Green Plan Research Workshop

1995

Summaries

Lamplighter Best Western Inn
LONDON, Ontario

March 28 - 29, 1995

FORWARD

This report is one of a series of **COESA** (Canada-Ontario Environmental Sustainability Accord) reports from the Research Sub-Program of the Canada-Ontario Green Plan. The **GREEN PLAN** agreement, signed Sept. 21, 1992, is an equally-shared Canada-Ontario program totalling $64.2 M, to be delivered over a five-year period starting April 1, 1992 and ending March 31, 1997. It is designed to encourage and assist farmers with the implementation of appropriate farm management practices within the framework of environmentally sustainable agriculture. The Federal component will be delivered by Agriculture and Agri-Food Canada and the Ontario component will be delivered by the Ontario Ministry of Agriculture and Food and Rural Assistance.

From the 30 recommendations crafted at the Kempenfelt Stakeholders conference (Barrie, October 1991), the Agreement Management Committee (AMC) identified nine program areas for Green Plan activities of which the three comprising research activities are (with Team Leaders):

1. **Manure/Nutrient Management and Utilization of Biodegradable Organic Wastes** through land application, with emphasis on water quality implications
   A. Animal Manure Management (nutrients and bacteria)
   B. Biodegradable organic urban waste application on agricultural lands (closed loop recycling) (Dr. Bruce T. Bowman, London Research Centre, London, ONT)

2. **On-Farm Research**: Tillage and crop management in a sustainable agriculture system. (Dr. Al Hamill, Harrow Research Station, Harrow, ONT)

3. **Development of an integrated monitoring capability** to track and diagnose aspects of resource quality and sustainability. (Dr. Bruce MacDonald, Centre for Land and Biological Resource Research, Guelph, ONT)

The original level of funding for the research component was $9,700,000 through Mar. 31, 1997. Projects will be carried out by Agriculture and Agri-Food Canada, universities, colleges or private sector agencies including farm groups.

This Research Sub-Program is being managed by the Pest Management Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St., London, ONT. N5V 4T3.

Dr. Bruce T. Bowman
Scientific Authority

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A Context for the Green Plan Research Program

Dr. Bruce MacDonald, Land Resource Div., Agriculture and Agri-Food Canada, Guelph, ONT.

The quality of water in the Great Lakes System has been a longstanding concern of both the government of Canada and the government of the United States of America. The rights and obligations of both countries were officially outlined in the spirit of friendship and cooperation in the Boundary Waters Treaty signed on January 11, 1909. In more recent times the obligation not to pollute boundary waters while recognizing the rights of each country in the use of its Great Lakes waters has been reaffirmed in a series of Great Lakes Water Quality Agreements.
The state of the Great Lakes is monitored and reported regularly by the International Joint Commission.

In the Great Lakes Water Quality Agreement (GLWQA) of 1972, emphasis was placed on nutrients from point sources (municipal sewage treatment facilities) as a major concern to water quality in the Great Lakes Basin Ecosystem. In addition, the PLUARG (Pollution from Land Use Activities Research Group) studied rural pollution and confirmed agriculture as a non-point source of pollution.

The GLWQA was reviewed and updated in 1978. In this agreement, target levels were established for phosphorus loadings to the Great Lakes. A phosphorus management plan was developed for the lakes which included pollution from rural non-point sources. SWEEP (the Soil and Water Environmental Enhancement Program) was established to carry out research and transfer of technology related to agriculture. At the time of this agreement a Canada-Ontario Agreement (COA) was signed respecting the Great Lakes Basin Ecosystem. The purpose of the COA was to coordinate the activities of federal departments and provincial ministries in support of the Great Lakes Water Quality Agreement.

The 1987 protocol (an updated version of the GLWQA) emphasis was placed on limiting the release and impact of toxic chemicals in the Great Lakes Basin ecosystem. A non-point source pollution annex was added to the agreement providing detailed targets for various pollutants. The focus of activities was broadened to include an ecosystem approach.

The result of the 1987 protocol was several Great Lakes Action plan (GLAP) initiatives; specifically, the GLAP research program was a five year $ 5 million multi-disciplinary research project carried out from 1989 to 1994. It dealt with agricultural non-point sources of pollution related to pesticides, manure and nitrogen. In addition, there were federal and provincial programs designed to promote permanent cover or maintain high residue ground cover as ways to minimize erosion by water.

The Green Plan agreement was developed as an equally-shared Canada-Ontario program to encourage and assist farmers with the implementation of appropriate farm management practices within the framework of environmentally sustainable agriculture. Approximately 30% of the federal component of this program has been directed towards research (to be reported on at this workshop) to address objectives which were identified at a Stakeholder conference (Kempenfelt Centre, Barrie, October 1991) and subsequently refined by research project committees.

Other Green Plan initiatives deal with technology transfer and demonstration of good innovative practices. These include the Rural Conservation Club Program which is coordinated by the Marketing and Industry Services Branch and has supported more than forty projects developed and carried out by groups of farmers. The woodlands, wildlife and wetlands program has a series of projects designed to promote healthy ecosystems with a mix of agriculture, forest areas and wetlands. The joint federal-provincial program to develop booklets which describe Best Management Practices provide a standard reference for farmers and the general public about the position and interactions of agriculture in the rural ecosystem. The farmer led Environmental Farm Plans are providing several thousand Ontario farmers with an assessment of their individual farming operations.

The most recent Canada-Ontario Agreement (COA) was signed in July 1994. It provides details of cooperative activities to restore, protect and conserve the Great Lakes basin ecosystem. This agreement and other Canadian and international initiatives (listed later) provide an indication of how agricultural and environmental concerns are continuing to evolve. It is these programs as well as others yet to come which will shape our thinking and, in reality, they will provide the context within which the results of our current Green Plan Research projects will be assessed and interpreted. It is important for all of us to take note of these developments and consider not only how well our research projects meet their original objectives but also how they will contribute to new and developing interests and concerns. The following few paragraphs provide a brief outline of recent program and policy developments.

The 1994 COA continues and expands the emphasis on ecosystems which was clearly enunciated in the 1987 Protocol. Four areas of focus (streams) are identified; namely,

- restore degraded ecosystems (RAPs)
- prevent and control pollutant impacts
- conserve human/ecosystem health
- integrated ecosystem management.

These trends represent a more comprehensive and holistic view of agriculture in the environment as it interacts with other ecosystem components (aquatic, wetland, and forest) and the overall societal requirements for quality of life.

Several associated government programs deserve mention because they will provide part of the framework for interpreting Green Plan Research. These include National Environment Strategy for Agriculture and Agri-Food, State of Environment Reporting and Indicators. The activities related to indicators encompass the Environmental Indicator Bulletin Series produced by Environment Canada, the Agri-Environmental Indicators being developed by Agriculture and Agri-Food Canada and the OECD (Organization for Environmental Cooperation and Development) indicators which are currently under development.

The first draft of the National Environment Strategy for Agriculture and Agri-Food was circulated in 1990 as the report on Environmental Sustainability. In 1995 this report is being revised. Four main issue areas are identified;

- resource-based issues
- regulatory issues
- trade issues
- awareness and education issues.

The results of Green Plan research projects will contribute most directly to the section dealing with resource-based issues.

Environment Canada produced the first State of Environment (SOE) Report in 1986 to correspond with the census. The third SOE report is scheduled for release after the 1996 census. It will provide a general assessment of sustainable development within an ecosystem framework. In simple terms this third SOE report will attempt to answer four key questions related to agriculture and sustainable development;

- what is happening? (Conditions and trends)
- why is it happening (links between human activities and ecological changes such as environment-economy interactions)
- why is it important (what are the implications for ecosystems, human health, economic and social well-being i.e. are the trends sustainable?)
- what are we doing about it? (Responses at all levels of society).

Clearly, most Green Plan research projects deal very directly with one or other of these questions.

Indicators are developed to provide information which is clear and easily understood on the current trends and state of the natural environment in agriculture, to assist policy makers in the analysis of the environmental impacts of policy decisions and market processes, and to monitor the effectiveness of policies promoting sustainable agriculture. In general, we must first carry out sound scientific study and documentation of a situation and then provide a more simplified view for broader distribution. In Canada there are three specific indicator activities underway. The Environment Canada Indicator Bulletin Series is designed to monitor and report trends for the public at large. The Agri-Environmental Indicators under development by Agriculture and Agri-Food Canada will monitor trends and provide a tool to evaluate the effects of policies. The OECD Agri-Environmental indicators will be used to facilitate international agri-environmental comparisons for purposes of trade. A cooperative project is underway with INRA (Institut National de la Recherche Agronomique), France to model the movement of potential contaminants in small watersheds. The resulting workshops and parallel studies will contribute to the indicator of risk of water contamination.

The Green Plan Research Projects were developed through a consultative process to address the needs of the agricultural community in addition over and above the ongoing A-base research activities. The objectives identified at the outset remain of primary importance as the research is carried out. However, we as coordinators of the research would be remiss if we did not pay close attention to developing programs, concerns and interest and all of us as an agricultural research community need to continue to reevaluate how our research activities can be integrated with other research initiatives to contribute to societies needs. We will continue to share our understanding of trends with you and count on your input and discussion assist all of us in achieving the most useful interpretations and applications of our efforts.

