OTRF Project No.

OTRF Funded Research Project

☐ Interim Report ☒ Final Report

Title	**Quantification of soil loss from commercial sod production in Ontario**
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Graduate Student and Affiliation (if applicable)	Research Associate Dr. Irina Solntseva, Department of Plant Agriculture, University of Guelph.
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Executive Summary

Commercial sod production requires the removal of a certain amount of soil to ensure that the rhizomes stay knit together and that the roots stay moist until the sod is put down. However, there is concern over the net soil loss following years of continuous sod production, both through harvesting and through erosion during fallow periods. The purpose of this study was to determine if there is indeed net loss of mineral soil from sod farms throughout Ontario and how much. In addition, a detailed study of changes of soil quality parameters from fields with a long history of sod production, as well during one sod production cycle (from harvest to harvest) was performed. Study parameters included: organic matter content, water aggregate stability, ratio of humic acid to fulvic acids and structure of humic substances.

Two years of our research has revealed that some soil types are more susceptible to the erosion process on the basis of an integrative multi-parameter approach. Current findings show that soil loss due to water erosion is a concern while fields are fallow. Also, the amount of soil removed during harvesting is substantial and its magnitude varies from about 7 kg to 14 kg per square meter. This could result in a loss of 1 inch of soil every 9 years for a 2-year sod cycle, and sooner if the cycle is shortened. Results of detailed analysis of soil characteristics during the sod production cycle revealed differences in the quality of soils between established turf, fields that were post-harvest and/or fallow and fields with alternative crops. Specifically, fields with established sod had significantly more organic matter in the top 10 cm of soil than fallow or alternative crop fields and this difference was greater in sod crops that were 2 years old or more. However, a long-term effect of sod production, when compared to long-term agricultural fields, was a reduced A horizon suggesting that topsoil and organic matter were depleted over time (see Fig. 1-3). It is important to note, however, that this depletion of A horizon material is not a complete loss because the nature of sod harvesting allows high quality soil to be relocated to the final destination of the sod. This is preferable to loss as a result of erosion or other types of loss since the soil will improve in quality at the location where the sod is moved.

Studies conducted by our research group identified soil types that are possibly more vulnerable

to soil erosion. Vulnerability existed due to a combination of factors including soil texture (with sandier soils being less vulnerable), presence of organic matter and soil structure (see Table 2). Therefore, no one characteristic could predict erosion potential but a healthy combination of sandy soils, higher organic matter and subsequently higher aggregate stability led to a reduced potential for erosion. Additionally, physical factors of the field, such as slope, also played a role but would be more difficult to manage. Obtained data suggested that since some of the investigated soils require special attention, development of improved soil management practices should be a priority for sustainable and long lasting profitability of the sod production industry. However, to develop the best management practices for sustainable and profitable sod production, more research is vital.

Background

Turfgrass provides environmental benefits that include prevention of soil erosion, glare, noise and air pollution, and heat buildup in urban and suburban landscapes (Beard and Green, 1994), Although these benefits may be experienced at both the sod farms and in areas where the sod is eventually planted, it is often perceived that this may come at the expense of mining of soil as an unintended consequence of sod harvesting practices. In commercial sod production, conventional harvesting (by sod cutting) involves removing a layer of soil just below the thatch layer of the turfgrass, which could result in the permanent depletion of soil resources. A recent study conducted in Rhode Island (Millar et al., 2010) examined the loss of mineral soil specifically in sod production and suggests that losses are significant and could lead to unproductive soils over time. This contradicts a number of reports from trade organizations, government agencies, and other university researchers regarding soil losses from sod harvesting with studies suggesting that sod harvesting does not result in net soil loss (Sheard, and Van Patter,1978; Skogley and Hesseltine,1978; Turf Resource Center, 2009).

Upon examining the research conducted in the most recent study, it was recommended by our group that more data should be collected to determine the potential for soil loss, as well as the cause of any losses and that this research would benefit from a collaboration of both soil scientists and turfgrass scientists.

