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Program

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10:40	Kevin Tiessen, *Natural Resource Sciences*	Efficiency of Fall-Banded Urea in Manitoba: Interactive Effects of Application Date and Landscape Position, **page 7**
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16:50	Robert Kok, *Chair Bioresource Engineering*	*Presentation of Undergraduate Essay Award and Competition Awards*
17:00	Chandra Madramootoo, *Director Brace Centre for Water Resources Management*	*Closing Remarks*

Legume Production under Water Scarcity in the Aral Sea area

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Central Asia is a region constrained by water scarcity and whose previous overexploitation of water resources for cotton contributed to the Aral Sea Crisis. Compounding the pressure on water resources is a growing population, which will require additional food resources and water for industrial and domestic use. Given the dry climate of the growing season, increased land and water productivity are the research objectives of this work. Specifically, the plant physiological response, water use efficiency, nitrogen fixing and water saving potential of deficit irrigation (3 levels) and two different surface irrigation strategies (alternate and every furrow) are investigated for two dry bean crops (*Phaseolus vulgaris* and *Vigna radiata*). Irrigations are scheduled for each treatment using local climate data and a water balance that accounts for available soil water, daily crop evapotranspiration, precipitation and groundwater contributions. Irrigations are applied when the soil water reaches the depletion level specific to each crop and stress level. Phenological characteristics and temporal components are monitored. Stomatal conductance, transpiration and leaf water potential are measured before and after irrigation. Biomass weight, leaf area, root depth as well as nodule number and dry weight are determined at four stages. Yield (measured over several harvests), number of seeds per pod and 100-seed weight is determined at the end of the season. Nitrogen from biological fixation and protein content of seeds are also determined. Preliminary results of the first field season will be discussed.

A Systematic Assessment of Global Optimization Methods for Conceptual Hydrologic Models Calibration

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ABSTRACT

The major difficulty concerning the use of conceptual rainfall-runoff (CRR) models in practice is related to their calibration. In general, the CRR model calibration could be considered as a global optimization problem. Hence, several global optimization methods (GOM) have been proposed in hydrology. However, there is no general agreement as to which method is the most appropriate one for CRR calibration purposes. The main objective of the present paper is to propose a systematic procedure for assessing the performance of various GOM methods based on their robustness, accuracy and efficiency. In the present study, the performance of seven popular calibration methods were judged based on the use of a number of benchmark theoretical functions as well as relying on the rainfall-runoff simulation given by a typical TANK model for both cases of real and synthetic streamflow data. Results have indicated that the Multistart and the original SCE methods are the most accurate and robust while the CRS and Cluster methods are the most efficient. Results have also pointed out the limitation of the modified SCE method. Finally, it has been observed that it is still difficult to take explicitly into account the interactions between model parameters using existing calibration procedures.

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Immunogenicity of a transmission-blocking DNA vaccine encoding the cyst wall protein 2 (Pro-CWP2) of *Giardia lamblia.*

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Abstract:

Giardia lamblia is a ubiquitous enteric protozoan parasite, whose life cycle alternates between trophozoite and cyst forms. The cyst ensures parasite survival and successful transmission to susceptible hosts. Hence, designing a vaccine against the cyst stage can interfere with parasite transmission and reduce the level of environmental contamination.

We have previously reported that oral administration of recombinant Pro-CWP2 in mice resulted in a significant reduction of fecally shed cysts. Therefore, we investigated the potential of using a transmission-blocking DNA vaccine targeting giardial encystation. We began by transfecting mammalian cells with a plasmid encoding Pro-CWP2. Using Western blot analysis, rPro-CWP2 was expressed and secreted by transfected mammalian cells. We then immunized mice with Pro-CWP2 plasmids and found that immunization stimulated the production of IgA, IgG, IgG1, and IgG2a antibodies that reacted with encysting parasite Ag as well as rPro-CWP2. Taken together, these results suggest that Pro-CWP2 administered as a DNA vaccine was immunogenic and capable of stimulating the production of antibodies capable of reacting with recombinant and native parasite-derived Ag.

