1971
PROGRESS REPORT
DEPARTMENT OF
LAND RESOURCE SCIENCE
Research - Teaching - Extension
SOIL SCIENCE
GEOLOGY
AGROMETEOROLOGY
ONTARIO AGRICULTURAL COLLEGE
UNIVERSITY OF GUELPH
GUELPH, ONTARIO, CANADA
JUNE 1972
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FOREWORD

The 1970-71 year gave birth to the Department of Land Resource Science. It has resulted in little visible change in the operation of the Department (previously known, and often still referred to, as Soil Science), but nevertheless our new name does give us a new sense of direction in these rapidly changing times. We, of course, are continuing those programs of the past that have been the mainstay of the department and which continue to be of importance at the present time; we are strengthening our programs in land use and environmental quality.

On July 1, 1971 Dr. M.H. Miller returned to full-time teaching and research within the Department and was replaced by Dr. D.E. Elrick as chairman. Murray Miller's five years saw many changes take place within the Department. The faculty has grown from 17 to 23 members and both the geology and meteorology disciplines have become established within the Department. Such accelerated growth is not anticipated for the near future; however, it is hoped that the addition to the building will be started by 1975 in order to relieve the present crowded conditions.

A number of faculty visited various parts of the world during the 1971-72 year. Dr. Eric Beauchamp spent a month as part of the A.I.C. Commonwealth Foundation Exchange Program in Ghana and Nigeria. Dr. Cliff Acton visited the West Indies the previous year under the same program. Dr. David Elrick attended the I.U.G.G. Symposium in Moscow, U.S.S.R. and the Pacific Science Congress in Canberra, Australia. Dr. Erv Mackintosh and Dr. Peter Martini attended scientific meetings in Europe. Mr. Ted Presant left in January 1972 for Tanzania where he will be spending two years conducting the soil survey of that country.

We have enjoyed and profited from the presence of several post-doctorate fellows. Dr. Larry King and Dr. Larry Rudgers have been associated with the land disposal projects of Prof. Len Webber; Dr. Arend Smid has returned to Guelph to work with Dr. Eric Beauchamp and Dr. W.R. Watts has left for Aberdeen, Scotland after close to two years with Dr. Ken King and the Agrometeorology group. Dr. Keith Krupp, on leave from the International Rice Research Institute, is spending several months in the Department.

The only change in our full-time faculty was brought about by the resignation of Dr. W.M. Blacklow who accepted a position in the Department of Agronomy at the University of Western Australia, Perth. We wish Marcus the very best in his new position.

This year we have listed the staff of the department. We hope in this way to acknowledge the extremely important role they play in the departmental activities.

This report has been compiled and edited by Dr. J.W. Ketcheson.

As in past years, we have enjoyed our association with many individuals from organizations such as the Ontario Ministry of Agriculture and Food, Canada Department of Agriculture, Ontario Ministry of Treasury, Economic and Intergovernmental Affairs, Ministry of Natural Resources, Ontario Ministry of Health, Ministry of the Environment, as well as several other Departments of the Ontario Agricultural College, the Ontario Soil and Crop Improvement Association, and the
Advisory Fertilizer Board for Ontario. In particular, the provision, without charge, of land and facilities by a large number of interested farmers greatly assisted our programme.

We gratefully acknowledge the financial assistance for our research and advisory programmes from the following organizations:

Ontario Ministry of Agriculture and Food
Canada Department of Regional Economic Expansion (through A.R.D.A.)
National Research Council
Canada Department of Agriculture
Atmospheric Environment Service (formerly Canadian Meteorological Service)

Canada Department of Environment
Ontario Ministry of the Environment

June, 1972

D.E. Elrick, Chairman
Department of Land Resource Science
PERSONNEL AND INTERESTS

D.E. ELRICK, B.S.A. (Toronto), M.S., Ph.D. (Wisconsin), Professor and Chairman of the Department. Transport mechanisms through soils and applications to soil pollution.

W.A. MITCHELL, Administrative Assistant to the Department.

AGROMETEOROLOGY

Faculty


D.M. BROWN, B.S.A., M.S.A. (Toronto), Ph.D. (Iowa State) Associate Professor. Climate related to land use planning, crop zonation, climatological reference stations, relationships of crop growth and development to climate and weather.

T.J. GILLESPIE, B.Sc. (British Columbia), M.S.A. (Toronto), Ph.D. (Guelph) Assistant Professor. Relationships of plant diseases and pests to weather, computer modelling of soil and air microclimates.


G.W. THURTELL, B.S.A., M.S.A. (Toronto), Ph.D. (Wisconsin) Associate Professor. Physics of soils, plants, and atmosphere.


Technical Staff

M. Evans, Weather records. Transferred to data handling May 1972.
R.E. Sweetman, Electronic instrument operations and plot work.

Clerical Staff

Mrs. J. Knipe

SOIL SCIENCE

Faculty


E.G. BEAUCHAMP, B.Sc. (Agr.), M.Sc. (McGill), Ph.D. (Cornell) Associate Professor. Soil-plant relationships, plant nutrition, fertilizer use and residues.
W.T. EWEN, B.S.A., M.S.A. (Toronto) Associate Professor. Soil conservation in relation to crop production, teaching diploma and correspondence courses in soils.

T.J. HEEG, B.S.A., M.S.A. (Toronto) Associate Professor. Soil management, in charge of provincial soil testing laboratory.

D.W. HOFFMAN, B.S.A., M.S.A. (Toronto) Associate Professor. Soil classification and land use, Agricultural and Rural Development Act Projects.

B.D. KAY, B.S.A., M.Sc. (Guelph), Ph.D. (Purdue) Assistant Professor. Physico-chemical reactions in soils, including frost heaving and mobility of water and plant nutrients at mineral surface, soil physical chemistry.

J.W. KETCHeson, B.S.A. (Toronto), M.S., Ph.D. (Illinois) Associate Professor. Soil management for better tilth, tillage related to fertilizer use, run-off and erosion studies, manure and crop residues.


T.H. LANE, B.S.A., M.S.A. (Toronto) Professor. Extension co-ordinator, soil management and land use.

E.E. MACKINTOSH, B.S.A. (Saskatchewan), M.Sc. (British Columbia), Ph.D. (Adelaide) Assistant Professor. Study of soil properties and their relationship to land use, applied clay mineralogy.

M.H. MILLER, B.S.A. (Toronto), M.S., Ph.D. (Purdue), Professor. Soil fertility and plant nutrition. On leave to Australia.

R. PROTZ, B.S.A., M.Sc. (Saskatchewan), Ph.D. (Iowa State) Associate Professor (on leave of absence on Canadian International Development Agency sponsored planning study in Malaysia, Feb. 12 - Mar. 12, 1972.) Soil genesis and classification, soil variability, soil clay mineralogy, mapping techniques and soil landform relationships.

N.R. RICHARDS, B.S.A. (Toronto), M.S. (Michigan State), D.Sc. (Laval) Professor, Dean of Agriculture.


R.W. SHEARD, B.S.A. (Saskatchewan), M.S.A. (Toronto), Ph.D. (Cornell) Associate Professor. Harvest management and fertilizer use for production, longevity and quality of perennial forage species.


J.A. SMITH, B.S.A., M.S.A. (Toronto) Assistant Professor. Soil and plant analysis development.

L.R. WEBBER, B.S.A. (Toronto), M.S. (Cornell) Professor. Waste utilization and disposal, pollution abatement, environmental quality.


Technical Staff
N. Baumgartner - Soil physics and management analysis.
Miss L. Becker - Soil testing operations.
J.F. Brown - Soil testing operations.
J.C. Bryant - Soil management and plant nutrition plot work supervisor.
R. Cooper - Data handling. Resigned May, 1972.
E.L. Dickson - Run-off collection and analysis, greenhouse operations.
J.A. Ferguson - Soil management and plant nutrition plot work.
Mrs. S. Finora - Soil analysis.
E.F. Gagnon - Supervisor, soil testing operations.
G. Harlick - Soil management and plant nutrition field plot operations.
D. Kubinec - Soil analysis.
Miss C. Miller - Water analysis.
D. Morrow - Soil Management and plant nutrition plot work.
D. Tel - Pollution control and waste management, soil and water analysis.

GEOLOGY

Faculty
H.S. ARMSTRONG, B.A., M.A. (Toronto), Ph.D. (Chicago), D.Sc. (McMaster) Professor. Dean of Graduate Studies and Research.

M.E. BROOKFIELD, B.Sc. (Edinburgh) Assistant Professor. Palaeoecology, palaeontology, stratigraphy and tectonics.

W. CHESWORTH, B.Sc., M.Sc. (Manchester), Ph.D. (McMaster), F.G.S. Associate Professor. Geochemistry, petrology, mineralogy, geological mapping.

J.P. MARTINI, Doct. Geol. Sci. (Florence), Ph.D. (McMaster) Assistant Professor. Sediments and sedimentary rocks, sedimentology, glacial and pleistocene geology.

CO-OPERATING PERSONNEL LOCATED IN THE DEPARTMENT

Ontario Ministry of Agriculture and Food
G.H. HENRY, B.S.A. (Toronto) Soils and Crops Extension Specialist.

Technical Staff
Mrs. B. Vreugdenhil - A.R.D.A.
Canada Department of Agriculture

Professional:


Technical Staff
R. Howes, Soil analysis.

Clerical Staff for Department
Mrs. P.E. Beirnes - Departmental secretary.
Miss G.V. Palmer - Draftswoman
Miss F.I. Peer
Miss S. Robinson
SERVICE TO AGRICULTURE AND TO THE PUBLIC

Weather and Climatic Information

The Land Resource Science Department has the responsibility for recording and summarizing the weather at the Guelph and Elora Research Stations. Daily observations of air and soil temperatures, humidity, precipitation, evaporation and sunshine duration were made at Guelph. In addition to these elements, dew duration, wind and radiation were recorded at Elora. This information is used by government, industry, and research agencies.

Computer summaries of these records for both sites were submitted to the Atmospheric Environment Service for publication and distributed locally for use in connection with research projects and extension activities.

Weekly reports of corn heat units and degree days were provided for the Soils and Crops extension specialists and of dew duration and rainfall periods for the Southern Corn Leaf Blight reporting program conducted in the U.S.

Average daily minimum and maximum temperatures and total monthly precipitation, together with departures from normal, were tabulated for 13 Ontario weather stations for the 1971 growing season. This information has been published by the Ontario Field Crops Committee in their 1971 annual reports. It is also available on request from the Department of Land Resource Science.

There were many individual requests for climatic information received during the year. Historical climatic data cards were assembled for use in Agrometeorological and other research projects on campus.

See also list of PUBLICATIONS.

D.M. Brown

The Weather in 1971

Guelph - The temperature pattern at Guelph through 1971 is illustrated in Figure 1. Temperatures averaged much below the long-time average for the first 5 months, with February the only month in that period near normal. There were only 7 days in the first 5 months above the 1 in 10 probability level, whereas 25 days had minimum temperatures below that level. A trend to warmer temperatures started in during the latter half of May and continued through June, with at least seven warm spells occurring during that period. The 92°F high for the year occurred on June 28. Cooler than normal temperatures prevailed through July and August, with no days above the 1 in 10 probability level and 15 days with minima below that level. September and October partially made up for the cool summer, with 14 days above and 2 below the 1 in 10 probability levels. November temperatures averaged near normal and December was mild except when the mercury dropped to 2°F on the 2nd and 1°F on the 31st.
FIGURE 1  Temperature pattern at Guelph, 1971.
Table 1: Summary of 1971 Weather at Guelph

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<th>1971</th>
<th>Normal</th>
<th>Departure from Normal</th>
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<tr>
<td><strong>General</strong></td>
<td></td>
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<tr>
<td>Mean Maximum Temperature ($^\circ$F)</td>
<td>52.9</td>
<td>53.1</td>
<td>-0.2</td>
</tr>
<tr>
<td>Mean Minimum Temperature ($^\circ$F)</td>
<td>35.0</td>
<td>35.2</td>
<td>-0.2</td>
</tr>
<tr>
<td>Mean Annual Temperature ($^\circ$F)</td>
<td>44.0</td>
<td>44.2</td>
<td>-0.2</td>
</tr>
<tr>
<td>Total Degree Days Below 65$^\circ$F</td>
<td>7896</td>
<td>7916</td>
<td>-20</td>
</tr>
<tr>
<td>Total Degree Days Above 42$^\circ$F</td>
<td>3518</td>
<td>3360</td>
<td>+158</td>
</tr>
<tr>
<td>Corn Heating Units between May 11 and First Killing Frost</td>
<td>2945</td>
<td>2791</td>
<td>+154</td>
</tr>
<tr>
<td>Total Rainfall (inches)</td>
<td>24.1</td>
<td>27.1</td>
<td>-3.0</td>
</tr>
<tr>
<td>Total Snowfall (inches)</td>
<td>63.5</td>
<td>57.5</td>
<td>+6.0</td>
</tr>
<tr>
<td>Total Water Equivalent of Snowfall</td>
<td>6.9</td>
<td>5.7</td>
<td></td>
</tr>
<tr>
<td>Total Precipitation (inches)</td>
<td>31.0</td>
<td>32.8</td>
<td>-1.8</td>
</tr>
<tr>
<td>Total Bright Sun (hours)</td>
<td>2163</td>
<td>1940</td>
<td>+223</td>
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**Miscellaneous**

Temperatures:
- Highest for year: 92$^\circ$ June 28
- Lowest for year: -11$^\circ$ February 1
- Last Frost in Spring: 32$^\circ$, May 15
- First Frost in Autumn: 28$^\circ$, October 8

Precipitation:
- Greatest Rainfall in a day: 2.40" July 26
- Greatest Snowfall in a day: 5.5" January 26
- Longest period with measurable precipitation each day: 8 days, Feb. 7-14
- Longest period without measurable precipitation each day: 10 days, July 31-Aug. 9
- Last measurable snowfall in spring (0.1") April 25
- First measurable snowfall in autumn (0.1") November 3

**Number of Days With:**

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<th>J</th>
<th>F</th>
<th>M</th>
<th>A</th>
<th>M</th>
<th>J</th>
<th>J</th>
<th>A</th>
<th>S</th>
<th>O</th>
<th>N</th>
<th>D</th>
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</thead>
<tbody>
<tr>
<td>Freezing rain</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Hail</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<td>Thunderstorms</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>0</td>
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<td>13</td>
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Precipitation at Guelph (Figure 2) in 1971 was below normal for most of January and above normal through February and most of March. The extra snowfall during the winter accompanied by high winds with fresh snow on the ground caused blocked roads on several occasions. Dry weather prevailed for most of April and May resulting in timely seeding and above normal soil temperatures, so crops got off to a good start. Rainfall during June, July and August (13.6 inches) was much above normal for the summer period, resulting in bumper yields of hay, small grains and corn in the area. Then much below normal rainfall in September and October (2.3 inches) provided excellent harvest conditions. Precipitation in December brought the accumulated total to within an inch of the normal 32 inches.

