Ni and HNO₃-Ni, but moderate between EDTA-Cd and HNO₃-Cd and highly significant between Pb extracted by the chelate and the acid solution from the soil. Lead and Cd concentrations in leaf of wheat were responsible for 63 and 78% of the variability of their respective levels in wheat seed. Although Ni concentrations in leaf and seed of wheat were poorly related, content of this metal and that of Cd and Pb were higher in the latter plant organ in most sites, suggesting the absence of a physiological barrier in the transfer of metal from plant vegetative tissue to storage organ and reflecting a matter of concern about the consumption of this grain by animal or human population.

EVALUATION OF TWO MULTI-ELEMENT EXTRACTANTS FOR MEASURING SOIL SULFATE. Dennis J. Chessman¹ and Allen T. Leonard².

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Multi-element extractants speed the process of soil analysis for the commercial agricultural testing laboratory. In recent years, sulfur has become limiting on some of the sandy soils of the southeastern United States. Our objective was to determine if the Mehlich-3 or ammonium acetate-EDTA multi-element extractants could be used for measuring sulfate sulfur ($\text{SO}_4^{2-}$), thereby eliminating the need for an additional test to measure soil-sulfate. These extractants are primarily used to determine plant-available cations, and there is indication they may overestimate available sulfur by removing some organic-S in addition to $\text{SO}_4^{2-}$. Eighty surface soil samples (0–15 cm) from 22 east Texas counties were selected to represent a range of sulfate levels. Mehlich-3 and ammonium acetate-EDTA extracts of the soils were analyzed using inductively coupled argon plasma spectroscopy (ICAP). To determine sulfate-S, the same samples were extracted with 0.15% calcium chloride (CaCl₂), or a solution of 500 mg L⁻¹ of P as calcium phosphate (Ca(H₂PO₄)₂). Both of the extractants have been shown to provide a good estimate of sulfate-S. Aliquots of the calcium chloride and calcium phosphate extracts were analyzed for sulfate-S with a Dionex DX 500 ion chromatograph (IC). Each of the four extractions was duplicated and averaged. Sulfur results obtained with the multi-element
extractants were compared with the sulfate results obtained with CaCl$_2$ and Ca(H$_2$PO$_4$)$_2$ to determine how well the multi-element extractants predict soil sulfate.

**EVALUATION OF SOIL NUTRIENT VARIABILITY FOR DEVELOPMENT OF TURFGRASS SOIL TEST SAMPLING METHODS.** Stephen J. Donohue. Department of Crop and Soil Environmental Sciences, Virginia Polytechnic Institute and State University, Blacksburg, VA, USA 24061. Fax: (540) 231-3075; E-mail: donohue@vt.edu

One of the most important factors in soil testing is selecting a good, representative soil sample. The sample must accurately reflect the nutrient status of the area being sampled. Sampling instructions usually call for separating each location being sampled into uniform areas and collecting a composite sample within each area. An important question that sometimes arises is how many subsamples are needed for a representative composite sample. For turfgrass, sampling instructions from different sources vary from 5 to 20 or more subsamples per composite sample. The objective of this experiment was to evaluate natural soil nutrient variation in a uniform turf area and determine the minimum number of subsamples required for a representative composite sample. Two sites were selected, a 20,000 ft$^2$ turf area behind the Virginia Tech Research Center Laboratory in Blacksburg, VA and a 10,000 ft$^2$ area alongside the Hampton Roads Agricultural Research and Extension Center in Virginia Beach, VA. Both areas received minimal fertilization and liming for over 10 years prior to the study. Grid sampling for pH, P, and K at both locations identified unique areas significantly higher or lower than the average value. Large differences were found in coefficient of variation depending on the number of subsamples/composite. Recommendations will be made regarding optimal sampling strategies based on the results of this study.

**EDTA–OSMOTICUM AS DIAGNOSTIC TEST FOR DETECTING HIDDEN HUNGER OF POTASSIUM AND ZINC IN SUGARCANE GENOTYPES.** R. Snehi Dwivedi and K.K. Srivastava. Indian Institute of Sugarcane Research, Raebareli Road, Lucknow—226 002, India. Fax: 91 522 480738; E-mail: rsdwivediatiisr@123india.com
EDTA–Osmoticum (EDTA–O) was analysed in ten sugarcane genotypes viz *Saccharum spontaneum*, *Eryanthus arundenaceous*, *Schlerostachya* sp. and *Saccharum* hybrid complex lines COS 8118, CO 1148, LG 9001 (tolerant to K and Zn deficiency) and COJ 64, CO 419, COLK 8001 and COLK 8901 (sensitive to K and Zn deficiency) growing under field conditions at Zn-0 (0.56 ug g \(^{-1}\) Zn in Soil) and K-0 (65 Kg K ha \(^{-1}\)) and Zn-10 and K-49 levels at 90 days and 240 days of crop age after planting. Tolerant genotypes recorded significantly higher EDTA–O in the range of 1750–2200 ug g \(^{-1}\) leaf dry wt. than that of 750–900 ug g \(^{-1}\) leaf dry weight of sensitive lines at 90 days of growth. The Zn and K contents in EDTA–O ranged from 5.6–9.2 ug Kg \(^{-1}\) and 41–64 ppm, respectively, in tolerant genotypes which was significantly higher than 1.0–1.8 ug Kg \(^{-1}\) Zn and 22–28 ug g \(^{-1}\) K of sensitive lines. On the contrary, tolerant and sensitive lines at Zn-0 and K-0, and Zn-10 and K-49 levels did not differ significantly in total K and Zn contents at any of the growth stages. However, dry matter production increased significantly with Zn-10 and K-49 levels at 90 days and at 240 days of growth. Cane and sucrose yield increased significantly at maturity stage in sensitive genotypes only. Positive correlation values of \( r = 0.89 \) between EDTA–O and dry matter, \( r = 0.91 \) between EDTA–O and Zn in EDTA–O, and \( r = 0.88 \) between EDTA–O and K in EDTA–O were noted, indicating usefulness of EDTA–O as a diagnostic test for predicting hidden hunger of K and Zn in plants at the early stage of growth. Like bound zinc, bound potassium in EDTA–O might be biologically active but no such report has appeared, so far, in the literature. The possibility is discussed in details in this paper.

EVALUATING 0.01 M CACL\(_2\) AS AN EXTRACTANT FOR ESTIMATING AVAILABLE N FROM SOILS AMENDED WITH ANIMAL MANURES. Jennifer L. Forkes\(^1\) and Michael J. Goss\(^2\). \(^1\)Department of Land Resource Science, University of Guelph, Guelph, ON, Canada. Fax: (519) 824-5730; E-mail: jforkes@lrs.uoguelph.ca; \(^2\)Department of Land Resource Science, University of Guelph, Guelph, ON, Canada. Fax: (519) 824-5730; E-mail: mgoss@lrs.uoguelph.ca

The current Ontario soil test for N measures the nitrate present in the soil at planting and side-dressing. Farmer experience suggests that the test commonly fails to include the N released through the microbial breakdown of organic sources, including animal manures and legume-based forages. This exclusion has been shown to result in the over application of nitrogen, which is both costly to the farmer and the environment. The modified 0.01 M CaCl\(_2\) procedure undergoing detailed investigation involves extracting a soil or manure sample...
with 0.01 M CaCl₂ solution at 20°C, 80°C and then digesting an aliquot of the 20°C fraction in H₂SO₄. The robustness of the 0.01 M CaCl₂ extraction procedure is evaluated in this study using an aerobic incubation and a field-scale experiment. The incubation experiment examines the ability of the procedure to estimate the mineralization of N from soils from a range of clay contents, that have been amended with various manure types. The field experiment examines the ability of the procedure to estimate N availability from different manure types and relates it to N uptake by a corn crop. This study demonstrates the capabilities of the 0.01 M CaCl₂ extraction procedure for use for soil, soils amended with manure and manure alone, in an effort improve to efficient use of manure nitrogen.