Efficiency of Fall-Banded Urea in Manitoba: Interactive Effects of Application Date and Landscape Position

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In western Canada, nitrogen (N) fertilizers are commonly applied during the fall for spring-sown crops. The objective of this study was to determine if fall-banded N requires delaying of application date to improve grain yields, as is the case for broadcast and incorporated fertilizers, and if the efficiency of fall-banded N is further influenced by landscape position. At each of four sites in southern Manitoba, individual high and low landscape positions were chosen throughout the field. In each landscape position, granular urea fertilizer (46-0-0) was banded three times during the fall, between September 15th and October 20th, and once in the spring at planting. In the spring, large losses of fall-banded N were observed, with greater losses in the low landscape positions than in the high landscape positions. Over-winter losses were significantly reduced by delaying application in the fall, especially in the low landscape positions of the field. At harvest, delaying application until late fall improved crop responses by as much as 40% in the low landscape positions. In contrast, the efficiency of fall-banded urea in the better-drained high landscape positions was not affected by fall application date. This suggests that early fall application of N fertilizer is a viable option on land that is well drained. However, on poorly drained land, where the potential for early spring flooding is high, producers in Manitoba should wait as long as possible in the fall, or until the spring, to apply nitrogen fertilizer.

A Solar Radiation Model with a Fourier Transform Approach

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Abstract:
The objective for this project is to build a solar radiation model which will be incorporated in a larger ecosystem model. The method for calculating solar radiation intensity outside of the Earth's atmosphere is well known, but this is attenuated considerably while travelling through the atmosphere. The attenuation depends mostly on atmospheric composition and cloud distribution, which are difficult to predict. The model described here is based on historical data. Surface solar radiation records of four Canadian cities (Vancouver, Winnipeg, Montreal, Halifax) were acquired from the Canadian Meteorological Service. These data were then analyzed, and decomposed with a Fourier transform procedure. This resulted in sets of descriptive parameters for the four sites. Annual radiation patterns can then be re-constructed from these. The results were tested to ensure that the generated data were statistically sufficiently similar to the original sets to be suitable for ecosystem simulation purposes.

Water Demand Management in the Caribbean: A Case Study of Barbados

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The management of our water resources has predominately focused on augmenting supplies to meet the demands for water. However, less attention has been given to the sustainable, efficient and equitable use of water. It is now recognized that more emphasis should be placed on managing water from a demand side.

Water demand management (WDM) is necessary in water scarce regions like Barbados, which is ranked among the world's ten most water scarce countries. This Caribbean island is almost entirely dependent on groundwater to meet the various water demands. The Government of Barbados has recognized the need for WDM as demonstrated by the implementation of measures such as universal metering, water pricing, and reduction of unaccounted for water.

This research evaluates the impact of various variables affecting residential water use in Barbados such as metering, water pricing and income. An understanding of the effects of these variables is crucial to analyze the impacts of future water demand management policies such as increasing water tariffs.

To asses the potential of price and metering as tools to conserve water demand in Barbados, an econometric demand model of residential water demand has been developed. The analysis relies on cross-sectional annual time-series data for seven districts in Barbados. The results confirm the hypothesis that water price does have a positive effect in reducing domestic water demands. Furthermore, preliminary results indicate that water production decreased considerably from 1997 to 2000, coinciding with the implementation of the Universal Metering Program.

Creating a Virtual World

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Abstract: Most current ecological engineering activities are based on experience, experiment, or trial and error because there is no comprehensive theory for engineering ecosystems. However, it is possible to create understanding and basic theory by studying and engineering virtual ecosystems. A virtual ecosystem exists only in the computer and can be manipulated much more easily than a physical system and years' worth of interactions simulated in a single day. Working with the computer program and simulation environment that makes one such virtual ecosystem, it is possible to study how system, species, and individual attributes affect the overall dynamics and survival of the system. It is quickly apparent that creating a system that persists beyond a few simulated years can be a difficult and time consuming process. Continued study of this virtual world and the relationship between its constitution and resulting comportment will allow virtual ecosystems to be engineered easily. From there, theory for engineering physical ecosystems can be developed.

