DEPARTMENT OF SOILS

1958

Progress Report

RESEARCH AND ADVISORY SERVICE

1. New Facilities.
2. Using Fertilizer for Maximum Profit.
3. Fertilizer for Forage Crops.
4. Crop Rotations and Manure.
5. Soil Testing.
6. Developmental Research and Soil Advisory Program.
7. Fundamental (Basic) Research.

APRIL 1959

ONTARIO AGRICULTURAL COLLEGE

GUELPH CANADA
DEPARTMENT OF SOILS

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ONTARIO AGRICULTURAL COLLEGE, GUELPH, CANADA.
DEPARTMENT OF SOILS

N.R. Richards, Professor  
B.C. Matthews, Professor  
F.F. Morwick, Professor  
T.J. Heeg, Associate Professor  
J.W. Ketcheson, Associate Professor  
N.J. Thomas, Associate Professor  
L.R. Webber, Associate Professor  
A.L. Willis, Associate Professor  
R.J. Bryden, Assistant Professor  
W.T. Ewen, Assistant Professor  
K.M. King, Assistant Professor  
T.H. Lane, Assistant Professor  
D.E. Logan, Assistant Professor  
M.H. Miller, Assistant Professor  
R.W. Sheard, Assistant Professor (on leave)  
J.A. Smith, Assistant Professor  
W.L. Campbell, Lecturer  
R.M. Irving, Lecturer  
C.G. Sherrell, Assistant  
E. Rustad, Assistant  

Canada Department of Agriculture:  
R.E. Wicklund, Senior Pedologist  
D.W. Hoffman, Junior Pedologist  
J.E. Gillespie, Junior Pedologist  
A.B. Olding, Junior Pedologist  

Head of Department  
Co-ordinator of Research  
Land Use Planning  
Soil Testing and Lime Studies  
Soil Fertility  
Soils Extension  
Soil Physics  
Soil Chemistry  
Soils Extension  
Soils Extension  
Agrometeorology  
Soils Extension  
Soils Extension  
Soil Fertility  
Soil Fertility  
Soil Chemistry  
Soils Extension  
Soil Survey  
Soil Fertility  
Soil Chemistry  
Soil Survey  
Soil Survey  
Soil Survey
# TABLE OF CONTENTS

**FOREWORD**

NEW FACILITIES OF DEPARTMENT OF SOILS ............................................................... 1

The Main Building ................................................................. 1
The Greenhouse Facilities ......................................................... 6
Puslinch Field ................................................................. 6

THE RESEARCH PROGRAM, DEPARTMENT OF SOILS .................................................. 7

Applied Research ................................................................. 8
Fundamental Research ............................................................ 8
Developmental Research .......................................................... 8
1958-59 Research Projects in Department of Soils ................................. 8

APPLIED RESEARCH ............................................................................. 10

Using Fertilizer for Maximum Profit .................................................. 11
  Fertilizer for wheat ............................................................ 12
  Fertilizer for oats .............................................................. 14
  Fertilizer for corn .............................................................. 14
Return Per Dollar Invested In Fertilizer .............................................. 15
Fertilizer for Seeding Down - Decrease Nitrogen and Increase .............. 18
Phosphorus and Potassium on the Companion Crop ............................. 19
Regular Fertilization of Established Grass-Legume is Profitable ............ 22
Crop Rotations and Manure .......................................................... 22
  Legume-Grass sod increases returns from succeeding crop ............... 22
Crop rotation in a farm program .................................................... 23
Returns per dollar invested from five rotations at the Regional Research 24
Station at Cayuga ..................................................................... 24
Net returns from five different rotations at Regional Research Station 24
  Cayuga .............................................................................. 24
When should manure be applied? ...................................................... 26
Soil Testing ............................................................................. 27
  Soil testing means extra dollars for the farmer .............................. 27
  Testing muck soils ................................................................ 27
Sampling .................................................................................. 27

DEVELOPMENTAL RESEARCH (FIELD DEMONSTRATIONS) AND SOIL ADVISORY PROGRAM 28

Fertilizer Trials on Field Basis ...................................................... 29
Land Judging In Ontario ............................................................... 29
Land Use Planning ..................................................................... 31
Land Use Planning - An Important Part of Farm Management .......... 32

FUNDAMENTAL (BASIC) RESEARCH ................................................................. 34

Soil Surveys and Soil Maps ............................................................ 35
Fertilizer Placement for Sugar Beets ................................................. 36
Release and Fixation of Potassium by Soils ..................................... 36
Soil Temperature and Nutrient Supply ........................................ 37
Effect of Manure on Manganese Availability ................................. 37
Effect of Calcium, pH, and Chloride on Yield of Alfalfa ..................... 38
Effect of Artificial Compaction and Cultural Treatment on Some Moisture Properties of Soils ............................................. 38
Agrometeorological Studies ...................................................... 39
    Water balance of Guelph loam ............................................ 39
    Energy balance of corn crop .............................................. 40

PUBLICATIONS ............................................................................. 41

Reprints of Technical Papers ...................................................... 41
Theses ...................................................................................... 41
Bulletins and Circulars .............................................................. 42
FOREWORD

The 1958 Progress Report once again brings a review of the departmental activities. The material in the Progress Report is presented in a manner that we hope will be useful to extension personnel for newspaper and radio purposes. We encourage you to make full use of it and assure you that Soils Department personnel will be pleased to discuss the report with you at any time.

The Department of Soils is the youngest department on the campus. References to the study of soils can be found in the annual report of 1874, and in the Legislative Bill of 1880 in which provision was made for the establishing of the College and Experimental Farm. From the time of the founding of the College until 1945 practically all the soils work was administered by personnel located in the Chemistry Department. A separate Department of Soils was formed by 1945.

In September 1958, the department was transferred from the "Old Hort" to a new modern building located on College Lane. The transfer to the new location marked an important milestone for soils work in Ontario.

Research work in the department will continue to investigate the reactions that occur at the soil-plant interface and the plant-atmosphere interface. Much of the research has been of an applied nature designed to provide answers to current problems in soil management and fertilizer use. The effects of rotations, manure and crop residues on yield and soil conditions influence the productivity of the soil. Fertilizer trials under field conditions provide a basis for making generalized fertilizer recommendations. While the applied research program increases our knowledge of soil-plant relationships there must be a strong fundamental or basic research program.

The objective of the fundamental or basic research program is to provide answers to the question Why? Why does soil structure affect plant growth? Why does nitrogen affect the uptake of phosphorus by a plant? The result of fundamental research seldom has direct application, yet it does provide the basic principles required to develop a strong applied research program.

Another important responsibility in the departmental program is teaching at the undergraduate and graduate level. Students receive instruction in soil classification and geography dealing with soil resources and their uses; soil physics which deals with the physical properties of soils in relation to plant growth; in soil conservation the effects of crops, rotations and cultural practices on land use are discussed; soil management establishes the importance of chemical, physical and biological properties of soils in relation to soil fertility and crop production.

Through our research endeavours we will continue to increase our knowledge of our soil resources. The teaching program provides us with the opportunity to educate young people to further a better understanding of our resources. Such efforts are of little value, however, unless they are reflected in the improved use and management of the soils on Ontario farms.

The soil advisory endeavours of the department are designed to interpret the results of our research program for the farmer and thereby encourage and promote the most effective use of our soil resources. To achieve this objective, members of the department meet with individual farmers, groups of farmers, representatives of industry, conservation groups and many others to interpret available information concerning soil management and land resource use.
Land is many things to many persons - to the farmer, a livelihood; to the man in the city and town a place on which to build a home; to the child a playground; to the forester the combination of soil and climate that make timber. The soil scientist recognizes his responsibility in seeking a better understanding of land resources for many different uses. To achieve such a purpose requires a continuing fact finding program interpreted and extended to those who use the land for profit or pleasure. To this end the talents and facilities of the department will be used.

The material in the report represents the work and observations of the staff of the Department of Soils. The report has been written and edited by Dr. B.C. Matthews.

Guelph, April 13, 1939.

N. R. Richards
Professor and Head
Department of Soils.
NEW FACILITIES FOR THE DEPARTMENT OF SOILS

The year 1958 was a year of great change for the Department of Soils at the Ontario Agricultural College. In the spring of 1958, field investigations in soils were transferred to a new experimental field adjacent to the campus. This new experimental field - Puslinch field - will be the centre of field investigations in soil fertility, soil management, and agrometeorology. It replaces the Soils and Agricultural Engineering farm on which soils research has been conducted since 1951. On September 15th, 1958, the Department of Soils began operations in the new Soils Building which has been constructed on the campus adjacent to the Apiiculture Building. At the same time the new greenhouses and headerhouse became available for experimental work. The main Soils Building and the greenhouse building replaced the previous building and greenhouses which the Department had occupied since its formation in 1945. The pictures which are included in the following discussion will give some indication of the adequacy of the building, and the up-to-date equipment which is now available for research and teaching in Soil Science.

THE MAIN BUILDING

The main Soils Building contains approximately 43,000 square feet in three floors.

Research Area (Second Floor):

The second floor houses the laboratories for research. There is a laboratory for soil survey analysis and studies in soil genesis, in addition to the drafting room in which the soil maps are prepared for final publication. The graduate student program in the Department of Soils forms an important part of the research program. In 1958-59 there are twelve graduate students proceeding to M.S.A. degree in the various field of Soil Science. The graduate students' laboratory is equipped with modern instruments. The use of radioactive isotopes in soils research is becoming more and more common and the new building has facilities for radioactive research. Other laboratories are equipped for research in soil physics and in soil chemistry.
The Departmental library, the Ruhnke Memorial Library is located on the Second Floor. This library contains most of the books available on Soils and related fields as well as current literature. A portrait of Professor G. N. Ruhnke, first head of the Department of Soils, is hung in this room.

The drafting room located on the Second Floor is equipped with light tables, pantographs, etc., for preparation of soil maps.
The research laboratory for graduate students in soil chemistry and fertility is on the Second Floor. There are twelve graduate students in Soil Science in 1958-59.

This is the soil physics research laboratory. This laboratory is used by graduate students as well as research staff concerned with the study of physical properties of soils.
A laboratory is set up in the research area of the building for handling and counting radioactive isotopes. The room is air-conditioned for proper functioning of equipment such as the automatic scaler, sample changer, and analytical balance.