Projects Completed by March 31, 1995

1.1 Title: Literature Search on Manure/Nutrient Management
Contractor: Dr. Michael Goss, Dept. of Land Resource Sci., U. of Guelph, Guelph, ONT, N1G 2W1
Status: *COMPLETED , AVAILABLE SEPT. 1994* COESA Report No.: RES/MAN-001/94

1.9 Title: Literature Review on Wildlife Habitats in Agricultural Landscapes
Contractor: Mr. Lyle Friesen, Canadian Wildlife Service, Environment Canada, 100 Gamelin Blvd., Hull Que K1A 0H3. (Contributors: A.D. Tomlin, Agriculture And Agri-food Canada; Alain Baril and Christine Bishop, Canadian Wildlife Service, Environment Canada).
Status: *COMPLETED; AVAILABLE FEB 1995* COESA Report No.: RES/MAN-009/94

2.1 Title: Literature Review of Methods Used to Conduct and Evaluate On-Farm Research
Contractor: Ms. Jane Sadler-Richards, Ecologistics Ltd, 490 Dutton Drive, Suite 1A, Waterloo, ONT N2L 6H7
Status: *COMPLETED, AVAILABLE JAN 1995* COESA Report No.: RES/FARM-001/94

3.1 Title: Development of Standard Methodologies: Resident Biomass and Organic Carbon
Contractor: Mr. David Charlton, Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ONT N1G 3M5
Status: *TO BE COMPLETED MARCH 1995* COESA Report No.: RES/MON-001/95

3.4 Title: State of Resources: A proposal to Assess the State of Agricultural resources: Improving the Land Resource Database
Contractor: Mr. David Cressman, Ecologistics Limited, 490 Dutton Drive, Waterloo, ONT, N2L 6H7 Status: *COMPLETED, AVAILABLE, FEB. 1995* COESA Report No.: RES/MON-004/94

3.5 Title: State of Resources: Proposal for the Upgrade of Soil Survey Information in Oxford County
Contractor: Mr. D. Charlton, Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ONT N1G 3M5
Status: *TO BE COMPLETED MARCH 1995* COESA Report No.: RES/MON-005/95

3.6 Title: State of Resources: Development and Application of Standardized Methodology for Sampling Soil Landscape Polygons
Contractor: Mr. J. Hagarty, Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ONT, N1G 3M5
Status: *TO BE COMPLETED MARCH 1995* COESA Report No.: RES/MON-006/95

3.7 Title: State of Resources: Development and Testing of "State of Agricultural Resources" A Reporting and Monitoring Methodology for Ontario.
Contractor: Mr. Harold Moore, Gregory Geoscience Ltd, Kanata Square, Suite 504, 260 Hearst Way, Kanata ONT, K2C 2B5
Status: *TO BE COMPLETED MARCH 1995* COESA Report No.: RES/MON**-007/95**

AVAILABLE GREEN PLAN RESEARCH REPORTS

Please "check" those reports you wish to receive and return this form to:

Dr. Bruce T. Bowman
Pest Management Research Centre
Agriculture and Agri-Food Canada
1391 Sandford St.
London, ONT N5V 4T3

____ **1.1 Title: Literature Search on Manure/Nutrient Management. Contractor:** Dr. Michael Goss, Dept. of Land Resource Science, U. of Guelph, Guelph, ONT, N1G 2W1
NOTE: This report was previously distributed in 1994.

____ **1.9 Title: Literature Review on Wildlife Habitats in Agricultural Landscapes**
Contractor: Mr. Lyle Friesen, Canadian Wildlife Service, Environment Canada, 100 Gamelin Blvd., Hull Que K1A 0H3. (Contributors: A.D. Tomlin, Agriculture And Agri-food Canada; Alain Baril and Christine Bishop, Canadian Wildlife Service, Environment Canada).

____ **2.1 Title: Literature Review of Methods Used to Conduct and Evaluate On-Farm Research**
Contractor: Ms. Jane Sadler-Richards, Ecologistics Ltd, 490 Dutton Drive, Suite 1A, Waterloo, ONT N2L 6H7.

____ **3.4 Title: State of Resources: A proposal to Assess the State of Agricultural resources: Improving the Land Resource Database**. **Contractor:** Mr. David Cressman, Ecologistics Limited, 490 Dutton Drive, Waterloo, ONT, N2L 6H7.

____ **4.1 Title: Maintenance Program for Three Southwestern Ontario Watersheds.**
Contractor: Mr. David Hayman, Upper Thames Conservation Authority, R. R. #6, London, ONT N6A 4C1. (*LMAP funded project*)

____ **4.3 Title: Influence of Soil Texture and Tillage Practices on the Susceptibility of Legume-N to Leaching. Contractor:** Dr. B.D. Kay, and Dr. V. Rasiah, Dept. of Land Resource Science, Univ. of Guelph, Guelph, ONT N1G 2W1 (*LMAP funded project*)

____ **4.4 Title: A Program to Assess Surface- and Groundwater Quality At Farm Sites Selected for Artificial Wetland Construction**. **Contractor:** Assoc. of Conservation Authorities of Ontario, 418A Sheridan Street, Peterborough, ONT K9H 3J9 (Contact: Mr. David Hayman, Upper Thames Conservation Authority, R. R. #6, London, ONT N6A 4C1). (*LMAP funded project*)

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____ **Great Lakes Water Quality Program, Agriculture and Agri-Food Canada - SUMMARY OF ACHIEVEMENTS 1989 - 1994.** C.J. Wall, D.R. Coote, C. DeKimpe, A.S. Hamill and F. Marks, Great Lakes Advisory Committee, March 1994.

1. MANURE NUTRIENT MANAGEMENT & CLOSED LOOP RECYCLING.

Project Leader: Dr. Bruce T. Bowman

1995 Project Updates

1.2 Title: Nitrogen & Carbon Transformations in Conventionally-Handled Livestock Manures.

Contractor: Dr. G. Kachanoski, Environ. Soil Services, 605 Arkell Rd., Arkell, ONT N0B 1C0.

SUMMARY

The project has focussed on summer and winter cycles of a solid poultry manure system and a solid beef manure system. At the poultry system, the manure pile present in the spring of 1994 was sampled by coring to a depth of 1 m and the pile was surveyed to determine its volume. Sampling in the poultry barn was conducted from June to early August, and mid November to mid January. Litter off the floor was collected at 0, 3, 5, 6, 7, and 8 weeks of a production cycle. A wire covered box that the chickens could roost on was used to collect fresh droppings. Feed samples were collected from feed bins in the barn. Concentrations of greenhouse gasses {N_20, CO_2, CH_4) in the barn air were determined by 24 hour collection into gas sampling bags at eight weeks in the summer and five to eight weeks in the winter. Concentrations of NH_3 were determined by spot measurements using detector tubes. Barn ventilation rates were determined by anemometer readings. Production of gasses from the litter on the floor was measured by a chamber method during the winter cycle. Feed usage and chicken weight gain were obtained from farmer records. Cages containing known amounts of manure were buried in the manure pile from the winter flock, and will be retrieved at the time of manure spreading. Measurements of temperature to 1 m depth and gas flux from the manure pile were determined on March 3.

The solid beef manure site includes a cow-calf barn, manure storage pad, and runoff storage tank at the Elora Beef Research Centre. Samples and weight of manure scraped from the cow-calf barn on a given day have been obtained every six to eight weeks. Feed and fresh excrement were sampled from the barn. Cages of manure were buried in the top-loaded pile and in used straw bedding (manure packs) on the pad for retrieval at the time of spreading. Temperature of manure to 1 m depth and gas production have been measured under summer and winter conditions. Bulk density of manure on the pad was determined before spreading in October, by cutting blocks from the manure with a gas powered hedge-trimmer, and by filling a 20 L pail with loose material from the pile surface. Runoff collected in the liquid storage tank was sampled approximately monthly as a composite of the entire depth or from various depths. When manure was spread in October, samples were collected by placing pans of known area on the soil surface in front of the manure spreader. Soil sampling was conducted to 30 cm depth for four weeks after application, to monitor changes in soil mineral N. Research station records are being used to calculate inputs of nitrogen and carbon from straw and feed to the cow-calf barn.

Laboratory incubation of 40 manure samples is currently underway, to determine mineralizable carbon and nitrogen. These incubations are for 32 days, or 64 days if necessary.

Work for the comparative economic assessment of the manure handling and storage systems has begun with creation of an extensive questionnaire. A student will be working with the farmers/managers to obtain the information requested in the questionnaire.

1.3 Title: Manure Composting Techniques: Understanding N and C Conservation

Contractor: Mr. Richard St. Jean, Ecologistics Ltd, 490 Dutton Drive, Suite A1, Waterloo, ONT N2L 6H7

Summary

During the past year all on line process monitoring equipment was site installed, debugged, and modified as project demands indicated, to meet the needs of the monitoring program.

The expanse of online data collected and the format of the daily data files generated was discovered to be incompatible with Lotus 123 data import capabilities. As a result, some effort was spent developing Excel data analysis capabilities.