The Unexpected Odyssey of an Air Parcel Traversing the Nocturnal Boundary Layer

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Although GHG measurement techniques are well-documented for daytime and windy nighttime conditions, an accurate estimate of nighttime GHG concentration on calm nights at large scales remains difficult. The nocturnal boundary layer (NBL) technique involves using the layer of the atmosphere closest to the ground as a giant measurement chamber. This technique has the advantage of using a layer which is large enough to include the spatial variability in emissions from the field (i.e. integrates hotspots). However, the chamber lid - being the stability of the nocturnal inversion - is not impermeable. Gases thought to be mainly propagating in horizontal layers are in fact moving in the vertical as well, affecting the gas accumulation that is assumed to be constant by the NBL technique. Studies suggest that intermittent events of turbulence control vertical gas propagation, but observations on a longer time scale prove that background vertical motion throughout the night has a greater influence on the dispersion and mixing of gases. In effect, the air parcel emitted at the ground is traveling in a more complex path than first expected. In this presentation, I will discuss the need to quantify the uncertainties with an understanding of mechanisms in the NBL and vertical movement of GHG's under its top.

Tertiary Treatment of Municipal Wastewater Using Floodplain Filtration Technique

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Densely populated industrialized areas worldwide are producing and discharging increasingly large volumes of wastewater into their rivers. Though wastewater is treated prior to discharge into water bodies, many contaminants still reach river water, which leads to considerable river water quality deterioration, especially during drought periods. The wastewater after the secondary treatment still contains many contaminants like nitrate-nitrogen, ammonium, phosphorus, pathogenic bacteria, heavy metals, cod, bod, etc. Land treatment processes, commonly termed "natural systems", combine physical, chemical, and biological treatment mechanisms and produce water with quality similar to or better than that from advanced wastewater treatment technologies. When the contaminated river water is discharged over a floodplain, microbial processes in the rhizosphere can simultaneously remove organic matter and nitrogen during soil filtration. It remove the suspended solids, organic matter, ammonia, nitrogen, phosphorus, cod, bod, bacteria, and viruses in the wastewater. The floodplain filtration technique requires no chemicals additives and produces no sludge, making it an environmentally friendly process. Water savings and increased river flow rates, important in the management of low flow rate rivers, are anticipated dividends of this technique.

Sediment and Nutrient Removal Efficiencies in a Constructed Wetland in Southern Quebec

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A study was conducted to assess the efficiency of a constructed wetland for sediment and nutrient removal from a riverine source containing NPS pollution. The constructed wetland, built in Mystic, Quebec, consists of a sedimentation basin, a sinuous subsurface horizontal flow section and a surface flow basin that continuously receives up to 5% of the Walbridge creek. Water flows by gravitation and can be adjusted by a gate on the intake structure, along with a series of three flumes; each located at the end of every section of the wetland. There are five sampling sites, one located in the river, at the inlet of the wetland, and at each flume. Two sampling strategies were devised for data collection; the first was based on grab samples taken at least once a week and more frequently when storm events occurred. The second strategy consisted of an automated sampler that would take continuous samples during important storm events. Sampling spans over a two year time period, winters excluded. The water samples are analyzed for orthophosphates, dissolved phosphorous, organic phosphorous, nitrates, ammonia, dissolved nitrogen, and total suspended solids. From these results mass balances for the sediments and nutrients will be determined in addition to whether or not there was a significant diminution of nutrients and sediments from inlet to outlet.

Use of Hyperspectral Remote Sensing for Identification of Water, Weed and Nitrogen Stress in Corn-Fields of Eastern Canada.

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A major challenge to agricultural division at the dawn of the 21st century is to provide food security to the rapidly growing world's population by achieving long-term economical and environmental sustainability of crop production through precision agriculture.

Very subtle differences exist in crop spectral responses due to varying crop growth conditions. With recent advancements in the hyperspectral airborne and satellite observation techniques, observations of slight differences in crop growth can now be recorded in different spectral wavebands. Growing interests in hyperspectral observation techniques and their applications in agricultural crops led us to develop this study.