Teaching Area (First Floor):

On the first floor of the main building are the laboratories and the large lecture room for the teaching of undergraduate courses. The classroom as shown in the picture has a total capacity of 154 students. Also on the first floor, there are four undergraduate laboratories, each of them exactly alike as indicated by the one in the picture shown here. These laboratories are capable of holding 32 students at one time, giving each student the regulation amount of laboratory space.

The administrative offices as well as offices of the soil advisory personnel are also located on the first floor.

There are four laboratories like this one for undergraduate teaching purposes. These laboratories are fully equipped for laboratory experiments in Soil Science. Capacity - 32 students in each laboratory.
The main lecture room contains 154 seats. Lecture table is serviced with water, gas and electricity for demonstration purposes.

Service Area (Ground Floor):

There is one large laboratory on the ground floor of the main building. This laboratory is set up for soil testing. It is capable of handling 2000 samples per week with an adequate number of technicians. At the present time this laboratory is analyzing about 12,000 samples per year. A small research laboratory adjoins the soil testing laboratory. Rooms for sample drying and grinding as well as a room for preparation of material for field experiments are located on the ground floor.

In addition, there are two classrooms with a capacity of 60 and 30 students as well as offices for soil testing personnel.

The soil testing laboratory on the ground floor is equipped with the latest instruments for soil analysis.
THE GREENHOUSE FACILITIES

A good portion of the research work in Soils Science involves the growing of plant under controlled conditions. For this purpose, a greenhouse and headerhouse has been built immediately behind the main Soils Building. There are two separate greenhouses with facilities for automatic control of the temperature and the lights. In addition, in the headerhouse itself, there are two growth chambers which permit even greater control of humidity, light and temperature. These greenhouses and growth chambers are being used for studies on nutrient uptake and mineral nutrition of plants, the placement of fertilizer as related to uptake by plants and the effects of moisture and temperature on the release of nutrients by soils and their uptake by plant roots.

The greenhouse and headerhouse facilities provide for studies on nutrient uptake by plants under controlled conditions.

PUSLINCH FIELD - THE EXPERIMENTAL AREA

The Puslinch Field which was established as a Soils Experimental Field in 1958 is 23 acres of relatively level land, consisting of Burford loam and Brisbane loam. The field is underlain by gravel at varying depths. A watermain has been installed through the center of the field, and this is providing irrigation water for the entire field. In addition, a building, which serves as headquarters for the field work as well as for storage of equipment and drying of crop samples, is located at one end of the field.
Puslinch field is an area of 23 acres located on loam soil underlain at depths varying from six inches to two feet with sorted water-laid calcareous gravel. This is the new location for long-term field experiments in soils at Guelph. First projects were established on this field in 1958.

It is intended that this experimental field will be used primarily for fundamental studies in Soil Science, particularly in Soil Fertility on a long term basis.

It is apparent from this picture and word summary of the new facilities of the Department of Soils that the buildings, land and equipment, are most satisfactory for teaching at the graduate and undergraduate level and for research at the graduate level including fundamental studies in many fields of Soil Science.

THE RESEARCH PROGRAM DEPARTMENT OF SOILS

The research in the Department of Soils embraces many of the fields in Soil Science although by no means all of them. It is not possible and probably not desirable that every phase of soil research be given equal emphasis. We must be guided in our research program by the current problems in soil management in Ontario and by predicted problems of the future. All research need not be related to a current problem in the field. Fundamental research whose sole purpose is to increase our understanding of soils in general is also necessary and important.

In order to make real progress in research, however, it is necessary to concentrate personnel and resources in rather narrow fields and to carry the research through until it is accepted by the farmer. During the years from 1935 to 1950 the major emphasis was on soil surveys and soil testing. More effort was directed toward this aspect of soil research than toward any other because it was recognized that this inventory of our soil resources would provide the basis for applied research in the whole field of soil management.
APPLIED RESEARCH

Since 1950 however, there has been a major increase in personnel for Soils Research. Continuing emphasis has been placed on research in soil testing methods and their calibration with yield response of crops to fertilizer application in the field. This work has led to the new improved soil test methods now being used to provide more accurate recommendations to farmers. The response of crops to applied fertilizer is being measured on many of the soil types in the Province.

Also in the field of applied research, field studies are underway to determine the long-term effects of different crop rotations on yield of crops, soil physical properties, and economic returns. The long-term effects of lime treatment are also being evaluated on field plots. These projects are located on regional research stations at Cayuga, Brampton and Guelph.

FUNDAMENTAL RESEARCH

Real progress in soil management practice is based on advances in our understanding of fundamental relationships between soil, plant, and atmosphere. This phase of soil research has been expanded in the past three years.

The effect of placement of fertilizer on uptake of nutrients by different plants is being studied in field, greenhouse, and laboratory. Radioactive fertilizer materials that permit experimenters to trace the path of the fertilizer from soil to plant greatly facilitate this kind of research. The radioactive tracer technique is currently being used in studying phosphorus and manganese reactions in soils and plants.

The influence of temperature on the availability of plant nutrients and their uptake by plants is also being investigated. Attempts are being made to evaluate effects of soil moisture level and nutrient uptake by plants. A neutron moisture meter is being used to measure moisture characteristics of soils in the field by means of gamma ray radiation.

The effects of climatic variables such as net radiation, wind velocity, relative humidity, temperature, etc., on crop growth and yield are being evaluated. Research in this field of agrometeorology has been very limited in the past. Even now there is only a small number of research stations in North America with research of this nature underway. The Department of Soils here has the latest types of equipment for research in this field and should be able to provide leadership in this work in the future.

DEVELOPMENTAL RESEARCH

The value of new findings from research is realized only when those findings are accepted by the farmer on the land. This acceptance comes through an extension program and particularly through a demonstration program on farmer's own fields.

Furthermore, this demonstration program can provide results on many farms and provide support and therefore greater confidence in research results from a limited number of locations. Developmental research of this kind is being expanded by the Department of Soils.

1958-59 RESEARCH PROJECTS IN DEPARTMENT OF SOILS

The following is a list of the research projects that are active in the Department of Soils. The name of the staff member(s) in charge of each project appears after the title.
Project Number:

S.S. 1 - Taxonomic classification of soils, soil surveys and their interpretation: B.C. Matthews* and R.M. Irving.

S.S. 2 - Genesis and morphology of virgin and cultivated soils: B.C. Matthews.

S.F. 21 - Control of soil reaction, calcium fertility and liming in relation to yield and nutrient content of crops: T.J. Heeg.

S.F. 22 - Co-operative investigation of response of field crops to nitrogen, phosphorus, and potassium on different soil types: C.G. Sherrell.

S.F. 23 - Correlation of soil testing methods of nitrogen, phosphorus and potassium with crop response to added nutrients and with fertilizer requirement: J.A. Smith.

S.F. 25 - Effects of fertility levels and cropping systems on soil and on yield and nutrient uptake by crops: J.W. Ketcheson.

S.F. 26 - Effects of different fertilizer materials, placement, time and methods of application on crop growth, yield, and nutrient uptake: J.W. Ketcheson.

S.F. 30 - Factors affecting root distribution patterns and feeding zones of crops at various stages of growth: M.H. Miller.

S.F. 31 - Utilization of micro-nutrients by plants as influenced by chemical, physical and biological factors: M.H. Miller.

S.C. 41 - Chemical behaviour of plant nutrients in organic soils as indicated by soils and plant analysis: A.L. Willis.


S.P. 60 - Measurement and interpretation of climatic and weather characteristics with respect to soils and crop yields: K.M. King.

S.P. 61 - Removal of soil water by evapotranspiration and percolation and its effect on crop yields: K.M. King.

S.P. 71 - Crops, cultural practices, and soil additives on the physical properties of soils: L.R. Webber.

S.P. 72 - Infiltration, movement and availability of moisture in soils: L.R. Webber.

S.P. 78 - Soil and water losses under different land covers and cultural practices: L.R. Webber.

*With co-operation of personnel of Canada Department of Agriculture.
APPLIED RESEARCH

This section contains the results of the applied research conducted in 1958. The experiments are designed to answer current questions in soil management. The results obtained should be useful to guide farmers in increasing crop yields or decreasing costs of production or both.

This research must be carried out on a field plot basis. Therefore the Department of Soils has experimental plots established -

(1) on Puslinch field at Guelph
(2) on the Regional Research Station at Cayuga in the heart of the fine textured soil area of the Niagara Peninsula
(3) on the Brampton Seed Farm.

These experimental areas are rented or owned on a continuing basis so that long-term studies can be carried on.

The wide variety of soils and crops in Ontario, however, requires that information on fertilizer requirements be collected from experiments on many farms. This is done through the regional fertilizer trial program which has just completed its fifth year. The Department of Soils is indebted to the many farmers in Ontario who have co-operated in this work by providing land for the experimental plots.
USING FERTILIZER FOR MAXIMUM PROFIT

One of the most important decisions a farmer must make each year in regard to his crop production program is made when he orders his fertilizer. The fertilizer industry to-day offers a wide variety of analyses to the farmer. Of course, these different fertilizer grades come at different prices per ton. Some farmers buy fertilizer on the basis of price per ton regardless of the analysis. Some farmers buy and use more fertilizer than necessary for maximum returns. But they have the satisfaction of having a high yield per acre. Highest yields per acre, however, do not usually result in highest net returns per acre or lowest costs of production per unit. Most farmers should use fertilizer to give maximum net returns, not maximum yields.

Fertilizer should not be used to compensate for improper handling of the on-the-farm resources such as sod crops and farmyard manure, straw and cornstalks. But for the farmer who is managing his soils and crop rotations well, and making full use of crop residues and manure, the right amount of fertilizer at the proper time can increase returns and lower the unit costs.

During the past few years, the Department of Soils has carried out trials on many privately-owned farms in Central and Western Ontario. These trials have provided information on yields and returns that can be expected from different fertilizers on general farm crops. These results should apply to the average farmer. No special treatment was given the fields before the experiments were set down. Seeding, fertilizing and harvesting were done by personnel of the Department of Soils but all other operations, e.g. tillage and weed control, were done by the farmer in his usual way.

More than thirty different fertilizer treatments were compared in terms of crop yields and increases in dollar returns after paying for the fertilizer. A few of the most favourable fertilizer treatments are reported here. These results are average only. Any particular soil may vary significantly from the average in both yield and net returns per acre. Calculations are based on wheat \( @ \ 1.45/\text{bu.} \), oats \( @ 75\c/\text{bu.} \), and corn \( @ 1.25/\text{bu.} \).