Objectives

Objective 1.
Determine changes in soil parameters in soils with a long history sod production versus soils under non-sod production.

Planned	Performed	Revealed
Select sites for research, collect samples	Three sod farms, two from the York Region and one from the Waterloo Region, were chosen and assessed based on production cycles to include established sod, fallow areas and fields to be seeded in 2010 season. In addition, fields not planted to sod with the same or similar soil type were chosen at each site.	Each farm contained 5-6 fields that were selected for a detailed examination and analysis

Classify obtained samples into soil types, subtypes and series for a better understanding of their formation and properties in order to compare their potential susceptibility for erosion Compare soil profiles from fields with different history of sod production	Eighty soil cores up to 1 m depth were collected from the fields with a long history of sod production and non-sod fields. Analysis of soil texture, pH of horizons and organic matter were done (Attachments Table 1)	1. Comparison of soil cores from the fields with a long history of sod production and fields under alternative crop production revealed reduced thickness of the most fertile soil horizon on the fields with long history of sod production. (Attachments Figs. 1-3) 2. Soils were categorized by their erosion susceptibility. Investigated soils fell into the following categories: 1.Highly susceptible, 2.Moderately susceptible, 3.Slightly susceptible 4. Very slightly susceptible. (Attachments Table 2) Soils of the two first groups should be used for long term sod production with caution.

Objective 2.
Determine potential and actual soil movement (deposition or loss) in sod fields with soils previously categorized by various levels of susceptibility to erosion in long term experiments.

Planned	Performed	Revealed
1. Analysis of field contours and field mapping for installation of catch basins. Real Time Kinematic (RTK) method was used	1. Topographic maps of each field obtained. (Attachments Fig. 4)	1.Critical points for ideal location of soil traps installation basins revealed. (Attachments Fig. 5)
2. Design and installation of sediment traps	2.Thirty individual sediment traps (ten in each farm) were constructed and installed (Attachments Figs. 6 and 7)	2.Installation revealed proper determination of trap location since collection of water erosion sediments from the sod fields was abundant
3. Monitoring and collection of soil sediments.	3.Samples of sediments were collected several times during the season 2011-2012: 1.Fall 2011 2. Snow melt 2012 3. Spring 2012 4. Summer 2012 5.Fall 2012	3.Compared data of total amount of collected sediments on the fields with different soil types in different stages of sod production cycle (fallow, 1 year old sod, 2 year old sod and non-sod fields). General tendency revealed (Attachments Tables 3 and 4)

	Total amount of the collected sediments recorded. (Attachments Fig.8)	
4. Monitoring lateral movement of soil using LiDar scanning technique	4.Two consecutive LiDar scans were conducted during the various stages of sod production (Attachments Fig.9)	4.Soil surface movement was revealed More information would require 2-3 additional scanning events during a whole production cycle period in order to determine changes from seeding to harvest

Objective 3.
Determine soil losses during harvesting

Planned	Performed	Revealed
1.Studying soil losses associated with harvesting	1.Obtained data of the amount of mineral material in harvested sod strips (sizes 10X10 cm) for each of the investigated farms by loss-on-ignition (LOI) method at 550^{o} C for four hours	1.Overall data showed that during each harvest, the removal of the mineral part of the soil is significant and its magnitude varies from about 7 -14 kg per square meter (Attachment Table 5)

Objective 4.
Studying of changes of soil organic matter in the long history sod production fields with comparison to non-sod fields

Planned	Performed	Revealed
1.Studying of soil organic matter (SOM) on long history sod production fields with comparison to non-sod fields	1.Obtained data of soil organic matter by loss-on-ignition (LOI) method at 550^{o} C for four hours	1. Comparative assessment of SOM on the fields with a long history of different agricultural practices (sod production versus alternative) revealed that SOM tends to be highest in fields that are sod covered. (Attachment Fig.10). Statistical analysis of averaged results obtained by LOI method did not show a significant difference in soil organic matter content between sod-covered fields and fields with alternate crops. It was confirmed statistically that bare fields have lower organic matter content.
2. Determination of water aggregate stability	2.The analysis of collected soil samples for aggregate stability by wet sieving was performed using an	2. The tendency of a positive effect of sod cover on water aggregate stability was revealed. In all studied soil type groups,