Accumulated degree days above 42F (Figure 3) were near normal to the end of June, below normal through July, August and September, but ended 125 above the normal 3350 by October 31st. The last four years have been above normal. Other 1971 totals and means and their departures from normal are summarized in Table 1. The first frost in the fall occurred on October 8th, the latest date since 1951. However, it can be expected to be as late as October 8th, or later once every five years according to records for the last 40 years.

Ontario - Cool, dry weather prevailed throughout most of Ontario for April and most of May. Northern Ontario was closer to normal than the south during this period. June temperatures were above normal. June precipitation was below normal in most areas; Guelph and Ottawa areas appeared to be the only exceptions. July and August temperatures were below normal and September and October temperatures above normal throughout all of Ontario. Late summer precipitation benefitted crops in some areas, but other areas continued dry through October. The distribution of precipitation during the early part of the 1971 growing season was mapped to show small isolated areas where rainfall was adequate (see I.F.E.P. 074, Mar. 1972).

Mark Evans

Extension Activities

The extension activities of the Department of Land Resource Science are varied and complex since they involve advice on educational planning, production and environmental aspects of our land resource. In all of these aspects it is important that our extension commitments are relevant to today's problems. A large proportion of this activity related to O.M.F.A. matters.

Besides service to individuals and small groups (tours) extension activities for the period April 1, 1971 to April 1, 1972 included presentations to the following organizations and committees: Soil and Crop Improvement Association in eleven parts of the Province, Plant Food Council, Advisory Fertilizer Board, Association of Ontario Assessors, Ontario Regional Planning Branch, Ontario Assessment Branch, Dunnville Chamber of Commerce, Goderich Lions Club, Ontario Turnip Growers' Association, Ontario Horticultural Societies Association, Ontario Federation of Agriculture, Sod Growers' Field Day, Canada Committee on Agricultural Meteorology, Ontario Pesticide Committee, Ontario Soil Management Committee, Ontario Hybrid Corn Committee, Ontario Climatologists, Ontario Hydro, Ontario Department of Environment, Ontario Water Resources Commission, Canada Centre for Inland Waters, Conservation Council of Ontario, Federal Department
FIGURE 2 Accumulated precipitation, Guelph, 1971.

FIGURE 3 Accumulated degree-days, Guelph, 1971.
of Environment, Royal Botanical Gardens (Hamilton), Ontario Institute of
Agrologists, Junior Farmers of Ontario (Soil and Land Use Tour).

Special reports were prepared: "Aerospace Technology in Agriculture
and Resource Management", "Remote Sensing Imagery for Soil Terrain Mapping" and
"Remote Sensing and Weather Prediction".

Special courses were assisted: Soil Fertility and Fertilizer Course,
Soil and Crop Specialists' Course, Correspondence Course Preparation, Turf
Managers' Short Course, Nursery Producers' Short Course, Meteorology Course at
Ridgetown C.A.T., 4-H Leadership Course, Dryden Conservation School, School for
Rural Assessors.

See also PUBLICATIONS.

T.H. Lane

Ontario Soil Testing Service

From July 1, 1970 to June 30, 1971, a total of 48386 samples were
tested for 11018 Ontario growers. This represents an increase in samples over
the previous 12-month period when 45388 samples were analyzed. However the
number of growers submitting samples in 1970-71 decreased by 3337 compared to
the previous year. The average number of samples per grower using the service in
1970-71 was 4.03 compared to 3.16 the year before.

There were no new tests and no new programs initiated during the above
period, but some new equipment was purchased to modernize the laboratory. A new
combination flame photometer-atomic absorption spectrophotometer was purchased
to update our potassium determinations. This unit can also be used to determine
calcium and magnesium, and will serve as a "back-up" instrument in the event of
failure of the equipment currently in use for these tests. A new pH meter with
digital read-out was also added to the laboratory early in 1971.

County summaries have been tabulated and are available on request.
Table 2 lists the average soil test values for the Province which can be com-
pared over the years in which such data are available. Phosphorus values have
been omitted for the first five years because the test procedure was changed
at the end of this period, and values should not be compared between periods.

Both pH and potassium average levels have been relatively constant
over the years in which this type of computer summary data are available. There
is nevertheless a noticeable variation in potassium during the year 1967-68 when
the average was higher than usual, and in 1968-69 when it was lower. No expla-
nation can be given for these deviations.

With the use of larger amounts of fertilizer nitrogen there is some
concern that soil acidity will increase. While this has been observed in some
individual cases, the average values for about 45000 samples do not appear to
have significantly changed.
Organic Materials Analysis Service

A new service for the chemical analysis of plants and other organic materials such as sludges and manure has been initiated by the Department. This service is available to growers, researchers and extension personnel in government, industry, and universities, and others requiring this information, on a charge per sample basis.

This new service has grown out of the routine plant analysis capability developed over the past three years in conjunction with the Department’s soil management and plant nutrition research program, and was the direct result of numerous requests for such a service from the fertilizer industry, government extension specialists, and others. It was first offered in June, 1971, and was expanded in February, 1972 by the addition of a special fast service for greenhouse growers. The response obtained over the past year indicates that the service is filling an important need.

Plant, manure, and sewage sludge samples were analyzed routinely for total nitrogen, phosphorus, potassium, calcium, magnesium, manganese, copper, zinc, and boron, and in some cases for sodium, iron, and lead also. It is hoped that certain other heavy metals and sulfur may be added in the near future.

The analysis of approximately 3500 plant samples during the year from the Department’s research projects contributed significantly to the interpretation of fertilizer trial data, to the development of plant sampling techniques, and towards attempts to establish critical nutrient levels in plant parts under Ontario conditions.

Plant analysis is becoming recognized more and more by agricultural researchers and extension personnel as a very useful tool for diagnosing crop problems and as a guide to fertilizer practice. It is probably best used as a supplement—or a complement—to soil testing. In many cases one augments the other. Plant analysis may provide the answer to the question, “What’s wrong with the nutritional levels in the plant?” Soil test results may then provide an explanation for the condition and suggest a remedy for it. If not, other environmental factors must be looked to for an explanation. Plant uptake is our best criterion of nutrient availability, and it is indispensable in evaluating those nutrients such as nitrogen and several micronutrients for which a routine or dependable soil test is not available.

It is expected that manure and sewage sludge analysis will become increasingly important as the vast problems of waste disposal and the protection of our environment are attacked.

J.A. Smith
Table 2: Comparison of Average Soil Test Values for the Province of Ontario for the Years 1964-65 Through to 1970-71.

<table>
<thead>
<tr>
<th>Soil Test Year</th>
<th>Phosphorus</th>
<th>Potassium</th>
<th>Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ppm P</td>
<td>ppm K</td>
<td>pH</td>
</tr>
<tr>
<td>1964-65</td>
<td>-</td>
<td>120</td>
<td>6.9</td>
</tr>
<tr>
<td>1965-66</td>
<td>-</td>
<td>128</td>
<td>7.0</td>
</tr>
<tr>
<td>1966-67</td>
<td>No Summary Available</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1967-68</td>
<td>-</td>
<td>147</td>
<td>6.7</td>
</tr>
<tr>
<td>1968-69</td>
<td>-</td>
<td>115</td>
<td>6.9</td>
</tr>
<tr>
<td>1969-70</td>
<td>32</td>
<td>128</td>
<td>6.8</td>
</tr>
<tr>
<td>1970-71</td>
<td>26</td>
<td>130</td>
<td>6.8</td>
</tr>
</tbody>
</table>

Table 2 lists the number of samples analyzed and average soil test values for each county and district in Ontario. Counties having history of cash-cropping and higher fertilizer use have higher fertility values. This is particularly true of phosphorus, an element which is naturally low in most soils. Among the counties with higher than average available phosphorus are Norfolk, Elgin, Essex, Kent, Lambton, Middlesex, Oxford, Brant, Waterloo, Welland, Lincoln, Wentworth, York, South Simcoe, Northumberland and Prince Edward.

While potassium values follow the same trend, the explanation is complicated with the fact that many Ontario fine-textured soils such as clay loams and clays are naturally high in this element. However, in Norfolk county which is predominantly sand, the average potassium value is much higher than normally would be the case because of high fertilizer use for more than thirty years.

A small change in the operation of the Soil Testing Laboratory will take place beginning July 3, 1972. On payment of a fee, fertilizer companies will be mailed the soil test report forms involving their farm clients without previous processing through an O.M.A.F. office. A copy of such reports will be mailed by the Ontario Soil Test Laboratory to agricultural representatives in the county in which such samples originated. It will be the fertilizer company's responsibility to mail the report to the farmer along with any recommended treatments in addition to those appearing on the computerized report from the laboratory. The cost to the fertilizer company for this service will be $4.00 per sample for the first 1,000 samples and $3.00 per sample for all additional samples in any one official soil testing year of July 1 - June 30.

Farmers may still send samples free of charge provided they are processed by O.M.A.F. or university officials, and this is expected to make up the bulk of our samples. Fertilizer companies may still request and receive copies of soil reports sent to farmers on this free basis. The costs involved in farm samples processed by O.M.A.F. officials will continue to be born by the Ontario Government.
SOIL SCIENCE RESEARCH

SOIL SURVEY

The Ontario Soil Survey Unit, located in the facilities of the Department of Land Resource Science, University of Guelph, continues to receive its support from the Canada Department of Agriculture, Ontario Ministry of Agriculture and Food and the University of Guelph. The Ontario Department of Municipal Affairs also contributed to the program for the first time by supporting three student assistants during the 1971 field season. Continued excellent cooperation was received from personnel of the Civil Engineering Department, University of Waterloo, and the Ontario Department of Transportation and Communication in the sampling, testing and interpretation of soils for engineering uses.

The program conducted by the Ontario Soil Survey Unit during the current year involved a continuation of those projects already underway in a number of locations throughout Ontario, with three projects being brought to their conclusion, as well as the commencement of a new project in Middlesex County.

The soil survey projects in both Halton and Waterloo counties were completed with the publication of soil reports for these regions. Of significance is the fact that the Waterloo County project was the first of its kind in Ontario conducted on a detailed scale (1:20,000) with the soil map published on an aerial photomosaic base.

Field work continued during the year in Brant and Peterborough counties involving field checking, correlation and soil sampling. Field mapping was completed in the bog areas in the Organic Soils Mapping program in Southern Ontario. All areas of organic soils greater than 50 acres in size in Southern Ontario have been mapped and classified. Their location and extent are shown on maps of the National Topographic Series at two scales; 1:250,000 and 1:50,000. Also on these maps is the capability classification for vegetable production for each organic soil area. Therefore, the maps can be used to determine such characteristics as depth of the deposit, stage of decomposition and potential productivity for all the mapped bogs in southern Ontario.

The maps have been prepared on a plastic base (auto-positive) so that copies can be easily produced for distribution. A legend accompanies each map.

A report is written in which the organic soils are described. Also included in the report are brief descriptions of agricultural productivity, present vegetative cover and moisture conditions.

Considerable interest has been shown by the vegetable growing industry in reclaiming bogs for agricultural purposes. Many bogs are not suitable for vegetable production nor is it wise to reclaim all bogs because of the effects of such a program on wildlife production and water tables. The information presented in this project will show the best sites for agriculture and will indicate the limitations for agricultural use.
The information can serve as one basis on which to develop policy for the development of bog areas. It can also be used as a basis for evaluating land for assessment purposes.

Progress continues to be made in the compilation of the soil maps for the areas in Northern Ontario. Ozalid prints of the preliminary soil maps are available on request for many of these areas pending final publication of the soil maps and reports. In most cases final publication of the maps are being delayed until the accompanying soil report for that area has been prepared.

Soil correlation was carried out mainly in Western Ontario in the counties adjacent to and including Middlesex County. Several members of the Soil Survey Staff also participated in an Organic Soil correlation tour throughout Eastern Ontario, Quebec and the Maritime provinces.

In most soil survey projects under investigation by personnel of this Unit there is considerable research involvement, which may include studies relating to soil genesis or classification of certain soils of an area, the development and testing of interpretive classifications, or land use planning studies utilizing basic soils information.

See also list of PUBLICATIONS.

D.W. Hoffman and C.J. Acton

LAND USE

During the past year land use research has continued to emphasize the role soil and soil characteristics play in allocating land for alternate uses. In particular, we are concerned with the potential of soils and their limitations for such uses as agriculture, recreation, waste disposal, and urbanization. Thus work has continued in the area of land capability analysis for different uses and also in evaluating the significance of different soil properties as limitations.

Soil Capability Studies

Soil capability is a measure of soils under a particular climate to produce crops. It is a prediction of potential yield. Projects concerned with estimating the potential of soil classes for three groups of crops are as follows:

1. The Soil Capability Classification for Agriculture for Common Field Crops was a project of the Canada Land Inventory program of ARDA. Although the field work for this project was completed a year ago soil capability maps remain to be published and significant progress has been made in relating the yields of certain field crops to soil class. Maps are printed on a scale of 1:250,000 and they show the potential productivity of various areas for agriculture. Maps have been printed for all of Southern Ontario and those for Northern Ontario will be available shortly.
The potential productivity of grain corn, oats, barley and forage has been determined for each soil class. Corn, oats and barley yields by class are shown in Table 1.

Table 1: Potential Yields by Class of Selected Crops

<table>
<thead>
<tr>
<th>Classes</th>
<th>Grain Corn</th>
<th>Oats</th>
<th>Barley</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>136 ± 13.3</td>
<td>90 ± 7.2</td>
<td>81 ± 9.5</td>
</tr>
<tr>
<td>2</td>
<td>105 ± 10.5</td>
<td>73 ± 5.2</td>
<td>67 ± 6.8</td>
</tr>
<tr>
<td>3</td>
<td>80 ± 9.8</td>
<td>62 ± 4.5</td>
<td>52 ± 7.1</td>
</tr>
<tr>
<td>4</td>
<td>59 ± 8.1</td>
<td>52 ± 7.5</td>
<td>38 ± 4.6</td>
</tr>
</tbody>
</table>

Farmers, in general, do not use classes 5, 6 or 7 land for arable crops, hence, no yields of corn, oats or barley are available for those classes but yields are available for forage on classes 5 and 6 as well as the first 4 classes.