FERTILIZER FOR WHEAT

When wheat followed two years of cereals or corn, the yield without fertilizer = 32 bu/ac. The fertilizer treatment giving highest net returns (average of 10 farms) was:

125 lb/ac. of 0-20-20 drilled with the seed and 60 lb/ac. of ammonium nitrate or its equivalent topdressed in early spring.

Average yield = 44 bu/ac.
Increase in yield due to fertilizer = 12 bu/ac.
Average increase in returns due to fertilizer = $11.50 per acre.

The next highest net returns were obtained from:

125 lb/ac. of 16-20-0 drilled with the seed.
Average yield = 39 bu/ac.
Increase in yield due to fertilizer = 7 bu/ac.
Average increase in returns due to fertilizer = $6.00/ac.
200 lb/ac. of 6-12-12 drilled with the seed.
Average yield = 39 bu/ac.
Increase in yield due to fertilizer = 7 bu/ac.
Average increase in returns due to fertilizer = $6.00/acre.

When wheat followed legume-grass sod the yield without fertilizer = 41 bu/ac. The fertilizer treatment giving highest net returns (average of 6 farms) was:

125 lb/ac. of 0-20-20 drilled with the seed.
Average yield = 47 bu/ac.
Increase in yield due to fertilizer = 6 bu/acre.
Average increase in returns due to fertilizer = $5.50 per acre.

The next highest net returns were obtained from:

200 lb/ac. of 6-12-12 drilled with the seed.
Average yield = 47 bu/acre.
Increase in yield due to fertilizer = 6 bu/acre.
Average increases in returns due to fertilizer = $2.83 per acre.

It is important to reduce the rate of nitrogen application on wheat if the wheat is following a legume-grass sod. Too much nitrogen may cause lodging and will likely reduce the net returns because of excessive fertilizer cost.

Time and Rate of Application of Nitrogen for Winter Wheat:

In 1958 field trials were continued on nitrogen fertilization of winter wheat on six different farms. Yields of wheat in Ontario were unusually high in 1958. The average yields reported here are also higher than reported in 1957 Progress Report. The relative effects of the different rates of nitrogen fertilization and different times of application, however, were similar in the two years.

In these trials 250 lbs. of 0-20-20 per acre was applied on all plots. Nitrogen was applied at 0, 10, 20, 40, and 80 lbs. of N per acre, i.e., 0, 30, 60, 120, 240 lbs. of ammonium nitrate per acre. These treatments were applied (1) with the seed at planting time (2) as a topdressing in early spring just as crop growth began and (3) as a topdressing in late spring when the wheat was 12-18 inches high. These trials were carried out on twelve farms in 1957-58 but only six gave response to nitrogen. The average results for three farms in 1957 and three in 1958 are as follows:

No Nitrogen Fertilizer - Yield of Wheat = 42 bushels/acre.

10 lb. N. per acre @ $1.30 per acre (30 lb/ac. ammonium nitrate)

<table>
<thead>
<tr>
<th>Time</th>
<th>Yield (bu/ac)</th>
<th>Return over fertilizer cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>at seeding time</td>
<td>43</td>
<td>$0.15/acre</td>
</tr>
<tr>
<td>early spring</td>
<td>46</td>
<td>$4.50/acre</td>
</tr>
<tr>
<td>late spring</td>
<td>44</td>
<td>$1.70/acre</td>
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20 lb. N. per acre @ $2.60 per acre (60 lb/ac. ammonium nitrate)

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<tr>
<th>Time</th>
<th>Yield (bu/ac)</th>
<th>Return over fertilizer cost</th>
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</thead>
<tbody>
<tr>
<td>at seeding time</td>
<td>47</td>
<td>$4.65/acre</td>
</tr>
<tr>
<td>early spring</td>
<td>52</td>
<td>$11.90/acre</td>
</tr>
<tr>
<td>late spring</td>
<td>45</td>
<td>$1.75/acre</td>
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</table>
40 lb. N. per acre @$5.20 per acre (120 lb/ac. ammonium nitrate)

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<tbody>
<tr>
<td>at seeding time</td>
<td>49 bu/ac.</td>
<td>Return over fertilizer cost</td>
<td>$5.00/acre</td>
</tr>
<tr>
<td>early spring</td>
<td>56 bu/ac.</td>
<td>Return over fertilizer cost</td>
<td>$15.00/acre</td>
</tr>
<tr>
<td>late spring</td>
<td>49 bu/ac.</td>
<td>Return over fertilizer cost</td>
<td>$5.00/acre</td>
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80 lb. N. per acre @$10.40 per acre (240 lb/ac ammonium nitrate)

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</thead>
<tbody>
<tr>
<td>at seeding time</td>
<td>53 bu/ac.</td>
<td>Return over fertilizer cost</td>
<td>$5.60/acre</td>
</tr>
<tr>
<td>early spring</td>
<td>60 bu/ac.</td>
<td>Return over fertilizer cost</td>
<td>$15.60/acre</td>
</tr>
<tr>
<td>late spring</td>
<td>49 bu/ac.</td>
<td>Return over fertilizer cost</td>
<td>$0.00/acre</td>
</tr>
</tbody>
</table>

NOTE:

(1) In above figures wheat price was taken as $1.45/bushel.

(2) Highest average yield per acre (60 b.u.) was obtained from 240 lb. of ammonium nitrate in early spring but returns over fertilizer cost ($15.60) was about the same as returns from 120 lb. of ammonium nitrate in early spring.

(3) At all rates of nitrogen application, the early spring application gave highest returns per acre and per dollar invested in fertilizer.

(4) Late spring application generally gave lower returns than application with seed or in early spring.

(5) Return per dollar invested in fertilizer varied with rate of application.

at 10 lb. N per acre in early spring - return/dollar spent for fertilizer = $4.50
at 20 lb. N per acre in early spring - return/dollar spent for fertilizer = $5.60
at 40 lb. N per acre in early spring - return/dollar spent for fertilizer = $3.90
at 80 lb. N per acre in early spring - return/dollar spent for fertilizer = $2.50

(6) Considering yield as well as returns per fertilizer dollar, these figures show that 20-40 lb. of N per acre topdressed in the early spring is most profitable in general, i.e. one (80 lb.) bag of ammonium nitrate or its equivalent is the recommended topdressing in early spring.

(7) It is important to apply the nitrogen in early spring just as growth begins. Readily available nitrogen, at this time when the soil is still too cold for rapid release of nitrogen from the soil organic matter, gives the wheat crop an earlier start, increases tillering, and usually increases yield.

(8) Even on wheat following a legume-grass sod a small amount of nitrogen topdressed in the spring may be worthwhile. The need for nitrogen is determined to some extent by the weather. If the spring is cool and the soil is slow to warm up, extra nitrogen fertilizer is required for maximum returns.
FERTILIZER FOR OATS

When oats followed two years of cereals or corn, the average yield without fertilizer = 42 bu/ac.

The fertilizer treatment giving the highest net returns (average of 14 farms) was:

200 lb/ac. of 10-10-10 drilled with the seed.
Average yield = 56 bu/ac.
Increase due to fertilizer = 14 bu/ac.
Average increase in returns due to fertilizer = $4.00 per acre.

The next highest net returns were obtained from:

125 lb/ac. of 16-20-0 drilled with the seed:
Average yield = 53 bu/ac.
Increase Due to Fertilizer = 11 bu/ac.
Average increase in returns due to fertilizer = $2.80 per acre.

or

170 lb/acre of 6-12-12 drilled with the seed.
Average Yield = 52 bu/ac.
Increase due to fertilizer = 10 bu/ac.
Average increase in returns due to fertilizer = $2.50 per acre.

Higher yields were possible by using more fertilizer. For example, 400 lb/ac. of 10-10-10 drilled with seed gave average yield of 60 bu/ac. but a net return of only $2.00 per acre compared to $4.00 per acre for the 200 lb. rate of 10-10-10 above. Too much fertilizer can reduce profits.

When oats followed legume-grass sod, the average yield without fertilizer was 61 bu/ac.

The fertilizer treatment giving highest net returns (average of 6 farms) was:

125 lb/ac. of 0-20-20 drilled with the seed.
Average yield = 66 bu/ac.
Increase due to fertilizer = 5 bu/ac.
Average increase in returns due to fertilizer = $1.25 per acre.

None of the fertilizers containing nitrogen showed a profitable return on oats after legume-grass sod.

FERTILIZER FOR CORN

When corn followed cereals or corn, the average yield without fertilizer = 44 bushels/acre.

The fertilizer treatment giving highest net returns (average of 11 farms) was:

400 lb/ac. of 10-10-10 banded to side and below seed.
Average yield = 68 bu/ac.
Increase due to fertilizer = 24 bu/acre.
Average increase in net returns due to fertilizer = $16.00 per acre.
The next highest net returns were obtained from:

600 lb/acre of 10-10-10 banded to side and below seed.
Average yield = 73 bu/acre.
Increase due to fertilizer = 29 bu/acre.
Average increase in net returns due to fertilizer = $15.50 per acre.

or

325 lb/ac. of 6-12-12 banded to side and below seed.
Average yield = 64 bu/acre.
Increase due to fertilizer = 20 bu/acre.
Average increase in net returns due to fertilizer = $14.50 per acre.

When corn followed legume-grass sod, the average yield without fertilizer = 70 bu/ac.
The fertilizer treatment giving highest net returns (average of 9 farms) was:

400 lb/acre of 0-20-20 banded to side and below seed.
Average yield = 85 bu/acre.
Increase due to fertilizer = 15 bu/acre.
Average increase in net returns due to fertilizer = $5.00 per acre.

RETURN PER DOLLAR INVESTED IN FERTILIZER

On many farms where ready cash is limited, the decision to spend the available dollar for fertilizer or for some other part of the farm enterprise is an important one. The farmer must know how the returns from the dollar spent for fertilizer will compare with the returns from the same dollar spent from some other purpose.

Some average costs of land, power, machinery, labour, and seed and weed control were used in Tables 1, 2, 3, to illustrate how the return per fertilizer dollar varies with the rate of fertilizer application and with preceding cropping practice.

From the results shown in these tables, the farmer has some indication of the amount of return he can expect from money spent for fertilizer on these three crops under two systems of management. If he feels that he can realize greater returns from his money invested in a new machine or a better cow, then of course he should not invest in fertilizer. This decision can be made only by the farmer himself.