**SPATIAL SPECIATION—A NEW APPROACH TO ASSESS SOIL ANALYSIS METHODS.** Anja Gassner, Jürgen Fleckenstein, Silvia Haneklaus, and Ewald Schnug. Institute of Plant Nutrition and Soil Science, Federal Agricultural Research Centre, Bundesallee 50, D-38116 Germany. Fax: 49531 377; E-mail: pb@fal.de

The spatial distribution of plant available phosphorous in agricultural soil was investigated to generate “Digital Agro-Resource-Maps” (DARM). Chemical images of agricultural fields are essential to ensure the efficient and environmentally sound use of fertilisers and are, therefore, the basis for precision agriculture. Given the low background concentrations of P in most soils, it is assumed that the spatial distribution of P in soils is more or less random, reflecting only the spatial sum of distribution faults of past fertiliser applications. According to research already done by our group the spatial dependency (the so called “lag value”) of available P (CAL extracted P) in northern European soils is around 100 M. As different extraction methods for P relate to different physico-chemical binding forms of P in soils, differences in the spatial relations of P extracted by different methods were expected. Samples were analysed for soil texture, pH, Fe, Al, CaCO₃ and organic matter concentrations. P species were determined by using a range of different extraction methods (aqua regia digestion, AAC (Silanpää) CaCl₂). Geostatistical analysis was carried out using the software package Variowin, 2.2. Analysis of variograms showed that the spatial distribution of acid extracted P differed from that of AAC and CaCl₂ extracted P. Variograms of the latter displayed larger lag values than the former. Additionally, variograms of acid extracted P displayed nested structures, indicating that the distribution is governed by scale-dependent environmental factors.
A SIMPLE METHOD FOR ASSAYING TOTAL GLUCOSINOLATE CONTENT OF PLANT MATERIALS BY USING ION CHROMATOGRAPHY. Sham S. Goyal and Melissa Naguwa. Department of Agronomy and Range Science, University of California at Davis, Davis, CA, USA 95616. Fax: (530) 752-4361; E-mail: ssgoyal@ucdavis.edu

Naturally occurring phytochemicals possessing unique medicinal properties have become a matter of high interest in recent years. A good example is the enormous increase in the use of Saint John’s Wort in Europe to treat depression. The anticancerous property of the vegetables of the family cruciferae, e.g., cauliflower, kale, broccoli, cabbage, mustard, and Brussels sprouts, has been attributed to a class of sulphur-containing phytochemicals known as glucosinolates. In the practical sense, the total glucosinolate content is generally considered the important parameter and hence that is what would generally be needed as a marker of product quality. The most frequently used method for the assay of total glucosinolates so far has been by assaying glucose which is produced stoichiometrically by the action of enzyme myrosinase. Various approaches for glucose assay have been employed and most are time-consuming and expensive. Fortunately, all glucosinolates, as a group of compounds, possess a sulfate group along with glucose which can be easily and stoichiometrically released by the action of enzymes myrosinase or sulfatase. The resulting sulfate can be easily and conveniently assayed by the use of ion chromatography. This paper presents the results of research that was undertaken to develop a simple method for assaying total glucosinolates in plant materials by sulfate ions release and using Suppressed Ion Chromatography.

FACTORS AFFECTING NUTRIENT SUPPLY RATE MEASUREMENTS WITH PRS™-PROBES. K.J. Greer¹, J.J. Schoenau², V. Baron³, and C. Sulewski¹. ¹Western Ag Innovations Inc., 208-111 Research Drive, Saskatoon, SK, Canada S7N 3R2. Fax: (306) 978-4140; E-mail: westernag@westernag.ca; ²Department of Soil Science and Land Resources, University of Saskatchewan, Saskatoon, SK, Canada. E-mail: schoenau@sask.usask.ca; ³Lacombe Research Station, Agriculture & Agri-Food Canada, Lacombe, AB, Canada. E-mail: barony@em.agr.ca

Plant Root Simulator (PRS™) probes are an effective tool for measuring nutrient supplies to plant roots in situ under soil conditions similar to those in which plant roots grow and absorb nutrients. They are comprised of an anion or cation exchange resin membrane encapsulated in a plastic holding device. Due to the high concentration of ion adsorption sites on the resin surface, the PRS™
membrane acts as an ion sink in the soil, similar to a plant root surface. Ion movement to this sink is a function of the size of the various ion pools in the soil as well as soil physical, chemical and biological conditions. Thus, it is important to consider all factors of the soil environment when planning experiments with the PRS™ and when interpreting PRS™ supply rate data. Some of the major factors affecting in situ supply rate measurements include soil moisture content, soil temperature, the duration of burial of the PRS™-probes, and competition for ions from other ion sinks including plant roots and micro-organisms. This paper discusses the effects of variations in these factors on PRS™ supply rates.

COMPARISON OF SOIL K ASSESSMENT BY PRS™-PROBES AND NH₄OAC EXTRACTION. K.J. Greer and C. Sulewski. Western Ag Innovations Inc., 208-111 Research Drive, Saskatoon, SK, Canada S7N 3R2. Fax: (306) 978-4140; E-mail: westernag@westernag.ca

Soils were sampled across a field in southern Saskatchewan, Canada and assessed for soil K content. PRS™-probes were buried in field moist sub-samples of these soils for a 24-hour period to assess K supply rates. Separate sub-samples were extracted with NH₄OAc to determine extractable K content. PRS™ K supply rates represent the flux of K ions from the soil to a plant root under conditions specific to the plant root environment while chemical extractions are used as an index of the exchangeable K in the soil. Potassium supply rates were correlated with the NH₄OAc extractable K ($r^2 = 0.58, n = 83, \beta = 0.01$). A significantly stronger correlation existed between the PRS™ K supply rate and the %K estimated to exist on the CEC ($r^2 = 0.78, n = 83, \beta = 0.01$). Comparisons were made to plant yields in the field using GPS co-ordinates and a yield monitor. Ammonium acetate extractable K levels did not correlate with flax yields harvested in the fall of 1999 ($r^2 = 0.001, n = 20$), conversely, PRS™-probe measured K supply rates were significantly correlated to flax yields ($r^2 = 0.20, n = 20, \beta = 0.05$). Removal of one sample with known salinity and two samples with known yield measurement errors improved the correlation of flax yield with K supply rate to $r^2 = 0.68 (\beta = 0.05)$ and with extractable K to $r^2 = 0.08$.

NITROGEN DETERMINATION IN PLANT MATERIAL USING X-RAY FLUORESCENCE SPECTROSCOPY. S. Haneklaus¹, M. Banzhaf², and E. Schnug¹. ¹Institute of Plant Nutrition and Soil Science, Federal Agricultural
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The determination of light elements for example sulphur, calcium, chlorine, magnesium, phosphorus, potassium, silicon and sodium in plant material by instrumental, sequential X-ray fluorescence (X-RF) spectroscopy provides a high level of accuracy, precision and performance in comparison with other methods. Furthermore this technique enables the indirect determination of the total glucosinolate content in seeds of Brassica species which is a standardized ISO method (ISO/CD 9167.2). The Kjeldahl method is the oldest of all analytical procedures in use today and still widely applied for determining the nitrogen content of organic materials. Until now X-RF could not be employed for the analysis of ultra-light elements such as nitrogen, because the measured intensities were too low and relationships with plant nitrogen contents very poor. But using an enclosed proportional counter with a high transmission, this problem could be overcome efficiently. In this study the nitrogen content of plant material with a wide range of matrices was determined by Kjeldahl and a dry combustion method and compared to X-RF analysis. In this paper, sample preparation for X-RF analysis, X-RF settings and calibration with standard reference materials for the determination of the total nitrogen content in plant material will be described and the results of the quality assessment will be discussed comprehensively.

AUTOMATION OF ROUTINE SOIL EXTRACTION PROCEDURES.
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Hill Laboratories have developed an automated system for soil extractions. Pre-dried, milled soils are loaded into a robot. The robot dispenses soils into beakers, doses reagent, mixes for a specified time period, automatically filters, and delivers extracts into test tube racks for subsequent instrumental analysis. The robot processes one sample per minute; each sample can be analyzed for four tests (Olsen P, Cations, Sulfate-S, and online pH). The robot uses a continuous process; incorporating a washing station to prepare the beakers for
reuse. This robot is configured to analyze soils on a volume basis. The robot
also determines volume weight so it can be programmed to analyze soil on a
weight basis, if required. The robot will more than double operator
productivity, and also improve analytical precision. It is seen as having
application in other routine soil analyses.

**COPING WITH EFFECTS OF HIGH DISSOLVED SALT SAMPLES ON
THE INDUCTIVELY COUPLED PLASMA SPECTROMETER.** J.E.
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Research on acidic forest soils typically uses unbuffered salt solutions as
extractants for exchangeable cations. Our lab uses 1 M NH₄Cl extractant for
exchangeable cations (Ca, K, Mg, K and Na) and 1 M KCl for exchangeable
aluminum. The resulting high dissolved salt solutions presented chronic
analytical problems in flame atomic absorption spectrophotometer (AAS) and
direct current plasma spectrometer (DCP). More recently, the analyses
completed on a simultaneous, axial inductively coupled plasma-atomic
emission spectrometer (ICP-AES) have continued to be problematic. Although
ICP manufacturers provide application notes that list some precautions to help
minimize the salt effect, such issues are seldom mentioned in published
articles and can be misleading when interpreting results. This poster describes
various modifications that have been tried to eliminate the effects of high
dissolved salts when using ICP. Adjustable parameters such as gas flow rates,
sample introduction rates, dilution rates, and accessories were tested. Results
of each modification were evaluated by comparing method detection limits,
recovery rates, and carry-over values to determine the most effective
operating ICP system. For example, a 15 second increase of sample uptake
and rinse times for the KCl method decreased the method detection limit
(MDL) by 12%, recovery rate by 12%, and carry-over by 25%.

**ANALYTICAL METHODS: EVALUATION AND STATUS OF
PHOSPHORUS FRACTIONATION IN CALCAREOUS SOILS OF
SAUDI ARABIA.** Ali A. AL-Jaloud¹*, Ghulam Hussain¹, and I.I. Bashour².
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Availability of phosphorus is a major concern for crop production due to the presence of high level of calcium carbonate in soils of Saudi Arabia. Although total phosphorus is very high in soils, its availability to plants is extremely low. To evaluate P availability, different analytical methods were used to fractionate P in soils. Organic matter was determined by Walkley and Black Method. Different digestion methods used for phosphorus fractionation were: total P, organic P, available P, inorganic P fractionation with modification. The P in all the extracts was determined by ascorbic acid-molybdate blue colour method of Murphy and Riley. The ranges for different P-fractions expressed as mg L\(^{-1}\) were: Total-P (182–1,088), inorganic-P (0–90) and Ca-P (182–902) being the largest amount. Other fractions such as Al-P and occluded-P were negligible whereas Fe-P and residual-P were present in slightly higher amounts. However, amount of available-P was below critical limits as compared to the established standards elsewhere. Overall results indicated that P concentration is closely related to the total amount of organic matter present in soils in an arid environment. The study highlighted the importance of increasing organic matter status of agricultural soils for increasing P fertilizer use efficiency in calcareous soils.