Simple equations have been developed that can be used to predict yields of the crops treated. Soil class can be used to predict yield. In the case of grain corn, soil class accounts for almost 75% of yield variability in the following prediction equation:

\[ \text{Yield (corn)} = 162.79 - (28.02 \times \text{class}) \] bushels per acre

Similarly, equations are available for yield predictions of other crops.

2. Land Capability System for Horticultural Crops. Most of the general classification schemes used to assess climatic limitations for tree fruit production include the following factors: (i) minimum winter temperature, (ii) date of occurrence of last spring frost, (iii) degree-day accumulation before last spring frost and (iv) wind speed when fruit is present. The most important soil properties related to tree fruit production appear to be those that influence root growth i.e. depth to impermeable layers, drainage, etc.

A pilot project was undertaken on the apple orchards at the C.D.A. Experimental Station at Smithfield to test some of the variables that might be used for the classification. Yield data was collected on an individual tree basis for the ten-year period, 1958 to 1967. Data were collected for approximately ninety trees which were divided between two varieties, McIntosh and Red Spy. Each tree was treated as an individual field and a number of soil site properties were measured. Climatic data was obtained from the station and the variables used included (i) minimum winter temperature, (ii) precipitation May-June, (iii) precipitation July, (iv) precipitation August, (v) hours of sunshine August, (vi) hours sunshine September, (vii) degree days above 42°F to the last 28°F spring frost.
Soil parameters measured included the texture and depth of soil layers, slope and aspect.

In all twenty-two variables were punched onto computer cards and analyzed by multiple regression analysis. Although final processing of the data has not been completed, several trends are evident. One major trend is the large variety interaction which is apparently related to the rooting habits of the two varieties. For the McIntosh variety climatic factors come out as the most significant variables whereas for the Red Spy, soil parameters related to moisture holding capacity in the subsoil are most important.

A draft copy of a land capability system for tree fruits and vegetables has been written. It is a five class system and includes criteria for placement into each class.

3. Soil Capability for Vegetables on Organic Soils. This project deals with the characteristics of organic soil and climate affecting vegetable production and with the estimation of potential yield for each soil class. Working with onions as the indicator crop, it was discovered that depth of organic soil, stage of decomposition, temperature and precipitation are most highly correlated with yield. More data concerning climate, especially wind, is required before much of the yield variation can be explained.

One of the prime uses of the information provided by these projects is to estimate potential agricultural production and to suggest land which should be set aside for agriculture. This information will help the decision making process. It will not provide the whole answer to the solution of land allocation problems, but it will help delineate areas of exceptional productivity from those which are better left as open spaces for certain reasons.

In addition, capability systems provide a means of equitable assessment of all lands in Ontario according to their inherent ability to produce agricultural crops.

The Significance of Soil Water Table Levels in Relation to Land Use Interpretations.

One of the more important soil parameters required for interpretation of soil information for a range of land uses is depth to water table. This project is concerned with two aspects: i) development of a prediction model for water table levels based on soil characteristics and ii) evaluation of the effects of urban development on water table levels in soils.

In the former instance a total of twelve piezometer sites have been located on the well, imperfect, poor and very poorly drained members of three different soil catenas. Water table levels at these sites have been monitored over the past year.

Hanlon Creek Ecological Study

This is a cooperative project undertaken by a number of Departments at the University of Guelph. The project consists of three phases, two of which have been completed. The respective objectives of Phase A and Phase B are to evaluate the effect of the Hanlon Expressway upon the ecology of Hanlon
Creek and to evaluate the possible effects of long range urbanization upon the Hanlon Watershed area. Both of these phases were concerned with establishing policy and guidelines for planning, development and construction with the Watershed area.

Phase C is a long-term project concerned with monitoring the changes in water quality, groundwater, stream flow, erosion, etc. as urbanization and development of the area progresses.

The Surface Reactivity of Clays and their Sensitivity to Slumping

Further work on evaluating the effect of amorphous coatings on the surface reactivity of clays has been carried out using a combination of viscometer measurements and selective dissolution techniques. It is anticipated that the changes in shear strength of some clays is closely related to changes in surface chemistry arising from adsorption of amorphous materials.

See also list of PUBLICATIONS.

E.E. Mackintosh, D.W. Hoffman

SOIL-PLANT RELATIONS

The Effectiveness of N-serve as a Conserver of Fall-applied Anhydrous Ammonia in Field Experiments with Corn.

The application of N fertilizer in the fall is not recommended because of apparent losses which occur. Nitrate ions may be lost by leaching or through the denitrification process. However, it would be economically advantageous for growers and fertilizer distributors if N fertilizer could be applied in the fall along with P and K fertilizers. N-serve (Dow Chemical Company) is known to be a specific inhibitor of the transformation of ammonium to nitrate ions and might make fall application feasible. A field experiment, conducted in two successive years to test this possibility, indicated that N-serve is not an effective conserver of fall applied N fertilizer (such as anhydrous ammonia). It was also concluded that N-serve may share a small adverse residual effect which may be offsetting any beneficial effect resulting from reduced N fertilizer loss.

In the 1970 experiment, N fertilizer increased the grain yield only in the absence of N-serve (Table 1). For a not readily perceptable reason, N-serve itself increased the grain yield when applied at one pound per acre. In the 1971 experiment, the N-serve treatments had no influence on the grain yield at any of the N fertilizer treatment levels (Table 1). The N-serve was applied through concentric tubes with anhydrous ammonia the fall preceding each experiment. Placement was made during plowing at the bottom of every third furrow (42" apart).

N-serve had no influence on leaf N concentration in the 1970 experiment (Table 2). However, there was a significant decrease in leaf N with increasing N-serve applied in the 1971 experiment where N fertilizer was not applied. When N fertilizer was applied, N-serve had no effect on leaf N concentration in both experiments.

See also PUBLICATIONS.

E.G. Beauchamp
Table 1: Yield of Grain Corn as Affected by Applications of Anhydrous Ammonia (spring and fall) and N-Serve (fall only) in 1970 and 1971 at the Elora Research Station.

<table>
<thead>
<tr>
<th>Year</th>
<th>Time of Application</th>
<th>N-serve^1 (lb/ac)</th>
<th>N applied (lb/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>1971</td>
<td>Fall</td>
<td>84 c 95 ab</td>
<td>87 b 97 c</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>92 ab</td>
<td>98 ab</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>88 abc 96 ab</td>
<td>97 ab</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>--</td>
<td>100 a</td>
</tr>
<tr>
<td>1972</td>
<td>Fall</td>
<td>134 ab 137 ab</td>
<td>145 a</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>133 ab</td>
<td>137 ab</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>130 b 139 ab</td>
<td>144 a</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>---</td>
<td>136 ab</td>
</tr>
</tbody>
</table>

^1 N-Serve applied through concentric tubes with anhydrous ammonia, to bottom of every third plow furrow.
Yield data (within years) followed by the same lower case letter are not significantly different at the 95% probability level.

Table 2: N Content of Leaves Opposite and Below the Ear of Corn Plants At Anthesis treated with Applications of Anhydrous Ammonia (spring and fall) and N-serve (fall only) in 1970 and 1971 at the Elora Research Station.

<table>
<thead>
<tr>
<th>Year</th>
<th>Time of Application</th>
<th>N-serve (lb/ac)</th>
<th>N applied (lb/ac)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>1970</td>
<td>Fall</td>
<td>3.65 bc 3.93 a</td>
<td>3.84 abc 3.93 a</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>3.58 c 3.75 abc</td>
<td>3.84 abc 4.00 a</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>3.83 abc 3.79 abc</td>
<td>3.94 a 3.89 ab</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>--</td>
<td>3.76 abc</td>
</tr>
<tr>
<td>1971</td>
<td>Fall</td>
<td>3.62 b 3.81 a</td>
<td>3.83 a 3.96 a</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>3.51 bc 3.75 ab</td>
<td>3.80 a 3.98 a</td>
</tr>
<tr>
<td></td>
<td>Fall</td>
<td>3.34 c 3.80 a</td>
<td>3.95 a 3.96 a</td>
</tr>
<tr>
<td></td>
<td>Spring</td>
<td>--</td>
<td>3.69 b 3.79 a</td>
</tr>
</tbody>
</table>

Percent N data (within years) followed by the same lower case letter are not significantly different at the 95% probability level.
Manure as a Source of Nitrogen for Corn.

Liquid poultry manure (100 lb N/ac/application) applied annually over the past five years has produced higher yields of corn grain than similar amounts of nitrogen from commercial fertilizer (Table 3). The decline in yield at N rates (50 lb fertilizer N with manure in this experiment) below those giving maximum yields has appeared in sufficient instances to warrant further attention. The yield decline with 200 pounds fertilizer N and manure is real and is due to the excess application of N over that required for maximum corn yield on this soil.

The significance of these findings is the importance of utilizing manure in crop production and of avoiding excess fertilizer N applications. The reason for manure giving yields above those with fertilizer N may be the micro nutrients supplied, or by improvement in the physical condition of the soil from the organic matter in the manure. Our data to date do not indicate micro nutrient deficiencies in the absence of manure. We intend to investigate soil physical conditions further.

Table 3: Effect of Manure on Grain Corn Yield

<table>
<thead>
<tr>
<th>Fertilizer N lb/ac</th>
<th>No Manure bu. grain corn/ac</th>
<th>Manure (15.5% moisture)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>87</td>
<td>110</td>
</tr>
<tr>
<td>50</td>
<td>98</td>
<td>108</td>
</tr>
<tr>
<td>100</td>
<td>104</td>
<td>112</td>
</tr>
<tr>
<td>150</td>
<td>104</td>
<td>112</td>
</tr>
<tr>
<td>200</td>
<td>104</td>
<td>104</td>
</tr>
</tbody>
</table>

1 P and K requirements supplied by commercial fertilizer.

2 Liquid poultry manure at rates to supply 100 lb total N per acre per year for 5 years (1967-1971). Stover from previous crop removed each year. Yields are based on 5-year averages (1967-1971).

J.W. Ketcheson

Long Term Fertilizer Trials on Corn

Fertilizer trials have been continuing with corn since 1967 on three sites: a sandy loam, a loam and a clay loam soil. The rates of fertilizer used in these trials covered a wide range, but each plot received a constant rate of fertilizer each year.
In 1971 growing conditions were ideal at the Elora Research Station (loam soil) resulting in the highest corn yields obtained so far in these trials. However, there was no nitrogen response in 1971 on this site with plots receiving no nitrogen for five years in grain corn, producing the same yield as those receiving nitrogen fertilizer (Table 4). The 1970 response is presented to show a more normal year.

Table 4: Corn Yield at Elora as Affected by Nitrogen Fertilizer

<table>
<thead>
<tr>
<th>Nitrogen 1b/ac/yr</th>
<th>Grain Yield 1970 bu/ac</th>
<th>1971</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>80</td>
<td>144</td>
</tr>
<tr>
<td>50</td>
<td>122</td>
<td>139</td>
</tr>
<tr>
<td>100</td>
<td>126</td>
<td>140</td>
</tr>
<tr>
<td>150</td>
<td>123</td>
<td>150</td>
</tr>
<tr>
<td>200</td>
<td>118</td>
<td>143</td>
</tr>
<tr>
<td>300</td>
<td>117</td>
<td>144</td>
</tr>
</tbody>
</table>

We expect corn to require more nitrogen for a high yield potential. However nitrogen release from the soil is also benefitted by a favourable growing season and may explain the unusual response in 1971. Fertilizer response to other elements and in the other trials in this study yielded results similar to those presented in previous Progress Reports.

T.E. Bates

Fertilizer Response and Time of Seeding of Barley

Fertilizer response of barley has been studied at two seeding dates at the Elora Research Station each year since 1968. Herta variety was used each year until 1971 when it was replaced with Fergus. Trent was also included. Both Herta (in the past) and Fergus barley (in 1971) have responded more to nitrogen fertilizer when seeded in April than when seeded in mid May (Table 5). Trent appears to have responded as well to nitrogen when seeded mid May as it did with April seedings.

No conclusions should be made from this until results are available for several seasons. If Trent continues to respond in this manner, however, it could be particularly useful for those areas of the province where April seeding is frequently impossible.
Table 5: Response of Barley to Nitrogen Fertilizer as Affected by Seeding Date

<table>
<thead>
<tr>
<th>Nitrogen 1b/ac</th>
<th>Fergus Seeded April 19</th>
<th>Fergus Seeded May 14</th>
<th>Trent Seeded April 19</th>
<th>Trent Seeded May 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>32</td>
<td>43</td>
<td>34</td>
<td>41</td>
</tr>
<tr>
<td>20</td>
<td>60</td>
<td>58</td>
<td>57</td>
<td>42</td>
</tr>
<tr>
<td>40</td>
<td>59</td>
<td>50</td>
<td>63</td>
<td>66</td>
</tr>
<tr>
<td>80</td>
<td>63</td>
<td>61</td>
<td>71</td>
<td>73</td>
</tr>
<tr>
<td>160</td>
<td>69</td>
<td>51</td>
<td>73</td>
<td>76</td>
</tr>
</tbody>
</table>

T.E. Bates

Molybdenum Deficiency on The Holland Marsh near Bradford.

Preliminary investigations conducted during the growing season of 1971, indicate an increasing incidence of molybdenum deficiency. While only onions were checked for this condition, because of their relatively high molybdenum requirements, other crops like lettuce and cauliflower could be similarly affected.

Development of molybdenum deficiency is coincident with a development of increasing acidity in many soil areas on the marsh. Since the total molybdenum content of these soils is quite small, and the amount available for plant growth decreases with increasing soil acidity, it is expected that deficiencies of this element will become more widespread in the future. The increase in soil acidity has been noted over the past several years and is believed due to nitrogen fertilizer use.

A.L. Willis

Stover Effects on Soil and Fertilizer P Run-off.

In a field run-off study with simulated and natural rainfall, it was found by using radioactively-tagged P fertilizer that losses can be reduced from 2.15 kg fertilizer P per hectare (total of both events) where stover is not used, to 0.2 kg where stover is used (Table 6). This amounted to 60 and 15 percent of 29 kg P per hectare broadcast application for the no stover and stover treatments respectively, and represented an overall reduction of 90
percent due to stover. Proportionately more of this P was found in the
coarser soil fraction which quickly settles than in the finer fraction which
remains in suspension longer. The liquid portion of the run-off carried
negligible P.