The first composting experiment involving the comparison of three composting technologies has been completed. The experiment involved the composting of beef cattle manure from livestock on a roughage diet. Turned pile, static pile passive aeration, and static pile forced aeration technologies were compared. The processes were all conducted simultaneously using the same manure source and all started the same day to eliminate any process difference which may result from climatic or manure differences.

All data collected has been statistically analyzed and summarized in significance tables. A year end interim report has been completed which describes the on line monitoring system developed for the project, outlines the methodology for the first set of composting processes, summarizes the experiment results and includes condensed data collected from the composting experiment.

1.4 Title: Transformations in Soil: Crop Response to Nitrogen in Manures with Widely Different Characteristics

Contractor: Dr. E. G. Beauchamp, J. Buchanan-Smith and M. Goss, Department of Land Resource Science, University of Guelph, Guelph, ONT, N1G 2W1

Summary

Phase 5 of the project was completed in May, 1994, and a final report submitted in January, 1995. The results in summary, suggested that the protein (N) level and its degradability had a relatively small influence on the characteristics of the urine and especially the faeces produced by lactating cows. The protein level in the feed could be reduced by 1 or 2 percentage points and yet have only a small influence on milk production and protein content. Urine N concentration appeared to vary most with respect to protein level and degradability in the diet. Faeces N was quite stable whereas urine N was rapidly transformed to nitrate in incubated soil.

Phase 1 was commenced in the fall, 1994, but there is little progress to report other than two field trials were established. Phase 3 on the effect of soil texture N transformations has not yet commenced but will be in 1995-96. The laboratory work for Phase 4 has been completed. This study involves the effects of soil acidity on manure N transformations. The data have not yet been fully assessed.

The first year (1993-94) of field work for Phase 2 was completed and that for the second year (1994-95) was commenced. An interesting observation already is the low recovery of mineral N applied in the manures soon after application and the gradual release of it over the next few weeks. The rate of release is related to the ammoniacal content of the manures, which in turn affects corn yield response. Contrary to expectations, wood shavings bedding appeared to have less effect on manure N availability than straw bedded manure. Assessment of the data from this Phase is continuing.

Phase 5 Summary

SUGARY Sixteen cows in mid-lactation were assigned to a high (16%), medium (14.4%) or low (12.8%) crude protein diet. The cows were fed the diets at both recommended (NRC, 1989) and high (10% increase) rumen degradable nitrogen. The recommended and high degradability form of each diet were fed in two consecutive periods. The periods were 4 weeks long and during the last 2 weeks voluntary intake of diets was restricted to 95% of the ad libitum intake measured in the first 2 weeks. Faeces and urine were collected and sampled during the last week of each period. Milk production was recorded and milk and feed ingredients were sampled for the entire study. Diets were fed as total mixed rations and were based on corn and alfalfa silages and corn grain with soybean meal and urea used to balance protein requirements and degradability. Data from 15 cows were analyzed and statistical analysis of the data was using a split-plot design with period as the sub-plot. Unadjusted milk production was greater in period I (mean, 26.2 kg d-l) **than in period** 2 (mean, 22.5 kg d-') and was unaffected by diet protein level. Apparent nitrogen digestibility was enhanced by feeding higher protein diets and by increasing degradability of the and undegradable protein in the diet is appropriate. Thus, diet protein degradability, in addition to diet protein level, was evaluated in this experiment.

1.5 Title: Impact of Manure Application Methods on Water Quality, Focusing on Nitrogen and Bacteria Transport in Soil.

Contractor: Dr. Greg Wall, Land Resource Division, C.L.B.R.R., Agriculture and Agri-Food Canada, 70 Fountain St., Guelph, ONT N1H 3N6

Summary

On-farm evaluation of manure application methods was completed in identifying paths and process of nutrient and bacterial transport to tile drains and ground water. Tile quantity and quality from all 12 tiles was monitored throughout the growing season with NO_3-N levels consistently at or exceeding drinking water quality standards. Under no-till corn management, surface application of liquid hog manure resulted in significantly greater contamination of NH_4-N and manure bacteria in tile water than the two injection methods. The disturbance of the soil surface in the area of injection reduces the downward movement of contaminants by preferential (macropore) flow as tile water contamination was limited to the three hour period after application of all three methods. The loss of nutrients to tile drains is relatively low from a crop production standpoint (less than 2% of applied). The control treatment of pre-plant incorporated mineral fertilizer and without side-dressed manure showed no advantage of crop performance and yield over the manured treatments. The energy requirement of each manure application treatment monitored by the Agriculture Canada instrumented tractor indicated a practical limitation to draft power requirements however the injection methods required only a 1 to 2 L/ha fuel increase over surface applied.

1.6 Title: Closed Loop Recycling - Composted Biodegradable Organic Urban Waste Application on Agricultural Lands.

Contractor: Mr. David Charlton (Valerie Alder), Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ONT N1G 3M5

Summary

The research subprogram of the Canada-Ontario Green Plan is designed to encourage and assist farmers with the implementation of appropriate farm management practices within the framework of environmentally sustainable agriculture. The Green Plan research activities are designed to promote reduced tillage and improved soil quality in the context of sustainable agriculture.

The objectives of the studies on composted organic urban waste application to agricultural lands are to evaluate the impact of the composted products on soil quality, crop growth and yields, and on surface and subsurface water quality. The study consists of three field seasons of data collection - 1994, 1995 and 1996 - with the project to be completed in 1997.

Sites for the field trials have been established on farms in Halton and Hamilton-Wentworth Regions. The sites are mapped as a Guelph loam and Chinguacousy clay loam and the farmer cooperators use reduced tillage systems.

The treatments involve a comparison of two compost sources and a zero application. While the total amount of tillage in each trial is constant, the timing of the tillage, with respect to compost application, differs such that the compost is incorporated by the tillage operation or left unincorporated. In successive years of the study comparisons will be provided for cumulative applications of compost.

Evaluation includes the effect of composts and their management on early season soil moisture, corn emergence and stand, and final yield. Soil samples and soil solution samples are used to examine the migration of decomposition products of the compost in the soil profile. Soil microbial biomass measurements are being used as an indicator of changes in the soil environment as a result of compost applications.

The 1994 growing season was characterized by later than normal corn planting at both sites due to the timing of rainfall during May and the resultant wet soil conditions. For this reason, compost application was carried out over a two week period until corn planting on May 23 (clay loam site) and May 30 (loam site).

The compost had varying effects on final emergence of corn and corn silking date, as well as grain yields. At the loam site corn silked earlier where compost was applied, and corn grain yields were increased as a result of compost application. At the clay loam site, the data suggested that corn silked later and grain yields were depressed where one of the compost sources was applied. Corn growth at this clay loam site was variable and significant block to block differences, where blocks related to slope position, were observed in plant stand, silking date, and grain yield. Nitrogen response data suggest the N application rate was below the maximum economic rate at this site.

Compost applications had no effect on the soil microbial biomass carbon levels measured in the soil on any of the sampling dates.

Compost applications had no measurable effect on soil moisture in the upper (0-20 cm) or lower (0-80 cm) soil profile throughout the season. At the clay loam site, soil moisture related to slope position, with the mid slope position having lower soil moisture levels generally than the upper and lower slope.

1.7 Title: Soil Organisms as Bioindicators of Agronomic Practices.

Contractor: Dr. A. Tomlin, Pest Management Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St., London, ONT N5V 4T3

Summary

! Several of the selected soil faunal and microbial indicator organisms are responding very differently to conventional and no-till regimens

! In consequence, there will be important differences in soil structure, and water and nutrient transport processes between conventional & no-till regimens

! There are differences in pore structure classes (using the tension infiltrometry technique) between conventional and no-till; hydraulic conductivity is higher in conventional till below 5 cm soil depth

! Soil organic matter and Cs-137 are accumulating in toe slope positions in the watersheds at both soil surface and depth relative to mid and upper slope positions

! There is a depletion of Cs- 137 in top 3 cm of no-till not observed in the conventional till due to either or both of:

(1) dilution of Cs-137 with crop residue at surface
(2) dilution of Cs- 137 with worm-transported material from below the plow layer

! There are some exceptionally high levels of DDT remaining in orchard soil ecosystem compartments (soil and earthworms), especially in the Okanogan Valley, and to a lesser extent in the Niagara fruit-growing region. These residues are apparently still leaking into wildlife food chains via earthworms (used as food by ground foraging birds) nearly 25 years after use of DDT ended.

1.8 Title: Effect of Controlled Drainage/Subirrigation on Tile Drainage Water Quality and Crop Yields at the Field Scale.

