OTRF Project No.

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ONTARIO TURFGRASS RESEARCH FOUNDATION

OTRF Funded Research Project

■ Interim Report ☐ Final Report

Title	Use of biosolids for fertility and improvement of soil health
Principle Researchers and Affiliation	Dr. Katerina Jordan
Graduate Student and Affiliation (if applicable)	
Date of Submission to OTRF	Re-submitted March 9, 2018
OTRF Funding Period	May 2017 to March 2020

Executive Summary	Summary of the entire report that includes the intended goal, a brief summary of the results and the conclusion. Interpret the results and explain how the research and results will benefit the turfgrass industry. It is intended to encourage the reader to further examine the full project report. The executive summary should be no more than ½ page in length and written in a manner appropriate for the target audience (generally non-scientific)

Sewage sludge is a product produced from municipal waste treatment and is composed primarily of dewatered microbial biomass from an anaerobic digester (Ivanov et al., 2004). Disposal of this by-product can be redirected from landfills and incinerators to use as an agricultural fertilizer, as long as it is devoid of heavy metals and other organic pollutants (Larsen et al., 1991). Composted biosolids improve soil fertility and structure while providing disease suppression for root and foliar pathogens (Darmody et al., 1983, Epstien et al., 1976, Hoitink and Boehm, 1999). Soil health is improved through the addition of organic matter, nutrients, and beneficial microorganisms. Biofertilizers have a high rate of nutrient mineralization that is sustained over several years (Darmody et al., 1983, Loschinkohl and Boehm, 2001). Using biosolids can help to reduce the need for fertilizers over time through the slow release of nutrients while increasing the organic matter content of the soil over time.

The objectives of this study are 1) to determine the potential for biosolids as a fertilizer source for turfgrass systems and 2) to assess how the addition of biosolids affects soil health over time. To achieve the first objective, a greenhouse study was conducted to determine the safety of biosolids as a fertilizer for establishment of different species of turfgrass. Two sources of bio-fertilizers were tested – one was an industry standard, Milorganite, while the other was a locally sourced biosolids product – Lystegro. These were compared to a slow-release inorganic fertilizer.

This study was followed by a field study to determine the potential for biosolids as a fertilizer source on two different stands of turfgrass – Kentucky bluegrass and a 3-way lawn species mixture (Kentucky bluegrass, perennial ryegrass and fine fescue). The second objective will be tested in years 2 and 3 of the study.

The results of the greenhouse study suggested that the biosolids products had no phytotoxic effects on turfgrass germination and establishment. However, the locally sourced biosolids products (whose nitrogen was obtained solely from waste material) did not perform as well as either the inorganic standard or the industry organic standard. That said, all ratings were above the minimum acceptable range for turfgrass quality.

For the field study, we compared the same three products, but varied the rate of nitrogen and the frequency of application. The results of this study were somewhat similar to the greenhouse study in that the turf grown with the locally sourced product was not of as high quality as those grown with the two industry standards (inorganic and organic), although the observed difference was primarily present at the lower rate of nitrogen application. It is important to note that the industry organic standard, Milorganite, had only 60% of its nitrogen sources from solid waste, while the other 40% was supplemented with a water-soluble source of N. This might suggest that the rate of nitrogen release may have accounted for the differences that were observed.

For the 2nd and 3rd years of the study, we will be incorporating a third biosolids product (also locally sourced) to determine if the reduced turfgrass quality was a result of the source of nitrogen (solid waste) or if it was the specific product that was chosen. A new turf area will be established at the Guelph Research Station for this study so that we can determine the products' effects on both establishment and maintenance over time. We will also be collecting data on soil health prior to treatment application (spring 2018) and in fall 2018, spring 2019, fall 2019 and, if time permits, spring 2020.

Background	Description of the rationale of the project including references to a literature review

Sewage sludge is a waste product produced from municipal water treatment and is composed primarily of dewatered microbial biomass from the anaerobic digester (Ivanov et al., 2004). Disposal of this bi-product can been redirected from landfills and incinerators to use as an agricultural fertilizer as long as it is devoid of heavy metals and other organic pollutants (Larsen et al., 1991). Further treatment of this waste product can inactivate harmful pathogens, stabilize the microbial communities present, and reduce the smell of the product (Larsen et al., 1991).