Soil P, in comparison to fertilizer P, constituted a greater loss,
particularly in the finer soil fraction, and amounted to 15.8 kg compared to
2.15 kg fertilizer P for no stover, and 4.15 kg compared to 0.2 kg fertilizer
P for stover.

These findings help confirm the value of stover in reducing run-off
losses, and justify management practices which leave stover on soil surfaces
in those situations where erosion is a problem. The extent of soil and P
movement from the run-off site, and its likelihood of entering waterways will
be studied in subsequent work.

J.W. Ketcheson, J.J. Onderdonk

Table 6: Phosphorus in Run-off

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Simulated Rainfall</th>
<th>Natural Rainfall</th>
<th>Fertilizer P</th>
<th>Soil P</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liquid</td>
<td>Fine</td>
<td>Coarse</td>
<td>Total</td>
</tr>
<tr>
<td>No Stover</td>
<td>0.05</td>
<td>0.20</td>
<td>1.10</td>
<td>1.35</td>
</tr>
<tr>
<td>Stover ³</td>
<td>Nil</td>
<td>0.05</td>
<td>0.05</td>
<td>0.10</td>
</tr>
<tr>
<td>No Stover</td>
<td>0.10</td>
<td>3.55</td>
<td>1.15</td>
<td>4.8</td>
</tr>
<tr>
<td>Stover ³</td>
<td>0.05</td>
<td>0.50</td>
<td>0.15</td>
<td>0.7</td>
</tr>
</tbody>
</table>

¹ Intensity 19 cm x hr⁻¹
² Intensity 15 cm x hr⁻¹
³ Chopped corn stover at 4500 kg x ha⁻¹ applied in a 30-cm band over 29 kg
   broadcast P/ha.
Tillage and Soil Tilth.

Our studies so far have indicated that better corn yields result when our finer textured soils are plowed than when not plowed.

The reason, in part, is related to soil tilth. Plowing a clay loam soil can, for instance, reduce the bulk density from 1.4 to 1.2 and this is accompanied by a marked reduction in mechanical impedance to root development (Table 7).

Table 7: Effect of Tillage on Bulk Density and Mechanical Impedance.

<table>
<thead>
<tr>
<th>Tillage</th>
<th>B.D.</th>
<th>Mechanical Impedance (Resistance to Penetration)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not plowed</td>
<td>1.4</td>
<td>50 bars</td>
</tr>
<tr>
<td>Plowed</td>
<td>1.2</td>
<td>10</td>
</tr>
</tbody>
</table>

1 Moisture maintained at one atmosphere matric pressure.
2 Determined by a Chatillon penetrometer.

Bulk density and moisture relations are interrelated. For instance, if the moisture content of a soil is held constant, a reduction in bulk density can result in a reduction in the tension at which the moisture is held. This helps explain the marked reduction in resistance. Conversely, if the soil is dried at a certain initial bulk density, it can shrink to a higher density, and undergo an increase in its resistance to penetration by roots.

From thesis research, we have shown that root growth is not dependant on resistance to penetration alone, but is restricted more, for any one resistance value, when the moisture level is low than when high. This phenomenon has been explained in the basis that the soil moisture affects not only the resistance of the soil, but may affect the turgor of the root and its ability to penetrate a given soil condition. The higher the moisture (up to the field capacity) the greater the ability of the root to penetrate a given soil resistance situation (Table 8).
Table 8: Effect of Soil Resistance and Moisture on Root Growth.

<table>
<thead>
<tr>
<th>Soil Resistance</th>
<th>Moisture</th>
<th>Primary Root Growth</th>
<th>cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>bars</td>
<td>atmosphere matric pressure</td>
<td>1.5</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>3.0</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>5</td>
<td>0.2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1.2</td>
<td></td>
</tr>
</tbody>
</table>

1 Over 2-day interval.

Our results point to the need for soil management practices which will maintain optimum bulk density and moisture conditions, if we want high yields and maximum profits. We hope to characterize present modifications in tillage and cropping systems to determine whether favourable conditions are present. Any deterioration will bring attention to the need for appropriate remedies.

(extracted from H.F. Mirrehs Ph.D. Thesis)
H.F. Mirrehs, J.W. Ketcheson

The Control of Nitrate Reductase Activity by Light

The assimilation of nitrate, the predominant form of N absorbed by plants, depends upon the activity and concentration of the nitrate reductase enzyme in plant tissues. The activity of this enzyme is generally held to be the rate-limiting step in the process of nitrate assimilation into amino acids and hence into proteins. An understanding of the factors controlling this rate-limiting step in plant protein synthesis is fundamental in the search for higher protein levels in food crops. Light is one of the most influential environmental factors involved.

The precise nature of light control has not been fully explained, although it is suggested that the control is by the energy of light absorbed and/or stored during photosynthesis. We examined the idea of the sole control of enzyme activity by photosynthesis for the light-dependent induction of nitrate reductase activity using the terminal buds of dark-grown etiolated field peas (Pisum arvense cv. century) to avoid the complicating aspects of a green, photosynthetic plant.
When the etiolated peas were exposed to white light (600 μW.cm\(^{-2}\)) for two hours, the nitrate reductase activity of the terminal buds showed a three-fold increase (Table 9). A substantial portion of this increase, however, occurred after only five minutes of exposure followed by 115 minutes in darkness. When the plants were briefly exposed to red (565-720 nm) and far red (645-800 nm) lights, singly and in sequence, marked induction occurred only when red light terminated the light programme. The red/far red reversible nature of light control clearly indicated that the pigment phytochrome, rather than the chlorophyll-carotenoid system of photosynthesis was involved in the enzyme induction in peas.

Our observations, while demonstrating red/far red light control in the non-green plant, suggest the possibility of phytochrome control of this critical enzyme in protein synthesis in green plants, a possibility which is being examined in our current studies. It is possible, for example, that nitrate assimilation, and hence protein synthesis, can be sustained at higher levels during the night by terminating the photosynthetically active daylight period with a brief exposure to low intensity red light.

Table 9: Nitrate reductase activity of etiolated pea terminal buds as affected by white, red, and far red lights.

<table>
<thead>
<tr>
<th>Light Programme 2</th>
<th>Nitrate reductase activity 3</th>
<th>Increase over dark</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(n moles NO(_2)(^{-}) • gFW(^{-1}) • hr(^{-1}))</td>
<td>(%)</td>
</tr>
<tr>
<td>dark, untreated</td>
<td>353</td>
<td>-</td>
</tr>
<tr>
<td>2 hr W</td>
<td>1450</td>
<td>309</td>
</tr>
<tr>
<td>5 min W, 115 min D</td>
<td>1231</td>
<td>249</td>
</tr>
<tr>
<td>30 sec R - 2 hr D</td>
<td>981</td>
<td>178</td>
</tr>
<tr>
<td>30 sec FR - 30 sec R - 2 hr D</td>
<td>945</td>
<td>168</td>
</tr>
<tr>
<td>30 sec FR - 2 hr D</td>
<td>476</td>
<td>35</td>
</tr>
<tr>
<td>30 sec R - 30 sec FR - 2 hr D</td>
<td>523</td>
<td>48</td>
</tr>
</tbody>
</table>

1 Plants were grown for seven days in darkness at 23 ± 1°C and about 80% R.H., on a medium containing 20 mM KNO\(_3\).

2 D-dark; W-white light (Sylvania cool white fluorescent); R-red light; FR-far red light. R and FR energies were 80 μW. cm\(^{-2}\).

3 Extracted under dim green safelight. Data from one experiment of two that gave similar results, each value being the mean of quadruplicated subsamples.

(Extracted from R.W. Jones' Ph. D. Thesis) 
R.W. Jones, R.W. Sheard
Soil Temperature and Nitrification.

Temperature effects on nitrification during cooling periods influence the efficiency of utilization of fertilizers supplying ammonium forms of nitrogen. Most studies reported in the literature use a static type of incubation whereas the natural soil situation is a more dynamic one. Temperature effects on nitrification under more ideal condition were therefore investigated. This required the attainment of a steady rate of nitrification in which population build-up was not a confounding factor, and in which substrate addition and product removal were not limiting.

If a low temperature treatment was imposed before the nitrifying population reached its maximum in a static incubation procedure, the treatment appeared to initially affect the population growth and ultimately the activity of the organisms. Using preincubation in this procedure indicated, however, that an enhanced nitrification could be attained at low temperature, but this was still not considered adequate to satisfy the requirement for substrate addition and product removal. A reliable continuous flow procedure was therefore developed in which a steady rate of nitrification could be attained for a period of 10-12 days which was considered long enough for temperature studies.

With the continuous flow method, nitrification rates decreased with decreasing temperature from 25°C and continued at rates around 0.4 µg NO₃-N g⁻¹ soil hr⁻¹ at 0°C. Furthermore the rate of nitrification at any temperature throughout this decrease was greater than that attained on returning to that temperature after passing through the 0°C treatment. Nitrification rates responded within three hours (shortest measurable time) to changes in temperature. Freezing the soil for one or two months after enrichment with nitrifiers inhibited nitrification on subsequent thawing only when ammonium-N had been previously adsorbed on the soil.

An examination of prevailing soil temperature at Guelph during October, November and December showed that in the light of the findings in this study considerable nitrification of fertilizer N could take place even into December. Furthermore, short daily intervals of increased temperature could account for further contributions to the total nitrate produced. These findings suggest that the majority of fall applied ammonium-N is not likely to remain in this form unless the soil freezes immediately following application. Its conversion to NO₃-N renders the nitrogen susceptible to leaching and or denitrification and hence a low efficiency of utilization occurs.

See also THESIS TITLES.

(Extracted from D.A. Carandang's Ph.D. Thesis)
D.A. Carandang, J.W. Ketcheson
Soil Temperature and The Direction of Corn Root Growth

Soil temperature, as a physical factor influencing the direction of root growth, has received little attention. Thesis research established, however, that the primary root of a corn plant will grow closest to the horizontal ($10^\circ$) at $17^\circ$C. Above or below this temperature it grows more toward the vertical, reaching about $45^\circ$ at $10^\circ$C and at $30^\circ$C.

This information is very important in designing fertilizer band placement relative to seed. Since the maximum of temperature fluctuations was found to determine the behavior of the root, soil temperatures would only need to reach $30^\circ$C for short periods to result in a $45^\circ$ root angle. A fertilizer band would then be most effective if placed equal distances below and to the side of the seed. Root temperature in the field during May and June may in fact exceed the above level.

It also appears that uptake of surface broadcast fertilizer may be improved by reducing soil temperature maxima and thereby encouraging a more horizontal growth (nearer the surface). The effect of mulch in increasing surface fertilizer uptake may be by this means, although growth and uptake is also dependent on a moisture supply in a region once it is directed into this region.

See also THESIS TITLES.

(extracted from J.J. Onderdonk's M.Sc. thesis)

J.J. Onderdonk, J.W. Ketcheson

FREEZING PROCESSES IN SOILS

Every region of Canada is subject to seasonal surficial soil freezing. The effects of freezing which include changes in soil structure and bearing strength, winter survival of forages and the development of heaving pressures have been well documented. Many of the phenomena associated with soil freezing are economically undesirable. For instance, the cost of repairing frost-damaged roads in Canada has been estimated to range from $200-$1000 per mile, while the cost of railway maintenance due to frost action has been estimated at $7 million annually. Clearly then, phenomena related to freezing in soils should be of major concern to Canadian scientists. Successful attempts to diminish the detrimental effects of freezing require a better understanding of the factors and interrelationships of the factors influencing freezing processes. The following studies are currently underway to achieve this end.

1. Quantitative Characterization of Mass and Heat Transfer in Freezing Soils. The development of a mathematical model which is capable of predicting mass (water and salts) and heat transfer under dynamic conditions of freezing in soils should make possible evaluations of the interrelationships among variables influencing freezing. This study was initiated with the following long-term objectives: (1) to quantitatively characterize the processes causing mass and heat fluxes in freezing soils and to develop a mathematical model which relates these fluxes to appropriate driving forces; (2) to determine the capability of this model in predicting the rate of frost-heaving and the subsequent changes in solute distribution and hydrologic properties in soils under a range of laboratory and field conditions.
Unidirectional freezing of artificially packed soil cores are currently underway in the laboratory. Initial measurements indicate that the flux of water to the freezing front is linearly related to the removal of heat from the freezing soil (the flux of water to the freezing front is the phenomenon responsible for frost heaving). This relation remains constant over a number of freeze-thaw cycles indicating no hysteresis effects for the soil under consideration (a loam sieved to 0.2 mm and packed to a uniform bulk density). The failure to observe hysteresis effects in this study is particularly significant and is thought to arise from the facts that existing soil structure was largely removed due to the sieving technique employed and that particle size analysis at the conclusion of the experiments indicated no evidence of particle sorting or clay migration.

For a given freezing temperature the flux of water (and associated frost heaving) was found to decrease with increasing hydraulic conductivity indicating that the driving force for water movement to the freezing front is the principal factor controlling frost heaving.

This study is giving new insights into the general phenomenon of frost heaving. This will permit a more realistic search for techniques to limit the detrimental effects of this phenomenon.

2. Factors Affecting Frost Heaving of Forage Species. The variation in formation of ice lenses in soil is being studied in the laboratory under different simulated environmental conditions. Ice lens formation and the associated frost heaving is more extensive when soil is near saturation and increases with decreasing surface temperature.

The mode and extent of heaving of alfalfa under different conditions of ice lens formation is being studied in the laboratory using special core samples. Cylinders of PVC piping (8" O.D.) were located in the field in May 1972 with the upper rims of the cylinders coincident with the soil surface. The cylinders were filled with soil, seeded with alfalfa and left in the field until January. The cylinders were then dug up, maintaining the soil core and plant intact, and transferred to the laboratory for frost heaving studies. Preliminary data suggest that consolidation of the soil sample is a major factor in "apparent" frost heave of alfalfa during initial freeze-thaw cycling. The flux of water to the freezing front also tended to decrease as freeze-thaw cycling continued. These results are distinctly different from those of the study reported above (item 1) and are thought to arise because most of the original soil structure was still intact prior to initiating freezing. An additional complicating factor arises in that the movement of the alfalfa plants do not appear to be closely related to the amount of water moving upward into the soil from the water table i.e. the frost heaving of alfalfa does not appear to be closely related to the conventional engineering concept of frost heaving.