Contractor: Dr. Chin Tan (Dr. I. van Wesenbeeck), Harrow Res. Station, Agriculture & Agri-Food Canada, Harrow, ONT, N0R 1G0

Summary

The selection of three on-farm demonstration sites was completed. Farms were selected based on the following criteria:

- ! Farmer willing to participate in this study.
- ! Minimum of 4 years of zero tillage on one of the farm sites before initiation of this study.
- ! Must allow for the comparison of water table management system and regular tile drainage system.
- ! Must allow for the same crop/year at paired sites
- ! Subirrigation site must meet the specific criteria (i.e. impermeable layer, high to medium hydraulic conductivity, water source and flat topography)
- ! A minimum area of 2 hectare for each treatment

INSTRUMENTATION

1. **Laboratory**

- ! Specially designed tipping buckets to measure tile flow were built, tested and calibrated.
- ! Data loggers were purchased and their performance in logging the signals from the tipping buckets was evaluated.
- ! ISCO autosampler's capability to receive signals from these Data loggers for initiation of sampling was also tested.

In summary a prototype flow measurement instrumentation set up which can handle a flow of up to 28,000 L/hour was installed in the laboratory and its performance was tested.

2. Farm

a. Subirrigation site (Farm of Mr. George Bicrel)

- ! Two (2) ha fields were identified and their respective drainage systems were modified to allow the implementation of the two water table management systems (i.e. subirrigation and free drainage).
- ! A complete subirrigation system including an OASIS control chamber, pump station and necessary tile work was installed.
- ! During a two week trial period performance of the subirrigation system was tested.

b. All three sites (Farms of Mr. Bicrel, Mr. Shanahan and Mr. Chevalier)

- ! 2.3 m diameter by 4.3 m deep manholes to house tile flow measurement units were installed. These manholes were covered by 3.3 by 3.3 m garden sheds.
- ! Necessary tile work to direct subsurface tile discharge to these manholes for the flow measurement and water sampling was completed.
- ! Control drainage chambers were installed.
- ! Electrical service was installed in each shed.
- ! Installation of tipping buckets and pumps were completed.
- ! Some preliminary flow data in the field were collected.

At the present time our three field demonstration sites are fully instrumented and designed to determine economic and environmental benefits of the CD/SI system at the farm scale to the farmer.

1.10 Title: Assessment of the influence of manures for the control of soilborne pests including nematodes, fungi and bacteria.

Contractor: Dr. George Lazarovits, Pest Management Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St, London, ONT, Canada, N5V 4T3**.**

Objectives: 1) The objective of this study is to assess the potential use of manures and related organic materials for reducing plant diseases caused by soilborne pests.

Expected Outputs: 1) To conduct an initial survey of a variety of manures (animal, poultry) from a various sources and in various stages of decomposition to determine whether these materials exhibit an ability to suppress Verticillium; 2) To produce quantitative data as to the capacity of the "active" manures from various sources for reducing the survival of Verticillium and therefore controlling disease; 3) To monitor changes in populations of beneficial microbes in the various types of manures; 4) To identify factors which may influence disease control efficacy, such as: the source of the manure, rates of application, procedures used for composting, effect of soil type, etc. Treatments found effective in the laboratory will be field tested in microplots and on farm locations growing potato and tomato crops. Field observation will measure pathology, soil microbiology and agronomic changes in the crop plants tested. Information as to the appropriate methods of application of manures for disease control will be generated.

No progress to date

1.11 Title: Measuring (Changes in) Soil Microbial Populations by Analysis of Their Phospholipid Signatures.

Contractor: Dr. Ralph Chapman & Ms. Joy Kohlmaier, Pest Management Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St, London, ONT, Canada, N5V 4T3

Summary

Phospholipids (mixed esters of fatty acids, phosphoric acid, glycerol and selected other alcohols) are a major component of microorganism cell walls, and as such are quantitatively related to microbial biomass (a soil biological parameter useful but difficult to measure). Phospholipid composition (differences in the relative concentrations of the fatty acids or the selected other alcohols) is dependent on the species of microbes and growth conditions. Differences in the concentration of phospholipids and their composition may provide a measurable difference in microbial activity and community structure in soils.

Two methodologies for phospholipid analysis were investigated:

1) Phosphorus nuclear magnetic spectroscopy (NMR), for determining total phospholipid and phospholipid composition based on, so called, phospholipid classes in crude lipid extracts from soils. Phospholipids belonging to a particular class have one of eleven other alcohols bonded to phosphorus and either one or two fatty acids bonded to glycerol. This work was done in collaboration with Dept. of Chemistry, UWO.

2) Gas chromatography, for determining total phospholipid and the fatty acid composition of the mixture of phospholipids separated from a crude lipid extract obtained from soil.

The technique for obtaining high resolution phosphorus NMR spectra of phospholipids described by Meneses and Glonek (J. Lipid Res. 29, 679-89 (1988)) we were able to reproduce with spectra almost identical in chemical shift and line width to those published, with a number of pure chemicals representing a variety of phospholipid classes. Signals of similar line width were obtained from extracts of 50 g of soil without further purification - apparently the first observation of phospholipids from unpurified soil extracts by NMR. However, due to the low concentration of phospholipids (ca. 2 mg total in the soil sample), relatively long NMR observation times (ca. 15 hr/sample) were required to obtain useful spectra. The chemical shifts of some signals were affected by the other extractives in the samples (the co-extractive effect) to the extent that positive identification could only be achieved by spiking the sample with a standard of the suspected phospholipid class. This effect was observed to be concentration dependent. Six soil samples were examined (two pairs from organic/conventional (ORCON) pest control plots at PMRC experimental farm, and one pair from till/no-till (Green Plan) plots. Clear differences in phospholipid class composition were observed between the ORCON and Green Plan suite of soils. Differences between matched organic/conventional and till/no-till pairs were not great. The soils from the organic plots produced greater co-extractives than the soil from the conventional plots at equivalent concentrations, presumably a result of the increased organic matter present in organically-farmed soils (ca. 2x more total lipid extracted); this is a suggestive observation in and of itself. If methods can be modified to overcome the co-extractives effect, the technique will be useful for measuring total phospholipid and phospholipid class composition in crude lipid extracts. Clearly, there are some intriguing possibilities for characterizing soil microbial populations; the challenge is to determine this methodology's practicality.

Techniques for separating and quantitating methyl esters of fatty acids derived from phospholipids by gas chromatography are relatively routine and little development work was required. Eight soil samples (3 ORCON pairs and 1 Green Plan pair) were examined. Total phospholipid and differences in the fatty acid composition were determined. Total phospholipid ranged from 8 to 14 u mole/100 g with no clear differences between organic and conventional treatments being observed for the limited number of samples tested (most of the 2x greater amount of lipid extracted from the organic treatment soils appeared in the glycolipid fraction). Consistent differences in fatty acid composition were observed between the three organic and the three conventional soils suggesting that similar, crop-independent changes had occurred in the three pairs. More detailed gas chromatographic analysis of the methyl esters of the fatty acids is required before the affected components can be identified and the likely changes in the microbial community determined. Differences in the fatty acid composition for the till/no-till pair (Green Plan soils) were also observed. These were both larger than and different from the differences observed for the organic/conventional soils.

In summary, we have made some progress in advancing the methodology for analysing for microbial content of soils using chemical assays, and there is some evidence that these chemical assays for soil microbes may work.

2. ON FARM RESEARCH

Project Leader: Dr. Al Hamill

2.2 Title: **Investigating Methods of Integrating Liquid Manures into a Cropping System and the Effect on Soil and Water Quality.**

Contractor: Mr. David Charlton (George Schell), Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ONT N1G 3M5

Summary

The integrated liquid manure project is made up of a series of research experiments on field length plots at farm sites in southwestern and eastern Ontario. Ecological Services for Planning are managing the project along with two research partners, REAP-Canada and Ag-Knowledge.

The objectives of the project are to evaluate the influence of manure application rate, timing and technique on corn growth and soil nutrient content in a conservation tillage system. The research is funded by the Canada-Ontario Green Plan. Green Plan research activities are designed to promote environmentally sustainable agriculture within the farming community. The 1994 field season was the first of three years of field studies and data collection. Experimental sites were established at one dairy farm and three hog farms in southwestern Ontario, and at a poultry farm and a dairy farm in eastern Ontario. The management systems practised at the six farms include no-till, minimum tillage (using the Aerway), chisel tillage and ridge tillage on strips.

The nutrient treatments included the application of 100% of the estimated nitrogen requirement from manure, 100% from inorganic fertilizer and a combination of approximately 75% of the nitrogen requirement from manure and 25% from inorganic fertilizer. Both preplant and side-dress manure applications were evaluated at one site, while two different manure side-dress timings were evaluated at another site. All of the manure treatments were applied by tanker. Manure incorporation was achieved using either the Aerway tillage implement (pre-plant applications only) or a disk. The inorganic fertilizer treatments were applied either as a starter with the planter or as a side-dress application. The agronomic effects of the different manure and inorganic N treatments were evaluated through measurement of ear leaf nitrogen, final corn yield and weed counts. The nutrient status of the soil was evaluated through soil fertility and soil N tests, immediately before and after manure and/or fertilizer applications, during mid-summer and at harvest time. Open well piezometers were installed at two of the sites to permit observation of the water table depth and periodic sampling for nitrate analysis. The 1994 growing season was favourable at all of the southwestern Ontario sites, except for a mid-summer drought that affected yields at the clay soil site in Lambton County. In eastern Ontario, wet conditions in the spring and early summer caused difficulties with the side-dress manure applications at one of the sites. It may be preferable to apply the manure to standing corn at an earlier date (2 to 4 leaf stage) to reduce the risk of getting delayed by bad weather.