THE APPLICATION OF THE N\(_{\text{MIN}}\)-METHOD IN RATIONAL FERTILISING OF WHEAT AND BARLEY. Z. Jovanovic, M. Veskovic, C. Radenovic and S. Sredojevic. Maize Research Institute, Zemun Polje, Belgrade, Yugoslavia.

The N\(_{\text{min}}\) method is one of the most important methods in the nitrogen (N) rational use in fertilising of wheat and barley. The determination of the content of easy available forms of nitrogen (NO\(_3\)-N) and NH\(_4\)-N) for top-dressing during the growing season is a decisive factor in yield formation of small grain cereals. This method is quite reliable under Yugoslav agroecological conditions and has been applied for the last 15 years. For the last 12 years, it has been annually used at the area of 600 ha of chernozem and marshy black soil by the Maize Research Institute, Zemun Polje. The content of NO\(_3\)-N, NH\(_4\)-N and NO\(_2\)-N is observed over three different layers at the depth of 0–30, 31–60, and 61–90 cm. In such a way, nitrogen requirements are determined in relation to needs of a variety (genotype) of wheat and barley. The application of the N\(_{\text{min}}\) method save approximately 25% of nitrogen fertilisers in top dressing in comparison to
previously applied rates, while the average yield amounts to 5.7–6.3 t ha\(^{-1}\). In Yugoslavia, 450,000–500,000 ha out of 850,000 ha under wheat is covered by the application of this method. In general, top dressings with 60–90 kg N ha\(^{-1}\) are annually applied.

**THE CURRENT STATUS OF INTERNATIONAL METHODS VALIDATION FOR SOIL ANALYSIS.** Yash P. Kalra. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, 5320-122 Street, Edmonton, AB, Canada T6H 3S5. Fax: (780) 435-7359; E-mail: ykalra@nrcan.gc.ca

The AOAC INTERNATIONAL (AOACI) promotes methods validation and quality measurements in the analytical sciences. An earlier paper by the author gave information on the role of two AOACI committees (Methods Committee on Feeds, Fertilizers, and Agricultural Related Topics and Methods Committee on Environmental Quality) and the Soil Science Society of America Committee S889 (Coordination of Official Methods of Soil Analysis Committee) in the official methods program. The present paper gives details on the review and approval process. It discusses the current status of the collaborative studies on these topics: (1) Soil pH (2) Nitrates in soil (3) Plant available P for acid soils (4) Plant available P for calcareous soils (5) Plant available K for soils (ammonium acetate Method) (6) Plant available Cu, Fe, Mn, and Zn (DTPA Method) (7) Calcium carbonates in soils and (8) Lime requirement determination in soils.

**THE EFFECT OF QUANTITATIVE FILTER PAPER BRAND ON KCL EXTRACTED SOIL FILTRATE PH AND ON THE TITRIMETRICALLY DETERMINED EXCHANGEABLE Al AND H DETERMINATION.** Takashi Muraoka and Anderson R. Trevizan. Laboratorio de Fertilidade do Solo, CENA, Centro de Energia Nuclear na Agricultura, Universidade de S. Paulo, Caixa Postal 96, 13400-970 Piracicaba, SP, Brazil. Fax: 55 19 4294610; E-mail: Muraoka@cena.usp.br

Exchangeable acidity (Al + H) or exchangeable Al ions are most commonly extracted with an unbuffered salt solution, such as 1 M KCl. Although some laboratories just leave the supernatant after shaking for a time varying from some hours to overnight for decanting, the correct procedure is to filter it through a
quantitative filter paper immediately after shaking the soil plus extractant. Several methods are available for Al and H determination, but the most used one is by titrimetry (pH dependent). Two predominant quantitative filter paper brands available for this purpose in Brazil are Whatman 42 and Framex Faixa azul (commercial local name of Schleicher and Schleicher). They are basically made with a cellulose material submitted to a double acid washing. The study compared the effect of these two different brands of filter papers on: a) pH of filtrates and b) pH and Al and H determined by titration method of a range of local and Amazonian soils. Considerable differences were observed in the results obtained using the two different brand filter papers. The pH of 1 M KCl solution, originally 5.89, decreased to 4.31 when Whatman filter was used and to 3.87 with Framex. The decrease in pH of soil KCl extracts was always higher with Framex filter papers, resulting in higher values of Al + H, but lower Al. In order to overcome these differences, blank should always be included using the same brand of filter paper.

EVALUATION OF FOUR SOIL TEST METHODS FOR PLANT AVAILABLE P IN RELATION TO RELATIVE ABUNDANCE OF INORGANIC P FRACTIONS FOR PEANUT IN SEMIARID SUBTROPICAL SOILS. N.S. Pasricha, R.K. Vempati, and M.S. Aulakh. Department of Soils, Punjab Agricultural University, Ludhiana—141004, India.

Crop species respond differentially to soil test P when grown in the same field suggesting that Olsen’s extractable P, a commonly used soil test method to predict crop responses and fertilizer P requirement, may not be applicable to all types of soils and crops. We investigated the performance of four chemical extractants and relative abundance of different inorganic soil-P fractions of 15 peanut-growing semiarid subtropical soils in relation to P nutrition of peanut (Arachis hypogea L.). Amounts of P extracted by different extractants were in the descending order: Nelson’s acid extractant (0.05 N HCl + 0.025 N H₂SO₄) > Colwell (0.05 M NaHCO₃, pH 8.5, 16 h) > Bray (0.03 N NH₄F + 0.025 N HCl) > Olsen (0.5 M NaHCO₃, pH 8.5, 0.5 h). Of these extractants, only Nelson’s acid extractable P showed significant correlation with peanut dry matter (r = 0.89**). A critical level of Nelson’s acid extractable soil P below which response of peanut to fertilizer P can be observed, as calculated by the method of Cates and Nelson, was 165 kg P ha⁻¹. Amongst the inorganic phosphorus fractions, calcium bound P was most abundant followed by aluminum-, iron- and saloid bound-P in that order. Hence calcium bound P correlated significantly with dry matter (r = 0.71*). These results suggest that in the coarse textured, neutral to
ESTIMATION OF SOIL MICROBIAL BIOMASS—AN INDEX OF AVAILABLE N. Dharani D. Patra, Sukhmal Chand, and Mohamad Anwar. Soil Science and Water Technology Division, Central Institute of Medicinal and Aromatic Plants, PO CIMAP, Lucknow—226015 (U.P.), India. Fax: 91 522 342666; E-mail: cimap@satyam.net.in

A study was conducted to evaluate microbial biomass, C, and N in different mint (Mentha arvensis) growing soils and soil microbial biomass as an index of plant-available N. Five soil (0–15 cm) samples were collected from the mint growing areas of Lucknow and Barabanki districts of Uttar Pradesh, India. The soils differed widely in pH (7.2–8.2), EC (0.48–0.79 dS m\(^{-1}\)), organic C (0.35–1.12 \%), alkali-KMnO\(_4\) extractable N (65–167 ug g\(^{-1}\)), available P (3.5–28.0 ug g\(^{-1}\)), and K (175–250 ug g\(^{-1}\)). Biomass C was estimated by the fumigation–extraction technique. Mint was grown for 16 weeks in the same soils to correlate soil available N with dry matter yield and other yield attributes. Estimates from the initial soil indicated that biomass-C, as a percentage of organic C, ranged from 6.1 to 7.1\%. Biomass C significantly decreased with incubation in all soils. At week 8, it was reduced to 35–45\% of initial amount. Soil microbial biomass-N which amounted to 4.7–8.6\% of the total N, also decreased with incubation. The flush of N (expressed as the difference between inorganic N extracted from the fumigated- and non-fumigated soil) could be used as an indirect measure of soil N mineralization potential, and as an index of plant available N. The results indicate that all forms of available N showed a significant and positive correlation with herb yield and N uptake by plants. The highest positive correlation with respect to N uptake by plants was observed with microbial N and the lowest with mineral N.

NITRATE EXTRACTION FROM FRESH PLANT MATERIAL BY MEANS OF A METHANOL:WATER EXTRACTION SOLUTION. Joost A.P. Salomez, and Georges E.R. Hofman. Ghent University, Faculty of Agricultural and Applied Biological Sciences, Department of Soil Management
Nitrate determination from fresh plant material is common in routine analysis but comparisons between extraction solutions, detection techniques or combinations of both show that there is a wide range in performance in methods for determining plant nitrate. Therefore, the performance of methanol:water (1:1, V:V) as extraction solution was compared against water and KCl as extractants. Measurement results of methanol:water extracts were consistently higher than the water or KCl results, respectively 72 and 47% higher. Even compared to a recommended nitrate determination method, using dried plant material, significantly higher results were obtained with methanol:water as extraction solution. Whereas the outcome of the recommended method was on average 29.8 mg NO₃ L⁻¹, the result of the methanol:water extraction was on average 87.8 mg NO₃ L⁻¹. Furthermore, the results of the methanol:water extracts of two common determination techniques, i.e. segmented flow analysis and HPLC detection technique, were highly comparable (R² = 0.996), stating that mostly not the detection technique but the pre-treatment phase and the extraction solution are critical to accurately measure the nitrate concentration of plant material.