Although the data on frost-heaving of alfalfa is of a preliminary nature it suggests that frost-heaving theories, developed for the movement of foundations, pilings, etc. by engineers, may not be applicable to plants. Climatic conditions in Ontario are often particularly favorable for frost heaving. The development of successful management techniques which reduce winterkill of alfalfa due to frost heaving, will be expedited by an adequate understanding of the mechanisms and factors which actually cause frost heaving.
3. Effect of Snowpack Management on Water and Nutrient Movement in Soil. Preliminary measurements are currently being made in the field to determine the effects of different forms of ground cover on depth of snowpack, soil temperature, frost penetration and soil water distribution. Four different ground surfaces are being considered: unplowed with and without corn stover and plowed with and without corn stover. Preliminary data suggest that the nature of the ground cover influences the development of a frozen layer in the soil. The presence of such a layer will have an important bearing on the overwinter and spring leaching losses of nutrients and erosion of soil. Both of these factors have a bearing on the economics of crop production and the quality of ground and surface water.

Arctic Research Feasibility Study. Several faculty of the department of Land Resource Science are currently involved in an interdisciplinary study with members of the Departments of Microbiology and Geography to assess the feasibility of the University of Guelph becoming extensively involved in a research program in the Canadian Arctic.

The principal thrust of such a program would be an evaluation of the effects of disturbing the surface of permafrost as a consequence of a change in land use. The growing demand for petroleum, metals, hydroelectric power and even tourist attractions will draw an ever increasing number of people into the Arctic. The presence of man in Arctic areas of Canada is capable of causing major changes in what is a very fragile environment. One of the most critical changes which may occur is a change in the temperature profile within the permafrost. This temperature change may arise as a consequence of changing the aerial environment above the permafrost, and subsequently changing the heat flux patterns at the permafrost surface. Man-made changes of the aerial environment include alteration or destruction of the ground cover and the introduction of structures such as pipelines, roadbeds, etc. Depending on the local conditions of climate, terrain and composition of the permafrost, these changes may change the heat flux enough to result in an increase in thickness of the active layer or complete disappearance of permafrost. The net effect will be to melt, on a seasonal or permanent basis material that has heretofore been frozen.


B.D. Kay

SOIL PHYSICS

Double Membrane Diaphragm Technique for Absolute Measurements of Diffusion Coefficients. A new technique for measuring diffusion coefficients utilizing two thin porous membranes separated by a spacer of known cross-sectional area and thickness is presented. The method permits absolute measurements of diffusion coefficients of chemical and biological materials in solution. The technique is based on the free-diffusion space between two membranes, thus avoiding the problems of solute-membrane interactions and tortuosity of the pore space that are present with single membrane diaphragms. Diffusion coefficient measurements of \(5 \times 10^{-4}\) M NaCl and \(5 \times 10^{-4}\) M KCl are in good agreement with values reported in the literature.

D.E. Elrick, D.E. Smiles
WASTE DISPOSAL AND POLLUTION CONTROL

Disposal of Pulverized Municipal Refuse on Agricultural Land

Disposal of pulverized municipal refuse on agricultural land is being investigated as a method to supplement or replace commonly used methods of landfilling. The application of refuse to agricultural land has several advantages over disposal in landfills. With proper timing of refuse application and cropping, the area can serve as both crop land and a disposal site. Since the refuse is incorporated to a depth of only 12 to 18", the physical properties of the soil below this depth are not likely to be altered. Thus, if in the future the disposal area is diverted to other uses, settling will not be a problem. With the proper selection of refuse application rates it is possible that a land disposal area, unlike a land fill, could be used for an indefinite period of time.

The relatively high C/N ratio of municipal refuse offers the advantage that lower C/N wastes, such as sewage sludge and animal manures, can be beneficially combined with the refuse for disposal. This simultaneous disposal will increase the decomposition rate, provide nitrogen for crop growth, and through the incorporation of nitrogen into microbial tissue, reduce the danger of nitrate pollution of the groundwater under the disposal site.

Experimental field plots were established during July and August of 1971 with the following treatments:

- pulverized refuse (125 tons/ac) alone, with 0.9" liquid sewage sludge, and with 0.55" liquid poultry manure;
- 0.9" liquid sewage sludge alone;
- and pulverized refuse (250 tons/ac) with 1.83" liquid sewage sludge.

With the exception of poultry manure, the treatments used in the field studies have also been set up in lysimeters. The drainage water from the lysimeters is being analyzed to determine if nitrates and/or soluble organic materials (both potential water pollutants) are leaching out of the refuse-treated soil.

Results to date.

The analyses in Table 1 represent an average of five samples taken from the refuse used in the field study and two samples from the lysimeter study.

| Table 1: Physical Composition of Municipal Refuse |
| Glass | Paper | Plastic | Metal | Cloth & Dust | Misc. | Moisture |
| Percent - oven-dry basis |
| Field Plot Samples (obtained 7-15 July) | 71.2 | 5.2 | 8.3 | 5.0 | 8.9 | 1.3 | 48.6 |
| Lysimeter Samples (obtained 14 Sept.) | 66.8 | 9.8 | 1.9 | 0.6 | 13.7 | 7.0 | 76.0 |

1 Average of seven samples.
The chemical composition of the refuse and sludge is given in Table 2.

Table 2: Chemical Composition of the Refuse and Sludge Used in the Field and Lysimeter Studies.

<table>
<thead>
<tr>
<th></th>
<th>Refuse</th>
<th>Sludge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Field</td>
<td>Lysimeters</td>
</tr>
<tr>
<td></td>
<td>ppm</td>
<td>ppm</td>
</tr>
<tr>
<td>N</td>
<td>5695</td>
<td>5987</td>
</tr>
<tr>
<td>P</td>
<td>804</td>
<td>750</td>
</tr>
<tr>
<td>K</td>
<td>3135</td>
<td>2970</td>
</tr>
<tr>
<td>Ca</td>
<td>8505</td>
<td>8700</td>
</tr>
<tr>
<td>Mg</td>
<td>2090</td>
<td>2240</td>
</tr>
<tr>
<td>Na</td>
<td>1871</td>
<td>1851</td>
</tr>
<tr>
<td>Mn</td>
<td>253</td>
<td>93</td>
</tr>
<tr>
<td>Zn</td>
<td>399</td>
<td>253</td>
</tr>
<tr>
<td>Cu</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>Pb</td>
<td>199</td>
<td>350</td>
</tr>
<tr>
<td>Cd</td>
<td>1.5</td>
<td>34</td>
</tr>
<tr>
<td>Cr</td>
<td>30.7</td>
<td>66.1</td>
</tr>
<tr>
<td>PERCENT</td>
<td>37.1</td>
<td>38.0</td>
</tr>
<tr>
<td>OM</td>
<td>64.0</td>
<td>65.5</td>
</tr>
<tr>
<td>Solids</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>C/N Ratio</td>
<td>(65.1)</td>
<td>(63.4)</td>
</tr>
</tbody>
</table>

1 Oven-dry basis
2 Wet weight basis (as the sludge was obtained from the treatment plant.)

In November, samples of the rye which had been planted on the field plots in September were taken for chemical analysis. The treatments had no significant effect on N, K and Cu levels, but increased Zn and Cd and reduced Mn and Pb content of the forage.

Preliminary results from the lysimeter study indicate that the refuse is effectively immobilizing the N mineralized from the sludge. Average NO₃-N levels in the leachate from refuse + sludge treatments is 8 ppm; from the sludge treatment 43 ppm.
Conclusions.

A valid estimate of the feasibility of this disposal method cannot be made until a corn crop is grown during the summer of 1972 and until more data from the lysimeter study is collected. With the exception of the difficulty encountered in incorporating the refuse in the field plots, the system is operating successfully to date.

L.D. King

Liquid Animal Manure Utilization in Alfalfa-Brome Production.

Intensive livestock production on Ontario farms has increased the output of wastes (manure) from the feed lot or housing. In conjunction with the increased output there has been a recent trend toward handling in liquid form as a move toward more efficient handling. Emphasis has been placed on utilization of the manure in corn production, although a greater percentage of Ontario farm land remains in forage species.

Forage species offer several advantages over row crops in the disposal-utilization of liquid animal wastes. The vegetative cover greatly retards potential erosion losses. An actively growing crop is available over a greater period of the year to absorb nitrates released by mineralization of nitrogen. Two or more applications are feasible each year in the spring and one after each harvest. The sod cover aids in carrying the heavy application tanks for early spring applications. On the other hand odor control by plowing under the manure is not possible. Furthermore, applications to grass-legume mixtures may favour competition from the nitrogen fertilized grass, reducing the legume component in the stand.

The objective of the experiment summarized herein was to examine the feasibility of a single spring application of liquid cattle manure on an alfalfa-brome mixture.

A maximum increase in total dry weight of forage of 1940 lb/ac was obtained (Table 3).

Table 3: Yield of Alfalfa-Brome Grass Mixture Resulting from Applications of Liquid Cattle Manure.

<table>
<thead>
<tr>
<th>Volume of Liquid (gal/ac)</th>
<th>Weight of Nutrient 1 (lb/ac)</th>
<th>Harvest Yield (lb D.M./ac)</th>
<th>Total Yield</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>P</td>
<td>K</td>
</tr>
<tr>
<td>6620</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>13240</td>
<td>100</td>
<td>20</td>
<td>85</td>
</tr>
<tr>
<td>26480</td>
<td>200</td>
<td>40</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>80</td>
<td>340</td>
</tr>
<tr>
<td>Average % alfalfa</td>
<td>--</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>h.s.d. for yield</td>
<td>n.s.</td>
<td>620</td>
<td>270</td>
</tr>
</tbody>
</table>

1 N, P, and K based on analysis of .15% N, .03% P and .13% K on a volume of liquid basis.
The major increments in total yield were obtained by the application of liquid animal manure at rates supplying up to 200 lb N/ac. Exceeding this rate tended to decrease the yield of the first harvest where sever lodging occurred. The overall yield increase of 1700 lb. dry matter per acre, valued at one cent/lb, from the application of 13,000 gal/ac of the manure may be considered the immediate cash value of the waste.

The use of high rates of N did not reduce the legume percentage of the mixture. The first harvest comprised three-quarters grass, however, by the third harvest the composition was reversed so that three-quarters of the yield was composed of alfalfa, which is the tendancy for successive harvests, provided N is not used in excess.

Application of the manure did not alter the total N concentration in the legume tissue but did increase the N in the grass from the first two harvests (Table 4).

Table 4: Total Nitrogen and Nitrate Nitrogen in Alfalfa and Bromegrass Receiving Rates of Liquid Cattle Manure.

<table>
<thead>
<tr>
<th>Rate of Nitrogen Application</th>
<th>Cut 1</th>
<th>Cut 2</th>
<th>Cut 3</th>
<th>Cut 1</th>
<th>Cut 2</th>
<th>Cut 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total NO₃</td>
<td>Total NO₃</td>
<td>Total NO₃</td>
<td>Total NO₃</td>
<td>Total NO₃</td>
<td>Total NO₃</td>
</tr>
<tr>
<td>0</td>
<td>3.19 .040</td>
<td>4.20 .025</td>
<td>3.55 .022</td>
<td>2.12 .051</td>
<td>3.15 .087</td>
<td>3.67 .085</td>
</tr>
<tr>
<td>100</td>
<td>3.29 .049</td>
<td>4.07 .029</td>
<td>3.55 .026</td>
<td>2.24 .052</td>
<td>3.08 .074</td>
<td>3.49 .082</td>
</tr>
<tr>
<td>200</td>
<td>3.19 .074</td>
<td>3.80 .042</td>
<td>3.52 .030</td>
<td>2.53 .080</td>
<td>3.20 .127</td>
<td>3.62 .083</td>
</tr>
<tr>
<td>400</td>
<td>3.46 .108</td>
<td>3.75 .059</td>
<td>3.36 .033</td>
<td>3.08 .157</td>
<td>3.44 .179</td>
<td>3.66 .127</td>
</tr>
<tr>
<td>h.s.d.</td>
<td>n.s. .042</td>
<td>n.s. .016</td>
<td>n.s. n.s.</td>
<td>.80 .088</td>
<td>0.29 .072</td>
<td>n.s. n.s.</td>
</tr>
</tbody>
</table>

The increase in the total N in the grass was only observed at the highest rate of application, 400 lb N/ac. Liquid manure applications increased the NO₃-N in both the alfalfa and the brome grass from the first two harvests. The most significant increases occurred with the heaviest rate of manure application where the values for the bromegrass approached the 0.20% NO₃-N level which may be considered potentially toxic to livestock. Applications of 13000 gal/ac or 200 lb N/ac, however, did not generate nitrate levels greater than one-half the potentially toxic limit.

Analysis of soil samples removed in late September revealed only twelve additional pounds per acre of N as nitrates in the 0-30 inch profile from the 400 lb N/ac rate of application.

Conclusions

A single yearly application of liquid cattle manure at rates up to 200 lb N/ac may be made to an alfalfa-brome mixture without significantly increasing the NO₃-N concentration in the forage, increasing the NO₃-N levels in the soil profile, or reducing the legume component of the forage.
Increased yield, in this case 1700 lb D.M./ac, was accompanied by increased total N, P and K in the tissue and Soil Test P and K values in the soil. (Data on file.)

Rates in excess of 200 lb N/ac are not recommended because of potential nitrate toxicity in the forage.

R.W. Sheard

Nitrogen Removal from Animal Manure by Columnar Nitrification and Denitrification

Research was initiated in July of 1971 to investigate the feasibility of removing nitrogen from the liquid portion of manure slurry through biological nitrification followed by denitrification in a trickling filter system. Nitrogen in manure slurries is predominantly in the organic and ammonium forms. In an aerobic trickling filter, the organic nitrogen is mineralized to ammonium-nitrogen followed by microbial oxidation or nitrification of the ammonium-nitrogen to nitrate-nitrogen. The effluent containing nitrate-nitrogen can then be transferred to an anaerobic filter. Under anaerobic conditions in the presence of an energy source, nitrate-nitrogen is denitrified and released as gaseous nitrogen.