Reduced yields were observed at two of the farms in southwestern Ontario on the plots treated with manure only. Heavy weed pressure contributed to the yield reduction on the manured plots. At the two sites where weeds were adequately controlled, there was a trend for greater corn yields on the plots where manure was applied with an inorganic starter fertilizer. At these sites, the lowest yields were observed on the 100% inorganic fertilizer plots. In eastern Ontario, there was a trend towards reduced yields on the plots fertilized with 100% manure compared to plots where a combination of manure and inorganic nitrogen fertilizer was used. At the clay soil site, the plots on which manure was applied between rows in mid-June recorded greater yields than the plots where manure was applied in early July. This trend was not evident at the sandy loam site, where the greatest yields were observed on the plots where manure was incorporated with a disk in early July. The research project will continue for another two field seasons. The results obtained in the first field season have been used to improve the strategies for the field experiments in the next two years. The final results will allow us to evaluate the agronomic benefits and some of the environmental effects of the different methods, timings and rates of manure application.

2.3 Title: **Environmental Effects of Conservation and Conventional Cropping Systems.**

Contractor: Ms. Jane Sadler-Richards, Ecologistics Ltd, 490 Dutton Drive, Suite 1A, Waterloo , ONT N2L 6H7

Summary

The Canada- Ontario Green Plan agreement was designed to encourage and assist farmers with the implementation of appropriate farm management practices within the framework of environmentally sustainable agriculture. This project addresses the environmental effects of conservation and conventional crop production systems, based on selected soil and water quality parameters.

Fields were selected from farms which represented viable production systems where respective conservation (no-till) or conventional (moldboard plough) production systems were in place for a minimum of four years. Eight paired fields (16 fields total) were selected based on their similar soil type, drainage, slope, geographic area, crop rotation, crop inputs and cooperator willingness to participate.

Soil and water monitoring occurred on a seasonal and rainfall event basis. The table below summarizes the status of samples collected for all sites in 1994.

Sample Type	Total No. of Samples Possible	Total No. of Samples Analyzed
Soil Inherent Properties		
Particle size distribution	16	16
Landscape position	16	16
Slope	16	16
Soil profile	16	16
Depth to impervious layer	16	16
Soil Dynamic Properties (see 2.2 Comments)		
% organic matter	16	16
Water release characteristics	64	64
Infiltration rates	160	160
Biomass carbon	54	54
Extractable nitrate, nitrite, ammonium; Total P	140	133, 123
Extractable pesticides (2,4-D or metolachlor)	140	136
Water Quality Properties (see 2.2 Comments)		
Ground Water		
Extractable nitrate, nitrite and ammonium; Total P	70	60, 59
Extractable pesticides (2,4-D or metolachlor)	70	54
Tile Drain Runoff		
Extractable nitrate, nitrite and ammonium; Total P	70	28, 29
Extractable pesticides (2,4-D or metolachlor)	70	27
Surface Water Runoff		
Extractable nitrate, nitrite and ammonium; Total P	70	42, 44
Extractable pesticides (2,4-D or metolachlor)	70	32

It is anticipated that a similar monitoring program will continue for the next two cropping seasons.

2.4 Title: Determining the Factors Responsible for, and Methods to Overcome the Limitations of Conservation Cropping Systems on Clay Soils

Contractor: Drs. T.J. Vyn and C.J. Swanton, Crop Science Building, University of Guelph, Guelph, ONT, N1G 2W1

Summary

Research projects were designed to examine the effects that tillage for clay textured soils will have on 1) rates of spring seedbed dry-down; 2) in-row seedbed physical properties (ie. aggregation, soil strength, porosity, temperature, and moisture); 3) corn and soybean yield following wheat or in a corn-soybean rotation; and 4) weed seedbanks paying particular attention to species shifts and vertical distribution. Also, the effect of rye cover crop and soybean row width on the effectiveness of selected weed control management strategies (consisting of combinations of 1 or more of pre-emergent herbicides, post-emergent herbicides, and row cultivation) and yield of soybeans when planted no-till on clay textured soils will be examined. Although the sites were established in 1993, the first year of data collection occurred in 1994.

As expected, faster rates of soil dry-down occurred with fall moldboard tillage when compared to no-till following wheat. However, both fall disking and fall zone tillage resulted in soil drydown rates similar to fall moldboard plowing (at least for measurements taken in the loosened zone).

Aggregate size distribution was the soil property most consistently affected by tillage. Eliminating, or at least reducing, the amount of wheat straw in a no-till system increased the proportion of fine aggregates and tended to result in faster early season corn and soybean growth. Lower proportions of fine aggregates were observed as tillage intensity declined. For both corn and soybeans following wheat, as well as corn following soybeans, yields were positively correlated with the proportion of fine aggregates.

No-till was associated with lower corn yields than fall moldboard plowing following both soybeans and wheat. However, reduced tillage systems such as fall zone-tillage, fall disking with no secondary tillage, spring secondary tillage only (following soybeans) or use of an Aerway (following soybeans only) generally resulted in yields that were similar to either the fall moldboard or fall chisel plow tillage systems and greater than no-till.

Following wheat, no-till soybean in 76-cm wide rows yielded less than in the fall zone-till, fall disk with no secondary tillage, fall chisel plow or fall moldboard plow tillage systems. However, no-till planting in 38-cm wide rows resulted in yields that were greater than any of the tillage systems examined in 76 cm wide rows; indicating that tillage systems such as fall zone-till may be associated with lower yield potential than tillage systems that allow for narrower row widths.

Tillage systems had no influence on yield of soybeans planted in 38-cm wide rows following corn.

A spring killed rye cover crop did not suppress weed growth in no-till soybeans and had inconsistent effects on soybean performance; resulting in a 19% yield reduction at one site and a 9% yield increase at another site. There was a tendency for improved weed control and higher yields if soybeans were planted in 19 cm rather than 76 cm wide rows. When planted in 19 cm wide rows, a burn-down application of glyphosate resulted in similar weed control than a broadcast preemergent herbicide application in 76 cm wide rows. When planted in 76 cm wide rows, banding pre-emergent herbicides with row cultivation resulted in soybean yields that were comparable to a broadcast pre-emergent application.

Preliminary economic analysis indicates that soybeans grown in 19 cm rows with a glyphosate burn-down alone, provided the greatest net return of all treatments evaluated.

2.5 Title: To Obtain Information on Variable Rate Technology for Nitrogen Application and Determine the Feasibility of Implementing this Production Tool

Contractor: Dr. Gary Kachanoski, Dept. of Land Resource Science, U. of Guelph, Guelph, ONT N1G 2W1

Summary

The goal of the study is to determine the feasibility of variable rate technology for N fertilizer application, to maximize economic crop response while minimizing environmental impacts on water quality. Specific objectives include
(1) To assess different methods of obtaining the field map for variable application N of fertilizer,
(2) Determine the economic benefits of variable application of N fertilizers, and
(3) Determine the change in potential nitrate loading to the groundwater from variably applying N fertilizer.

Two sites established in the spring of 1993 in Huron Co. near Londesboro, Ontario on the farm of Bruce Shillinglaw. Each site consisted of 4 adjacent blocks of no-till planted corn. Each block consisted of 2 treatments; (1) Fertilizer added (F) @ 160 kg N/ha, and (2) No fertilizer N added (NF). Each treatment was 8 rows of corn with 75 row spacing and a length of approximately 325 m. Spatial patterns of yield with fertilizer added and yield with no fertilizer were obtained from detailed hand harvesting (approx. 250 m hand yield samples per field). Yield patterns were also obtained using a commercial on-the-go yield sensor attached to a combine. Soil cores were taken in a dense grid from each field to obtain the spatial pattern of the soil N test. Extensive soil sampling to a 90 cm depth was also carried out in the fall period to obtain the spatial patterns of residual mineral soil N. and the subsequent loss of N by leaching. All of the instrumentation and sampling was referenced to a detailed elevation map of the site obtained from a laser theodolite survey of each site. The data from the first year of results was used this past year to construct two variable rate maps for fertilizer N application for each of the two field sites (S 1, S2). The 2 variable rate maps were based on 1) the N soil test and 2) a differential yield map (fertilizer yield - check yield). Thus, in 1994 each of the two field sites had N fertilizer rate treatments consisting of; check (0 Kg N/ha), Constant rate @ 150 Kg N/ha, variable rate from soil test prediction, and variable rate from the differential yield map. Each treatment consisted of 4 replications of 4 corn row wide x 400 m long. This fall (1994), hand sampled yields (2 rows x 5 m long) were taken every 10 m for each of the treatment strips. This resulted in 640 hand sampled yields per site. Hand harvesting finished in late November and samples were dried and weighed in December. The data just finished being keyed into the computer and data analysis is on-going.