Composted biosolids improve soil fertility and structure while providing disease suppression for root and foliar pathogens (Darmody et al., 1983, Epstien et al., 1976, Hoitink and Boehm, 1999). Additions of biosolids to plants grown in the field can help to naturally supress disease infiltration by the addition and/or encouragement of antagonistic organisms. Soil health is improved through the addition of organic matter, nutrients, and beneficial microorganisms. Using biosolids can help to reduce the need for fertilizers over time through the slow release of nutrients while increasing the organic matter content of the soil over time.

Newly constructed sand-based rootzones have minimal microbial activity (Bigelow et al., 2002, Hoitink and Boehm, 1999). Within the first year of turfgrass establishment microbial communities are fragile and easily stressed in the summer months when temperatures are at their highest. Additions of composts and biofertilizers can help to provide a source of nutrition for antagonists of common soil pathogens (Hoitink and Boehm, 1999). Introducing a source of nutrition that can help to support beneficial microorganisms can reduce the incidence of disease in newly seeded turfgrass stands (Hoitink and Boehm, 1999).

Sustainable production of organic fertilizers from reclaimed human waste may help to reduce the need for inorganic fertilizers while also reducing the amount of waste sent to landfill from water treatment facilities (Darmody et al., 1983). Diversion of this waste stream can help to reduce the rate at which landfills are filled while providing an important commodity to growers. Although there are currently products available to turfgrass managers, opening up the market by providing research support for new products will help to grow this industry. Determining the suitability of locally sourced biofertilizers for use in non-food crops may help to expand this industry resulting in a greater proportion of municipal waste redirected from Ontario landfills. Improving the availability of biosolids products is beneficial to the turfgrass industry because this is an important step towards sustainability.

A locally-sourced liquid biosolids product was tested in 2016 at the Guelph Research Station for its potential as a source of nutrients for newly established turfgrass stands. The results from 2016 showed no significant difference between the liquid biosolids product and either the commercially available bio-fertilizer, or the inorganic fertilizer product. However, the liquid product required specialized farming equipment to apply it to a field and this could be problematic as most facilities with managed turfgrass do not possess this type of equipment. For the turfgrass industry it is important to create products that do not disrupt the functionality of the turfgrass space. In addition, application of the liquid fertilizer would likely disrupt play on a golf course due to the smell and the required method of application. Following the field trials in 2016, we suggested to the company whose product we tested that the development of a pelletized product would be more useful to the turfgrass industry.

The objectives of this study were to test two pelletized biosolids products – one locally sourced (Lystegro), and one that is currently an industry standard (Milorganite), against a slow-release form of inorganic fertilizer (Multicote) – for their potential as a source of nutrients on a turfgrass stand and for their potential to improve soil health over time.

References

Bigelow, C.A., D.C. Bowman, and A.G. Wollum. 2002. Characterization of soil microbial population dynamics in newly constructed sand-based rootzones. Crop Sci. 42(5): 1611-14.

Darmody, R.G., J.E. Foss, and M. McIntosh. 1983. Municipal sewage sludge compost-ammended soils: Some spatiotemporal treatment effects. J. Environ. Qual. 12: 231-6.

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Holtlnk, H.A.J., Y. Inbar, and M. J. Boehm. 1991. Status of compost-amended potting mixes naturally suppressive to soilborne diseases of floricultural crops. Plant Dis. 75(9) 869-73.

Hoitink, H.A.J. and M.J. Boehm. 1999. Biocontrol within the context of soil microbial communities: A substrate-dependent phenomenon. Annu. Rev. Phytopathology 37:427–446.

Ivanov, V.N., J.-Y. Wang, O.V. Stabnikova, S.T.-L. Tay, and J.-H. Tay. 2004. Microbiological monitoring in the biodegradation of sewage sludge and food waste. J. Appl. Microbio. 96: 641-7.

Larsen, A.B., F.H. Funch, and H.A. Hamilton. 1991. The use of fermentation sludge as a fertilizer in agriculture. Wat. Sci. Tech. 24(12): 33-42.

Loschinkohl, C., and M.J. Boehm. 2001. Composted biosolids incorporation improves turfgrass establishment on disturbed urban soil and reduces leaf rust severity. HortSci 36(4):790-4.

Objectives	Using the outline of expected deliverables from the project proposal indicate the completion or progress from each objective and milestone. Also indicate if objectives or milestones were revised and the reason for revision.

OBJECTIVE 1: Determine the potential for bio-solids as use as an alternative fertilizer either replacing or supplementing current conventional products in lawncare, sod production and on golf course turf (roughs and fairways).