These are average returns only. Greater returns may be expected if each farmer uses the proper fertilizer analysis and rate for his particular soil. For maximum returns per dollar or per acre, obtain a soil test recommendation.
### Table 1

Cost of Producing Wheat at Different Yield Levels

<table>
<thead>
<tr>
<th>Production Factor</th>
<th>Following two years of Cereals or Row Crop</th>
<th>Following Legume-Grass Sod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>32 bu/ac.</td>
<td>44 bu/ac.</td>
</tr>
<tr>
<td>Land</td>
<td>$10.00</td>
<td>$10.00</td>
</tr>
<tr>
<td>Power, Labour, etc.</td>
<td>15.00</td>
<td>17.00</td>
</tr>
<tr>
<td>Seed, Weed Spray, etc.</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>0.00</td>
<td>6.15</td>
</tr>
<tr>
<td>Total Cost</td>
<td>27.50</td>
<td>35.65</td>
</tr>
<tr>
<td>Value of Wheat @ $1.45 per bushel</td>
<td>46.40</td>
<td>63.80</td>
</tr>
<tr>
<td>Net Returns/acre</td>
<td>18.90</td>
<td>28.15</td>
</tr>
<tr>
<td>Cost of Production/Bushel</td>
<td>0.86</td>
<td>0.81</td>
</tr>
<tr>
<td>Return/Fertilizer Dollar</td>
<td>--</td>
<td>2.50</td>
</tr>
<tr>
<td>Return/Dollar Invested</td>
<td>1.68</td>
<td>1.79</td>
</tr>
</tbody>
</table>

(1) Lowest cost of production per bushel was obtained following legume-grass sod.

(2) Use of moderate amount of the right fertilizer gave highest return per fertilizer dollar i.e. $2.50 return for each dollar spent for 0-20-20 at 125 lb/ac. and 60 lb/ac. of ammonium nitrate topdressed in early spring. This treatment, however, did not give highest yields.

(3) Money spent wisely for fertilizer for winter wheat will return more than $2.00 for each dollar spent.
Table 2
Cost of Producing Oats at Different Yield Levels

1955-56-57-58

<table>
<thead>
<tr>
<th>Production Factor</th>
<th>Following Two Years of Cereals or Row Crop</th>
<th>Following Legume-Grass Sod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>42 bu/ac. (200 lb. of 10-10-10)</td>
<td>56 bu/ac. (400 lb. of 10-10-10)</td>
</tr>
<tr>
<td>Land</td>
<td>$10.00</td>
<td>$10.00</td>
</tr>
<tr>
<td>Power, Labour, etc.</td>
<td>15.00</td>
<td>16.50</td>
</tr>
<tr>
<td>Seed, weed spray, etc.</td>
<td>2.50</td>
<td>2.50</td>
</tr>
<tr>
<td>Fertilizer Cost</td>
<td>0.00</td>
<td>6.40</td>
</tr>
<tr>
<td>Total Cost</td>
<td>27.50</td>
<td>35.40</td>
</tr>
<tr>
<td>Value of Oats @ .75¢/bu.</td>
<td>31.50</td>
<td>42.00</td>
</tr>
<tr>
<td>Net Returns/acre</td>
<td>4.00</td>
<td>6.80</td>
</tr>
<tr>
<td>Cost of Production/Bushel</td>
<td>0.65</td>
<td>0.63</td>
</tr>
<tr>
<td>Return/Fertilizer Dollar</td>
<td>-</td>
<td>1.40</td>
</tr>
<tr>
<td>Return/Dollar Invested</td>
<td>1.15</td>
<td>1.19</td>
</tr>
</tbody>
</table>

NOTE:

(1) The oats crop is not a highly profitable crop. If oats are following two years of cereals or corn, returns per dollar invested in production is small even with correct amount of fertilizer i.e. 10-10-10 at 200 lb/acre.

(2) When oats follows a good legume-grass sod directly it is a more profitable crop because yields are higher even without fertilizer.

(3) Insofar as the oats crop is concerned, it is doubtful if it pays to fertilize if the preceding sod crop has been adequately fertilized.

17
### Table 3

**Cost of Producing Corn at Different Yield Levels**  
1955-56-57-58

<table>
<thead>
<tr>
<th>Production Factor</th>
<th>Following Two Years of Cereals or Row Crops</th>
<th>Following Legume-Grass Sod</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>44 bu/ac.</td>
<td>61 bu/ac.</td>
</tr>
<tr>
<td>Land</td>
<td>$10.00</td>
<td>$10.00</td>
</tr>
<tr>
<td>Power, Labour, etc.</td>
<td>20.00</td>
<td>20.50</td>
</tr>
<tr>
<td>Seed, Weed Spray, etc.</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Fertilizer</td>
<td>0.00</td>
<td>13.00</td>
</tr>
<tr>
<td>Total Cost</td>
<td>33.00</td>
<td>46.50</td>
</tr>
<tr>
<td>Value of Corn @ $1.25/bu</td>
<td>55.00</td>
<td>76.25</td>
</tr>
<tr>
<td>Net Returns/Acre</td>
<td>22.00</td>
<td>29.75</td>
</tr>
<tr>
<td>Cost of Production/Bushel</td>
<td>0.75</td>
<td>0.76</td>
</tr>
<tr>
<td>Return/Fertilizer Dollar</td>
<td>-</td>
<td>1.60</td>
</tr>
<tr>
<td>Return/Dollar Invested</td>
<td>1.66</td>
<td>1.64</td>
</tr>
</tbody>
</table>

**NOTE:**

1. The 68 bushel yield was obtained with the same fertilizer cost as the 61 bushel yield. This indicates the importance of using not only the correct amount of fertilizer but also the correct analysis for your soil and crop.
2. Returns per dollar invested in fertilizer was highest on corn following cereals or corn ($2.30 per dollar compared to $1.45 per dollar). Highest return per dollar invested in all production items was obtained on corn following sod.
3. The use of sod crop in rotation with corn appreciably lowers the cost of production per bushel.

**Fertilizer for Seeding Down-Decrease Nitrogen and Increase Phosphorus and Potassium in the Companion Crop**

In another section, the most profitable fertilizer on oats following cereal or corn was reported to be 200 lb. of 10-10-10 per acre. This fertilizer treatment resulted in an average increase of 14 bu/ac. in yield and a net increase in returns of $4.00 per acre.

When seeding grasses and legumes with the oats, however, use less nitrogen and increase the amount of phosphorus and potassium.

In 1957 fertilizer trials were set-up on oats seeded with a grass-legume mixture. The oats were harvested in 1957 and the first cutting hay yields were taken in 1958 without any additional fertilizer treatment. The results for three soils, Huron silt loam (Perth Co.), Otonabee loam (Peterboro Co.) and Schomberg silt loam (York Co.) are shown in Table 4. The soils differed widely in soil test levels for nitrogen, phosphorus, and potassium.
Table 4
Response of Oats and Hay to Fertilizer Applied at Time of Seeding (average of three locations)

<table>
<thead>
<tr>
<th>Fertilizer Applied at Time of Seeding (per acre)</th>
<th>Oats Yield bu/ac</th>
<th>Hay ** Yield tons/ac</th>
<th>Total Returns Above Cost of Fertilizer</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-0-0</td>
<td>62</td>
<td>1.62</td>
<td></td>
</tr>
<tr>
<td>200 lb. 10-10-10</td>
<td>73</td>
<td>1.66 $2.65</td>
<td>1.60 $0.80 $3.45</td>
</tr>
<tr>
<td>200 lb. 5-10-10</td>
<td>70</td>
<td>1.70</td>
<td></td>
</tr>
<tr>
<td>400 lb. 5-10-10</td>
<td>74</td>
<td>0.40</td>
<td>1.75 2.60 3.00</td>
</tr>
<tr>
<td>100 lb. 0-20-20</td>
<td>69</td>
<td>2.25</td>
<td>1.76 2.80 5.05</td>
</tr>
<tr>
<td>200 lb. 0-20-20</td>
<td>71</td>
<td>0.75</td>
<td>1.89 5.40 6.15</td>
</tr>
<tr>
<td>200 lb. 5-20-20</td>
<td>74</td>
<td>1.70</td>
<td>1.84 4.40 6.10</td>
</tr>
</tbody>
</table>

* Oats valued at 75¢/bu.; hay at $20.00/ton
** Total cost of fertilizer was charged against the oat crop.
First cutting only.

NOTE: As indicated from other results the highest net return from the oats crop came from 200 lb. of 10-10-10 per acre. The increase in hay yield however was small. The relatively large nitrogen application stimulated the oats at the expense of the seeding stand.

Regular Fertilization of Established Grass-Legume is Profitable

As shown in the previous section, fertilizer applied at the time of seeding on oats does have a "residual" effect on yield of first year hay. But fertilizer applied as a topdressing on established forage stands also gives profitable increases in yield.

Two experiments on topdressing grass-legume stands were seeded in 1955. Hay yields were taken in 1956, 1957, and 1958. One trial was on Oneida clay loam in Halton Co., one on Guelph loam in Oxford Co. A total of twenty-seven different fertilizer treatments were applied as topdressing in early October in 1955 (the year of seeding) and in early October 1956. No additional fertilizer was applied in 1957 or 1958.

The most profitable fertilizer treatments are listed in Table 5.
Table 5

<table>
<thead>
<tr>
<th>Fertilizer Applied October 1955, 1956</th>
<th>Yield Increase Tons/Ac.*</th>
<th>Returns After Subtracting Fertilizer Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 lb. 0-20-20</td>
<td>0.35 0.69 0.37 1.41</td>
<td>$19.20/acre</td>
</tr>
<tr>
<td>300 lb. 5-10-10</td>
<td>0.39 0.85 0.39 1.63</td>
<td>$19.70/acre</td>
</tr>
<tr>
<td>600 lb. 5-10-10</td>
<td>0.78 1.50 0.62 2.90</td>
<td>$22.20/acre</td>
</tr>
<tr>
<td>300 lb. 0-20-20</td>
<td>0.73 1.01 0.57 2.31</td>
<td>$28.20/acre</td>
</tr>
</tbody>
</table>

Yield Without Fertilizer -

2.38 3.00 1.43 6.81

*Two cuttings in 1956 and 1957. One Cutting in 1958 (15% moisture) Hay at $20.00 per ton.

**NOTE:** (1) All fertilizer was applied in October. There was some indication that the nitrogen topdressing at this time of year reduced the stand of legume. However, the 5-10-10 fertilizer (600 lb/ac) gave higher yields than 0-20-20 (300 lb/ac) although the 0-20-20 at 300 lb/ac. was less expensive and so gave greater net return.