The constant rate application @ 150 kg N/ha have an average corn grain yield of 6630 Kg/ha. Variable rate application based on the yield differential map resulted in an average application rate of 98 Kg N/ha and average yield of 6330 Kg N/ha. The variable rate application based on the soil N test resulted in an average application rate of 68 Kg N/ha with an average yield of 5930 Kg N/ha. An economic model for analyzing the data set and variable N management in general, is being developed by a graduate student in the Dept. of Agric. Econ. and Business (Univ. of Guelph). The project will continue at a smaller sale in 1995. The main objective of 1995 is to examine any residual N effects on the subsequent soybean crop (no effects are anticipated) and to set up the sites for examining the variable N response to barley in 1996. The variable N map for barley will be compared to the map obtained for corn (1993/94) to determine the consistency of the N fertility map for different crops.

2.6 Title: **Measuring the Effect of Crop Residue or Live Cover Crops in Conservation Tillage Systems on Soil and Water Quality.**

Contractor: Dr. Craig Drury [Dr. Ian van Wesenbeeck], Harrow Research Centre, Agriculture and Agri-Food Canada, Harrow, ON NOR lG0

Summary

In the 1994 growing season, red clover improved corn grain yields and N uptake especially for the no-till treatments. Conventional tilled corn within red clover resulted in significantly greater yields than the no-tiII bare treatments and the no-till red clover treatment that was band sprayed. However, the no-till red clover treatment (overall sprayed) was not significantly different from the two conventional Till treatments. Hence inclusion of red clover with no-tillage increased yields to that of conventional tilled corn when the red clover was completely killed in the fail. Delayed growth and maturity of the bare and band sprayed no-tiII treatments was also evident earlier in the growing season as these treatments required a longer time to reach the 75% silking stage than all other treatments and the kernel moisture content was also greater with the no-tiII bare treatment.

Red clover increased soil extractable NH_4^+ and NO_3^- levels in the top 0 -30 cm soil layer. This increase occurred earlier in the growing season with the conventional tilled treatments than with the no-tilI treatments. In fact, there was a depression in the soil NH_4^+ + NO_3^- levels with red clover in the no-tiII treatment in soil samples collected just prior to planting. This could readily be explained by an initial immobilization process as soil NH_4^+ and NO_3^- was being used by the microbes to decompose the red clover and wheat straw residues. Later in the growing season there was a net increase in soil NH_4^+ and NO_3^-. Perhaps in a no-till clover treatment, all of the N fertilizer should be applied at planting instead of splitting the application between planting (40 kg N ha) and sidedressing at the 6 leaf stage.

In 1994, we expanded the analysis to include soil respiration measurements. Soil respiration provides us with an estimate of the decomposition rate of the plant residues in soil. Conventional tilled crops had about a 60 % greater respiration rate from June until the beginning of August After this period, dry soil conditions and cooler temperatures in September and October resulted in lower soil respirations rate and no treatment differences. it was interesting to note that red clover did not appear to influence soil respiration rates.

Microbial biomass estimates were taken at monthly intervals from mid June unto mid October. Microbial biomass in June and July was greater when red clover was included in the rotation and was also greater with the no-till treatments. Hence the greatest microbial biomass levels occurred with the no-till red clover treatments. These estimates indicate the beneficial effete of no-tillage and cover cropping on improved nutrient cycling and microbial activity.

Soil physical properties that were examined included WAS, MWD, bulk density, soil moisture content and soil temperature. No-tillage resulted in lower soil bulk densities and greater MWD values. There were no noticeable differences in soil temperatures during the July 8 August periods between treatments. Soil moisture content was greatest with the no-till bare treatments and lowest with the no-till red clover treatment. Tillage significantly affected the weed populations in the unsprayed microplots. Annual weeds such as Velvetleaf were more abundant in the conventional tilled plots whereas perennial weeds such as dandelion and Canada thistle were more abundant in the no-till treatments. These differences were expected and the inclusion of a red clover cover crop did not affect the weed populations.

In summary, the inclusion of red clover was beneficial when the red clover was completely killed in the fall before planting corn. When red clover was Included in the no-till system (1st year), the increased soil N, lower soil moisture contents, improved biological and physical conditions ail contributed to yield increases which were not significantly different from the conventional tilled treatments. In 1995 we plan to drop the band sprayed no-till red clover treatments and include a no-till red clover treatment In which the wheat straw was baled. All other measurements will be conducted similar to 1994 expect for an expansion of the soil respiration measurements to the spring period.

2.7 Title: Crop Rotations and Cover Crop Effects on Erosion Control, Tomato Yields and Soil Properties in Southwestern Ontario (A program begun in 1989 under the Land Stewardship I Program, OMAFRA)

Contractor: Mr. R. W. Johnston, Horticultural Soil Management, Ridgetown College of Agricultural Technology, Ridgetown, ON NOP 2C0

Summary

On the five year average, red tomato yields have been increased 25.8% and 40.8% at Leamington and Dresden respectively by the best four crop rotations compared to continuous culture. Continuous culture tomato yields remain relatively static while at Dresden continuous tomato yields have decreased from 41 t/ha in 1991 to 27 t/ha in 1994.

Some earthworm counts were taken at both locations in early May. It is anticipated to obtain more counts in early May 1995. The numbers of earthworms were greatest in the legume plots compared to continuous tomatoes (35-39 vs 4-5 per 1/2 sq. meter). Samples were taken also in early May for soil fauna. In seven out of 10 counts at Leamington, there were fewer organisms in the continuous tomato soil and eight out of 12 at Dresden. Total nematode counts were lowest in continuous tomatoes at both locations. Nematodes were highest in soil with one year of red clover (5.98 x, 4.45 x Dresden). This rotation is one of the higher yielding rotations.

Soil samples taken for bulk density indicate that rotations have significantly lower bulk density than continuous culture. The percent water stable aggregates were lowest in continuous culture in the five rotations sampled.

Water holding capacity appeared to be slightly increased by rotation at Dresden but not at Leamington. One reading per tomato plot was taken with a Guelph permeameter at the 0-10 cm depth. As the equipment was borrowed this was all the measurements that could be taken. No K value could be calculated but it was evident that infiltrations were more rapid on rotated plots than continuous culture plots. A large rain (110 mm) on June 13, 1994 at Dresden caused flooding over most of the plot area. Continuous tomatoes, CuGBT and WSCT plots were slowest to drain. Tomatoes following alfalfa, red clover and winter wheat, soybeans, tomatoes were the fastest to drain.

Root lesion nematodes counts do not build up in continuous tomato plots. In Dresden, high root lesion nematode counts (up to 4 times the accepted critical level) have not appeared to affect tomato yields.

At both locations grass weed escapes are greatest on plots following alfalfa and red clover. In the plots with a rye cover crop, CT and CuGBT, there are very few weed escapes.

Rotations would appear to have had a very positive effect on tomato yields, colour and quality, a very positive effect has also been obtained on percent wet aggregate stability and soil bulk density.

3. DEVELOPMENT OF AN INTEGRATED RESOURCE MONITORING CAPABILITY

Project Leader: Dr. Bruce MacDonald

3.1 Title: Development of Standard Methodologies: Resident Biomass and Organic Carbon

Contractor: Mr. David Charlton, Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ONT N1G 3M5

Summary

Fiscal year 1994 1995 was the second and final year for this project. During this fiscal year 3 additional sites were located and sampled based on procedures established during 1993-1994 at the Rockwood site. Sites at Clinton, Teeterville and Bainsville were sampled at a variety of slope positions during both high and low corp periods. Soil carbon analyses and detailed soil physical and chemical analyses were completed for each of the sites to provide data sets comparable to the 1993-1994 data set. A review of the literature was completed focussing on relationships between soil carbon, soil properties, plant growth and soil resilience to climatic and management variables

Complete data sen were not available until late February 1995. Data analysis is ongoing with the benefit of comments received from the workshop in March 1995. Analyses conducted to date indicate the following trends:

More soluble carbon in August than either May or November;
Significantly higher levels of biomass at lower slope positions;
Higher biomass from 0-15 cm soil depth than 15-30 cm depth; and,
Higher biomass in natural (forest) and conservation systems (ridge till and no till) than in convention tillage systems.

The microbial quotient (microbial biomass C/total organic C) results show significant negative correlations between total organic C and the microbial quotient at Clinton and Teeterville. This is consistent with relationships reported in the literature. Rockwood data did not show a significant relationship and the Bainsville data showed a significant positive correlation. These apparent anomalies are being investigated further.

The limited data set did not yield information on variability of soil carbon due to climatic differences or soil type. Additional analyses are being conducted to test variability within fields and to draw conclusions on the number and spatial distribution of samples necessary to adequately sample variable fields.

Work to date suggests the following preliminary conclusions;
Soil carbon and biomass has promise as an agroenvironmental indicator;
Soil carbon is related to the agroenvironmental indicators crop yield, soil degradation risk, nutrient cycling and Greenhouse gas balance;
Soil carbon is highly variable with landscape position, season and crop management; interpreting the environmental implications of comparisons of soil carbon between fields is difficult;
Soil carbon may be a good short term indicator of long term changes within a field in response to management changes;
Improved understanding of spatial, temporal and soil related dynamics is required before the long term implications of short term changes in soil carbon can be interpreted with confidence.