Investigations to date have concentrated upon columnar nitrification of liquid animal waste. The aerobic trickling filter system in this study consisted of a 7-foot, 10-inch column packed with plastic media to provide a large surface area. The supernatant liquid, containing some solids, from poultry manure slurry was continuously recycled through the filter by pumping to the top of the column from a reservoir at the bottom. Air was forced through the filter in a direction opposite to that of the manure. The total nitrogen content of the above liquid was approximately 0.46%, of which 90% was ammonium-nitrogen and the remaining 10% organic nitrogen. The solids content was 3.5%, or roughly one-half the solids content of the manure slurry.

Results have indicated that the aerobic trickling filter system could nitrify 0.00037 pounds of nitrogen per day. Assuming that one laying hen excretes 0.0034 pounds of nitrogen per day, a trickling filter having a depth of 7 feet would require a cross-sectional area of nearly 6 acres in order to nitrify the nitrogen excreted by 50,000 laying hens. Before columnar nitrification can be included in an economically and technically feasible facility for removing nitrogen from animal wastes, techniques will have to be developed to substantially increase the nitrification capacity of the aerobic trickling filter. Future research should investigate factors such as carbon dioxide supply, oxygen level, type of filter media, and pH which might limit the rate of nitrification in an aerobic trickling filter system.

L. Rudgers

1 laying hens
Land Disposal of Sewage Lagoon Effluents

With the cooperation of local farmers, the Ontario Water Resources Commission (O.W.R.C.), the Ontario Department of Agriculture and Food (O.D.A.F.) and the Ontario Federation of Agriculture (O.F.A.) it was possible to arrange a trial programme whereby wastewater from the sewage lagoons at Listowel was applied to agricultural land by overhead irrigation.

The objectives in the land disposal of the sewage effluents were:

1. to permit a longer detention time in the lagoons to reduce odours and to lower the concentration of nutrients in the discharge.

2. to improve water quality in the Chapman drain and the Maitland River. (some farmers use these waters for livestock watering).

3. to remove the nutrients, primarily nitrogen and phosphorus, in the effluents by plant use and soil immobilization.

At the request of O.F.A., the Department of Land Resource Science at the University of Guelph acted as advisors to the farmers during the planning and operational stages. Suggestions as to land suitability, rates and amounts of irrigation were compiled and made available to farmers, O.W.R.C. and O.F.A. in September, 1971.

Irrigation commenced September 8 and ended November 7. The system spread slightly over one million gallons per day when in full operation.

To estimate the degree of renovation as the water moved through the soil, devices were installed that removed a sample of water below two feet of undisturbed soil. There were two installations and one set of water samples was obtained. The nitrate-nitrogen content ranged from 3.2 to 5.1 ppm, the total phosphorus 0.16 to 0.33 ppm and soluble potassium 2.6 to 4.9 ppm. The nitrate-nitrogen is well below the 10 ppm suggested by health authorities. The phosphorus content is due in part to mineral material that came through the coarse filter.

In our opinion the farmers involved in the project as well as several adjoining the lagoons and the Chapman Drain were satisfied with the operation.

If irrigation is to be continued, it is recommended that provision be made to institute a carefully planned programme to monitor and evaluate the results. The following should be considered:

1. intensive studies to assess water quality in:

(a) soil profile at 2 to 4 foot depth
(b) groundwater - requires installation of deep observation wells
(c) Chapman Drain, Maitland River, tile drainage discharges

2. health hazards to humans and animals
(a) from waters in (1) above
(b) from forage consumed by grazing animals or from forage clipped and taken to livestock in confinement.

L.R. Webber

Nutrient Loadings in Swan Creek

One method of characterizing the effects of agriculture on stream water quality is to monitor the concentrations of nitrogen, phosphorus and potassium in a stream over a period of time. A monitoring program was started in March 1970 on Swan Creek at the Elora Research Station. The program was terminated in March 1972. During this period the stream was sampled on 53 occasions at 5 to 9 sites. Sampling sites were shown on a diagram in the 1970 Progress Report.

Maximum concentrations of nitrate-nitrogen tended to show two seasonal peaks - in the spring coincident with peak volume discharges and in the late fall (Table 5). Phosphorus concentrations reached a maximum concentration in the Jan. to March quarter. Potassium values were greatest during the last quarter of the year.

Table 5: Nutrient Concentration Ranges in Swan Creek for 1971

<table>
<thead>
<tr>
<th>Time Period</th>
<th>NO₃ - N</th>
<th>P</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan. to Mar.</td>
<td>3.1 to 4.0</td>
<td>0.02 to 0.09</td>
<td>1.7 to 2.2</td>
</tr>
<tr>
<td>April to June</td>
<td>1.3 to 3.1</td>
<td>0.01 to 0.06</td>
<td>1.6 to 3.2</td>
</tr>
<tr>
<td>July to Sept.</td>
<td>1.1 to 2.2</td>
<td>0.02 to 0.03</td>
<td>1.8 to 2.6</td>
</tr>
<tr>
<td>Oct. to Dec.</td>
<td>1.5 to 3.5</td>
<td>0.01 to 0.04</td>
<td>2.0 to 5.0</td>
</tr>
</tbody>
</table>

Significance of Data

The concentrations of nitrate-nitrogen appear to be quite low and it is doubtful if these values constitute a pollution hazard. The upper limit for nitrates in water for human consumption is 10 ppm. Except for one event in 1970, the concentration of phosphorus has not exceeded 0.1 ppm; most values were in the range 0.02 to 0.06 ppm. Research has not indicated that potassium should be considered as an environmental pollutant.

See also PUBLICATIONS.

L.R. Webber
Sewage Phosphorus Retention and Movement in Soils

A positive correlation appears to exist between the amount of soluble phosphorus in a body of water and the nuisance growth of algae and aquatic plants. Improperly constructed human waste disposal systems could be an important source of phosphorus in bodies of fresh water.

The Ontario Department of Health recommends that tile-bed disposal systems for septic tank effluents be located fifty feet from a body of water and the tile lines at least three feet above bedrock or groundwater. The project reported herewith was a laboratory study designed to characterize the movement of phosphorus from sewage under aerobic soil conditions (well-drained) and anaerobic conditions (poorly drained).

Phosphorus Adsorption Under Aerobic Conditions

When sewage was added slowly to a core of well-aerated medium coarse sand (250 to 500 microns), 93 to 99 percent of the added phosphorus was adsorbed. This soil with the adsorbed phosphorus was used to evaluate the release of phosphorus under anaerobic conditions.

Phosphorus Desorption Under Anaerobic Conditions

Soil cores with the adsorbed phosphorus were brought to an anaerobic condition by flooding with de-aired, distilled water for a period of 149 days.

When anaerobic sewage was added to these cores, 46 to 77 percent of the added phosphorus appeared in the leachate. The concentration of the phosphorus in the effluent ranged from 13 to 43 parts per million.

To simulate the situation when tile-beds are not used for disposal purposes for a period, the anaerobic soil cores were leached with distilled water. Phosphorus continued to occur in the leachate, even though no additions had been made in the distilled water. The concentration ranged from 1.0 to 27 ppm.

When the cores were leached again with anaerobic sewage, phosphorus continued to appear in the effluent. The concentration covered the range 19 to 27 ppm. The concentration of cations such as magnesium, iron and calcium could be related to the phosphorus released from the soil. The percentages of the added phosphorus that occurred in the effluent ranged from 74 to 89 percent of the total added.

Conclusions

This laboratory study indicated several important features regarding the adsorption and release of phosphorus from sewage as a soil was changed from a well-drained condition (aerobic) to poorly drained (anaerobic).

1. Chemically extractable phosphorus increased when anaerobic or water-logging conditions occurred in the soil.

2. There was a significant increase in the amount of phosphorus leached under anaerobic conditions when compared with the aerobic conditions.
3. The movement of phosphorus was positively correlated with the naturally-occurring soil cations, calcium, iron and magnesium that occurred in leachate along with the phosphorus. No characterization was made of the chemical forms in which the phosphorus and cations occurred.

4. Laboratory methods designed to estimate the phosphorus fixation capacity of a soil were of limited value in predicting the suitability of that soil for sewage disposal purposes.

G.G. Roberts and L.R. Webber

**GEOLOGY**

*Stratigraphy, Palaeontology and Tectonics of the Harrison Lakes Area, British Columbia.* The object of this project is to interpret the geological history of the area during the Jurassic period (circa 195-140 million years ago). A zonal scheme, based on ammonites, is being erected, so that events at Harrison can be correlated with events elsewhere during this period. The area is highly deformed, and sliced up by strike-slip faults (relative movement on these is likely to have brought rocks originally near Seattle up toward the Harrison area). To work out the relative movement, petrographic studies on the source of the sediments were conducted, indicating that the area was an island arc in the Jurassic period, the islands being separated by deep trenches in which the sediments accumulated. A subsidiary part of the project is the radiometric dating of volcanics within the sedimentary sequence. This allows the precise measurement of the time spans of the ammonite zones, and ties them in with the radiometric time scale.

See also list of PUBLICATIONS.

M. Brookfield

*Quantitative Studies of Sands and Sandstones*

(a) The Grand River Watershed. Data collection and data analysis of the recent fluvial sediments is continuing. Particular emphasis is given to a braided reach of the river downstream from the Elora Gorge. In this area, studies relate to the processes of braiding, the building up of the braid island sediments and their incipient weathering, the relationship between pebble orientation and pebble shape, and finally the effect of abrasion on pebble shape and the downstream distribution of the pebbles derived from the Elora Gorge and their progressively increased mixing with pebbles derived from the surrounding Pleistocene gracio-fluvial terrains. The discrimination between the recent pebbles from the Gorge and the Pleistocene pebbles has been achieved through a modified and improved Factor Analysis Program originally obtained from the University of Calgary.
(b) Drumlins and drumlinoid features of South West Ontario. Extensive fabric data have been collected from the drumlin cut at the Canada Gypsum Quarry in Guelph. These data are needed to test the validity of modern theories on the formation of the drumlin. The results to this data are not conclusive. One difficulty has been the poor development of preferred appositional fabrics in the tills that have been studied. The experiment has been extended in other sections in the Guelph drumlins field showing more uniform tills and hopefully better pebble orientations.

(c) Anatomy of silurian deltaic and littoral environments - the Medina formation. The reconstruction of the environments of deposition of this Silurian rock sequence has been completed along the Niagara Escarpment. The unit was deposited in an ancient delta-shallow marine complex. The vertical and lateral facies relations have been illustrated in a publication contained in a guidebook for a field trip in the Hamilton area (Martini, 1972 in press). The emphasis of the study is now on the determination of the minimum amount of quantitative information needed to retain the environmental interpretation made utilizing outcrop data. Simulated core samples and simulated ditch cutting samples will be utilized. This type of analysis will indicate the degree of confidence that can be given to the reconstruction of environments of deposition of the rocks found in the subsurface of S.W. Ontario.

(d) The bioclastic sands of Bermuda. An exploratory study has been initiated on calcareous sands deposited in a small tidal delta in Bermuda. Selected recent and Pleistocene beach structures have been sampled and will be analyzed.

(e) Pleistocene sands and gravels on Ontario.
- The field analysis of the Outwash-Alluvial Fan exposed in the vicinity of Campbellville has been completed and the environmental model is illustrated in a guidebook for a field trip in the Hamilton area (Martini, 1972, in press).
- A preliminary study of key Pleistocene sections in the Wasaga Beach area has been initiated. The area is underlain by Wisconsin tills, Algonquin beaches, Nipissing beaches, lagoons, and aeolian dunes. The area is of great interest also for the recent environments and the erosional-depositional cycle revolving around the system Nottawasaga River - Nottawasaga Bay - recent beach - Nottawasaga River. The objective of the study is to reconstruct the Pleistocene history of the area and to define the preferred associations of textures and sedimentary structures in these types of lacustrine sediments. The study will have some input also in the development plans for recreation activity and urban growth of the area.

See also list of PUBLICATIONS.

I.P. Martini
AGROMETEOROLOGY

Climate and Crop Production

The objectives of this project are to define the climatic limitations and probabilities for agricultural operations and field crop production in Ontario.

The agricultural operations part of this project received the greatest emphasis during the past year as a result of the need for information on 'time-available' for field operations. The ODAF COMSOLVE program and the two ODAF bulletins, in preparation, required such information.

The model derived for estimating tractionable days in spring was applied to 50 years of climatic data at six sites in Ontario. The probability of tractionable days at these sites for various periods provided information on the likelihood of planting corn by specified dates for decision-making models. One use is in the COMSOLVE tractor selection computer program and another in a corn planter selection bulletin.

Climatic probabilities of sequences of good haying days in June have been used in the COMSOLVE program and provided information for a bulletin on Forage Handling Systems.

A study is underway to derive a model to provide the probability of good harvest days in fall in connection with a project in Program 19 on Field Mechanization Systems. In conjunction with this study and with the corn hybrid testing projects (in Program 20, Grain Crops), a method for predicting daily drying rates of grain corn from weather records is in the development stage. A preliminary method, derived from daily drying rates of grain corn collected in the fall of 1970 and 1971, was used to estimate the grain moisture of certain hybrids on a specific date, in order to compare the maturity of the hybrids among Corn Test sites. This was necessary to substantiate the Heat Unit rating in Renfrew county in connection with a study of the feasibility of crop insurance for grain corn in the northeastern townships of Renfrew. The latter project was carried out for the Ontario Crop Insurance Commission.

The phase of this project concerned with winter survival of alfalfa as part of Program 21 concerned with Forage-Management, has continued this past year. Information on soil temperatures, snow cover and soil heaving have been collected. No relationships to the standard climatological records have been developed.

Significance to Industry. Information on the probability of occurrence of certain soil and weather conditions are required to help assess the potential of land for agricultural purposes in each climatic region of the province. First, to determine if the land should remain in agriculture and, if so, then to determine the cropping practices, machinery purchases, crop insurance premium rates, and expected returns.

See also PUBLICATIONS.

D.M. Brown
Southern Corn Leaf Blight and the Weather

Leaf wetness duration measurements in corn along with air temperature records from a Stevenson screen standardly exposed above a turf grass surface have been successfully related to southern corn leaf blight (SCLB) outbreaks near Guelph, Ontario, in 1970 and 1971.

To compute an index of SCLB activity from weather data, we count the number of hours in each noon to noon period that leaves are wet with rain or dew while temperatures are 65°F or higher. These are called blight favourable hours (BFH). The SCLB index is simply a seven-day running mean of the number of BFH per day. An index of 6.5 or less predicts no development of the SCLB organism. Between indices of 6.5 and 8.5 development is slow, blending to moderate above 8.5 and then to rapid above an index of 11.