FRACTIONATION OF CD IN SOILS AS AFFECTED BY APPLIED CD AND BRASSICA GENOTYPES. Kuldeep Singh¹ and J.S. Brar². ¹Department of Soil Science, CCS Haryana Agricultural University, Hisar—125 004 India. Fax: 91 1662 34952; E-mail: coag@hau.hry.nic.in ²Punjab Agriculture University, Regional Research Station Bathinda, India.

Cadmium is one of the most toxic and mobile metallic elements found in soils. Determination of different chemical forms of Cd in soils is important to know its mobility and bioavailability. The chemical forms of Cd were characterised by sequential extraction analysis of soil samples collected after harvesting of seven Brassica genotypes Cd in the original soil ranged from 0.36 to 80 mg Cd Kg⁻¹ soil. Result show that there is a wide range in concentration of Cd associated with individual soil fractions. The highest concentration of Cd is associated with residual, Fe-Mn oxide and carbonate-bound fractions, while the lowest concentrations of Cd is in exchangeable and organic-bound fractions in the original soil. In Cd-treated soil, there is a shift toward exchangeable + water soluble, Mn oxide-bound, amorphous Fe oxide-bound, and crystalline Fe oxide-bound but there is little change in the residual fraction. This suggests that a substantial portion of added Cd in these soils has reverted to forms likely to be available for plant uptake. There is no
significant impact of genotypes on different factions of Cd in soil. The smallest percentage of Cd is bound to the organic matter fraction due to light texture and very low organic matter status of the soil. The relatively high proportion of Cd in exchangeable and carbonate-bound forms accounted for about 27% of the total extracted which indicates that Cd in soil is influenced by added Cd and represents a risk due to its bioavailability.

ANALYTICAL PROCEDURES FOR SOIL P IN ORGANIC-BASED SYSTEMS. Paul C. Smithson¹, Peter N. Mbugua¹, and Else Bünnemann². ¹International Centre for Research in Agroforestry, P.O. Box 30677, Nairobi, Kenya. Fax: 254 2 524001; E-mail: p.smithson@cgiar.org; p.mbugua@cgiar.org; ²Institute of Plant Sciences, ETH Zürich, P.O. Box 185, CH-8315 Lindau, Switzerland. Fax: 41 52 3549119; E-mail: else.buenemann@ipw.agrl.ethz.ch

Agroforestry and other organic-based cropping systems are common in tropical agriculture, while inorganic fertilizer use is generally low in smallholder farms. Soil inorganic P levels are often low in organic-based low-input cropping systems, and organic fractions of P assume greater importance for crop nutrition. Sequential P fractionation has been used to identify P fractions important in low-input systems, particularly the organic fractions. We are testing several methods of estimating active soil organic P fractions, including sequential P fractionation, particulate organic matter P content, microbial biomass P and acid phosphatase activity, in several agroforestry experiments in western Kenya. Some sequentially extracted inorganic P fractions appear to be useful measures of available P (NaHCO₃ and NaOH fractions) and undissolved Ca-P forms such as phosphate rocks (HCl or H₂SO₄ fraction). However, sequentially extracted organic P fractions have not proven to be sensitive measures of soil P dynamics under agroforestry. Microbial biomass P and particulate organic matter P have been useful in describing crop performance under agroforestry systems. Recent data on soil acid phosphatase activity suggest this to be a promising avenue for further research.

SOIL N AVAILABILITY: COMPARISONS OF SPATIAL DISTRIBUTIONS USING AEROBIC INCUBATION, PRS™, HOT KCL/HYDROLYSABLE ORGANIC N, AND INORGANIC N. T.T. Yates¹ and F.L. Walley². ¹Bioriginal Food and Science Corp., 102 Melville St. Saskatoon, SK, Canada, S7J 0R1. Fax: (306) 975-9252; E-mail: tyates@bioriginal.com;
The full potential of variable rate fertilization cannot be realized until a method of determining the soil N contribution from mineralization of organic matter is found that has a strong spatial relationship to crop yield. The objective of this study was to identify a measure of soil N availability that had a strong relationship to both landscape and wheat grain yield along a single transect in a typical Saskatchewan farm field. These relationships were examined spatially using landform element classification and geostatistics. Soil nitrogen (N) availability was estimated by aerobic incubation, Plant Root Simulator (PRS™), determination of soil inorganic N ($\text{NO}_3^- + \text{NH}_4^+$), hot KCl extractable N, and N hydrolyzed from organic matter.

With the exception of inorganic N, soil N availability and related soil properties were related to landform particularly hydrolysable organic N, spring soil moisture content, and grain yield, all of which showed significant differences between shoulder and foot-slope positions. Hydrolysable organic N showed the strongest correlation with grain yield ($r_s = 0.519$, significant to $P \leq 0.01$) and N uptake ($r_s = 0.538$, significant to $P \leq 0.01$). Soil inorganic N was unrelated to landscape position and to grain yield ($r_s = -0.170$, non-significant). Grain yield, hydrolysable organic N, and spring soil moisture were highly correlated with the N mineralization that occurred during the first 2 weeks of a long-term incubation. Geostatistics indicated a spatial relationship between hydrolysable organic N, spring soil moisture, and wheat grain yield.

The results suggest that hydrolysable organic N represents a source of available soil N important to, and related spatially to, wheat yield and N uptake. Strong similarities in the spatial distribution between hot KCl and PRS-N, as well as the similarities in their respective correlations to wheat grain yield and N uptake, suggest that the PRS™ access the same soil N pools as hot KCl and, in effect, sees the same source of N as does the plant. Thus PRS™ may be an effective tool to evaluate the N supply important to a crop.
Seven soil P extractants (Mehlich 2, Mehlich 3, CAL, Olsen, Egner, 0.01 M CaCl₂, and aqua regia) were compared, using 1,173 agricultural soil samples that represented all major soil types and proportions of agronomic cultures. Mehlich 3 is the official extractant for soil P. The amount of phosphorus extracted by the selected methods was, in comparison to Mehlich 3 (100%), approximately: aqua regia (80%), CAL (95%), Mehlich 2 (80%), Egner (80%), Olsen (40%), 0.01 M CaCl₂ (2%). Highly significant linear relationships between Mehlich 3 and Mehlich 2, Olsen, CAL, 0.01 M CaCl₂ were found. No relationship was found between aqua regia and the other extractants. Coefficient of determination (R²) for the linear regression between Mehlich 3 and the other methods for soils with carbonate content less than, or equal to, 0.3 % were 0.928 (Mehlich 2), 0.742 (Olsen), 0.515 (CAL), 0.492 (Egner) and 0.556 (0.01 M CaCl₂). For soils with carbonate content higher than 0.3 %, the coefficients of determination were usually lower: 0.879 (Mehlich 2), 0.630 (Olsen), 0.732 (CAL), 0.490 (Egner). The hypothesis that the Olsen extractant should be used instead of Mehlich 3 for soils with higher carbonate content was not proved; highly significant relationships between the methods were found for soils with higher carbonate content.

USE OF HIGH PERFORMANCE LIQUID CHROMATOGRAPHY FOR SOIL AND PLANT ANALYSIS. Sham S. Goyal. Department of Agronomy & Range Science, University of California at Davis, Davis, CA, USA 95616. Fax: (530) 752-4361; E-mail: ssgoyal@ucdavis.edu

Analytical methods have always played an important role in the development of many research areas and commercial ventures. An ideal analytical method would be the one that provides precise and reliable information and is sensitive, rapid, and inexpensive to perform. Unfortunately, rarely does a single method offer everything. Historically, the field of soil and plant analysis has been dominated by techniques in which the analyte is not isolated from rest of the sample prior to its estimation, e.g., atomic absorption/emission spectrophotometry, colorimetry. When using an analytical method in which the analyte of interest is not isolated from rest of the matrix, one can never be certain about the possible interference by other constituents in the sample. Analytical methods involving chromatographic techniques separate and purify the analytes prior to their quantification and hence are interference free. This feature greatly enhances reliability and hence makes these the methods of choice. The advent of high performance liquid chromatography (HPLC) made it possible to have many of these methods as “on-line” and on a “micro” scale. The net result is that HPLC has evolved into a powerful analytical technique offering high versatility, sensitivity, speed, reliability, precision, and simultaneous multi-
component analysis, small sample requirements, and reasonable cost. This presentation will discuss theory, practices, and applications of HPLC that have provided a major boost to soil and plant analysis.