Ongoing data analysis and interpretation will lead to a final report in May of 1995.

3.2 Title: Development of Standard Methodologies: Resident Biomass and Organic Carbon

Contractor: Dr. Gary Kachanoski, Environmental Soil Services, 605 Arkell Rd., Arkell, ONT N0B 1C0.

Summary

The objective was to characterize forms and spatial and temporal variations of soil C sufficient to distinguish a 20% change over and above seasonal and random variations, and to relate the soil C measurements to other soil properties. Two sites covering three textural groups were chosen. The sites are the Lobb farm (Huron Co.), which has a sand to sandy loam textured catena sequence and a silty clay-loam to clay-loam catena sequence, and the Pottruff farm (Brant Co.), which has a loam catena sequence. Each catena sequence has three benchmark monitoring locations; upper (eroded), middle (transitional), lower (depositional). The sites have considerable baseline data collected as part of the Tillage-2000 project. Sampling was based on soil horizons to obtain a measure of the solum specific mass (i.e. the amount of C and N per unit land area from the surface to the depth of the pedogenic B/C interface). A monitoring area (15 m by 15 m) was established at each benchmark. A sampling grid was established with 15 subsampling points of reference. At each sampling time, an undisturbed soil core (3.175 cm diam.) was taken in the immediate area surrounding each of the 15 subsample grid points The cores were sliced according to A and B horizon. Sampling times were set to characterize major crop growth stages (planting/spring, sidedress/emergence, full canopy, harvest/fall). A separate measurement of soil bulk density and thickness was obtained for each of the subsamples. Each of the subsamples were combined to get a single bulk sample representing the benchmark. Chemical analysis were completed on the composite samples. At the harvest/fall sampling, only 9 grid locations within each benchmark were sampled. However, at each grid location, the samples were separately dried. weighed and analysed for chemical properties to get an idea of the spatial covariance between chemical composition and solum thickness, and the inherent spatial variability. At each sampling time 2 measurements of surface residue were obtained. The above ground crop biomass at time of harvest was also sampled. Hand yield measurements were taken by sampling 2 rows x 5m length of row. All plant and surface residues samples were analysed for total C and N. Soil samples were analysed for, organic C, total N. mineral N (NH_4-N, NO_3-N), microbial biomass C and N, and macro-organic matter C and N. Chemical analyses of all soil samples are completed, but re-analysis of some of the samples is currently occurring. Data summary and statistical analysis is on-going. The number of samples is quite large especially for the detailed spatial variability sampling carried out in November. The data suggest that erosional processes are controlling the "state of the soil resource" and this translates into significant spatial differences in both the long term carbon storage in the soil and short term above ground plant biomass C production. The benchmarks have a range of solum thicknesses with considerable local scale variability. For example, at the Pottruff catena. coefficients of variation of A horizon mass were 14.5% in the lower slope and 36.2% to the upper eroded benchmark. Measurement of ^{137}Cesium content confirmed the erosional status. Solum soil mass (g/cm^2) varied from 139.9 in the lower slope to 71.9 in the upper slope. Despite the large differences in solum thickness and solum mass, organic matter (% wt.) in each horizon was quite constant. However. when organic matter content is multiplied by soil mass, differences in C value between slope position are obvious. The relative difference in yields were quite similar to the relative differences for both ^{137} Cesium and total organic C in the solum. Cesium-137 may be a very easily measured useful Agro-environmental indicator.

3.3 Title: Development of Standard Methodologies: Bio-indicators and Methodologies to Quantify Soil Quality.

Contractor: Dr. C. M. Monréal, Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Central Experimental Farm, Ottawa, ONT KlA 0C6

Summary

Our objective in the current year was to measure effects of agronomic practices and soil properties on soil enzyme activities, lipid content and the light fraction of soil organic matter. We measured treatment effects against background variability of these properties. Soil samples were collected on four dates (April through September) from each of four sites located in southern, central and eastern Ontario. For each of 674 soil samples, we measured six enzyme activities (dehydrogenase, urease, glutaminase, alkaline phosphatase, arylsulfatase and ß-glucosidase), and water, NH_4^+ and NO_3^- contents. In addition, for 74 samples collected to study spatial dependence at the central Ontario site, we also measured organic C content, the light fraction and ergosterol content. Kinetic constants (K_m and V_{MAX}) of phosphatase, \-glucosidase and arylsulfatase activities, and lipid content and aggregate stability were measured for selected samples from the site in southern Ontario.

Soil biological properties differed in spatial dependence. The distance beyond which one sample was independent of another varied from approximately 12 m for ß-glucosidase activity and the light fraction, to 118 and 123 m for phosphatase activity and organic C content, respectively. Fertilizer-N source affected three enzyme activities. Urease activity of the surface layer of the Ap horizon was increased by manure application, and decreased by application of 28E urea-NH_4NO_3 solution (UAN). In the lower layer of the Ap horizon, phosphatase activity was increased by manure and UAN application, and arylsulfatase activity was increased by UAN application. Dehydrogenase and urease activities were greater in a chisel-plowed field, compared to a ridge-tilled field. In these two fields, activities of dehydrogenase and ß--glucosidase (in the lower layer of the Ap horizon) were greater when corn rather than soybeans was planted in the previous year. At the southern Ontario site, tillage decreased activity of all six enzymes in the surface layer of the Ap horizon. As well, four enzyme activities were greater in coarse compared to fine textured soil. Activity measurements and determination of V_{max} provided similar information for ß-glucosidase, but only in part for phosphatase. At all sites, there was temporal variation in some enzyme activities. At some sites it was related to fertilizer application, or tillage practices.

3.5 Title: **State of Resources: Proposal for the Upgrade of Soil Survey Information in Oxford County**

Contractor: Mr. D. Charlton, Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ONT N1G 3M5

Summary

Environmental concerns have become a major issue for the agricultural industry in the 1990's. In particular, southwestern Ontario has been a focus of concern as a result of agreements under the International Joint Commission (IJC) to reduce phosphorus delivery from the Lake Erie Basin. The Lake Erie Basin is also one of the most intensively farmed areas in Ontario with major specialty crop, cash crop and livestock industries.

An upgraded provincial soil data base is available for much of the area. This information is essential for the protection and designation of agricultural lands in Official Plans and also forms the basis for delivery of programs dealing with environmental impact assessments and sustainable agriculture.

A major gap in the data base for this area is Oxford County. The existing soil map for Oxford County was upgraded so that it was compatible with adjacent county/regional municipality information. The selection of the Oxford County area was consistent with the objectives set out in the Green Plan program in terms of the scope, location, area of study and the study emphasis.

The upgrade was undertaken according to present standards outlined by the Ontario Centre for Soil Resource Evaluation (OCSRE). The study focused on slope information generation, soil reliability checking and development of information and maps in electronic format.

To generate the slope information for Oxford County, a Geographic Information System (GIS) was used to produce a digital terrain model. A triangulated irregular network (TIN) with a set of adjacent non-overlapping triangles was used to perform the digital terrain modelling. These non-overlapping triangles were computed from digital contour lines and spot elevations of the 110 Ontario Base Maps (OBM's) covering Oxford County. Because a TIN identifies and stores information about the relationships among the points (contour lines and spot elevations), how the points define triangles, and triangle adjacency, TINs produce accurate terrain models for analyses.

A stratified, random transect method was used for field verification purposes. This sampling procedure was used to verify slope mapping and provide an estimate of soil reliability for each soil polygon. The information compiled facilitated the production of an upgraded 1:50,000 map in electronic format. The field verification of the digitally generated slope information proved that the GIS generated slope information was accurate. The original soil information was also fairly accurate. Most of the discrepancies were due to differences in drainage class. In counties where no slope information is available, this method of digitally generating slope information can be used to upgrade soil maps to include slope information.

3.6 Title: State of Resources: Development and Application of Standardized Methodology for Sampling Soil Landscape Polygons

Contractor: Mr. J. Hagarty, Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ONT, N1G 3M5

SUMMARY

The "Soil Landscape of Canada" (SLC) is a consistent and comparable source of information about soil and land nation wide. It is a large scale planning tool used to assess land use potential for large areas of Canada. It maps soil landscape polygons at a scale of 1:1,000,000. Soil landscape polygons in southern Ontario generally consist of dominant and subdominant components. The dominant component is mapped and described in terms of a standard set of attributes considered important for plant growth, land management, and terrain sensitivity. The attributes include the mode of deposition, textural group of the parent material, soil development, surface form and slope class. Additional attributes further describe the dominant and subdominant components of each SLC polygon. The full array of attributes are located in a computerized data base.

The source of much of the soil and land attributes contained in the SLC data base is the National Soil Data Base in CanSIS. As a result, the information in the SLC data base may be outdated due to the age of the soil surveys and changes in the approach to soil survey and soil descriptions. Soil landscape polygon boundaries were often created using professional interpretations and judgements at a large scale rather than using smaller scale mapping to delineate polygon boundaries. This situation, combined with the discrepancies in data base quality, results in inaccurate descriptions of some soil landscape polygons. This potentially results in misleading information on the current state of Ontario's agricultural soil resources. This can be a serious problem as the 1:1,000,000 soil landscape map is increasingly being used to make decisions regarding the state of the soil resources and land use potential at regional, provincial and national scales.

