A Bibliography of Scientific Publications Based on Long-Term Crop Rotation Studies in the Canadian Prairies
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Summary
Field Experiments conducted over the past 100 years in the Canadian Prairie provinces have resulted in voluminous agronomic knowledge that has propelled Canada to become a major exporter of agricultural products. Hundreds of scientific publications have been produced and this knowledge is now being used to address emerging issues such as climate change, sustainable cropping systems, carbon sequestration, nutrient cycling and water use efficiency. The objective of this paper was to create an aggregated bibliography for long-term crop rotation studies in the Canadian Prairies with the intention of facilitating the research which is and will be conducted by present and future generations. Of the numerous types of long-term studies that have been conducted, we have restricted this treatise to include only experiments that dealt with crop rotations and were conducted for a minimum of 20 years. The aggregated bibliography with 24 subject areas covers 13 crop rotation experiments at 6 research sites in the Canadian Prairies. This involved collaboration of individuals at specific locations and knowledge expertise to sort the publications. Overall, this effort is a very simple example of what needs to be done to create and maintain this body of scientific literature. In addition to a static version, a searchable version of the aggregated bibliography has been developed which will make it easier to access the information and permit multiple ways of exploring the data and findings. This will add value to the aggregated bibliography and make it globally accessible.

Introduction
The challenge of agriculture is to provide sufficient safe and nutritious food and fibre products to meet the needs of an ever increasing world population within the constraints and demands imposed by the soil resources, weather conditions, consumer preferences, and international markets. This has to be accomplished under the umbrella of sustainable development defined by Brundtland¹ (1987) as: “economic growth that meets the needs of the present without compromising the ability of future generations to meet their own needs”.

To achieve these goals, Canada’s agronomists have, over the years, conducted numerous long-term field experiments, many of which are still ongoing while others have been discontinued². These experiments have been mainly conducted in the Prairie provinces, and they were designed to answer numerous questions that are important to the scientific community, to producers, the agricultural industry, to policy makers, and to society as a whole. Many of these studies are crop rotation, tillage, fertilizer, herbicide, and animal manure experiments that were designed to measure changes in such variables as crop production and produce quality, economic viability and risk assessment, energy use efficiency, water and nutrient use efficiency, crop pests, biodiversity, and soil, water, and air quality²,³.

Hundreds of scientific publications, describing the many findings emanating from these studies, pervade the pages of numerous scientific journals throughout the world literature. A few of the scientists that have participated in these very valuable studies thought it might be useful and appreciated by the scientific community and policy makers if we could summarize and bring together a list of these publications in one place as a Bibliography, both as a PDF (static) form, and as a searchable database. Of the numerous types of long-term studies that have been conducted, we have restricted this treatise to include only experiments that dealt with crop rotations and were conducted for a minimum of 20 years.
Materials and Methods:
First, the long-term crop rotations in the Canadian Prairies were identified and notated (Fig. 1, Table 1). Detailed descriptions of the crop rotations are presented in separate chapters in this volume of the Prairie Crops and Soil Journal. In order to develop an aggregated bibliography, a list of major subject areas was first developed and publications for the site/crop rotations were compiled into 24 major subject areas (Table 2). The primary refereed scientific publications were separated from other publications (e.g., reviews, book chapters, etc.). In order to prepare an online-searchable version of the bibliography, each citation was appended with the acronym for specific site/crop rotation (Table 3).

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Table 1. Notations used to designate crop rotation study sites