Milestone: Following two years of studies, we will be able to determine the suitability of biosolids as a replacement or supplement for commonly used inorganic fertilizers. Proposed completion time: December 2018

OBJECTIVE 2: Determine the effect of prolonged use of biosolids on soil health in turfgrass rootzones, with emphasis on organic matter content, aggregate stability and microbial respiration.

Milestone: This portion of the study will be followed for a 2-year period and the results will lead to information about the effect that addition of biosolids has on 3 parameters of soil health: organic matter content, soil aggregate stability and soil microbial respiration. This will give turfgrass managers information on whether the use of biosolids over time can improve soil quality and subsequently improve plant growth.

Proposed completion time: March 2020

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.

Objective 1: Determine the potential for bio-solids as use as an alternative fertilizer either replacing or supplementing current conventional products in sod production and on mixed species turf (lawns and golf course roughs and fairways).

Greenhouse Phytotoxicity Studies

Two phytotoxicity studies were conducted in the greenhouse to determine if biosolids were safe and potentially useful as a fertilizer. One was on ornamental plants and the second was on a variety of species of turfgrass. Only the turfgrass data are presented for the purpose of this report.

The turfgrass experiment was started on October 4th, 2017 and concluded on November 29th, 2017. The amount of product applied was based on nitrogen rate, with each experimental unit receiving a total of 0.5 kg/100m2 during the course of the 8-week study. The plants were fertilized twice over the course of the experiment. Analysis of N, P, and K as well as amount of product applied with each fertilization are presented in Table 1. The turfgrass plants were rated for colour (Fig. 1), quality (Fig 2), and phytotoxicity (Fig. 3) per week on a 1 to 9 scale. The plants were also rated for percent cover (Fig 4). Photos were taken of the individual pots on November 15th, 2017 and November 29th, 2017. These photos were used to determine the percent covered area of each pot and these area data were compared to determine if there was a difference between covered area and fertilizer applied (Fig. 5). Soil from each pot in this experiment was set aside for electrical conductivity measurements. Analysis performed on these data showed no significant differences between the electrical conductivity measurements and the fertilizers applied. All data were analyzed using a repeated measures analysis which averages the values for a treatment over the course of the study.

Table 1: Fertilizer rates, nitrogen content, and weight of product applied per pot for phytotoxicity experiments. The total rate was split over two applications

Fertilizer	Analysis	Total rate (kg N/100 m^2)	Weight of product/ application/ pot (0.01 m^2)
Multicote 4	40-0-0	0.5	0.063
Milorganite	6-2-0	0.5	0.417
LysteGro	2.8-2.3-1	0.5	1.136