(2) When the nitrogen was omitted, as with 100 lb. of 0-20-20, the returns from oats were lower but the increase in hay yields in the first year was more than enough to pay for the lower returns on oats. The 200 lbs. of 0-20-20 per acre gave even smaller net returns on oats but when first year hay returns were included, this treatment gave highest total returns.

(3) The 5-20-20 at 200 lb. per acre gave higher returns than 200 lb. of 0-20-20 on oats but lower returns on first year hay. The total returns for the 5-20-20 and 0-20-20 were practically the same.

It is evident that for good establishment of grass-legumes sod with an oats companion crop, you must not expect maximum returns from the oats crop. It is good business to accept a lower yield of oats to be certain of a good hay stand.

If the oats seeded down are following two or more years of corn or cereals, the best fertilizer treatment is 200 lbs. of 5-20-20 per acre. If the oats seeded down are following legume-grass sod, then 200 lbs. of 0-20-20 per acre is a better treatment.

On the basis of the figures in Table 4 and Figure 1, 5-20-20 or 0-20-20 at 200 lbs. per acre at time of seeding will return more than $6.00 per acre in addition to the cost of the fertilizer in yield of oats and first cutting of first year hay.
Figure 1 - Net Returns due to Fertilizer Applied At Time of Seeding on Oats and First Year Hay
(Actual yield of oats at top of black bar. Actual yield of hay at top of white bar.)

NOTE:

1. Highest average returns from oats were due to 200 lbs. of 10-10-10 per acre. However, this treatment gave lowest yields of hay in the first year.

2. For largest hay yields in first year use no nitrogen at time of seeding i.e. 0-20-20 at 200 lbs. per acre.

3. In general the most satisfactory fertilizer when seeding down on oats is 5-20-20 at 200 lbs./acre.
CROP ROTATIONS AND MANURE

There is no doubt that the use of commercial fertilizer can increase net returns to the farmer. At the same time no one can afford to ignore the on-the-farm resources such as crop rotations, crop residues and manure. Fertilizer cannot be used economically if maximum effective use is not made of grass-legume sod, straw, cornstalks and manure. Some field results reported here show the importance of on-the-farm materials in reducing costs of production and increasing net returns.

LEGUME-GRASS SOD INCREASES RETURNS FROM SUCCEEDING CROP

It is possible to increase wheat yields by nine bushels per acre without additional cost. Recent results from field plots on many different farms clearly show extra returns up to 31 dollars per acre after a legume-grass sod.

### Wheat

- Average yield of wheat following legume-grass sod: 41 bu/ac.
- Average yield of wheat after 2 years of cereals or corn: 32 bu/ac.
- Average yield of wheat after 2 years of cereals or corn with 125 lb. of 0-20-20 with seed and 60 lb. of ammonium nitrate top dressed in the spring: 44 bu/ac.
- Increase in yield due to sod: 9 bu/ac.
- Increase in average net returns (wheat @ 1.45/bu.) due to sod: 13.00/ac.
- Increase in average net returns (wheat @ $1.45/bu.) due to fertilizer: 9.25/ac.

### Oats

- Average yield of oats following legume-grass sod: 61 bu/ac.
- Average yield of oats after two years of cereals or corn: 42 bu/ac.
- Average yield of oats after two years of cereals or corn with 200 lbs. of 10-10-10: 56 bu/ac.
- Increase in yield due to sod: 19 bu/ac.
- Increase in average net returns (oats @ .75¢ bu.) due to sod: $12.00/ac.
- Increase in average net returns (oats @ .75¢ bu.) due to fertilizer: 2.60/ac.

### Corn

- Average yield of corn following legume-grass sod: 70 bu/ac.
- Average yield of corn after 2 years of cereals or corn: 44 bu/ac.
- Average yield of corn after two years of cereals or corn with 400 lb. of 10-10-10: 88 bu/ac.
- Increase in yield due to sod: 26 bu/ac.
- Increase in average net returns (corn At $1.25 per bu.) due to sod: $31.00/ac.
- Increase in average net returns (corn at $1.25/bu) due to fertilizer: $16.70/ac.
On these fields, the sod crop had already returned a profit in hay and pasture. The roots and extra nitrogen, however, stayed in the soil and benefited the succeeding crop. The farmer who makes good use of legume-grass sod in his crop rotation has highest returns per acre and lowest unit costs.

CROP ROTATION IN A FARM PROGRAM

Throughout the hundreds of years since the beginning of farming, the emphasis placed on the need for rotation of crops and the kind of crop rotations recommended have varied widely. Even today in Ontario there are people who believe that they can produce corn continuously. In fact, there are people who have demonstrated this very conclusively. On the other hand, there are people who believe that 50% of the rotation should consist of grass-legume crops. The fact is, that there is no rotation which can be considered as best for an area or for any kind of soil. The crop rotation must fit the farmer’s feed requirements, his soil type, and his use of commercial fertilizer. Crop rotations alone will not maintain high yields. High yields require a favourable soil physical condition and an adequate supply of nitrogen and other fertilizer elements supplied through a combination of leguminous crops and/or farmyard manure and commercial fertilizer.

On soils which have a low porosity or are subject to erosion, rotations with a high proportion of sod crop may be necessary. On the other hand, well aerated sandy soils lend themselves to greatest advantage to intensive production of row crops such as corn. The sod crops if sold for cash do not return as much profit as many of the grain crops. However the farmer who has livestock can economically follow a rotation including a high proportion of sod crops. This does not mean, however, that the cash grain farmer will deplete his soil while the livestock farmer will maintain soil productivity. It has been shown in many experiments that soil fertility can be maintained on a cash crop rotation as well as on the livestock rotation. On the cash crop rotation, however, considerably more must be invested in commercial fertilizer, particularly nitrogen, than on the livestock rotation.

In this respect, some of the data collected at the Regional Research Station at Cayuga in Haldimand County is of interest. The average yields of all crops in several rotations have been measured over the past six years.

(1) On continuous corn the average yield for an expenditure of $7.00 for fertilizer each year has been 51 bushels per acre, whereas for an expenditure of $16.00 per acre for fertilizer, the average yield has been 63 bushels per acre.

(2) On corn-oats-hay-hay rotation for an expenditure of $7.00 for fertilizer on corn, the average yield was 57 bushels per acre, and expenditure of $20.00 for fertilizer on corn increased the average yield to 68 bushels per acre.

(3) With the same expenditure for fertilizer ($7.00) on corn, the yield of corn was higher in the corn-oats-hay-hay rotation by 17 bushels per acre. Moreover, the cost of production per bushel of corn was 96¢ in the continuous corn rotation and only 86¢ in the corn-oats-hay-hay rotation. On the basis of yield of corn, and the cost of production per bushel, one would have to choose the corn-oats-hay-hay rotation.

For the cash grain farmer who cannot make profitable use of the oats and hay in the four year rotation, the continuous corn cropping may be desirable. Even in the six years of this study there has been a steady decline in yield of corn on the continuous corn plot on this Haldimand clay soil. It will be necessary at regular intervals to include a soil-building crop such as a grass-legume to maintain the soil structure aeration, and permeability.
RETURNS PER DOLLAR INVESTED FROM FIVE ROTATIONS AT THE REGIONAL RESEARCH STATION AT CAYUGA:

The average return per dollar invested in several rotations has been calculated on six year average for the Research Station at Cayuga which is located on fine textured Haldimand clay.

(1) Continuous Corn - Continuous corn with $7.00 worth of fertilizer each year returned an average of $2.20 for every dollar invested in planting, tilling, harvesting and fertilizer.

(2) Corn-Oats Rotation - The returns per dollar invested in the corn-oats rotation including $7.00 worth of fertilizer on the corn, and $1.00 worth of fertilizer on the oats per year was $1.44.

(3) Corn-Oats-Hay-Hay Rotation - The returns per dollar invested in this rotation using the fertilizer rates indicated for the corn-oats rotation with no fertilizer on the hay was $1.18.

(4) Corn-Oats-Wheat-Red Clover Rotation - This rotation using the indicated rates of fertilizer for corn-oats and $5.00 of fertilizer on the wheat - the returns per dollar invested over the full rotation was $1.44.

It is evident that over the period of six years in which this study has been underway, the continuous corn has given greatest returns per dollar invested in production. This result undoubtedly is due to the fact that the cash returns from corn are higher per acre than for oats or hay crops. For the farmer however, who has livestock, the value of the sod crop may be higher than the $20.60 per ton placed on it for these calculations.

NET RETURNS FROM FIVE DIFFERENT ROTATIONS AT REGIONAL RESEARCH STATION, CAYUGA:

Perhaps of greatest significance to most farmers is the net return per acre rather than return per dollar invested. The figures in Table 6 show gross and net returns per acre over a four year period for five crop sequences with two levels of fertilizer treatment and two rates of application of manure.

For these calculations the following prices were used:

(a) Cost of Production Other Than Fertilizer Cost -

(1) Corn - $35.00 per acre
(2) Oats - $30.00 per acre
(3) Wheat - $30.00 per acre
(4) Hay (including seeding) - $28.00 per acre.

(b) Price of Corn - $1.25 per bu.
Oats - $.75 per bu.
Wheat - $1.45 per bu.
Hay - $20.00 per bu.

Using these basic prices and the average yields obtained for crops in these rotations at the Regional Research Station, the figures in Table 6 were calculated.
# Table 6

Gross and Net Returns During a Four-Year Period of Several Rotations

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Fertilizer Cost</th>
<th>Manure</th>
<th>Gross</th>
<th>Returns (dollars/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Continuous Corn</td>
<td>$28.00</td>
<td>nil</td>
<td>255</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 T./ac.</td>
<td>205</td>
<td>147</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nil</td>
<td>305</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 T./ac.</td>
<td>360</td>
<td>160</td>
</tr>
<tr>
<td>2. Continuous Sod</td>
<td>27.00</td>
<td>nil</td>
<td>167</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 T./ac.</td>
<td>185</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nil</td>
<td>206</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 T./ac.</td>
<td>210</td>
<td>35</td>
</tr>
<tr>
<td>3. Corn-Oats</td>
<td>23.00</td>
<td>nil</td>
<td>227</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 T./ac.</td>
<td>249</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nil</td>
<td>255</td>
<td>76</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 T./ac.</td>
<td>284</td>
<td>100</td>
</tr>
<tr>
<td>4. Corn-Oats-Hay-Hay</td>
<td>14.00</td>
<td>nil</td>
<td>186</td>
<td>52</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 T./ac.</td>
<td>228</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nil</td>
<td>218</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 T./ac.</td>
<td>248</td>
<td>74</td>
</tr>
<tr>
<td>5. Corn-Oats-Wheat-Red Clover</td>
<td>15.00</td>
<td>nil</td>
<td>199</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 T./ac.</td>
<td>246</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td></td>
<td>nil</td>
<td>230</td>
<td>53</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20 T./ac.</td>
<td>264</td>
<td>87</td>
</tr>
</tbody>
</table>

**NOTE:**

(1) Highest net returns were obtained from continuous corn with 5 tons of manure and $16.00 worth of fertilizer per acre per year. Such a management may be unrealistic however as a farmer growing corn continuously would have no manure available.