The main objective of this research work is to develop a decision support tool for precision crop management (PCM) of corn (*Zea mays.* L.) production in Quebec, Canada. The specific objectives of this study are; (i) to evaluate a set of variable rate nitrogen strategies and to examine the variation in crop response to split nitrogen application in corn by classifying remotely sensed data and ground based observations, and (ii) to assess the potential of hyperspectral remotely sensed data to evaluate irrigation stress (plant water content) in corn. To meet these objectives a field experiment was established as a three-factor split-split-plot design with four completely randomized blocks as replicates. There were twelve main plots, with plot size of 12 x 12m each, in a block and the total number of plots was 48. The results obtained from this study will be discussed in this presentation.

Effects of an Entomophilic Parasite *Plagiorchis elegans* on non-target Insects

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P*lagiorchis elegans* is a parasitic trematode of mammalian and avian digestive tracts. Numerous insect species are compatible as the second intermediate host. Based on continuing research on this campus, it has been suggested that this parasite be used for mosquito control. *P. elegans* readily infects several mosquito species causing a significant increase in mortality. However, as with any control agent, the effects on non-target organisms must be properly understood before its application as a control measure. Field tests were used to examine the effects of *P. elegans* on several insect taxa in an aquatic habitat. Susceptible species were examined for degree of pathogenicity. Field experiments used mesocosms, circular enclosures, to isolate areas within the site for testing. The mesocosms were treated with 600 cercariae per day for five days and samples were collected on day six. All groups of insect taxa exposed to *P. elegans* exhibited no infection with metacercariae. Further statistical analyses are being conducted to determine whether size and abundance in different insect taxa are affected by exposure with *P. elegans*. Avoidance of parasitic infection may be due to behavioural or morphological adaptations of a given species, as well as environmental effects.

Salinity Effects on the Root Morphology of Container-Grown Trees in Different Substrates

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The effects of four soil substrates and four soil-applied NaCl levels (0, 0.5, 1.0, 1.5 g NaCl/kg soil) on container-growth of littleleaf linden (*Tilia cordata*) seedlings were evaluated grown in greenhouse for 3 seasons. The substrates consisted of: loam sand soil with bulk density (BD) of 1.53 g/cm ^{3} (L); a mix of ¾loam and ¼ peat by volume (LP) with BD of 1.26 g/cm ^{3}; a structural soil compacted to BD of 1.80 g/cm ^{3} (SS1.8) and the same structural soil compacted to BD of 2.0 g/cm ^{3} (SS2.0).

After 3 seasons of growth, trees in 0, 0.5 and1.0 NaCl levels survived. NaCl significantly decreased root and shoot dry weight and ratio of root/shoot by 60 and 47% whereas soil types had no effects on them except shoot dry weight. For root total length, SS1.8 had the longest root length when NaCl level was 0, SS2.0 had the longest total length when NaCl level was 0.5 and LP and L had the longest length when NaCl level was 1.0. In 4 substrates, higher NaCl level led to shorter root length. Salt increased root average diameter by 12~19%. L and LP had thicker diameter than SS. Soil types had no significant effects on root number while NaCl reduced root number significantly by 2.6~6 times.

Discriminating Water and Nitrogen Stresses using Hyperspectral Remote Sensing in a Corn Field

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Remote sensing can greatly assist in development and implementation of precision crop management systems on the farm that are not only economical and efficient but also friendly to the environment. The purpose of this paper is to evaluate the potential of hyperspectral observations in the discrimination of nitrogen and water stresses in corn (*Zea mays* L.). A field experiment was conducted in the summer of 2002 at the Macdonald Research Farm, McGill University, Ste-Anne-de-Bellevue, Quebec, Canada. Corn was grown in 40 test plots (9m x 10m), encompassing two water strategies and five different nitrogen treatments, replicated four times. The experimental plots were laid out in a split plot design with water stress as a main plot and nitrogen as the subplot. The water treatments were irrigated and non-irrigated and nitrogen fertilizer application rates varied from 50 to 250 kg N ha^{-1} in 50 kg increments. Hyperspectral measurements were made with the help of a field spectroradiometer (ASD, Analytical Spectral Device, Inc.) in 2151 wavebands (350 to 2500 nm). In addition, other measurements were also made, such as crop phenological growth stage, plant height, soil physical properties, soil moisture, greenness (SPAD reading), nitrogen content of the plant and grain, leaf are index (LAI), biomass, and yield. The paper will present and discuss the results obtained in this study.