SOIL ORGANIC MATTER DYNAMICS: UNIFYING MEASURABLE VARIABLES AND KINETIC CONCEPTS. W. B. McGill1, R.C. Izaurralde2, and Y. Feng3. 1University of Northern British Columbia, Prince George, BC, Canada. E-mail: mcgill@unbc.ca; 2Joint Global Change Research Institute—PNNL, University of Maryland, Washington, DC, USA. E-mail: cesar.izaurralde@pnl.gov; 3Univ. of Alberta, Edmonton, AB, Canada. E-mail: yongsheng.feng@ualberta.ca

Soil organic matter (SOM) quantity and quality are major determinants of ecosystem productivity and function. Carbon, the major constituent of SOM, also plays a major role in the modern C cycle from local to global scales. Significant progress has been made toward understanding the main biological, physical and chemical controls of soil organic C (SOC) stabilization and dynamics. The mathematical description of SOC dynamics has relied on the use of kinetic expressions such as zero order, first order, Monod, and Michaelis–Menten. However, some of the conceptual compartments (e.g., active, slow) used in these kinetic approaches have been difficult to characterize. Future progress will rely on rigorous mechanistic understanding of the processes operating and regulating C flows and stabilization in soil. Research to understand SOC stabilization and dynamics using a physical protection paradigm has led to the identification and measurement of discrete SOC entities (e.g., particulate organic matter). Efforts in reconciling our understanding of kinetic (i.e., knowledge of turnover times) components and discrete (i.e., measurable) entities will be presented and discussed.

ANALYTICAL PROSPECTS FOR DIFFERENTIATION OF INHERITED (GEOLOGICAL) ORGANIC CARBON FROM PEDOGENIC ORGANIC CARBON IN CONSTRUCTED SOIL PROFILES. D. Pluth. Department of Renewable Resources, University of Alberta, Edmonton, AB, Canada. E-mail: Don.pluth@ualberta.ca

Soil reclamation of highly disturbed areas such as in the engineered landscapes following open-pit coal mining usually begins with construction of a three-layered
profile in which the upper two layers may range from 0.5 to 1.5 M. The three layers commonly consist respectively of displaced materials of local solum (A and maybe B horizon), glacial drift, and soft sedimentary rock. In the glaciated Northern Great Plains region of North America the upper bedrock stratigraphy includes carbonaceous shale and lowly-ranked lignite to more mature bituminous coal. Quantitatively differentiating the plant and microbial carbon of recent origin (especially since profile construction) from the inherited, aged forms of organic carbon is desired information for discerning ecosystem processes and for estimation of rates of carbon sequestration. Undoubtedly interactions between soil–crop management practices and alternatives in soil profile layering influence accumulation and transformations of soil organic matter with profile depth. Physical and chemical analytical methods are critically reviewed from the standpoint of differentiating inherited from recently formed soil organic carbon. Some methods examine the chemical composition and structure of humic substances as proxies to inferred origin (age) of the organic carbon. Solid state $^{13}\text{C}$ nuclear magnetic resonance spectroscopy and Fourier-transform infrared spectroscopy are two of these indirect instrumental methods. However, results from these indirect methods may be confounded in that mild oxidation of mature bituminous coal leads to formation of “regenerated” humic acids that cannot be analytically distinguished from modern humic acids. Furthermore, the immature lignite and brown coal have native humic acids. Other proposed methods directly determine forms of organic carbon, and thus are appealing from the standpoint of widespread comparisons of results and of possible regulatory protocol in soil reclamation.

ADVANCED ANALYTICAL TECHNOLOGIES AND INSTRUMENTATION COMPARING LOSS-ON-IGNITION WITH DRY COMBUSTION METHOD FOR DETERMINATION OF ORGANIC MATTER FOR UPLAND AND LOWLAND FOREST ECOSYSTEMS. J.S. Bhatti$^1$, Ilka E. Bauer$^2$, and Dale H. Vitt$^3$. $^1$Northorn Forestry Centre, Canadian Forest Service, Edmonton, AB, Canada T6H 3S5. Fax: (780) 435-7359; E-mail: Jbhatti@nrcan.gc.ca, $^2$Department of Biological Sciences, University of Alberta, Edmonton, AB, Canada T6G 2E9. E-mail: ibauer@gpu.srv.ualberta.ca, $^3$Department of Plant Biology, Southern Illinois University, Carbondale, IL, USA 62901. E-mail: dvitt@plant.siu.edu

Forest and peatland ecosystems contain a large amount of soil organic matter (SOM). Improving the estimates of SOM, and increasing understanding of the factors influencing variability in these estimates are important in understanding the role of SOM in the global carbon cycle. Estimates vary considerably, and the
uncertainties associated with these estimates are difficult to determine. Most studies use the less intensive loss-on-ignition (LOI) method for SOM quantification; requiring only an accurate balance and high temperature oven. Although more intensive, quantification using the dry combustion method is more accurate and precise. The objective of this study was to compare the LOI method to the dry combustion method for determination of SOM for forest and peatland ecosystems. Forest floor samples from 15 sites across the Boreal Forest Transect Case Study area, and 256 peat samples from four different types of peatland in western Canada were used to evaluate the influence of vegetation, varying location, and climate on SOM. Estimation of SOM by LOI was well correlated with the dry combustion method for both forest and peatland ecosystems. Our results show that the appropriate conversion factor to estimate SOM is affected by the climatic zone and amount of particulate matter in the soil. The variation in the conversion factor (from 1.0 to 4.0) across the region indicates the need for study specific, rather than a single factor such as the Van Bemmelen factor (1.724), to accurately estimate SOM. Our results indicate that caution should be used in interpreting SOM data by LOI and we suggest the use of dry combustion analyses to confirm the data.

EMPLOYMENT OF A NEW MODEL OF LASER INTERFERENCE AUXANOMETER FOR THE STUDY OF RESPONSE REACTIONS OF PLANTS ON EFFECT OF EXTERNAL FACTORS. Natalia V. Budagovskaya¹ and Valery I. Guliaev². ¹Institute of Plant Physiology of the Russian Academy of Sciences, Botanicheskaya 35, Moscow 127276, Russia. Fax: 7 95 939 3181; E-mail: mbeloz@genebee.msu.su; ²All-Russian Institute of Genetics and Breeding of Fruit Plants, Michurinsk-10 393740, Russia.

A new model of laser interference auxanometer LINA-EM3D (differential type) was used for the study of effect of the changing conditions at the root zone (temperature, composition of nutrient media, addition of biologically active compounds) on the growth dynamics of plants. The measurement of the shoot growth and temperature of air and substrate at the root zone was performed in a permanent regime. Calcium channel blocker verapamil, added to the root zone, caused a decrease in the growth rate of leaves and stems of wheat, rice and buckwheat plants to zero or to a certain constant level (depending on concentration). At low verapamil concentrations an increase in growth rate was observed after its decrease for 1.5–2.0 h (restoration process took place). Susceptibility of plants to verapamil depended on their genotypic properties and growing conditions. Rice plants, grown at higher illumination and temperature or
on a mixture of sand and peat, were less susceptible to effect of verapamil than those grown at lower illumination and lower positive temperatures or on sand. The increase in temperature in the root zone from 22 to 32 °C resulted in increase in susceptibility of buckwheat but not rice plants to verapamil.

DETERMINATION OF TOTAL AND DISSOLVED PHOSPHORUS IN AGRICULTURAL RUNOFF SAMPLES BY ICP-MS. A. Cantarero¹, M.B. López², J. Mahía¹, M.A. Maestro¹ and A. Paz González². ¹Servicios Xerais de Apoio a Investigación, Universidade da Coruña, 15071, A Coruña. Spain. Fax: 34 981 167068; E-mail: sxaiicp@udc.es; ²Facultade de Ciencias, Campus da Zapateira s/n, Universidade da Coruña, 15071, A Coruña. Spain. Fax: 34 981 167065; E-mail: tucho@udc.es

The leaching of nutrients to the drainage network is an important factor in the pollution of surface waters, whereby phosphorus (P) is often the element of concern. Because P is strongly bound to sediments, different P fractions, including total, particulate and dissolved P are now routinely measured. Traditionally, for the determination of total P, a digestion followed by UV–Vis detection procedure is applied. The “true” total P content results from the digestion of a raw water sample containing suspended matter, whereas the digestion performed on the sample after filtration through a 0.45 micron membrane filter gives the concentration of total dissolved P. The goal of this study was to measure the different fractions of P by ICP-MS. In the case of total P, no addition of coloring agents was necessary after the digestion process. Dissolved P was measured directly after filtration, without the previous digestion and with no manipulation of the sample. Similar results were achieved by UV–Vis and by ICP-MS when measurements of demineralized water spiked with two different amounts of PO₄ were performed. Various agricultural runoff samples were digested with ammonium persulfate + 30% H₂SO₄ for total P determination. Four certified water samples from the Canadian National Water Research Institute were analyzed for dissolved P by ICP-MS. Be and Sc were added as internal standards for possible drift corrections.