<table>
<thead>
<tr>
<th>Notation</th>
<th>Site and Study</th>
<th>Duration of Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bret-AER</td>
<td>Breton Agroecological Rotation</td>
<td>1980 -</td>
</tr>
<tr>
<td>Bret-Class Rot</td>
<td>Breton Classical Rotation</td>
<td>1930 -</td>
</tr>
<tr>
<td>IH-Rot</td>
<td>Indian Head Rotation</td>
<td>1957 -</td>
</tr>
<tr>
<td>Leth-Rot 120</td>
<td>Lethbridge Rotation 120</td>
<td>1951 -</td>
</tr>
<tr>
<td>Leth-Rot ABC</td>
<td>Lethbridge Dryland Rotation</td>
<td>1911 -</td>
</tr>
<tr>
<td>Leth-Rot Chemist</td>
<td>Lethbridge Chemist plots</td>
<td>1911 -</td>
</tr>
<tr>
<td>Leth-Rot U</td>
<td>Lethbridge Irrigated Rotation</td>
<td>1911 -</td>
</tr>
<tr>
<td>Leth-Till POW</td>
<td>Lethbridge Tillage on POW</td>
<td>1955 - 1997</td>
</tr>
<tr>
<td>Mel-Rot</td>
<td>Melfort Rotation</td>
<td>1957 - 1994</td>
</tr>
<tr>
<td>SC-New Rot</td>
<td>Swift Current New Rotation</td>
<td>1987 -</td>
</tr>
<tr>
<td>SC-Old Rot</td>
<td>Swift Current Old Rotation</td>
<td>1966 -</td>
</tr>
<tr>
<td>SC-OMC Till</td>
<td>Swift Current Tillage</td>
<td>1982 -</td>
</tr>
<tr>
<td>Sco-Rot</td>
<td>Scott Rotation</td>
<td>1964 -</td>
</tr>
</tbody>
</table>
Table 2. Subject areas used to aggregate scientific publications for crop rotation studies in the Canadian Prairies

<table>
<thead>
<tr>
<th>Code</th>
<th>Subject Area</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>Production (Yields) and Grain Quality (Protein)</td>
</tr>
<tr>
<td>B</td>
<td>Nitrogen Disposition in Plant and Soil</td>
</tr>
<tr>
<td>C</td>
<td>Nitrate Leached</td>
</tr>
<tr>
<td>D</td>
<td>Phosphorus Disposition in Plant and Soil</td>
</tr>
<tr>
<td>E</td>
<td>Phosphorus Leached</td>
</tr>
<tr>
<td>F</td>
<td>Soil Biological and Biochemical Properties</td>
</tr>
<tr>
<td>G</td>
<td>Soil Organic Matter (Fertility Perspective)</td>
</tr>
<tr>
<td>H</td>
<td>Soil Quality</td>
</tr>
<tr>
<td>I</td>
<td>Soil Physical Properties</td>
</tr>
<tr>
<td>J</td>
<td>Soil Moisture</td>
</tr>
<tr>
<td>K</td>
<td>Economics</td>
</tr>
<tr>
<td>L</td>
<td>Energy</td>
</tr>
<tr>
<td>M</td>
<td>Disease</td>
</tr>
<tr>
<td>N</td>
<td>Greenhouse Gases</td>
</tr>
<tr>
<td>O</td>
<td>Carbon Sequestration</td>
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<tr>
<td>P</td>
<td>Legume Green Manure</td>
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<tr>
<td>Q</td>
<td>Sustainable Agriculture</td>
</tr>
<tr>
<td>R</td>
<td>Modelling</td>
</tr>
<tr>
<td>S</td>
<td>Salinity</td>
</tr>
<tr>
<td>T</td>
<td>Trace Elements</td>
</tr>
<tr>
<td>U</td>
<td>Erosion</td>
</tr>
<tr>
<td>V</td>
<td>Irrigation</td>
</tr>
<tr>
<td>W</td>
<td>Soil Biota and Soil Micromorphology</td>
</tr>
<tr>
<td>X</td>
<td>Sulfur deficiency in Gray Luvisols</td>
</tr>
</tbody>
</table>

The data presented in Tables 1-3 were imported into spreadsheets to fix the format. Then these were imported into a MS-Access database. Specific queries were written in ColdFusion software to create a web-based interactive bibliography which is available at the following URL: [http://www.pedosphere.ca/CanEduRes/crop_rotations/bibliography.cfm](http://www.pedosphere.ca/CanEduRes/crop_rotations/bibliography.cfm).

Results:

Table 3. Scientific publications classified by subject areas with notations for crop rotation study sites.