This study investigated the SLC and associated data bases to determine the quality of the data for selected soil landscape polygons in the Regions of Niagara and Haldimand-Norfolk. The study also developed a sampling methodology to determine the variability of selected soil attributes within the soil landscape polygons and developed a methodology to sample soil landscape polygons that can be applied over a large area of southern Ontario. Agricultural fields were sampled in a systematic manner, independent of land use history, which resulted in soil samples and soil attributes which are representative of the majority of agricultural soils within each of the SLC polygons.

To assess the quality of the SLC data base, the study compared relatively recent, detailed (1:25,000) soil data bases and the SLC computerized data base. The study determined that there was very limited correlation between the major soil attributes (soil development, mode of deposition, and textural class of the parent material) described by the SLC for the five SLC polygons studied. The study also determined that there is significant variability between the pH and soil organic carbon values within the soil landscape polygons. Using the information obtained from the first two components of this study, a sampling methodology was developed

and applied to Oxford County where each of the major soil landscape components for each within the SLC polygon was sampled.

3.8 Title: State of Resources: Monitoring Soil Loss and Redistribution Using ^{137}Cs

Contractor: Dr. Gary Kachanoski, Environ. Soil Services, 605 Arkell Rd., Arkell, ONT N0B 1C0.

Summary

The two major objectives of this project are:

(1) Construct a map of baseline ^{137}Cs (total deposition, Bq m^{-2}) values for south-western Ontario, and

(2) Determine the redistribution of ^{137}Cs/soil since 1965 within a watershed typical of Ontario conditions, including deposition within the watershed, export out of the watershed, and loss from the uplands.

Construct a map of the redistribution with geographic positioning so that the watershed can be used as a long-term monitoring site for similar studies in the future. A total of 39 sites were selected on the basis of availability of long-term precipitation records and geographic position. At each site an undisturbed, uneroded area was located. Two composite soil samples were obtained and analysed for fallout ^{137}Cs using high resolution gamma-spectroscopy.The data indicate that 82% of the variability of the ^{137}Cs values was accounted for by differences between sampling locations, and only 18% of the variability was attributed to within site variability. The ^{137}Cs values ranged from 1861 to 3015 Bq m^{-2}. Significant spatial trends were observed in the data. A preliminary baseline map of cesium fallout has been constructed. The Kintore watershed was chosen as the site for objective 2. The site has a significant amount of baseline information already collected and the Univ. of Waterloo's water partitioning study is being carried out within the watershed. In cooperation with the Upper Thames Conservation Authority, land owners within the basin were contacted and agreed to allow access to their land for detailed soil and elevation measurements. Maps of the watershed were obtained from the UTCA that showed the field boundaries and sampling was stratified to characterize fields as well as the major landforms within fields. Each sampling benchmark for 137-cesium was surveyed in with a laser theodolite, and numerous other points were also surveyed for elevation (but not sampled for cesium). At a cesium sampling benchmark, 9 soil cores (3.175 cm diam.) were taken in a 3 x 3 sampling grid (3m interval for a total area of 6m x 6m). The middle sampling point was centred on the laser theodolite location. Each of the cores were sliced at the bottom of the A horizon, and then bulked to form a single composite sample for the benchmark and for subsequent analysis of 137-cesium. The samples were air-dried, passed through a 2 mm sieve and subsampled to obtain an airdry soil water content. the sample was sent to the Univ. of Guelph for analysis of 137-cesium using high resolution gamma spectroscopy. Approximately 50% of the basin was sampled this past year, the remaining part of the watershed will be sampled in the coming spring and early summer. After these samples have also been analysed a map of 137-cesium distribution and surface elevation will be constructed and compared to other existing resource information (ie a preliminary detailed soils map is available)

3.9 Title: Development and Application of a Computerized System to Manage, Use and Distribute Data Collected by Green Plan Monitoring Research Projects

Contractor: Mr. Ken Denholm. On. Land Resource Unit, C.L.B.R.R., 70 Fountain Street, Guelph, ONT N1H 3N6

Summary

The work completed to date in this Green Plan contract is on schedule and has met the first objective of establishing the hardware and software necessary to carry out system maintenance and data management activities. The system is installed and functional and is located at the Ontario Land Resource Unit in Guelph. The second stage of the contract is well under way with the development of a conceptual database structure into which spatial data from Green Plan contractors will be stored, manipulated and made available to other agencies and projects.

The project is now at the point where data from Green Plan Monitoring contracts are being accepted and will be verified as to their content and quality. This activity will increase in intensity as more and more Green Plan contracts reach completion and the data become available for entry into the database management system. So far we have received data from RES/MON-004/94.

3.10 Title: Partitioning of Solutes from Agricultural Fields within the Hydrologic System at Two Sites in Southern Ontario and the Subsequent Impact on Adjacent Aquatic Ecosystems

Contractor: Dr. David Rudolph (Kachanoski, van Wesenbeeck, Barton), Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, ONT N2L 3G1

Summary

Surface water and groundwater contamination risk assessment must include identification of water flow and contaminant transport pathways. We will quantify the partitioning of solutes in an agricultural field of variable slope via water and nutrient balances. As well, we investigate the impact of exposure to agricultural lands on the biodiversity of a small creek. We will monitor water and nutrient inputs, pathways and outputs to the creek using the following instruments: 1) meteorological station to measure RH, temperature, incoming radiation, wind speed and rainfall; 2) microlysimeter with TDR and tensiometry to monitor soil-water conditions and infiltration; 3) tile drain water flow gauges; 4) multilevel piezometers and drive points to monitor groundwater levels; 5) seepage meters to monitor discharge through creek bed and seepage face; 6) thermocouples for soil, surface water and groundwater temperatures; 7) stream flow gauging using rating curves measured by the Upper Thames River Conservation Authority; 8) automatic and manual water sampling for analysis of NO_3, NH_4, DOC, total soluble N, DO, pH, Eh, EC and tracers such as Cl, ^{13}O, ^{2}H; 9) monitor creek biological health using emergence traps, sampling of benthic invertebrates and a fish census.

The most striking feature of the deeper groundwater system is the strong vertically upward potential gradient. It is particularly evident in the lower part of the field as two wells are under artesian pressure conditions. The concentration of nitrate in deep groundwater samples generally increase towards the water table. Some samples exceed 10 ppm nitrate-nitrogen. The vertically upward hydraulic gradient may also explain why to date water has flowed continuously from all but one of the tile drain outlets. As well, preliminary ^{18}O analyses on water samples from the creek and tile drains during a period of base flow conditions suggest that deep groundwater is the predominant source. Water samples collected from the creek show a progressive increase in nitrate concentration in the downstream direction. The average nitrate concentrations in tile drains for the same period are somewhat variable with some samples exceeding 10 ppm nitrate-nitrogen.

The biological data collected during 1994 indicate that there are measurable changes in the biota of the creek within the dimensions of the study area. The large numbers of animals at the downstream site, coupled with a decrease in the abundance of mayflies, is most consistent with the known effects of organic enrichment (eutrophication). Differences in water temperature and direct insolation may also be important.

3.11 Title: State of Resources: Improving the Land Resource data Base - Waterloo Region

Contractor: Mr. D. Cressman, Ecologistics Limited, 490 Dutton Drive, Waterloo, ON N2L 6H7

Summary

Digital soil polygon and attribute files were obtained from the Regional Municipality of Waterloo. The digital files consisted of the *Soils of Waterloo County* soil polygon information registered to digital Ontario Base Map (OBM). The OBM layer files included: cultural lines, hydrology, townlines and the digital terrain model (DTM).

A test of the digital soils information was conducted on select test areas within Wilmot Township. The results from the test areas indicated the digital soil coverage provided an accurate representation of the soil unit boundaries. The test methodologies were applied to the balance of the Region of Waterloo soils coverage.

A computerized grouping of the digital soil units was conducted by assigning a numerical value to each soil type in a particular soil/landscape association. The computer grouped soil units and dissolved soil unit boundaries between adjacent polygons of similar value. This process resulted in a net reduction of the total number of soil units to approximately one third the original number. The resulting soil unit coverage was a detailed and complex community. Due to the complex nature of the soil units, a manual editing and grouping was conducted. The digital soil unit coverage was modified to reflect the manual edits.

The Region of Waterloo provided access to two DTM coverages. One coverage was detailed and consisted of 72 separate files. The second coverage was a single file and contained less detail. A test was conducted on each coverage to determine the most appropriate coverage to be applied to the balance of the region. Slopes were evaluated through correlation to the Canadian System of Soil Classification (CSSC) slope categories. Slopes greater than 10 percent were determined according to the DTM.

The goal of this project was to apply methodologies developed during upgrade and interpretation of soil survey information for Wilmot Township, to the Regional Municipality of Waterloo.

The objective was to convert detailed soil survey information on an uncontrolled base to a scale and level of detail common to current mapping convention.

The objectives are being obtained through the methodologies developed in the pilot project. The digital files are being processed, resulting in the building of a soil/slope polygon map and associated attribute files.