LONG-TERM STORAGE OF MICROWAVE DIGESTS. Joel A. Crumbaugh and Yash P. Kalra. Natural Resources Canada, Canadian Forest Service, Northern Forestry Centre, 5320 122 Street Edmonton, AB, Canada,
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The use of microwave radiation for multi-element digestion of soil and plant materials has become a common procedure in many laboratories due primarily to increased efficiency over other conventional digestion methods. Little information is available, however, on the length of time that microwave digests can be stored prior to analysis, and if there is a point at which the digest quality starts to deteriorate. Also in question is if storage conditions are a factor in the longevity of digest quality. The experiment carried out involved the microwave digestion of two Standard Reference Materials (SRMs), one in-house check sample and one blank. Four replicates of the blank, in-house check and SRMs were made and one of each replicate stored under four different conditions. The storage conditions consisted of plastic Nalgene containers at room temperature, glass volumetric flasks at room temperature, plastic Nalgene containers refrigerated, and glass volumetric flasks refrigerated. The digests were analyzed for Ca, Fe, K, Mg, Mn, P, and S using ICP-AES. Analysis of each replicate was performed bi-weekly, commencing on the day of digestion and continuing for eight months. All data generated was subjected to statistical analysis for interpretation of results. The results indicate minimal variation of elemental concentration through duration of the study. Storage conditions compared in this study also show negligible changes over time.

DETERMINATION OF CHEMICAL OXYGEN DEMAND IN URBAN AND INDUSTRIAL WASTEWATER BASED ON MICROWAVE SIMPLE DIGESTION. Ignacio Gomez1, Roberto Ivorra2, Ana Perez3, Ana M. Santacruz4, Raul Moral4, Juan Navarro3, and Jorge Mataix4. 1Alicante University, Department of Agrochemistry and Biochemistry, P.O. Box 99-03080 Alicante, Spain. Fax: 34 965903880; E-mail: Ignacio.gomez@ua.cs; 2CAM-UA Agrochemistry Investigation Center, Alicante, Spain; 3Gestion Mediterranea del Medioambiente, S.A., Alicante, Spain; 4Miguel Hernandez University, Elche, Alicante, Spain.

This work is a continuation of a previous investigation in which optimum time and power were studied in order to determine the chemical oxygen demand in standard solutions, using microwave digestion. These solutions were prepared from potassium hydrogenphthalate. Gradual digestion in a domestic microwave oven has been compared with digestion in a stove at 150 ± 2°C for 2 hours. The method was applied to urban and industrial wastewater coming from different sources in
Alicante province. The composition of the organic load in urban wastewater is variable due to the contribution of different industrial sources. Samples were digested in a stove, according to the traditional method, as well as in a microwave oven applying different times and powers between 100 and 300 watts. The method was considered to be more effective if microwave digestion occurred over a range of power settings instead of requiring high power only. The analytical method that we propose is appropriate for samples of varied sources, such as urban and industrial wastewater, or water with a high contaminant load.

APPLICATIONS OF NCI/MS TECHNIQUE IN ENVIRONMENTAL ANALYSIS. Narine P. Gurprasad and Nizar A. Haidar. Environmental Protection Laboratory, Environment Canada, Edmonton, AB, Canada T6R 1V6. Fax: (780) 435-7268; E-mail: narine.gurprasad@cc.gc.ca

With the availability of Negative Ion Chemical Ionization (NCI) mode of ionization on most bench top Mass Spectrometry (MS), many analytical problems involving the analysis of electron capturing organic compounds can be easily resolved. The Negative Ion Chemical Ionization Mass Spectrometry (NCI/MS) technique has been utilized for many types of analysis at the Environmental Protection Laboratory on a regular basis for routine analysis and resolving sensitivity, matrix and interference problems. NCI/MS has been shown to provide inroads in the identification, lowering detection limit and providing higher sensitivity for halogenated pesticides, PCBs, CFCs, dioxins and furans. In addition to higher sensitivity, NCI/MS specificity and selectivity have shown to eliminate matrix interferences such as plasticizers and other non-halogenated compounds including petroleum products when analyzing contaminated sample extracts.

LC/MS DETERMINATION OF A SULFOLANE METABOLITE IN WETLAND VEGETATION EXPOSED TO SOUR GAS-CONTAMINATED GROUND WATER. J.V. Headley and K.M. Peru. National Water Research Institute, National Hydrology Research Center, 11 Innovation Boulevard, Saskatoon, SK, Canada S7N 3H5. Fax: (306) 975-5143; E-mail: john.headley@cc.gc.ca

Groundwater containing the process chemicals sulfolane (tetrahydrothiophene 1,1-dioxide) and diisopropanolamine (DIPA) has contaminated a wetland in the
vicinity of a sour-gas natural gas processing facility. Residues of the chemicals are found in wetland soil, water and vegetation. While it is known that DIPA undergoes transformation in wetlands plants, little is known regarding the degree of transformation of sulfolane. This is due in part to the lack of analytical methods suitable for the determination of transformation products of sulfolane in vegetation. Described is a new procedure, employing electrospray ionization with reverse-phase liquid chromatography mass spectrometry for the determination of the 3-hydroxysulfolane metabolite in plant tissue. The metabolite was determined using filtered water extracts of the vegetation, preconcentrated using solid-phase extraction with no further clean up or derivatization steps. Under positive ion electrospray conditions, there was preferential formation of a series of adducts with minimal MH$^+$ formation. Quantification was therefore, performed using selected ion monitoring of the sodiated, solvated adduct of the protonated molecular ion (MH.Na.Methanol)$^+$. Confirmations were based on comparison of the retention time and product ion scan of an authentic standard. Instrumental detection limits were attainable in the picogram range (50–100 pg injected). Successful application of the procedure is demonstrated for the determination of the metabolite in over fifty samples, collected from a sour-gas contaminated wetland and a control site. For roots, shoots, berries, seeds, grasses, and leaves, the recovery was 90–25% r.s.d with a detection limit of 20 ng g$^{-1}$. In general, the technique was rugged (based on a study period of 18 months in which over 175 runs were conducted), and relatively fast (~25 min per sample for a batch of 10 samples). For the study period, the results indicated that sulfolane is also transformed in the plants in a manner similar to DIPA, suggesting that degradation of both process chemicals occurs in wetland plants.

COMPARISON OF PI AND OLSEN METHODS FOR EXTRACTING P IN CALCAREOUS SOILS. Muhammad Ibrahim and Hamud-ur-Rehman. Soil Chemistry Section, Ayub Agricultural Research Institute, Faisalabad, Pakistan. Fax: 92 41 653874; E-mail: soilchem@fsd.paknet.com.pk; ibrahimwarriach@yahoo.com

Pi, a soil P extraction method claimed to be independent of various soil properties, has not been tested on calcareous soils as have the Olsen method. Both methods were compared using light and medium textured calcareous soils. In pots, soils were incubated with 11 P levels (0–100 mg Kg$^{-1}$). Soil samples were taken at 15 days interval up to 90 days for P extraction. In another greenhouse study, wheat was raised in pots at five P rates (0, 40, 60,
80 and 100 mg P kg$^{-1}$). Samples were collected 30 days after planting and at harvest. In a sandy loam soil, extractable P increased with increasing P levels by both methods. The Pi method extracted more P than the Olsen method for 15 days incubation. As incubation period increased up to 60 days, the Pi method extracted more P than the Olsen method at lower levels of added P (0, 10, 20 mg kg$^{-1}$) but in later extractions (after 75 and 90 days), the Olsen method was superior to the Pi method at all P levels. The trend was similar in clay loam and sandy loam soils. In a greenhouse study in which wheat was planted in pots, P extracted by both methods increased as P application increased. At all P levels, the Pi method extracted more P than the Olsen method from both soils. Wheat grown in the sandy loam soil did not respond to the added soil P due to its high original P, whereas, in the clay loam soil, both grain and straw weights increased, except at 100 mg kg$^{-1}$ level. In the clay loam soil, significant correlation was found between grain and straw yields and extracted P by both methods. It was concluded that P extracted increased as P rates increased in both methods. At low levels, Pi-P was higher than Olsen-P. In the greenhouse study, P extracted by both methods significantly correlated with yields of wheat grain and straw in P-deficient soil; however, the Pi method is more laborious, lengthy, and costly.

DETERMINATION OF URANIUM IN SOILS AND PLANTS BY ICP-MS.
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The use of depleted uranium (DU, $^{238}$U) as ammunition is currently a major topic for discussion. DU is considered to be less radioactive than natural uranium, but despite this, there is still a serious biological hazard due to the alpha-radiation that is emitted. $^{238}$U like other heavy metals, is a threat to both human health and the environment because of its pronounced toxicity. Significant amounts of uranium have been released in the last decade with the armour piercing ammunition that has been manufactured from depleted uranium. This has not only been used during major conflicts but also on numerous military shooting ranges all over the world. DU is the major byproduct from the processing of nuclear fuel ($^{235}$U). The paper describes trials performed to evaluate the mobilization and carry over of DU in ecosystems. Methods for the extraction of plant available DU from soils, digestion processes for DU determination in plant material, and the determination of $^{238}$U by ICP-MS are also described. The results of the experiments show that $^{238}$U is mobilized in soils and taken up by plants. They also reveal that rounds not
hitting a target but just buried in the ground (which is the fate of the large majority of rounds) are also a potential danger for soil and food quality.

**ANALYSIS OF SOIL TEST PHOSPHORUS TO ASSESS THE RISK OF P TRANSPORT IN A WATERSHED.** P. Manunta¹, T. Goddard¹, Y. Feng², A.M. Anderson³, and K. Cannon¹. ¹Alberta Agriculture, Food and Rural Development, #206,7000-113 Street, Edmonton, AB, Canada T6H 5T6. Fax: (780) 422-0474; E-mail: paolo.manunta@gov.ab.ca; ²Department of Renewable Resources, University of Alberta, Edmonton, AB, Canada; ³Alberta Environment, Water Quality Section—Water Sciences Branch, Edmonton, AB, Canada.