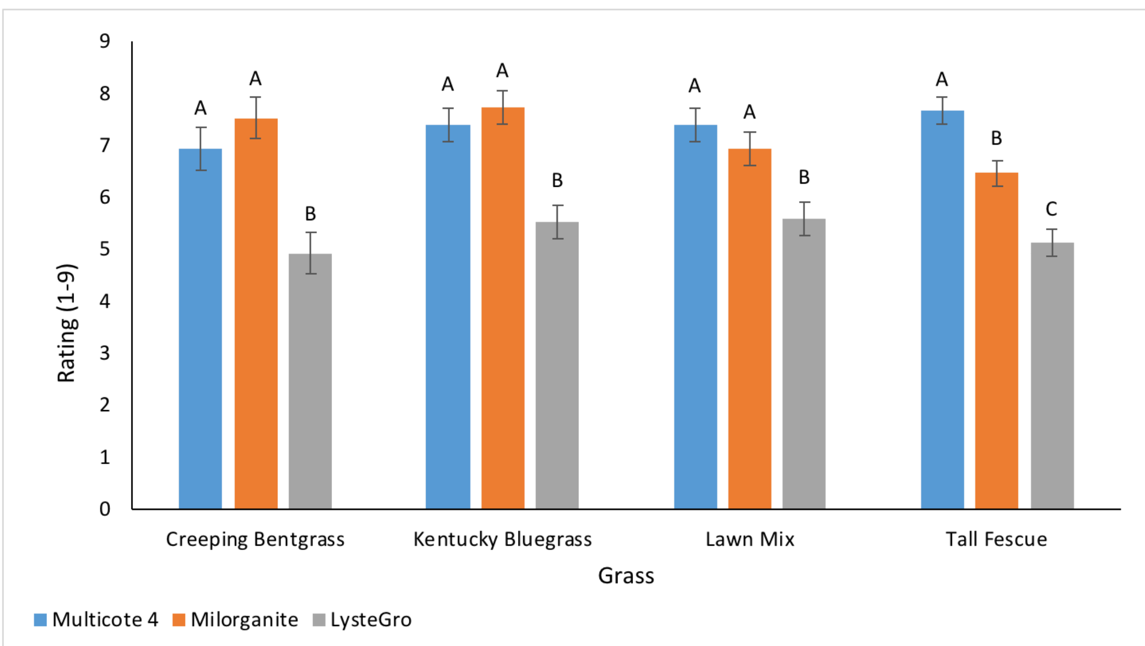

Figure 1: Mean visual rating of colour for plants from the greenhouse phytotoxicity study on turfgrass plants. Error bars represent the standard error of the mean, bars with the same letter are not significantly different; n=60. Visual colour ratings are based on the NTEP 1-9 rating scale, 9 = Ideal green colour for putting green turf, 1= poorest colour/yellow and dead putting green turf, 6 = minimum acceptable turf colour for a golf course putting green.

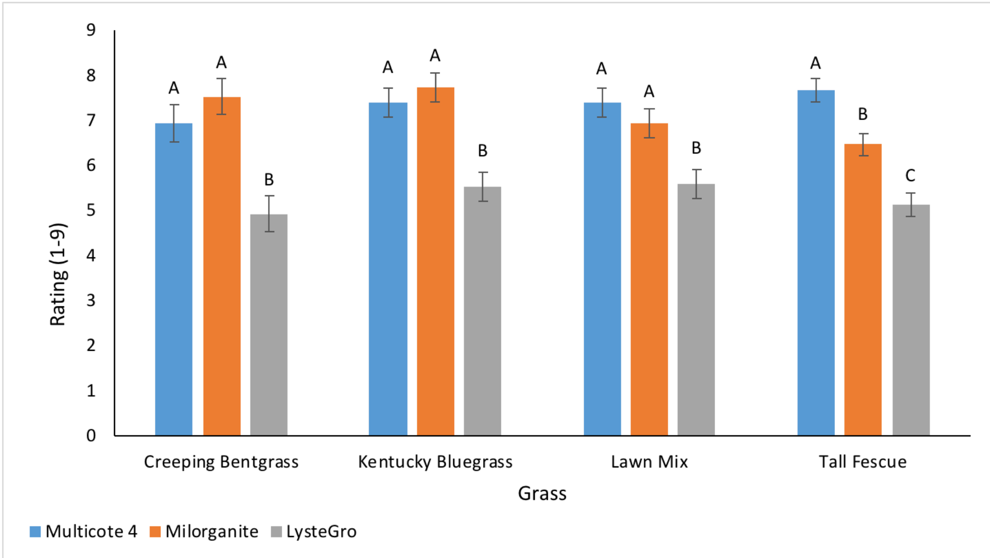

Figure 2: Mean visual rating of quality for plants from the greenhouse phytotoxicity study on turfgrass plants. Error bars represent the standard error of the mean, bars with the same letter are not significantly different; n=60. Visual quality ratings are based on the NTEP 1-9 rating scale, 9 = Ideal quality for putting green turf, 1= poorest quality and dead putting green turf, 6 = minimum acceptable quality for a golf course putting green.