No blight was reported following the slightly favourable weather of mid-July, 1970 (Fig. 1). By mid-August though, considerable blighting of Southwestern Ontario corn had occurred. This correlates very well with the high SCLB indices computed for late July and early August since it takes about a week after infection for lesions of this disease to appear and fully enlarge. The low to moderate multiplication rates calculated for the third week of August probably enhanced blight damage but available pathological observations are not sufficiently detailed to confirm this suggestion. It was however observed that development of the disease was retarded in much of Southwestern Ontario during late August and September as the blight index shows. Comparing the climate of 1970 with past records indicates that this blighty summer was not unusual, weatherwise.

During 1971, careful observations of susceptible corn varieties at Guelph revealed no lesions at all until September 16 when light to moderate blighting was seen. This correlates very well with the moderate multiplication rates indicated about one week earlier by the SCLB index (Fig. 2) and the zero multiplication rates computed for June, July and August.

Work on disease-weather problems will continue in 1972. Most Ontario corn growers will be planting varieties believed resistant to SCLB. If no blight appears yet the index suggests that favourable weather for the disease occurred, the defeat of southern corn leaf blight will be confirmed. The techniques developed during this study will now be applied to fruit and vegetable crop diseases where the objective is improved scheduling of chemical sprays by using weather data.

See also PUBLICATIONS.

T.J. Gillespie
ACTIVE RESEARCH PROJECTS

(Project leader and fund granting agency are shown following the title of each project.)

**Agrometeorology**

1. Crop micrometeorology with emphasis on water relations.
   Addition of temperature sensing capability to a leaf wetness recorder and study of its use as a guide for scheduling fungicide spray operations in orchards and fields. (T.J. Gillespie, Ontario Ministry of Agriculture and Food).

   Determination of evapotranspiration rates of a corn crop by lysimeters and the development of methods for predicting water use at various stages of growth. (K.M. King, Ontario Ministry of Agriculture and Food).

   Energy and water balances of agricultural land surfaces. (K.M. King, Meteorological Branch, Canada Department of Transport).

   Short term growth of field crops in relation to the micro-environment. (K.M. King, Canada Department of Agriculture).

2. Photosynthesis of crops in relation to productivity, (Funded by Canadian Committee for the International Biological Program).

   Modelling the early season growth of corn in controlled and field environments. (T.J. Gillespie)

   Atmospheric transport processes within crop canopies. (G.E. Kidd, G.W. Thurtell)

   Development of environmental research instrumentation. (G.E. Kidd)

   Micrometeorological measurements of photosynthesis. (K.M. King)

   Water potential and water movement in the soil-plant-atmosphere system. (G.W. Thurtell)

   The effects of water potential on stomatal and internal plant diffusive resistances for water vapour and carbon dioxide. (G.W. Thurtell)

   Environmental effects on the life cycles of pests and diseases. (T.J. Gillespie)
3. Climate and field crop production.

Effect of climate on agricultural practices and crop production. (D.M. Brown, Ontario Ministry of Agriculture and Food)

Climate and perennial forage crop production. (D.M. Brown, Atmospheric Environment Service, Canada Department of Environment)

Compilation and analysis of current and past weather records. (D.M. Brown, Ontario Ministry of Agriculture and Food)

4. Micrometeorology.

Turbulent transport processes above terrestrial surfaces and within plant canopies. (G.W. Thurtell, Canada Department of Transport)

Soil Management and Plant Nutrition.

Evaluation of macronutrient requirements for corn. (T.E. Bates and J.W. Ketcheson, Ontario Ministry of Agriculture and Food)

Evaluation of macronutrient requirements for cereal grains. (T.E. Bates and E. Reinbergs 1, Ontario Ministry of Agriculture and Food)

Ground and aerial photography for diagnosis of nutrient deficiencies in field crops. (T.E. Bates, National Research Council)

Time of application and source of nitrogen on corn. (E.G. Beauchamp and C.T. Corke 2, Ontario Ministry of Agriculture and Food)

Time and rate of application, and source of nitrogen for grass production. (R.W. Sheard and E.G. Beauchamp, Ontario Ministry of Agriculture and Food)

Time of application and placement of phosphorus and potassium for grasses, legumes, and mixtures thereof. (R.W. Sheard, Ontario Ministry of Agriculture and Food)

Interaction of fertilizer use and harvest management on production, quality and longevity of forage species. (R.W. Sheard, W.B. Towill 3, J. Wauthy 4, A. Skepasts 5, and J.E. Winch 1, Ontario Ministry of Agriculture and Food)

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1 Crop Science Department
2 Microbiology Department
3 C.D.A. Thunder Bay
4 C.D.A. Kapuskasing
5 C.A.T. New Liskeard
Method, source, and time of application of boron for field crops. (E.G. Beauchamp and R.E. Sheard and A.L. Willis, Ontario Ministry of Agriculture and Food)

Evaluation of zinc requirements for corn. (T.E. Bates and R.W. Johnson ¹, Ontario Ministry of Agriculture and Food)

Evaluation of corn hybrids and breeding lines for macro-and micro-nutrient requirements. (E.G. Beauchamp, L.W. Kannenberg ², and R.B. Hunter ², Ontario Ministry of Agriculture and Food)

Chemical behaviour of plant nutrients in organic soils as indicated by soil and plant analysis. (A.L. Willis, Ontario Ministry of Agriculture and Food)

Methods and techniques for chemical analysis of soils and plants. (J.A. Smith, A.L. Willis and R.L. Thomas, Ontario Ministry of Agriculture and Food)

Effects of tillage practices on soil properties and on growth and yield of corn. (J.W. Ketcheson, T.B. Daynard ³, and H. Lee ³, Ontario Ministry of Agriculture and Food)

Quantitative characterization of mass and heat transfer in freezing soils. (B.D. Kay, Ontario Ministry of Agriculture and Food)

Factors affecting frost heaving of forage species. (B.D. Kay, Ontario Ministry of Agriculture and Food)

Effect of snowpack management on water and nutrient movement in soil. (B.D. Kay, Ontario Ministry of Agriculture and Food)

Mineralization studies of soil organic matter with reference to nitrogen and phosphorus. (R.L. Thomas, Ontario Ministry of Agriculture and Food)

Interactions of soil drainage, species and plant nutrition. (R.W. Sheard, Ontario Ministry of Agriculture and Food, and Canada Department of Agriculture)

Changes in the level and nature of organic matter due to tile drainage of a poorly drained soil. (R.L. Thomas and R.W. Sheard, Ontario Ministry of Agriculture and Food, and National Research Council)

Effect of soil physical conditions on plant growth. (J.W. Ketcheson, Ontario Ministry of Agriculture and Food, and National Research Council)

Chemicals affecting cell membrane permeability and the absorption of foliar applied nutrient elements. (E.G. Beauchamp, National Research Council)

¹ C.A.T. Ridgetown
² Crop Science Department
³ Engineering Department
Reactions at the soil-root interface and their significance in plant nutrition. (M.H. Miller, National Research Council)

Characterization and identification of organic phosphorus compounds in soil. (R.L. Thomas, National Research Council)

Characterization and identification of organic nitrogen compounds in soil. (R.L. Thomas, Canada Department of Agriculture)

Relationship of visible radiation to growth and metabolism of plants. (R.W. Sheard, National Research Council)

Land in Relation to Water Quality

Movement of nutrients from liquid manure disposal. (L.R. Webber and J.W. Ketcheson, Ontario Ministry of Agriculture and Food, and Department of Energy, Mines and Resources)

The utilization of animal wastes in the production of forage species. (R.W. Sheard, Ontario Ministry of Agriculture and Food)

Surface movement of soil and nutrients as influenced by tillage and stover management. (J.W. Ketcheson, Ontario Ministry of Agriculture and Food)

Pollution potential from nitrogen applied to grain corn. (T.E. Bates, Canada Department of Agriculture)

Soil suitability and the disposal of septic tank effluents. (L.R. Webber, National Research Council)

Fertilizer use and water quality. (M.H. Miller in co-operation with the Soils and Crops Branch, Ontario Ministry of Agriculture and Food)

Microhydrologic characteristics of soils. (D.E. Elrick, National Research Council)

Dynamics of nitrogen transport in soils. (D.E. Elrick, Ontario Ministry of Agriculture and Food)

Osmotic effects in clay soils. (D.E. Elrick, National Research Council)

Virus transport in soils. (D.E. Elrick, Department of Energy, Mines and Resources)

Resource Inventory, Planning and Development

Relationship between geomorphic, morphological, and chemical variables within small landscape units. (R. Protz, Ontario Ministry of Agriculture and Food, and Canada Department of Agriculture)

Mineralogical characterization of soils from active soil surveys in Ontario. (R. Protz, Ontario Ministry of Agriculture and Food)
Quantification of soil variability. (R. Protz, National Research Council)

Use of the electron microprobe in soil genesis. (R. Protz, National Research Council)

Evaluation of soil color as used in soil classification. (R. Protz, National Research Council)

Quantification of initial chemical changes in various soils. (R. Protz, National Research Council)

Techniques in photogrammetry as aids in studies of soil properties and geomorphic parameters. (R. Protz, Canada Department of Agriculture)


Soil Survey and land use. (Funded by Canada Department of Agriculture and Ontario Ministry of Agriculture and Food)

Soil Survey of Peterborough County - J.E. Gillespie
Detailed soil survey of Brant County - C.J. Acton
Soil survey of Middlesex County - E.W. Presant
Soil survey of Northumberland County - D.W. Hoffman
Soil survey of Rainy River, Dryden area - D.W. Hoffman
Soil survey of Sault Ste. Marie, Sudbury area - D.W. Hoffman
Soil survey of Thunder Bay - D.W. Hoffman
Soil survey of Verner, Noelville area - D.W. Hoffman

Planning for Agriculture in Southern Ontario (D.W. Hoffman, Agricultural and Rural Development Act grant)

Interpretation of climate for land use planning. (D.M. Brown, Ontario Ministry of Agriculture and Food)

The development of soil capability classification for horticultural crops. (E.E. Mackintosh, Ontario Ministry of Agriculture and Food)

Studies of organic soils; their classification and uses. (D.W. Hoffman and G. Pohorol, Agricultural and Rural Development Act grant)

Relationship between water table levels and soil properties. (E.E. Mackintosh, Canada Department of Agriculture)

Hanlon Creek ecological study: Interdisciplinary study group evaluating the effect of urbanization on the Hanlon Creek watershed area. (J.W. Milliken 2, co-ordinator with D.E. Elrick, E.E. Mackintosh: funded by City of Guelph, Ontario Department of Transportation and Communication, Grand River Conservation Authority)

1 Canada Department of Agriculture Personnel
2 School of Landscape Architecture. A number of faculty from several other departments are involved in this project.
Computerization and interpretation of soil survey information for providing solutions to land use conflicts. (E.E. Mackintosh, Canada Department of Agriculture)

Ground truth program in the areas of geology, geomorphology and soils in Ontario. (C.J. Acton 1, I.P. Martini, R. Protz, Centre for Applied Research and Engineering Inc.)

Surface reactivity of clays in relation to engineering properties. (E.E. Mackintosh, National Research Council)

Geology

Study of drumlins and drumlinoid features of South-Western Ontario (I.P. Martini, University of Guelph Research Advisory Board)

Anatomy of Silurian deltaic and littoral environments - the Medina Formation. (I.P. Martini, National Research Council)

Analysis of the Grand River Watershed. (I.P. Martini, National Research Council)

A metamorphic grid for the Haliburton Highlands (W. Chesworth, National Research Council)

Effect of silurian spalerite-galena deposits on the environmental geology of regions along the Niagara Escarpment. (W. Chesworth, National Research Council)

Mineral-equilibria in system Al₂O₃-H₂O applied to soils (W. Chesworth, National Research Council)

Origin of hypersthene-granite. (W. Chesworth, National Research Council)

Studies related to the weathering of granite. (W. Chesworth, National Research Council)

Palaeoecology and diagenesis of the Guelph Formation around Guelph. (M. Brookfield, National Research Council)

Stratigraphy and palaeontology of the Harris Lakes area British Columbia. (M. Brookfield, National Research Council)

1 Canada Department of Agriculture
UNDERGRADUATE EDUCATION

The activities of the department in Undergraduate education are summarized in Tables 1 and 2. There were no significant changes in our course offerings or programs of studies.

Table 1: May 1972 Graduates in Soil Science and Resources Management

<table>
<thead>
<tr>
<th>NAME</th>
<th>HOME TOWN</th>
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<tbody>
<tr>
<td>\textbf{Soil Science Major}</td>
<td></td>
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<tr>
<td>William E. Curnoe</td>
<td>Islington, Ontario</td>
</tr>
<tr>
<td>John B. Dorsey</td>
<td>Beeton, Ontario</td>
</tr>
<tr>
<td>Jerry J. Felker</td>
<td>Hamilton, Ontario</td>
</tr>
<tr>
<td>John C. McLean</td>
<td>Guelph, Ontario</td>
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<tr>
<td>Terrence J. O'Neill</td>
<td>Scarborough, Ontario</td>
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<tr>
<td>Robert W. Wilson</td>
<td>Thedford, Ontario</td>
</tr>
<tr>
<td>\textbf{Resource Management Major}</td>
<td></td>
</tr>
<tr>
<td>Judith A. Barr</td>
<td>Kirkland Lake, Ontario</td>
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<tr>
<td>Winston L. Boyne</td>
<td>Jamaica, W.I.</td>
</tr>
<tr>
<td>Robin K. Dawe</td>
<td>Lakedore Lodge, Ontario</td>
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<tr>
<td>Lawrence W. Frank</td>
<td>Kitchener, Ontario</td>
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<tr>
<td>Richard P. Geisler</td>
<td>Powassan, Ontario</td>
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<tr>
<td>William J. Hastie</td>
<td>Guelph, Ontario</td>
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<tr>
<td>Richard W. Istead</td>
<td>Bloomfield, Ontario</td>
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<tr>
<td>Stephen J. Kendall</td>
<td>Norwood, Ontario</td>
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<tr>
<td>John W. King</td>
<td>Bolton, Ontario</td>
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<tr>
<td>David D. Kuehner</td>
<td>Hanover, Ontario</td>
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<tr>
<td>David N. MacDonald</td>
<td>Guelph, Ontario</td>
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<tr>
<td>Roger J. May</td>
<td>Sydney, N.S.</td>
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<tr>
<td>Gordon G. McKnight</td>
<td>Selby, Ontario</td>
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<tr>
<td>James F. McLarty</td>
<td>Sarnia, Ontario</td>
</tr>
<tr>
<td>Renald A. Siblock</td>
<td>Oshawa, Ontario</td>
</tr>
<tr>
<td>Robert H. Weir</td>
<td>Ottawa, Ontario</td>
</tr>
<tr>
<td>Dianne E. White</td>
<td>Mississauga, Ontario</td>
</tr>
<tr>
<td>David A. Whittington</td>
<td>Peterborough, Ontario</td>
</tr>
</tbody>
</table>
Table 2: Correspondence, Diploma and Undergraduate Courses Presented During 1971/72.