Phosphorus entering surface waters provides a nutrient base for eutrophication which degrades drinking water quality, kills aquatic life and diminishes the water use for recreation and tourism. The risk for soil P transport from soil to rivers and streams is a function of soil phosphorus concentration and runoff-erosion potential. The actual risk varies between years based upon key factors such as land management and climate. Water phosphorus contents are often monitored on a watershed basis. Thus the importance of soil P measurements for the formulation of a risk assessment needs to be verified at the watershed level. Essential data, especially soil phosphorus, are not always available at the scale of interest, e.g., watershed or soil polygons. We introduce a methodology that can derive soil P information from an analysis of data obtained at a coarser scale of ecodistricts across Alberta, Canada. Descriptive statistics of the ecodistrict level analysis was used to reconstruct a complete data set for a watershed nested within the ecodistrict and verified with measured data. A series of Monte Carlo simulations were used to calculate the probability of occurrence of soil phosphorus values within the watershed. The soil phosphorus data become part of an impact-probability table in which a linear probability is described on one axis and the magnitude of its logarithmic impact by the other. An example of a calculation methodology for P export risk is presented for a watershed in Alberta.

**SPAD CHLOROPHYLL METER TECHNIQUE: A NON-DESTRUCTIVE AND RAPID METHOD OF CHLOROPHYLL ESTIMATION IN VARIOUS CROPS.** Moinuddin¹ Shahid Umar², and Patricia Imas³. ¹Potash Research Institute of India, Sector 19, Dundahera, Gurgaon, Haryana—122 016,
A statistically significant ($p < 0.001$) linear relationship was found between chemically extractable total chlorophyll content and the SPAD chlorophyll meter readings with regard to four monocot (wheat, barley, maize and oats) and four dicot (potato, mustard, sweet pea and pigeon pea) crops. The relationship was determined using data of individual crops as well as pooled data of monocots, dicots and monocots + dicots separately. When quadratic function was fitted to the data of individual crops, a little improvement in the relationship was observed particularly in case of barley and oats, where $r^2$ values changed from 0.80 to 0.90 and 0.83 to 0.90, respectively. However, when the data of monocots, dicots and monocots + dicots were pooled as separate groups, $r^2$ values obtained for linear and quadratic relationships were unchanged, being 0.61, 0.71 and 0.54, respectively. When predicted values, calculated from the linear equation, were regressed against actual values of chemically extractable chlorophyll content, the relationship was noted to be again highly significant ($p < 0.001$, with $r^2$ values ranging from 0.89 to 0.93). This indicated the usefulness of the rapid and non-destructive technique of chlorophyll estimation by SPAD chlorophyll meter in areas of crop science where instant chlorophyll estimation of standing crops is required.

ICP VS COLORIMETRIC DETERMINATION OF MEHLICH III EXTRACTABLE PHOSPHORUS. Manjula V. Nathan, Antonio Mallarino, Roger Eliason, and Robert Miller. 

Mehlich III is being increasingly used by soil testing laboratories for rapid nutrient analysis using Inductively Coupled Plasma (ICP) technology. Research has shown significant correlation between Mehlich III extractable-P and Bray 1-P when determined calorimetrically. Mehlich III extractable-P
when determined by ICP on Missouri soils was about 30% greater than by colorimetry. Research was conducted at the University of Missouri, Iowa State University, University of Minnesota Soil Testing Laboratories and Colorado State University to verify the concept that ICP measures organic forms of P, which are not detected by colorimetric determination. This paper summarizes the comparison of Mehlich III extractable P by ICP and colorimetric determination on manured, non-manured soils, soils spiked with ATP, and poly molecular P. In addition, the summary of research done to evaluate the potential sources of variability using method survey, surrogate spikes, and collection of additional parameters from the North American Proficiency Testing program too will be presented.

DETERMINATION OF GLUCOSINOLATES IN CANOLA SEEDS USING ANION EXCHANGE MEMBRANE EXTRACTION COMBINED WITH THE HPLC DETECTION. Anna M. Szmigielski, Jeff J. Schoenau, and Vanessa Levers. 1Department of Soil Science, University of Saskatchewan, Saskatoon, SK, Canada S7N 5A8. Fax: (306) 966-6881; E-mail: szmigiel@duke.usask.ca

A rapid, simple and reliable method for the determination of individual glucosinolates in canola seeds is reported. In this one-step extraction procedure, a membrane (7 cm²) is placed in the seed suspension, prepared by grinding and boiling 0.8 g seeds in 20 mL of water. After 10 minutes of shaking on the mechanical shaker, the membrane is removed from the suspension, washed and transferred to a vial containing 5 mL of 1 N tetramethylammonium chloride. The glucosinolates are eluted from the membrane by shaking the membrane for 10 min with the eluting solvent. The glucosinolate content in membrane eluates is determined by HPLC using sinigrin standards. A coefficient of variation ranging from 1.9 to 7.6% for aliphatic glucosinolates indicated very good reproducibility of the method. Because of the instability of 4-OH glucobrassicin, the coefficient of variation for the determination of this indolyl glucosinolate was 13.9%. Comparison of the results with other methods showed very good correlation between the total glucosinolates determined by the membrane extraction/HPLC detection and the palladate colorimetric procedure ($R^2 = 0.98$); also very good agreement was obtained between this method and the GC determination for individual glucosinolates. The simplicity and low cost of the membrane extraction/HPLC method make it an attractive alternative to the existing procedures for the glucosinolate analysis in canola seeds.
IMPROVING SAMPLE THROUGHPUT IN ATOMIC ABSORPTION AND INDUCTIVELY COUPLED PLASMA SPECTROSCOPY. Byron Vaughan. MDS Harris Laboratory, 621 Rose St., Lincoln, NE 68502, USA. Fax: (402) 476-7598; E-mail: bvaug12345@aol.com

High-speed peristaltic pumps can be fitted on atomic absorption spectroscopy (AA) and inductively coupled plasma spectroscopy (ICP) to improve precision, accuracy, throughput, and reduce labor. Atomic absorption analysis of Ca and Mg in soil extracts requires dilution and the addition of La to minimize chemical interferences. Potassium and Na in soil extracts need the addition of Cs or Li to minimize ionization interferences. Manual dilution takes time and is a source of error. A peristaltic pump position between the burner and the autosampler can simultaneously mix with the diluent at a T-connection prior to be pumped into the spray chamber/burner. Sample and calibration standards are diluted in the same manner; therefore, the exact dilution ratio is not of a concern. The ICP does not have chemical and ionization problems like the AA, but speed of analysis makes the ICP expensive for extracts with less than four to five elements in a run. An AA can typically analyze a sample in less than 6 sec while an ICP with factory peristaltic pump setup is around 60 sec. A high-speed peristaltic pump can increase throughput up to 4 samples per minute. In addition to the faster throughput, detection limits are lowered because more of the sample (aerosol) is pumped into the torch. A high-speed peristaltic pump is a simple inexpensive way to reduce laboratory cost and increase AA/ICP accuracy and precision.

EVALUATION OF THE IMPACT OF VARIOUS LAND USE SYSTEMS ON SOIL NUTRIENT PROFILE AND QUALITY USING STANDARD SOIL TESTS UNDER SEMI-ARID TROPICAL ALFISOL. K.P.R. Vittal, H.P. Singh, P.V. Krishna, K.L. Sharma, and K. Srinivas. Central Research Institute for Dryland Agriculture, PO, Saidabad, Santoshnagar, Hyderabad, Andhra Pradesh—500059, India.

An experiment was carried out to study the changes in nutrient profile and soil quality under different land use systems. Soil samples were collected from 36 sites under different land use systems at Hyderabad, India. The soil samples were analysed for pH, EC, organic carbon, plant available major and secondary nutrients (N, P, K, Ca and Mg) and DTPA extractable micronutrients. Soils under silviculture system showed highest organic carbon content in two depths. Soils under agriculture and fallow showed lower organic carbon content. Silviculture system improved the available nitrogen, phosphorus and potassium content in soil.
over fallow land. Silvi-agriculture system also improved available phosphorus and potassium over fallow land. Exchangeable calcium and magnesium under silviculture and silvipastoral systems were higher than under the other systems. Agriculture and fallow land showed lower amount of secondary nutrients. Soils under agrihorticulture showed higher amounts of DTPA extractable copper and soils under silvipastoral showed higher amounts of DTPA extractable Zinc. Soil pH under silvipastoral system was highest followed by silvi-agriculture system. Agrihorticulture system showed highest soil EC values followed by silvi-agriculture and silvipastoral systems. Silviculture showed higher organic carbon, available phosphorus, available potassium, DTPA extractable Zinc, soil pH and soil EC values in the surface layer. A soil quality index (SQI) was developed to rate the systems in terms of general soil fertility and resistance to soil degradation. Soils under silviculture and agri-horticulture systems showed the highest soil quality index. The studies revealed that trees can prove as agents for improving soil quality by way of litter fall and contribution of root biomass.