(2) The corn-oats-hay-hay rotation with $3.25 worth of fertilizer and 5 tons of manure per acre per year returned $94.00 per acre in four years.

(3) On all rotations at both the high and low level of fertilizer application the application of 20 tons of manure per acre over the four year period increased net returns. Average increase in returns due to manure was as follows:

- **On Continuous Corn** - Increase of $50.00 or $2.50/ton of manure applied.
- **On Continuous Sod** - Increase of $12.00 or $0.60/ton of manure applied.
- **On Corn-Oats** - " 26.00 or 1.30 " " " "
- **On Corn-Oats-Hay-Hay** - " 36.00 or 1.80 " " " "
- **On Corn-Oats-Wheat-Red Clover** - " 40.00 or 2.00 " " " "

25
WHEN SHOULD MANURE BE APPLIED?

The answer to this question will vary from farm to farm. The hauling of manure is usually done during "slack" periods when labour is available on the farm. There are, however, certain times of application that give greatest returns from manure.

On a rotation of corn-oats-hay-hay at Guelph the following results were obtained. A total of ten tons of manure per acre was applied during the four-year rotation.

A. Yields of Corn:

(1) Ten tons of manure in spring and worked into the soil before corn gave highest yield of corn. (Average yield of 6.3 tons of silage per acre).

(2) Five tons in fall first year hay plus five tons in spring before corn crop gave second highest yield of corn. (Average yield of 6.02 tons of silage per acre).

(3) Lowest yield of corn was obtained when manure was all applied to new seeding and first year hay.

B. Yields of Oats:

(1) Highest yields of oats were obtained when manure was applied in spring before planting corn.

C. Yields of Hay:

(1) Higher yields of first year hay were obtained when ten tons of manure was applied in spring before corn rather than in the fall on the new seeding.

(2) Highest yields of second year hay were obtained when manure was applied in fall of first hay year.

D. Yields for Rotation:

If ten tons of manure were used per rotation of corn-oats-hay-hay, the highest yield of dry matter (total of all crops) was obtained when five tons were applied in the spring before corn and five tons in the fall after first hay year. Application of manure during the winter generally gave about 10 percent lower total yields over the rotation than manure applied at other times of the year.
SOIL TESTING

SOIL TESTING MEANS EXTRA DOLLARS FOR THE FARMER

Soils, like people, are different. No two fields even on the same farm are exactly alike. The average figures on yields and returns due to fertilizer as reported in the previous sections, therefore may not apply precisely to any particular soil. These averages provide only a general basis for use of fertilizer. For highest returns from fertilizer, the soil test provides the most satisfactory guide to choosing the right fertilizer.

On the basis of field trials carried out on several farms in Ontario, the use of fertilizer on corn according to soil test resulted in a return of $4.00 per acre more than the use of the best average fertilizer. In other words, for a ten acre field of corn, a farmer may gain $40.00 in returns simply by taking a few minutes to collect a soil sample and send it to the soil testing laboratory.

As a result of research work over the past six years, new improved methods of testing for nitrogen, phosphorus and potassium have been developed. The results of these methods have been standardized by field plot trials. Hence more accurate fertilizer recommendations can be made.

To be certain that the soil test report will be available when needed, the farmer should send the soil sample to the laboratory well ahead of the date he expects to order his fertilizer.

TESTING MUCK SOILS

In 1958 an extensive program of soil test evaluation was carried out on the Bradford Marsh. Several chemical methods for extracting phosphorus and potassium were used.

The field plots used to determine fertilizer response on soils of different test value were located on ten privately-owned farms on the marsh. The indicator crop was potatoes.

The use of 0.1 N. ammonium acetate for extraction of potassium gave the best correlation with response to application of potassium fertilizer. In general, if the soil test was greater than 450 lb. of K₂O per acre, there was no response to fertilizer.

Several solutions, i.e., .01 N. hydrochloric acid, .0135 N. hydrochloric acid, and 0.05 N. ammonium fluoride plus one N. hydrochloric acid, were used for phosphorus extraction. None of these extractants gave test values that correlated with yield increases due to fertilizers.

One of the difficulties with this type of investigation is that most of the soils on the marsh are already high in fertility due to heavy fertilization during the past years. Indeed on many fields the yield without any fertilizer was as high as the yield on the fertilized plots.

This raises an important question as to whether any soil testing should be done on muck soils that have been under cultivation for a long time except in special instances where some particular fertility problem is suspected.

SAMPLING

As on mineral soils, the sampling of muck soils to obtain a representative sample is an important problem. A sampling study in 1958 showed that at least ten and preferably twenty individual samples from an area are required in order to obtain a composite sample to represent that area.
DEVELOPMENTAL RESEARCH (FIELD DEMONSTRATIONS) AND SOIL ADVISORY PROGRAM

The ultimate value of an intensive basic and applied research program is realized when the results are interpreted and accepted by the farmer on his own farm. Therefore the Department of Soils has a co-ordinated program of field demonstrations (developmental research) as well as extension through addresses to farmer meetings, radio, and television broadcasts and press releases. In this work, the co-operation of the Extension Branch, Ontario Department of Agriculture is invaluable.

During 1958 assistance was given in establishing field demonstrations to show the proper use of fertilizer in crop production. Land judging competitions, the land use planning, and soil testing programs were continued to stimulate greater interest in good soil management and assist individual farmers with their particular problem in land use.
FERTILIZER TRIALS ON A FIELD BASIS

In 1958, field-scale fertilizer tests were established, with the cooperation of the Extension Branch, on Manitoulin Island. These tests were intended to show (1) the need for fertilizer on oats in this area, and (2) the need for adequate amounts of nitrogen in particular.

Four farms were included in these trials. The plots were one acre in size. Yields were determined by harvesting small samples from each plot and calculating the results on an acre basis.

Considering the average of the four farms, 25-30 lb. of N/acre, 25-35 lb. of P₂O₅/acre and 20-25 lb. of K₂O/acre were required for highest yields. The lowest yield without fertilizer was 36 bu. of oats/acre and highest yield was 102 bu/acre. In general on these four farms 200-300 lb. of 10-10-10 per acre was the best fertilizer for oats in 1958.

Ammonium nitrate fertilizer gave increases in yield both with and without phosphorus and potassium. Average increase in yield of oats was 11 bu/acre due to application of one bag (80 lb) of ammonium nitrate.

Field trials such as these are very useful in extending and supporting the results from small field plots as described previously. Plans are underway to obtain similar information from other Counties and Districts.

LAND JUDGING IN ONTARIO

There is an increasing interest on the part of many young people on the farms today in the study of land and soil. At least this is what one would conclude from the general increase in numbers of land judging competitions in Ontario in the last four years. Land judging is similar in many respects to judging of livestock, grain or vegetables. Judging is done on the appearance and the feel of the soil.

All land has particular physical characteristics or features which can be recognized and can be used to evaluate the capabilities and limitations of a particular piece of land. Some of the physical properties are advantages or assets while others are liabilities. In land judging, we attempt to recognize the inherent qualities of the soils and the land, in order that we may take advantage of the good qualities of the soil and carry out practices that improve or overcome the poor qualities of the soil. The particular management practices that are of greatest use on any particular farm are largely determined by the way that Mother Nature made the land.

Some of the soil and land characteristics, such as tilth, can be changed by management, while others such as slope or texture cannot be changed. It is important that we recognize those characteristics that cannot be changed and then arrange our farming program to make the best use of the land as it is. Herein lies the basic reason for land judging. Land judging is one of the most effective means of teaching the fundamentals of proper land use.
There are many kinds of soil in the Province of Ontario. The same kind of soil may occur under many different conditions of slope, erosion, stoniness, and so forth. Only a skilled soil surveyor can identify all the individual soils, but it is not difficult to learn enough about soils and land to place it in its proper use capability class. It is necessary that we look below the surface at the soil profile and the subsoil layers, as well as at the slope, stoniness etc., in order that we may make an accurate estimate of its land use capability class.

Land judging competitions stimulate interest in problems of soil management and crop production.

The important features about the soil that we look for in land judging are indicated on the land judging score card which has been developed by the Department of Soils at the Ontario Agricultural College. The features of texture, organic matter, drainage, stoniness, slope and erosion, are all given a rating in judging land. These ratings lead eventually to a land use capability rating which indicates the productivity and the versatility of that particular area of land.

The actual organization of land judging competitions varies from County to County. Usually the morning is used for instructional work on the characteristics to look for in judging land. All contestants are taken on a tour in the general area of the competition and shown different soils and different land capability classes. This provides them with some basis for making their judgments on the land areas selected for the competition. The judging competition itself is held on an individual farm. Usually four pits are used. The contestants are required to rate the land on the basis of the characteristics that they can see in the profiles of the pits as well as on the surface features of slope, stoniness, and erosion. After judging is completed, each contestant is required to give reasons for his placings of the different land areas into land capability classes.

Land judging competitions have been held in Peel, Oxford, Lennoxx, Addington, Ontario, York, Middlesex, Halton, and Waterloo Counties. In 1958 a total of six counties held land judging
competitions. Since 1955 more than three hundred contestants between the ages of 13 and 29 have participated in one or more of these competitions. In addition to the number who actually competed, there were over two hundred farmers who visited the area on the competition day, and heard discussions on land use and soil management for the area. It is hoped that these land judging competitions will continue to increase in number. They are proving to be a very useful means of bringing before the farmers, particularly the young farmers, the need for good soil management and soil conservation practices.

**LAND USE PLANNING**

Even though a farmer may recognize that he has some soil management problems such as low fertility or erosion or stoniness, etc., he often needs some advice in regard to improving his land use program. For these farmers the Department of Soils, with the co-operation of the Extension Branch of the Ontario Department of Agriculture, provides a land use planning service to farmers.

Personnel of the Department of Soils are available, on request, for consultation on individual farms and to make suggestions in regard to fertility maintenance, crop rotations, erosion control, drainage, stone removal, field re-arrangement, pasture management. If required, a land use guide is prepared for the farmer outlining land use plans for a four or five year period. Farmers who wish to make use of this service should make application to their Agricultural Representative.