<table>
<thead>
<tr>
<th>Course</th>
<th>Enrollment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Correspondence</strong></td>
<td></td>
</tr>
<tr>
<td>201 Ba</td>
<td>Introductory Soil Science 42</td>
</tr>
<tr>
<td>209 Aa</td>
<td>Soil Management 5</td>
</tr>
<tr>
<td><strong>Diploma</strong></td>
<td></td>
</tr>
<tr>
<td>87-001</td>
<td>Soil Science 13</td>
</tr>
<tr>
<td>87-010</td>
<td>Soils 162</td>
</tr>
<tr>
<td>87-011</td>
<td>Soils 113</td>
</tr>
<tr>
<td>87-020</td>
<td>Soils 17</td>
</tr>
<tr>
<td><strong>Degree</strong></td>
<td></td>
</tr>
<tr>
<td>64-304</td>
<td>Meteorology &amp; Climatology 89</td>
</tr>
<tr>
<td>64-403</td>
<td>Agrometeorology 8</td>
</tr>
<tr>
<td>64-405</td>
<td>Microclimatology 19</td>
</tr>
<tr>
<td>64-410</td>
<td>Physical Meteorology 7</td>
</tr>
<tr>
<td>64-411</td>
<td>Dynamic &amp; Snyoptic Meteorology 6</td>
</tr>
<tr>
<td>87-200</td>
<td>Soils Science 398</td>
</tr>
<tr>
<td>87-302</td>
<td>Soil Classification 15</td>
</tr>
<tr>
<td>87-304</td>
<td>Soil Science Seminar 3</td>
</tr>
<tr>
<td>87-305</td>
<td>Land Utilization 128</td>
</tr>
<tr>
<td>87-401</td>
<td>Soil Chemistry 8</td>
</tr>
<tr>
<td>87-402</td>
<td>Soil Physics 7</td>
</tr>
<tr>
<td>87-405</td>
<td>Soil Management 73</td>
</tr>
<tr>
<td>87-406</td>
<td>Problems in Soil Sci. I 3</td>
</tr>
<tr>
<td>87-407</td>
<td>Problems in Soil Sci. II 7</td>
</tr>
<tr>
<td>87-408</td>
<td>Environmental Quality 26</td>
</tr>
<tr>
<td>87-410</td>
<td>Soil Plant Relations 8</td>
</tr>
<tr>
<td>46-100</td>
<td>Principles of Geology 273</td>
</tr>
<tr>
<td>46-104</td>
<td>Study of the Earth 64</td>
</tr>
<tr>
<td>46-202</td>
<td>Stratigraphy 19</td>
</tr>
<tr>
<td>46-203</td>
<td>Palaeontology 21</td>
</tr>
<tr>
<td>46-205</td>
<td>Glacial Geology 23</td>
</tr>
<tr>
<td>46-208</td>
<td>Silicate Stuctures 10</td>
</tr>
<tr>
<td>46-301</td>
<td>Mineralogy 11</td>
</tr>
<tr>
<td>46-303</td>
<td>Petrology 19</td>
</tr>
<tr>
<td>46-305</td>
<td>Sedimentology 11</td>
</tr>
<tr>
<td>46-404</td>
<td>Geology of Canada 19</td>
</tr>
</tbody>
</table>
GRADUATE EDUCATION

Thirty graduate students were enrolled in the M.Sc. and Ph.D. programs in the Department in 1971-72 (Table 1). This compares with a total of 25 in 1970-71 and 35 in 1969-70. Degrees granted during year are listed in Table 2.

Table 1: List: Graduate Students and Advisors - Winter Semester, 1972.

<table>
<thead>
<tr>
<th>M.Sc. Students</th>
<th>Advisor</th>
<th>Ph.D. Students</th>
<th>Advisor</th>
</tr>
</thead>
<tbody>
<tr>
<td>R. DeJong</td>
<td>B.D. Kay</td>
<td>Mrs. N. Caramancion</td>
<td>L.R. Thomas</td>
</tr>
<tr>
<td>S. Griffith</td>
<td>L.R. Thomas</td>
<td>L. Crosson</td>
<td>R. Protz</td>
</tr>
<tr>
<td>J. Hagarty</td>
<td>D.W. Hoffman</td>
<td>A. Haq</td>
<td>T.E. Bates</td>
</tr>
<tr>
<td>B. Hilliard</td>
<td>W. Chesworth</td>
<td>J. Koch</td>
<td>B.D. Kay</td>
</tr>
<tr>
<td>S. Humphrey</td>
<td>E.W. Hoffman</td>
<td>H. Mirreh</td>
<td>J.W. Ketcheson</td>
</tr>
<tr>
<td>A. Jowett</td>
<td>E.E. Mackintosh</td>
<td>Y. Soon</td>
<td>M.H. Miller</td>
</tr>
<tr>
<td>S. Kargbo</td>
<td>R.W. Sheard</td>
<td>M.E. Watson</td>
<td>E.G. Beauchamp</td>
</tr>
<tr>
<td>J. Leyshon</td>
<td>R.W. Sheard</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Lobdell</td>
<td>E.E. Mackintosh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. MacDonald</td>
<td>D.W. Hoffman</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Patton</td>
<td>W. Chesworth</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Roberts</td>
<td>L.R. Webber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Signorelli</td>
<td>I.P. Martini</td>
<td></td>
<td></td>
</tr>
<tr>
<td>W. Stewart</td>
<td>L.R. Webber</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Symeonakis</td>
<td>R. Protz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>J. Tarzi</td>
<td>R. Protz</td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. Van Vliet</td>
<td>E.E. Mackintosh</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P. Warman</td>
<td>R.L. Thomas</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Agrometeorology Program

| S. Whiston     | T. Gillespie     | M. Coligado     | D.M. Brown       |
|                |                  | G. Den Hartog   | K.M. King        |
|                |                  | K. Heldorn      | G.W. Thurtell    |
|                |                  | H. Newmann      | G.W. Thurtell    |
|                |                  | S. Selirio      | K.M. King        |
Table 2: Graduate Degrees Granted October 1971, January and May 1972.

**Soil Science Program**

<table>
<thead>
<tr>
<th>Name</th>
<th>Degree</th>
<th>Advisor</th>
<th>Thesis Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>L.D. Bailey</td>
<td>Ph.D.</td>
<td>E.G. Beauchamp</td>
<td>Effect of temperature, moisture and roots on nitrogen transformations and redox potential in surface and subsurface soil samples.</td>
</tr>
<tr>
<td>D.A. Carandang</td>
<td>Ph.D.</td>
<td>J.W. Ketcheson</td>
<td>Temperature effects on nitrification rates in soil.</td>
</tr>
<tr>
<td>J. Onderdonk</td>
<td>M.Sc.</td>
<td>J.W. Ketcheson</td>
<td>Direction of corn radicle growth as influenced by temperature.</td>
</tr>
<tr>
<td>J. Cihlar</td>
<td>M.Sc.</td>
<td>R. Protz</td>
<td>Color aerial photography in soil mapping.</td>
</tr>
<tr>
<td>G.G. Roberts</td>
<td>M.Sc.</td>
<td>L.R. Webber</td>
<td>Sewage phosphorus retention and movement under aerobic and anaerobic soil conditions.</td>
</tr>
</tbody>
</table>

**Agrometeorology Program**

<table>
<thead>
<tr>
<th>Name</th>
<th>Degree</th>
<th>Advisor</th>
<th>Thesis Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Bootsma</td>
<td>M.Sc.</td>
<td>T.J. Gillespie</td>
<td>Environmental factors affecting the development of Yellow Leaf Blight (Phylllosticta maydis) in corn.</td>
</tr>
</tbody>
</table>
CONFERENCES AND SYMPOSIA

Assistance was given in arranging and conducting the following events:

Soil Erosion Conference, Toronto
Manure Symposium (O.S.C.I.A. Annual Meeting, Toronto)

Porous Media Conference, Guelph

Elanco Swine Conference (an Industry organized event)

Central Ontario Regional Conference for Agriculture and the Environment
Conservation Authorities Field Officers' Conference

Bradford Muck Growers' Conference

Environmental Protection Conference
Soils and Crops Branch, Toronto

Microfabrics of Soil and Sedimentary Deposits Symposium, Guelph
Participants: R. Brewer, J.E. Gillott, W.D. Nettleton, L.P. Wilding with M.H. Miller, R. Yong; organized by R. Protz (see Visiting Lecturers for topics).

VISITING PROFESSORS

Dr. R. Brewer, C.S.I.R.O. Canberra, Australia - one year.

Dr. M.G. Klages, Montana State University, Bozeman, Montana - one semester.

Dr. L.P. Wilding, Department of Agronomy, Ohio State University, Columbus, Ohio - six months.
VISITING LECTURERS

July 1, 1971 - June 30, 1972

Dr. R. Brewer, Division of Soils, C.S.I.R.O. Canberra, Australia, "Some Applications of Micromorphology to Soils Research", Microfabric Studies and Soil Genesis".

Dr. N. Collis-George, Department of Soil Science, University of Sidney, Australia, "Soil Physics and Biology".

Dr. J.D. Colwell, C.S.I.R.O. Canberra, Australia, "The Australian National Soil Fertility Project".

Dr. J.S. Clark, Director, Soil Research Institute, Ottawa, "Programs of the Soil Research Institute".

Dr. R.S. Dorney, Div. of Environmental Studies, University of Waterloo, "Ecology and Planning".

Dr. G.M. Gates, Professor of Botany, University of Michigan, Ann Arbor, Mich., "Energy Exchange for Plants and Animals".

Dr. J.E. Gillott, Associate Professor, Department of Civil Engineering, University of Calgary. "Applications of the Latest Techniques of Microfabric Studies to Engineering Geology".

Dr. W.D. Kemper, Director, U.S.D.A. Soils Laboratory, Beltsville, Maryland, "The five most important challenges facing soil scientists".

Dr. M.G. Klages, Department of Soil Science, Montana State University, Bozeman, Montana, "Clay mineral studies in Montana".

Dr. J.E. Klovam, Department of Geology, University of Calgary, "Some Applications of Multivariate Analysis".

Dr. J.N. Ladd, C.S.I.R.O. Adelaide, Australia, "Origin, properties and role of proteolytic enzymes in soils".

Dr. M.M. Mortland, Department of Crop and Soil Science, Michigan State University, East Lansing, Michigan, "Clay-organic matter complexes".

Dr. R.E. Munn, Atmospheric and Environment Service, Toronto, "Man's Impact on Climate".

Dr. W.D. Nettleton, Research Scientist, U.S.D.A., Riverside, California, "Microfabric Characteristics as Applied to Soil Classification".

Mr. D. Reuter, Department of Agriculture, New South Wales, Australia, "Soil Science in Australia".

Dr. K. Smith, Agricultural Research Council, Wantage, U.K., "Radioisotopes in Soil-Plant Studies".
Dr. L.P. Wilding, Department of Agronomy, Ohio State University, Columbus, Ohio, "Some Aspects of Pedological Research in Ohio".

Dr. L.P. Wilding with M.H. Miller, "Microfabric Studies as Related to Soil-Root Interface".

Dr. R. Yong, Professor, Civil Engineering and Applied Mechanics, McGill University, Montreal, "Microfabric Studies as Applied to Soil Mechanics".
PUBLICATIONS

REFEREED JOURNALS AND CHAPTERS IN BOOKS.


Beauchamp, E.G., see Rossi and Beauchamp.


Brown, D.M., see Selirio and Brown, 1971.

Brown, D.M., see Selirio and Brown, 1972.


Hoffman, D.W., see Maclean, Willis and Hoffman.


Protz, R., see Asamoza and Protz.

Protz, R., see Gillespie and Protz.

Protz, R., see Raad and Protz.


Siitam, P.E., see Beauchamp and Siitam.

Smiles, D.E., see Elrick, Smiles and Wooding.


Webber, L.R., see J.L. Townshend and Webber.

Willis, A.L., see Maclean, Willis and Hoffman.
BOOK REVIEWS


NON-REFEREED JOURNALS, REPORTS, CONFERENCE PAPERS AND ABSTRACTS.


Acton, C.J., see Presant, Acton and Webber.


Brown, D.M., see Gamble and Brown.


Gillespie, T.J., see Brown and Gillespie.


Ketcheson, J.W., see Beauchamp and Ketcheson.


Martini, I.P., see Cihlar, Protz, Martini and Acton

Miller, M.H., see Gillespie, Wicklund and Miller.

Miller, M.H., see Haq and Miller.
Miller, M.H., see Mosher and Miller.


Protz, R., see Acton and Protz.

Protz, R., see Cihlar, Protz, Martini and Acton.

Protz, R., see Crosson and Protz.

Protz, R., see Raad and Protz.


Webber, L.R., see Presant, Acton and Webber.

Wicklund, R.E., see Gillespie, Wicklund and Miller.

Wicklund, R.E., see Presant and Wicklund.

ONTARIO MINISTRY OF AGRICULTURE AND FOOD PUBLICATIONS

Information for Extension Personnel (I.F.E.P.)


Fact Sheets


PRESS ARTICLES


Lane, T.H. Watch for grass tetany in cattle this spring. April 1971.

Lane, T.H. Foliar fertilizers of dubious value. May 1971.

Mackintosh, E.E. Rural land taxation should be on the basis of soil productivity. December 1971.


RADIO TAPES


Lane, T.H. Foliar fertilizers -- Facts or Fallacies. April 1971.

Lane, T.H. Grass tetany -- Ailment connected with soil. May 1971.


Lane, T.H. Potential problems with sewage sludge. September 1971.

Lane, T.H. Computerized soil testing. October 1971.

Lane, T.H. Land study suggests new farm tax structure. January 1972.


Webber, L.R. Land disposal of lagoon effluents. CKNX.

Webber, L.R. Solid waste disposal on agricultural land. OMAF.

Webber, L.R. Soil Erosion Conference. OMAF.