	Eijkelkamp wet sieving apparatus	water aggregate stability of soil was higher in the fields under first and second year of sod. In a bare soil situation water aggregate stability is significantly lower than even in non-sod fields. (Attachment Fig.11)

Objective 5: Determine dynamics of changes of soil organic matter and dry root mass at different stages of sod production cycle (newly seeded (<1 year prior) versus fields with sod more than 2 years old)

Planned	Performed	Revealed
1.Study the changes of soil organic matter (SOM) and dry root biomass during a sod production cycle	1. Soil samples for organic matter analysis were collected simultaneously with samples for root mass. Soil organic matter data obtained by loss-on-ignition (LOI) method at 550^{o} C for four hours. Collection of soil cores from the fields for root measurement was performed in May-June 2012 (8 samples per field). Soil was washed from roots over a 1mm sieve. Roots were dried at 60^{o}C until constant weight (approx 24-36 hours) and weighed	1. Data show that over time, both root mass and organic matter increase, although there is a seasonal root turnover in turfgrass species. There was an observable increase in soil organic matter content noticed on all fields that were 2 years old compare with newer fields (Attachment Table 6). A statistically significant increase of SOM content in old seeded fields (more than 2 years after seeding) against recently seeded sod fields (less than 1 year after seeding) was observed for all farms. Denser plant cover and root systems contribute to relatively stable soil carbon pools. Soil organic matter under bare soil conditions differs significantly from sod covered and non-sod fields.

Objective 6: Determine if there are changes in structure of soil organic matter on the fields with a long history of sod production and determine the dynamic of soil organic matter composition during sod production cycle by detailed chemical analysis

Planned	Performed	Revealed
1.Studying of changes in carbon ratio of humic and	1.Analysis of ratio in carbon content in humic and fulvic	1. Data showed significantly higher ratios in buffer zones

fulvic acids in different stages of sod production cycle from the fields and buffer zones.	acids performed using a carbon analyzer (Shimatdzu, model TOC 5050).	than in the fields under agricultural practices for all studied fields. The ratio of humic acid to fulvic acids was noticeably lower in recently seeded fields in comparison with 3 year old fields (Attachments Fig.12). This fact could indicate obvious differences in the chemical nature and functionality of fulvic and humic acids depending on the stages of sod production and practice. Amount of stable humic acid significantly rising toward the end of cycle could be favorable
2.Studying of changes in chemical composition of humic substances under a long history of sod production	2. Elemental analysis of humic and fulvic acids isolated from 3 groups of fields was performed: a) fields with long history of sod production b) newly developed sod fields and c) fields with non- sod production	2. Our data suggest the structure of humic substances in soils with a long history of sod production is different than that from non-sod soils. (Attachment, Table 7). More research is necessary to reveal what soil amendments and soil management practices could serve for better stabilization

Methods & Results	Include as much of the methodology and results to fully explain the goals and objectives of the project. Graphs, pictures, tables, etc are encouraged to easily relay the study's findings.
Please see above	

Goals for completion [Interim Report only]	Outline the goals and milestones left to complete the project. Will the original objectives be delivered as outlined in the project proposal?
N/A	

Conclusions [Final Report]	

1. Soils were categorized for susceptibility to erosion. Highly susceptible and moderately susceptible soils should be used for long-term sod production with caution.

2. Comparison of soil cores from the fields with a long history of sod production and fields under alternative crop production revealed reduced thickness of the most fertile soil horizon on the fields with a long history of sod production.