**TABLE 7**

FARMS PLANNED IN 1958 AND REQUESTS ON HAND 1 MARCH '59

<table>
<thead>
<tr>
<th>County</th>
<th>No.</th>
<th>Acreage</th>
<th>Requests</th>
<th>Acreage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brant</td>
<td>3</td>
<td>700</td>
<td>4</td>
<td>500</td>
</tr>
<tr>
<td>Bruce</td>
<td></td>
<td>0</td>
<td>1</td>
<td>240</td>
</tr>
<tr>
<td>Dufferin</td>
<td>2</td>
<td>250</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>Dundas</td>
<td>1</td>
<td>150</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Durham</td>
<td>1</td>
<td>165</td>
<td>1</td>
<td>400</td>
</tr>
<tr>
<td>Elgin</td>
<td>3</td>
<td>475</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frontenac</td>
<td>1</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grenville</td>
<td>2</td>
<td>400</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grey</td>
<td>26</td>
<td>4,150</td>
<td>7</td>
<td>1,475</td>
</tr>
<tr>
<td>Haldimand</td>
<td>1</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Halton</td>
<td>10</td>
<td>1,725</td>
<td>3</td>
<td>650</td>
</tr>
<tr>
<td>Hastings</td>
<td>1</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Huron</td>
<td>11</td>
<td>2,000</td>
<td>4</td>
<td>670</td>
</tr>
<tr>
<td>Lambton</td>
<td>1</td>
<td>275</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leeds</td>
<td>1</td>
<td>300</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lennox &amp; Addington</td>
<td></td>
<td></td>
<td>1</td>
<td>240</td>
</tr>
<tr>
<td>Lincoln</td>
<td>1</td>
<td>175</td>
<td>1</td>
<td>100</td>
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<tr>
<td>Middlesex</td>
<td>9</td>
<td>2,000</td>
<td>14</td>
<td>2,450</td>
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<tr>
<td>Norfolk</td>
<td>1</td>
<td>225</td>
<td>1</td>
<td>50</td>
</tr>
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</table>
LAND USE PLANNING - AN IMPORTANT PART OF FARM MANAGEMENT

Although the land use planning program has been of great value to the farmers involved, it is recognized that limitations in staff restrict the number of farmers who can receive such detailed attention. On many farms, in fact, relatively few changes in land use are required. In Bruce County, for example, from a total of 125 farmers (admittedly these were among the top 15 percent of the farmers) only a few required a detailed land use plan. This evaluation was made during 1958.

The Department co-operated with the Bruce County Farm Management Association in advising its 125 members in regard to land use on their farms. A soils specialist prepared a map of field boundaries for each farm as a basis for recording soil test results, crop yields, etc. Each farmer was encouraged to keep records of soil and crop information. Such information is valuable in planning the farm program for the future. For this purpose a revised Soil and Crop Record Book has been prepared by the Department of Soils and is now available from Agricultural Representative offices.

The general observations made from this work in Bruce County in 1958 are as follows:

(1) Approximately 10 percent of the group of 125 farmers required a detailed land use plan. The remainder required advice only on one or two items of soil and crop management.

(2) On these farms, advice was most commonly required in regard to drainage improvement, hay and pasture mixtures and fertility maintenance.

(3) Among this group of farmers -

38% had never obtained a soil test
37% had soils tested occasionally
25% had soils tested regularly.
SOILS AND CPOPS RECORD BOOK

The Department of Soils with the cooperation of the Extension Branch, Ontario Department of Agriculture has prepared a new Soils and Crops Record Book. This book is designed to help you to establish an inventory of the soil resources on your farm.

A farm classification and rating guide is an important feature of the book. This guide makes it easy to evaluate and classify your soils and land use problems. Space is also provided for your records of size of fields, crop sequences, weed control program, soil test recommendations, fertilizer and manure applications and drainage improvement.

Complete records of your soil and crop program from year to year allow you to analyze and study the results obtained from different treatments on your farm. This is the first step toward soil improvement.

The Soils and Crop Record Book is available at the local office of the Agricultural Representative.
FUNDAMENTAL (BASIC) RESEARCH

Part of the research conducted each year has no immediate and direct application on the farm. This basic research is intended to increase our understanding of soil-plant-atmosphere relationships. Of course, such research will eventually lead to new improved techniques in soil management.

Some of the fundamental research is discussed in this section to indicate the particular facets of soil science that are under detailed investigation in the Department of Soils.
SOIL SURVEYS AND SOIL MAPS

An inventory of the soils and land resources of Ontario is a necessary step in land use planning and for the interpretation of experimental results obtained from field plots. The Ontario Soil Survey is providing such an inventory.

Soil maps and reports giving the description of the soils in some detail have been published by the Ontario Soil Survey for 25 Counties and Districts.

Soil Map only (no report) - Elgin, Haldimand, Kent, Middlesex, Norfolk, Welland.

Soil Map and Report - Carleton, Northwestern Ontario (i.e. Rainy River clay plain, Dryden area, Thunder Bay area), Durham, Prince Edward, Essex, Grey, Huron, Dundas, Perth, Bruce, Grey, Peel, York, Stormont, New Liskeard - Englehart area, Lambton, Ontario, Glengarry, and Victoria.

Soil surveys of several other Counties are complete and maps and reports are being prepared for publication as follows:

<table>
<thead>
<tr>
<th>County</th>
<th>Status of Surveys</th>
<th>Tentative Date of Publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hastings</td>
<td>Map &amp; Report Prepared</td>
<td>1959</td>
</tr>
<tr>
<td>Simcoe</td>
<td>Map &amp; Report Prepared</td>
<td>1960</td>
</tr>
<tr>
<td>Manitoulin Island</td>
<td>Map &amp; Report Prepared</td>
<td>1959</td>
</tr>
<tr>
<td>Prescott</td>
<td>Field Survey Complete</td>
<td>Not prepared for publication</td>
</tr>
<tr>
<td>Russell</td>
<td>Field Survey Complete</td>
<td>Not prepared for publication</td>
</tr>
<tr>
<td>Lennox &amp; Addington</td>
<td>Field Survey Complete</td>
<td>Not prepared for publication</td>
</tr>
<tr>
<td>Wellington</td>
<td>Field Survey Complete</td>
<td>Not prepared for publication</td>
</tr>
<tr>
<td>Frontenac</td>
<td>Field Survey Complete except for one township</td>
<td>Not prepared for publication</td>
</tr>
<tr>
<td>Wentworth</td>
<td>Field Survey Complete</td>
<td>Not prepared for publication</td>
</tr>
</tbody>
</table>

Photostat copies of soil map only are available at the price of one dollar from the Department of Soils for the following Counties:

Halton, Brant, Waterloo, Peterboro (South), Northumberland, Lincoln, and part of Renfrew.

DETAILED SOIL SURVEYS

Detailed soil surveys have been carried out for several years on individual farms as requested by the farm owners for land use planning. In addition, a detailed soil survey and land use survey of Louth township was completed in 1957. Subsequently, there have been requests from a number of areas for detailed soil surveys. Detailed soil surveys however are very time consuming, if the survey is made entirely on the basis of field observations. Detailed surveys involve traverses across all farms in the area, examining the soil at regular intervals. In 1958 a study was made of the use of aerial photographs as a means of increasing the rate that detailed surveys could be made. The township of Middleton in Norfolk County was chosen as a study area. Aerial photographs on a scale of 4" to 1 mile and on a scale of 3" to 1 mile were examined carefully with a stereoscope and attempts were made to correlate the features of the photograph with actual soil differences. The soil boundaries located by examination of the photographs were then checked by field observation. The general conclusions from this pilot study were as follows:
(1) The characteristics of different soils as they appear on the aerial photograph are modified by crop cover which in turn depend on the time of year at which the aerial photographs were made.

(2) The colour tones on the aerial photographs vary from one photograph to another because of differences in the printing process.

(3) It was not possible to determine the boundaries between well drained, imperfectly drained, and poorly drained soils with accuracy on the basis of the characteristics seen on the aerial photographs.

(4) It seems certain that detailed soil surveys cannot be made using aerial photographs alone. On the other hand, aerial photographs can be of some value in conjunction with field examination in the area. It is possible therefore to increase the area that can be surveyed in any given field season through the use of aerial photographs. However, aerial photographs cannot be used in Ontario for detailed surveys without a fairly large amount of field checking.

**FERTILIZER PLACEMENT FOR SUGAR BEETS**

It has been known for a long time that proper placement of fertilizer is important in order to obtain maximum efficiency of use by crops. This is especially true for phosphate fertilizer. More information is required on placement of fertilizer for sugar beets or other root crops. When the sugar beet seed germinates, the tap root grows directly downward without branching. When the plants are 6 to 8 weeks old, lateral roots begin to appear in two rows on the opposite sides of the tap root. Eventually these lateral roots form in large numbers in the top six to twelve inches of soil.

A study on fertilizer placement for sugar beets was conducted in the greenhouse. The uptake of phosphorus by sugar beet seedlings from fertilizer placed in different positions was measured.

The results so far indicate that:

(1) phosphorus uptake by sugarbeets from fertilizer placed one and one-half inches directly below the seed was the same as from fertilizer placed at the same depth but one inch to the side of the seed.

(2) fertilizer placed four inches below seed and one inch to side was no better than the plow-down application unless nitrogen was also placed in the band with the phosphorus.

(3) band application of fertilizer was generally superior to broadcast or ploughdown application, particularly when the fertilizer contained nitrogen as well as phosphorus.

**RELEASE AND FIXATION OF POTASSIUM BY SOILS**

Potassium in soil exists in available form and also non-available form. Furthermore, there is evidence that the available potassium is in equilibrium with the non-available form.

Soils differ in the amount of available, i.e. water-soluble and exchangeable potassium in the soil at any one time and also in the rate at which non-available potassium becomes available when the available supply is depleted by cropping.
Equilibrium Level of Exchangeable Potassium:

Preliminary studies here indicated that the amount of exchangeable potassium in soil tends toward a constant value. If the amount of exchangeable potassium is increased by fertilization or depleted by cropping, some exchangeable potassium will become fixed or released when the soil is dried.

In 1958, the exchangeable potassium content of 180 soil samples was determined on field moist soil, air-dry soil, and oven-dry soil. Drying of the soils increased or decreased the measured exchangeable potassium. Calculation showed however that soils having a potassium saturation of the cation exchange complex of 1.16% neither fixed nor released exchangeable potassium upon being dried. In other words, the equilibrium level of exchangeable potassium was a function of the cation exchange capacity.