Key words: Remote sensing, Hyperspectral data, nitrogen stress, water stress, Irrigation

Transport of Nutrients in Surface and Sub-surface Effluents from Drained Fields in the South of Quebec

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On many watersheds, agricultural non-point source pollution is considered the dominant source of P pollution. Surface runoff from fields is often considered the principal origin for this non-point source pollution and consequently, many studies have been devoted to this particular subject. As a result, few studies have been done on the movement of phosphorus via subsurface tile drainage systems. Since the majority of intensively managed agricultural lands in Quebec are subsurface drained, there is a great need to understand this particular phenomena.

To address this knowledge gap, two agricultural fields located on the Pike River Watershed were monitored from 2000 to 2004. The two sites were instrumented to measure and sample nutrient content of surface runoff and tile drains outlets.

With the data gathered, correlation between nutrient loads and physical properties of soils or of rainfall events will be explored and evaluated. A computer simulation model will be calibrated and validated to simulate runoff and phosphorus transport. The model will be applied to different management practices to view their impacts on nutrient loads and to determine how they could be minimized. The ability to measure, correlate and simulate the transport of nutrients on agricultural fields will aid in the development of best management practices to reduce nutrient transport.

Common bean (*Phaseolus vulgaris*) nodulation and plant growth can be accelerated by pre-induced *Rhizobium leguminosarum* bv. Phaseoli with Genistein and Methyl Jasmonate (MeJA).

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Abstract

Jasmonates, Jasmonic acid (JA) and Methyl Jasmonate (MeJA), are naturally occurring hormones in plants. Their role in induced disease resistance and biotic and abiotic stress responses of the plants is well characterized. They are also rhizosecreted from the roots into the rhizosphere, however their role in the rhizosphere and its effect upon microbial population has not been well investigated. We have previously shown that jasmonates can induce nodulation genes and the production of lipochito oligosaccharides (LCOs) from rhizobia, and are thus important signaling molecules in rhizobium-legume symbiosis. We have also previously shown that jasmonate preincubated rhizobia can enhance nodulation and nitrogen fixation of soybean plants. We designed an experiment to study the effect of pre-induced *Rhizobium leguminosarum* bv. Phaseoli with genistein, MeJA and both inducers together on nodulation, nitrogen fixation and early plant growth of common bean (*Phaseolus vulgaris*) plants. We report that both genistein and MeJA enhanced nodule number, nodule dry weight, leaf area, leaf number and plant dry matter accumulation. Genistein and MeJA when applied to cultures together showed synergistic effect on all studied variables. These results suggest that bacterial cells when induced with both inducers are more efficient at infection, nodule formation and nitrogen fixation, thus increasing leaf area, leaf number and plant dry matter accumulation. In conclusion, the results of this study indicate that MeJA alone or in combination with genistein can be used to promote bean nodulation, nitrogen fixation and early plant growth.

Surfactants/Ligands to Simultaneously Desorb Soils Heavy Metals and PCBs

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Abstract. Surfactants are efficient soil remediation agents for PCBs and PAHs, but not for heavy metals because of their hydrophobicity. Recently, for wastewaters, ligands were shown to change the character of heavy metals from hydrophilic to hydrophobic, thus enabling surfactants to simultaneously desorb both heavy metals and toxic organics from contaminated soils.
This project investigated Cd and PCB soil remediation potential of surfactants/ligands. Used with the ligand I^-, the 4 experimental surfactants were nonionic with a polyethylene oxide chain length of 7.5, 9.5, 30, and 40 units. Triplicate 1g soil samples were soaked in surfactant/ligand solutions, at respective levels of 0.025 or 0.50 and 0.0, 0.168 or 0.336 mol/L. The supernatant was analyzed for Cd desorption, and after 5 successive washings, the soil samples were analyzed for PCBs desorption.
Used with the highest ligand level, the shortest chain surfactant at the lowest concentration desorbed the most Cd (61%) and PCB (100%). Thus, the most Heavy metal and PCB are desorbed under the same surfactant/ligand conditions. Compared to PCBs, heavy metals were more sensitive to surfactant chain length and surfactant/ligand level.

Keywords : polyethylene oxide; ligand; heavy metal; PCB.