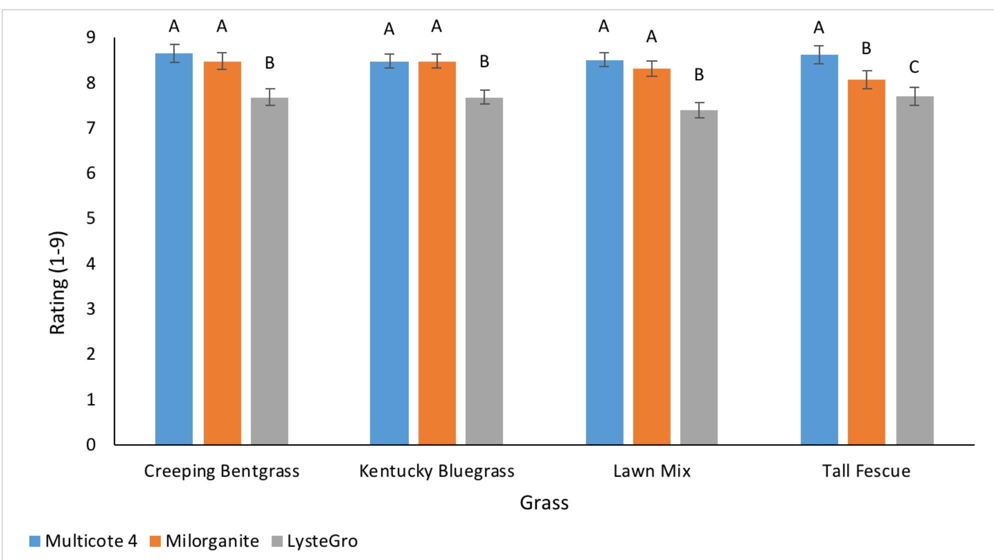

Figure 3: Mean visual rating of phytotoxicity for plants from the greenhouse phytotoxicity study on turfgrass plants. Error bars represent the standard error of the mean, bars with the same letter are not significantly different; n=60. Visual phytotoxicity ratings are based on the NTEP 1-9 rating scale, 9 = no phytotoxicity, 1= dead, 6 = minimum acceptable amount of phytotoxicity for a golf course putting green.

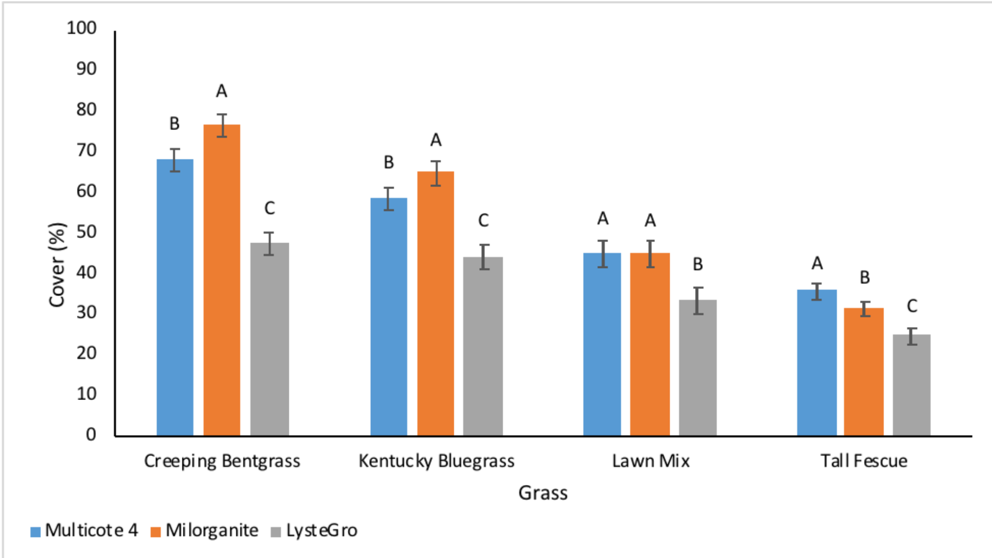

Figure 4: Mean visual rating of cover for plants from the greenhouse phytotoxicity study on turfgrass plants. Error bars represent the standard error of the mean, bars with the same letter are not significantly different; n=60.

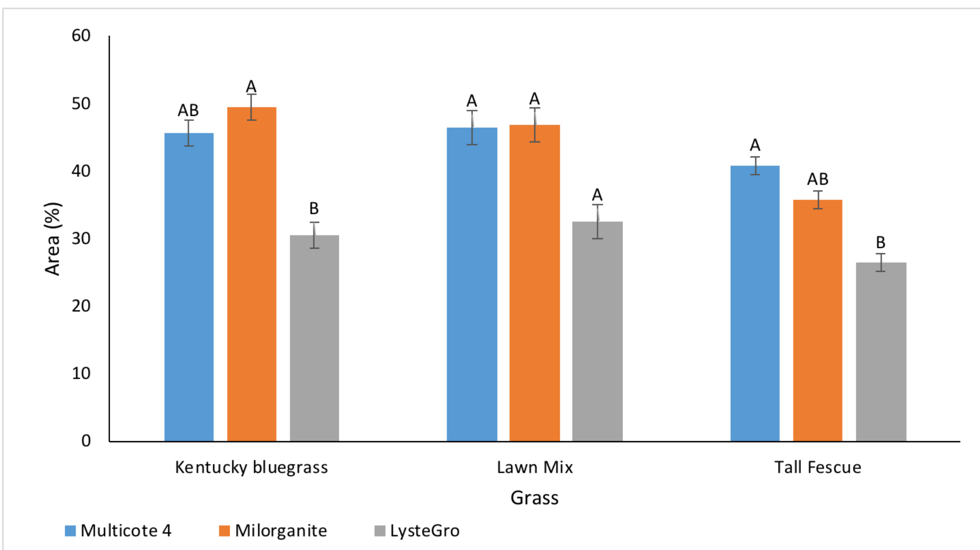

Figure 5: Mean area covered by grass for plants from the greenhouse phytotoxicity study on turfgrass. These data were obtained through analysis of photos taken of each pot. Error bars represent the standard error of the mean, bars with the same letter are not significantly different; n=45. Creeping bentgrass data was not included due to problems with the statistical model.