SOIL TEMPERATURE AND NUTRIENT SUPPLY

In 1958, a greenhouse study was carried out to evaluate the effect of soil temperature on uptake of phosphorus and nitrogen. Corn seedlings were used to measure availability of phosphorus in soil or resin media. Nitrogen was supplied in ammonia form or in the nitrate form.

It was found that

(1) the uptake of phosphorus as measured by radioactive tracer technique was least when all of the nitrate was supplied as ammonia.

(2) the difference in uptake of phosphorus in presence of ammonia nitrogen compared to nitrate nitrogen was greater at low soil temperatures than at high temperatures. At the higher temperatures, of course, the ammonia would be converted relatively quickly to nitrate form.

EFFECT OF MANURE ON MANGANESE AVAILABILITY

Preliminary studies have indicated that water extracts of farmyard manure increase the amount of manganese released by soil.

A water extract of manure was adjusted to pH 6.5 and mixed with soil. Soybeans grown in the greenhouse absorbed more manganese from the treated soil than from a similar untreated soil.

The colloidal material in the water extract was fractionated by lowering the pH until a heavy precipitate formed. The precipitate and the supernatant suspension obtained were mixed with different samples of the same soil. When soybeans were transplanted in the soils, the plants in the soil treated with the supernatant suspension died almost immediately. The plants in the soil treated with the precipitate absorbed more manganese than the plants in the soil treated with the unfractonated extract.

Analysis of the soils 96 days after treatment showed that the soil treated with the whole extract contained about one p. p. m. of exchangeable plus water-soluble manganese. At the same time the soils treated with the precipitate contained over two p. p. m. and the soil treated with the supernatant suspension contained 45 p. p. m. of exchangeable plus water-soluble manganese.
EFFECT OF CALCIUM, pH AND CHLORIDE ON YIELD OF ALFALFA

Alfalfa was grown in the greenhouse on Oneida clay loam soil that had been treated with calcium carbonate or calcium chloride. The calcium carbonate was mixed with the soil at the rate of 1000, 3000, 9000, and 27,000 lb. per acre; calcium chloride was mixed with the soil at 300, 900, 2700, and 8100 lb/ac. Six crops of alfalfa were harvested and chemically analyzed.

It was found that:

(1) Calcium chloride at the rate of 8100 lb/ac. prevented germination of the alfalfa seeds.

(2) Calcium carbonate at 1000 lb/ac. increased alfalfa yields but calcium chloride at 1,410 lb/ac. (supplying the same amount of calcium) caused a decrease in yield compared to untreated soil.

(3) Lime (calcium carbonate) increased yield because it caused a decrease in acidity. The increased supply of calcium due to lime treatment was not a factor in increasing yield.

(4) There was a high correlation between pH of the soil and the molybdenum content of the alfalfa tissue.

(5) Increased concentration of chloride in the soil by application of calcium chloride increased the uptake of potassium, calcium and phosphorus by the alfalfa plants.

THE EFFECT OF ARTIFICIAL COMPACTION TREATMENT ON SOME MOISTURE PROPERTIES OF SOILS

Field experiments were conducted to determine the moisture vs. time curves of the surface layers of two loam soils. The plots were saturated, covered to prevent evaporation, and sampled daily for a period of two weeks.

The objective was to test two hypotheses: (i) that artificially compacting a soil would result in an increase in the volume of water retained by the soil, and (ii) the net effect of an improvement in soil structure combined with an increase in organic matter would be a decrease in the moisture held by the soil.

Three significantly different levels of compaction were achieved: 1.18, 1.25, and 1.35 gm. per c.c. An analysis of the data expressed as inches of water per 3-inch depth of soil, showed that: (i) the volume of water retained by the soil increased as compaction increased, and (ii) there was no point on the moisture vs. time curve that could be designated as field capacity - the linear effect was significant. Partial desorption curves of cores of the soil showed that as compaction was increased the volume of pores that was drained up to a tension of 60 cm. of water decreased.

Four plots were selected where previous cropping practices had resulted in: (i) differences in soil structure as indicated by partial desorption curves, and (ii) different levels of soil organic matter. The moisture vs. time curve was linear; no point could be designated as field capacity. The volume of water retained by a soil depended upon the cropping practice: sod annually oats in rotation corn annually corn in rotation.
AGROMETEOROLOGICAL STUDIES

WATER BALANCE OF GUELPH LOAM

For the fourth year components of the water balance were evaluated at the Hydrologic Station. The rate of evapotranspiration from a corn crop also was continuously recorded in Puslinch Field. It is believed this is the first time in Canada that continuous recordings of the evapotranspiration from a corn field have been made.

Table 8 shows that there can be a sizeable change in the various water balance components from year to year. Also shown are estimates of potential evapotranspiration according to the methods of Penman and Thornthwaite. The seasonal values shown are daily values totalized. It seems that Thornthwaite's method particularly underestimates evapotranspiration under cool conditions. For example, in June 1958, in which temperatures were much below normal, the measured evapotranspiration was 5.1 in., Penman's estimate was 5.2 in., and Thornthwaite's estimate was 3.4 in.

The reasonable agreement on seasonal totals obscures the unreliability of the estimates of potential evapotranspiration for periods of a few days. A detailed study of the methods for estimating evapotranspiration is proceeding and will be published elsewhere.

Table 8

<table>
<thead>
<tr>
<th>Water Balance Components at Puslinch Field</th>
<th>1958</th>
<th>1957</th>
<th>1956</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precipitation</td>
<td>25.4</td>
<td>35.5</td>
<td>29.1</td>
</tr>
<tr>
<td>Runoff (continuous corn plot)</td>
<td>0.5</td>
<td>0.5</td>
<td>2.9</td>
</tr>
<tr>
<td>Percolation</td>
<td>1.5</td>
<td>7.3</td>
<td>10.4</td>
</tr>
<tr>
<td>Potential Evapotranspiration (PE)</td>
<td>21.7</td>
<td>20.7</td>
<td>17.4</td>
</tr>
<tr>
<td>Penman Estimate of PE</td>
<td>19.3</td>
<td>22.1</td>
<td>15.0</td>
</tr>
<tr>
<td>Thornthwaite estimate of PE</td>
<td>17.1</td>
<td>18.5</td>
<td>15.4</td>
</tr>
<tr>
<td>Class A Pan Evaporation</td>
<td>16.3</td>
<td>23.5</td>
<td>23.5</td>
</tr>
<tr>
<td>Sunken Screened Pan Evaporation</td>
<td>14.9</td>
<td>11.7</td>
<td>13.5</td>
</tr>
</tbody>
</table>

Note that precipitation, runoff, and percolation are annual values and the others are for the period May 22 to October 10 in 1957 and 1958 and for the period June 3 to September 26 in 1956.
During 1958 the energy balance or heat budget of a two-acre corn plot was determined at several stages in its development. The main objective was to see if the corn plant had any active control of the evapotranspiration from a corn field or if the changes in evapotranspiration obtained through a season are due only to changes in the physical environment of the crop. A secondary objective was to evaluate the effect of the crop cover on the major energy-balance terms, including the evapotranspiration, so that estimates could be made without the need for measurement. Measurements were made of the incoming solar radiation, the reflected solar radiation, the net radiation (Rn), the evapotranspiration directly by means of a floating lysimeter (Elys), the soil heat flux (S), and height-differences of temperature (ΔT), and vapour pressure (Δe) above the crop. The evapotranspiration was calculated by the Bowen rlation method as indicated in the following equation: \[ E = \frac{Rn - S}{1 + \frac{\Delta T}{\Delta e}} \] were determined with a reversing psychrometer lift which eliminated systematic measuring errors and which moved over a horizontal traverse of about four meters continuously to give a better spatial sampling.

There was an increase in the percentage reflected solar radiation with increases in the ground covered with vegetation. The change was from about 10 percent reflected with almost bare soil to 17 percent reflected when the ground cover was above 70 percent.

The soil heat flux was relatively constant for daylight hours through the season at an average of 23 cal/sq.cm./day. For 24-hour periods the soil heat flux was less than one percent of the net radiation.

The percentage net radiation used for evapotranspiration was generally in the range of 80 to 90 percent on a daylight day basis. For a 24-hr. day the percentage would be closer to 100 percent. With a dry soil surface or frozen corn, the ratio E/Rn dropped to about 0.6. Ratios greater than 1.0 were found when the plot was irrigated and surrounding fields were relatively dry.

It seems that as long as the soil surface is moist the amount of available energy (Rn-S) being used for evapotranspiration is nearly constant throughout the whole development of the corn crop. The stage of crop development seemed to have little effect on the evapotranspiration relative to the energy available. The relationship \( Rn - E = 1.0 \pm 0.5 \text{ mm.} \) of water/day held for daylight hours with 90 percent confidence as long as the soil surface was moist and surrounding fields were relatively of the same moisture. Under the normal weather conditions experienced in Ontario the dryness of the soil surface would have a much greater effect on the percentage of the available energy used for evapotranspiration.
PUBLICATIONS

Publications issued from the Department of Soils during 1958 are listed below.

REPRINTS OF TECHNICAL PAPERS


THESES

During 1958 five students completed the requirements for the M.S.A. degree in the Department of soils and presented the theses listed below:


2. Logsdail, D. E. - The effects of freezing and thawing on the physical properties of Haldimand clay, April, 1958.


BULLETINS AND CIRCULARS

<table>
<thead>
<tr>
<th>Circular</th>
<th>Category</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>Fertilizers</td>
<td>Intertilled Crops revised 1958</td>
</tr>
<tr>
<td>301</td>
<td>Fertilizers</td>
<td>Potatoes on Mineral Soils April 1958</td>
</tr>
<tr>
<td>302</td>
<td>Fertilizers</td>
<td>Vegetable Crops on Organic Soils Apr. 1958</td>
</tr>
<tr>
<td>303</td>
<td>Fertilizers</td>
<td>Fruit Crops, August 1957</td>
</tr>
<tr>
<td>304</td>
<td>Fertilizers</td>
<td>Cereals, Hay, and Pasture Crops Feb. 1959</td>
</tr>
<tr>
<td>305</td>
<td>Fertilizers</td>
<td>Tobacco December 1958</td>
</tr>
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<td>325</td>
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</table>

Circulars 300 - 306 are prepared by Advisory Fertilizer Board for Ontario.