THE ISO-GROUP CONCEPT AS A TOOL FOR OPTIMISING CROP PRODUCTION AT FARM LEVEL. Nancy Vogels¹, Hilde Vandendriessche², and M. Geypens². ¹Ministry of Small Enterprises, Traders and Agriculture/DG6. E-mail: nvogels@bdb.be; ²Soil Service of Belgium, W. de Croylaan 48, 3001 Heverlee. Fax: 32 16310929; E-mail: havandendriessche@bdb.be; megeypens@bdb.be

This paper presents the results of the monitoring of nine Belgian farms. Since the different parcels belonging to these farms do not have the same production potential, the parcels were initially grouped in so-called iso-groups, each member whereof having a comparable intrinsic production potential. This grouping is based on a set of permanent characteristics determined mainly by the physical environment. Basically these were soil physical parameters such as soil zone, soil texture, drainage class, profile, slope and exposition. Each unique combination of these characteristics, established using GIS-tools, gave rise to a new iso-group. Theoretically, all the parcels of an iso-group have the same intrinsic production capacity. In practice, however, the yields were not equal. Therefore, the differences within a group were due to factors other than those used to define the iso-groups. A number of these parameters were controllable, e.g., chemical soil condition (through soil analysis), crop variety, sowing date, fertilisation and crop protection. Using univariate and multivariate statistical methods, the contribution of each variable to the observed variation in yield and quality within an iso-group was determined. In this way, the most relevant variables were selected and the quantitative relationship
with yield and/or quality of the crop was established. Once these relationships were established, specific measures were suggested to optimise crop production within an iso-group. Within each iso-group, fertilizer recommendation based on soil analysis may be refined, based on characteristics of the group.

DISTRIBUTION AND OCCURRENCE OF ATRAZINE, DEETHYLATRAZINE AND AMETRYNE RESIDUES IN GROUNDWATER OF THE TROPICAL ISLAND BARBADOS. Beverley P. Wood¹, Frank Gumbs², and John V. Headley³. ¹Centre for Resource Management and Environmental Studies, Faculty of Science and Technology, University of the West Indies, Cave Hill Campus, Barbados; ²Department of Food Production, Faculty of Agriculture and Natural Sciences, University of the West Indies, St. Augustine Campus, Trinidad; ³National Water Research institute, 11 Innovation Boulevard, Saskatoon, SK, Canada S7N 3H5. Fax: (306) 975-5143; E-mail: john.headley@ec.gc.ca

The triazines herbicides atrazine (AT) and ametryne (AMET) are used extensively in Barbados to control weeds in sugar cane fields. These pesticides were monitored in groundwater (the primary source of potable water on the island) for the dry seasons of March–June, 1991 and January–May, 1992 and the wet season, July–December, 1992. Residues of either AT or AMET were detected in all 277 groundwater samples collected from 23 wells in three major groundwater catchments underlying heavily cultivated sugar cane fields. The concentration of AT and the metabolite deethylatrzine (DEAT) were in the range 0.11–2.61 µg L⁻¹, with the highest occurrence in the most heavily cultivated sugar cane area, the Hampton catchment. These measured levels of atrazine in the groundwater represent a relatively small fraction that may have leached from the annual application and was estimated to be 0.12, 0.17 and 0.19% of the total amount applied to the Belle, Hampton and Western catchments respectively. These levels, however, are in general higher than those reported for related studies and lower application rates of atrazine in sugar cane plantations should be considered to help preserve the quality of potable water on the island.

A SINGLE MEASUREMENT TO PREDICT POTENTIAL MINERALIZABLE N. Mingchu Zhang¹, R.E. Karamanos², L.M. Kryzanowski¹, K.R. Cannon³, and T.W. Goddard³. ¹Agronomy Unit, Alberta Agriculture, Food and
Although soil nitrate nitrogen (NO$_3$-N) has been used as a basis for N fertilizer recommendations in Western Canada, potential mineralizable N is believed to be a more accurate indicator of the N supplying power of the soil. In this study, N mineralization potential was used to predict N supplying power of the soil for plant growth. Potential mineralizable N, analyzed by extraction with hot KCl, and organic matter content were determined on several benchmark sites, following calibration with a laboratory incubation method. Using the results from the benchmark sites, we developed an approach to estimate Nt from soil organic matter, based on the equation, $N_t = N_0(1 - e^{-kt})t$, and validated the calculated Nt with hot KCl extracted N.

Results indicated that the potential mineralizable N released from soil differed between eco-regions and slope positions. Potential mineralizable N was lower in southern Alberta than central Alberta. The lower slopes released more N than higher slope positions. The results also showed that Nt released in soil over the growing season correlated well with hot KCl extractable N in three different slope positions. However, variability of Nt in upper slopes is greater than middle and lower slopes due to a shallow A horizon, and lack of soil moisture during the growing season. After removal of outliers (9% of the total data set), the values of $R^2$ (regression of hot KCl N with calculated Nt) are 0.527, 0.576 and 0.627 for upper, middle and lower slope position, respectively. Based on our calculated results, a map of potential mineralizable N in Alberta soils can be developed; it would guide producers in managing soil- and fertilizer N.

**TOTAL INORGANIC CARBON ANALYSIS BY MODIFIED PRESSURE-CALCIMETER METHOD.** L. A. Sherrod, G. Dunn, G. A. Peterson, and R. L. Kolberg. Great Plains Systems Research Unit, USDA-ARS, PO Box E, Fort Collins, CO, USA 80522; Soil and Crop Science Department, Colorado State University, Fort Collins, CO, USA 80522; Northern Plains Agricultural Research Laboratory, 1500 North Central Ave., Sidney, MT, USA 59270.

Soil organic carbon (SOC) analyses using high temperature induction furnace combustion methods have become increasingly popular because of advances in instrumentation. Combustion methods, however, also include C from CaCO$_3$ and CaMg(CO$_3$)$_2$ found in calcareous soils. Separate analysis of the inorganic C (IC)
Our objective was to develop a fast, efficient and precise IC method by modification of the pressure calcimeter method. We modified the pressure calcimeter by using Wheaton serum bottles (20 and 100 mL) sealed with butyl rubber stoppers and aluminum tear-off seals as the reaction vessel and a pressure transducer monitored by a digital V meter. Our gravimetric IC determination of six soils, representing a wide range of IC, from the North American Proficiency Testing Program (NAPT) showed a strong correlation when regressed against IC from the modified pressure calcimeter method (slope of 0.99, \( r^2 = 0.998 \)). The method detection limit (MDL) was 0.17 g IC Kg\(^{-1}\) for the 20 mL serum bottles and the limit of quantification (LOQ) was 0.30 g IC Kg\(^{-1}\). The 100 mL serum bottle had a MDL of 0.42 with a LOQ of 2.4 g IC Kg\(^{-1}\). When using a 100 mL Wheaton serum bottle as the reaction vessel with a 0.50 g sample size, soils containing up to 120 g IC Kg\(^{-1}\), which represent a 100% CaCO\(_3\) equivalent, can be analyzed within the V output range of the pressure transducer. The time allowed for the acid to neutralize IC in the NAPT soils was significant at 0.05 alpha level for five out of the six evaluated at 1, 2, 4, 6, 14, 18 and 24 h. The minimum time required to neutralize the maximum IC content for most soils was 6 h. Soil organic carbon determined by subtraction of IC from total C from combustion analysis correlated well with SOC determined by the Walkley–Black method for both NAPT soils and 72 soils from eastern CO, with slopes of 0.99, 0.96 and \( r^2 = 0.99 \) and 0.99, respectively.

**COMPARISON OF LEVELS OF SULFOLANE AND DIISOPROPAOLAMINE IN NATURAL WETLAND VEGETATION EXPOSED TO GAS-CONDENSATE CONTAMINATED GROUND WATER.** John V. Headley, Leslie C. Dickson, and Kerry M. Peru. National Water Research Institute, Environment Canada, 11 Innovation Blvd., Saskatoon SK, Canada S7N 3H5. E-mail: john.headley@ec.gc.ca

Groundwater containing the process chemicals sulfolane (tetrahydrothiophene 1,1-dioxide) and diisopropanolamine (DIPA) has contaminated a wetland in the vicinity of a sour-gas natural gas processing facility. Of concern is the extent of which these contaminants are taken up by vegetation and the associated risk to wildlife that may eat the plants. All sampled wetland plants contained detectable levels of sulfolane and DIPA. Sulfolane was distributed predominantly in portions of the vegetation above the surface, such as sedges (Caretex spp.) flower heads (e.g. 430 ± 80 mg kg\(^{-1}\) wet tissue mass), whereas the levels of DIPA were more evenly distributed and generally lower throughout the plants.
(e.g. cattail (*Typha latifolia*) roots, $9.4 \pm 1.7 \text{ mg kg}^{-1}$; sedges flower heads, $16 \pm 3 \text{ mg kg}^{-1}$). Sulfolane may, therefore, translocate to a greater extent than DIPA in wetland vegetation. A wide range of concentrations covering a factor of 10 was observed for both contaminants in plant tissue collected within close proximity (5–50 cm) of each other. The dose rates received by wildlife eating the plants will thus depend on which parts of specific plants are consumed. Site-specific factors, such as the heterogeneity in the levels of the contaminants, density and type(s) of biomass (e.g. roots, stem, leaves, berries) of specific vegetation in the wetland, must therefore be accounted for to properly assess the fate of sulfolane and DIPA in contaminated wetlands.