A. Production (Yields) and Grain Quality (Protein):

Research Publications

**McAllister, R.E. 1934.** The effects of fertilizers on the yield and composition of crops from the wooded soils of Alberta. Scientific Agric. **14**: 249-256. [Bret-Class Rot]

**Wyatt, F.A. 1934.** The necessity for growing legumes on gray wooded soils. Scientific Agric. **14**: 327-335. [Bret-Class Rot]

**Wyatt, F.A. and Leahey, A. 1936.** Activated carbon as a fertilizer. Scientific Agric. **17**: 1-10. [Bret-Class Rot]

**Wyatt, F.A. 1945.** Fifteen years experiments on the gray wooded soils of Alberta. Scientific Agric. **25**: 626-635. [Bret-Class Rot]

Long-Term Studies


Other Scientific


B. Nitrogen Disposition in Plant and Soil:

Research Publications


Other Scientific


C. Nitrate Leached:

Research Publications


Other Scientific


D. Phosphorus Disposition in Plant and Soil:

Research Publications


Other Scientific


E. Phosphorus Leached:

Research Publications


F. Soil Biological and Biochemical Properties:

Research Publications


Other Scientific


G. Soil Organic Matter (Fertility Perspective):

Research Publications


Other Scientific


H. Soil Quality:

Research Publications


Other Scientific


I. Soil Physical Properties:

Research Publications


J. Soil Moisture:

Research Publications


K. Economics:

Research Publications


Other Scientific


L. Energy:

Research Publications


M. Disease:

Research Publications


N. Greenhouse Gases:

Research Publications


O. Carbon Sequestration:

Research Publications


Other Scientific


P. Legume Green Manure:

Research Publications


Q. Sustainable Agriculture:

Research Publications


Other Scientific


R. Modelling (SPAW, EPIC, ECOSYS, CENTURY, LEACHMN, HERMES, CAMPBELL, ICBM):

Research Publications


Other Scientific


S. Salinity

Research Publications


T. Trace elements

Research Publications


U. Erosion

Research Publications


Other Scientific


V. Irrigation

Research Publications


W. Soil Biota and Soil Micromorphology

Research Publications


X. Sulfur Deficiency in Gray Luvisols

Research Publications

Newton, J.D. 1931. Sulphur oxidation in Alberta soils and related experiments. Scientific Agric. 11: 612-622. [Bret-Class Rot]

Newton, J.D. 1936. The fertilizing value of sulphate in natural ‘alkali’ for gray wooded soils. Scientific Agric. 16: 241-244. [Bret-Class Rot]


Discussion

We have created an aggregated bibliography for long-term crop rotation studies in the Canadian Prairies with the intention of facilitating research which is and will be conducted by present and future generations. It has been our experience that it takes time to sort through voluminous literature to get appropriate literature citations. It is generally easier to access papers published in referred scientific journals compared to those in the grey literature, such as conference proceedings, technical and extension bulletins, abstracts and so on. The other daunting task faced by students, professional and scientists is the availability of citations for comparative or scientific analysis of a particular topic for a number of related research sites. In our case, we have produced an aggregated bibliography for 13 crop
rotation experiments at 6 research sites in the Canadian Prairies. This involved collaboration of individuals at specific locations and knowledge expertise to sort the publications. Overall, this effort is a very simple example of what has to be done to create and maintain literature being produced for different crop rotations studies at different locations.

In our case, we have also set out to develop a searchable, version of the aggregated bibliography by entering all the data into a database. The second step of this activity was to develop queries to make the data searchable through web pages. We built on our experience of creating a searchable version of the Canadian System of Soil Classification\(^7\), which is currently residing on the pedosphere.ca website\(^6\). The advantage of a searchable version of a classification book or a bibliography is the ease of accessing information and multiple ways of exploring the data. For example, if one wanted to see all the work done at the Breton Plots across 24 subject headings, one would have to pull the references from the print or e-version of this document. It is much easier through a query via the web. The other advantage is the ease of global access.

Chinn and Beldsoe\(^4\) undertook a project to develop a US LTER All-site bibliography for 18 LTER sites that make up the LTER Network and make it accessible through the internet. They encountered enormous problems in gathering the information because it was being stored differently at individual sites. They used a simple, well-behaved dataset to learn how to assemble, structure and store data for online access. They also noted that it was more difficult to gather online information. Consistency of database is a primary problem and much computer programming is needed to create uniformity. By 1996, LTERnet had 12,000 citations. During the first five months of 1996, there were 1420 searches per month and by the end of the September 1996, the total was 34,119\(^4\). The key point from the above study is cutting-edge technology brings new problems and demands resources. However, if the database is maintained, then the utility of the searchable version increases exponentially.