3. Removal of the mineral part of soil during harvesting was anywhere from from 10 to 14 kg/m^2

4. No statistically significant differences were revealed in soil organic matter content (SOM) and percentage of water stabile aggregates (WSA) between farms with a long history (about 50 years), younger sod production (20 years) and non-sod fields.

5. Changes in soil organic matter (SOM) were found to be related to the sod production cycle. SOM increased with sod maturity. During one production cycle an observable increase in soil organic matter content and root biomass was observed on all fields of 2 years old compared with newly seeded fields. Fields with non-sod crops and bare fields have lower SOM during the growing cycle. Water aggregate stability of soil in bare conditions is significantly lower thus making the soil more susceptible to loss by water erosion.

6. Data showed significantly higher ratios of humic acids (HA) to fulvic acids (FA) in buffer zones than in the fields under agricultural practices for all studied fields.

7. Comparative assessment changes of composition in soil organic matter within the one sod production cycle showed that ratio of HA/FA acquire favorable characteristics toward the end, significantly raising amount of stabile humic acid constitutes.

8. Small changes were detected in chemical structure of humic substances in soils with a long history of sod production in comparison to non-sod soils. Our results indicate that the sod management practices of these soils have contributed to the selective degradation of carbon chain structures and a possible relative enrichment in condensed aromatic ring structures. This fact could serve as a signal of potential (in long term) soil quality deterioration. More data is needed to determine the significance of these data.

On the basis of these findings we suggest the following recommendations:

1. If possible, avoid bare soil situations. Use cover crops where practical. Legume species (family Fabaceae) such as alfalfa, clover, lupins, or soybean are recommended.

2. Benefit could be achieved by the incorporation of plant biomass from cover crops following harvest into the top soil.

3. Perform crop rotations using the species listed above and avoid continuous crop monocultures.

4. Use all possible forms of biosolids and/or composts. It could help to sustain good soil

health.

5. Ensure that the sod production cycle is no less than 2 years, as is the current convention in Ontario. This will allow for a build-up of organic matter in the soil to counteract the removal of both organic and mineral soil at harvest.

6. Attempt to utilize harvesting equipment that removes the least amount of soil with the sod.

More research is necessary to reveal what soil amendments and soil management practice could serve better for stabilization of important constitutes of soil organic matter.

Graduate Student	Provide a brief update of the status of any graduate student involved on project.
N/A	

Project Expenses	Using the project budget in the proposal, report the approximate expenditure of each line item. Submission of proof of expenditures will normally not be required
Funds from the OTRF went primarily to supplement salaries for a research associate and research assistant (most of this cost was covered by Environment Canada). In addition, traps and catch basins were constructed to collect soil and water. Finally, a portion of the funds from OTRF went to cover transportation costs and the costs of scanning (RTK) and LiDar to accurately place traps on the fields.	

Project Communication	List all industry and academic presentations and submitted publications

1. Solntseva I. Where is your soil going? Oral presentation at Ontario Turfgrass Symposium, February 2012.

2. Jordan K., Solntseva I., Lyons E .and J. Holdenried. Examination of Soil Sustainability Following Long-Term Sod Production. Abstract and poster presentation on International Annual Meeting ASA, CSSA, and SSSA, Cincinnati, October, 2012: Visions for Sustainable Planet.

3. Solntseva I., Holdenried J., E. Lyons and Jordan K. Examination of Soil Sustainability Following Long-Term Sod Production. Submitted for Soil Science Society of America Journal. December, 2012.

4. Jordan K., Solntseva I. Presenting field experiment setting and research findings on a field tour for participants from Le Centre D'Expertise en Horticulture Ornementale Du Quebec (Quebec Centre for Expertise in Ornamental Horticulture) and Ontario sod growers

5. Solntseva I. Quantification of soil and nutrient loss from commercial sod production in Ontario. Turf News Magazine. Sod News. Submitted for publication, April 2012.

6. Jordan K. 2013. Quantification of soil loss from commercial sod production. TPI International Education and Field Day. San Antonio, Texas, February 2013

NOTE: Portions of this report will be posted on the OTRF website