This bibliography focussed only on the primary refereed journal papers and on other research publications such as reviews and book chapters that have evolved from these long-term crop rotation experiments. These are no doubt invaluable, especially to the scientific community. However, we did not include graduate student theses and hundreds of technology transfer type articles and talks that emanated from these studies, which provided information in language designed to facilitate the understanding of our findings to producers, policy makers and agricultural industry personnel. Some may even argue that the latter aspect was even more important than the scientific writings. Unfortunately, space and practicality did not allow the inclusion of such information in this treatise. Readers requiring technology transfer type information are encouraged to contact the research establishments to unearth such material. Nevertheless we hope that this bibliography will serve to provide evidence that the tremendous amount of money, effort and time that has been expended on these studies have not been wasted; in fact, the knowledge generated from these studies is now being used to address emerging issues such as climate change, sustainable cropping systems, carbon sequestration, nutrient cycling and water use efficiency, many of which were not envisioned when the studies were first established.

As with any large data set compiled over many decades by many researchers, the findings presented in this bibliography will include some errors, misinterpretations, and oversimplifications. As research continues and understanding grows, these weaknesses are gradually corrected. For that reason, readers using this bibliography are steered to the most recent publications from a specific study, wherever possible. Further, they are encouraged to contact research personnel directly for current updates.
Table 4. Locations of crop rotation studies, names of research contacts and their respective institutions.

<table>
<thead>
<tr>
<th>Location</th>
<th>Research Contacts</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breton</td>
<td>Dr. Miles Dyck</td>
<td>Dept. Renewable Res., Univ. Alberta, Edmonton</td>
</tr>
<tr>
<td></td>
<td>Mr. Dick Puurveen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Jim Robertson</td>
<td></td>
</tr>
<tr>
<td>Indian Head</td>
<td>Dr. Guy Lafond</td>
<td>SPARC, AAFC*, Indian Head, SK</td>
</tr>
<tr>
<td>Lethbridge</td>
<td>Dr. Elwin Smith</td>
<td>LRC, AAFC, Lethbridge, AB</td>
</tr>
<tr>
<td></td>
<td>Dr. Henry Janzen</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Ben Ellert</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dr. Frank Larney</td>
<td></td>
</tr>
<tr>
<td>Melfort</td>
<td>Dr. Alan Moulin</td>
<td>BRC, AAFC, Brandon, MB</td>
</tr>
<tr>
<td>Scott &amp; Swift Current</td>
<td>Dr. Reynald Lemke</td>
<td>SRC, AAFC, Saskatoon, SK</td>
</tr>
<tr>
<td></td>
<td>Dr. Con Campbell</td>
<td>ECORC, AAFC, Ottawa, ON</td>
</tr>
</tbody>
</table>

*AAFC, Agriculture and Agri-food Canada

Intellectual property and copyright issues are important considerations. In our particular case, we have been given permission to create an online version of the aggregated bibliography from the management of the Prairie Soils and Crops Journal. This is most notable because permission from journal publishers is absolutely necessary in order to add value to the resource and make it globally accessible in alternate ways.

Acknowledgments
Ms. Erin Picard and Devon Worth, Agriculture and Agri-food Canada, Ottawa, for preparing the initial version of the bibliography and the diagram, respectively.

References
A long-term study was conducted at Lethbridge, Alberta, to determine the response of weed populations to various crop rotations and tillage treatments. Weed density and species composition differed with rotation, tillage, and date of sampling within years. Fewer weeds were found in winter wheat-fallow than continuous winter wheat, winter wheat-lentil, or winter wheat-canola rotations. A dense infestation of downy brome developed in the continuous winter wheat rotation. Crop Rotation Studies on the Canadian Prairies. Publ. 1841/E, Ottawa, ON. 131 p. Cardina, J., Regnier, E., and Harrison, K. 1991.