Conclusions - Greenhouse Study

Overall, the two biosolids products tested did not fare better than the inorganic standard. However, one of the products (Milorganite) was equal in colour, quality and fill-in to the iroganic products while the second, locally sourced biosolid product (Lystegro) was consistently lower in quality than the other two products. The actual applied nitrogen content was kept constant between the three fertilizers applied but it is possible that the rate of release was different between the three products. In addition, with the Milorganite product, only 60% of the nitrogen comes from biosolids while the remaining nitrogen is supplemented with a water soluble source of N. For the Lystegro product, all of the nitrogen is derived from biosolids. Moving forward we might consider tissue testing to determine if the nitrogen is reaching the plants at a consistent rate. We are also going to include an additional biosolids product that is locally sourced and contains all of its nitrogen from waste.

It is important to note that although the local biosolids product did not produce as high quality turf as the Milorganite or the inorganic product, the majority of the ratings were above 6, which is considered the minimum acceptable rating for turfgrass stands. This difference in quality between the plants fertilized with the inorganic product and the organic products may be due to the short duration of the experiment. It would be interesting to see how the fertilizers compared in a longer trial where the extended release characteristics of the organic fertilizers could be seen. Overall it appears that the biosolids product is safe to use on turfgrass but it may require more development to become as effective as the industry standards.

Field Trial

A field trial was established in 2016 (through NSERC funding) and continued through the 2017 season (through both NSERC and OTRF funding). The factorial design included two grass types (Kentucky bluegrass and a 3-way lawn mix), three nitrogen rates (1, 2 and 3 kg N/100m^2 over the course of the season), two application frequencies (1 or 3 times per season), and three fertilizers (inorganic slow release (Multicote), commercially available biosolid (Milorganite) and a locally sourced biosolids product (Lystegro) (Table 2). The data from 2017 are presented below. Plots were visually rated (on a 1 to 9 scale), five times throughout the season for colour (Table 3), quality (Table 4), and weed encroachment (Table 5). Plots were also visually rated for percent fill-in (Table 6). Normalized Difference Vegetative Index (NDVI) measurements were also taken five times throughout the season and are presented in Table 7. All data were analyzed using a repeated measures analysis which averages the values for a treatment over the course of the study.

Table 2: Fertilizer application rates for the field trial in 2017.

Fertilizer	Seasonal rate (kg N/ 100 m^2)	%N	Frequency of application	Weight of product (g) /plot (2.25 m^2) /application
Multicote 4	10	40	1	56.25
Multicote 4	1.0	40	3	18.75
Multicote 4	2.0	40	1	112.50
Multicote 4	2.0	40	3	37.50
Multicote 4	3.0	40	1	168.75
Multicote 4	3.0	40	3	56.25
Milorganite	1.0	6	1	375.00
Milorganite	1.0	6	3	125.00
Milorganite	2.0	6	1	750.00
Milorganite	2.0	6	3	250.00
Milorganite	3.0	6	1	1125.00
Milorganite	3.0	6	3	375.00
LysteGro	1.0	2.3	1	1022.73
LysteGro	1.0	2.3	3	340.91
LysteGro	2.0	2.3	1	2045.45
LysteGro	2.0	2.3	3	681.82
LysteGro	3.0	2.3	1	3068.18
LysteGro	3.0	2.3	3	1022.73

Table 3: Mean visual rating[1] of colour for Kentucky bluegrass and lawn mix plots.

Fertilizer	Rate (kg N/100m²)	Application Frequency	Mean[2] Kentucky bluegrass		Lawn mix	
Multicote 4	1	1	7.7	ABCD	7.65	BCDE
Multicote 4	1	3	7.25	BCDEF	7.4	DE
Multicote 4	2	1	7.95	AB	8.41	AB
Multicote 4	2	3	7.75	ABCD	8.35	ABC
Multicote 4	3	1	8.35	A	8.7	A
Multicote 4	3	3	8.25	A	8.6	A
Milorganite	1	1	6.73	FGH	7.1	EF
Milorganite	1	3	6.74	FGH	6.95	EFG
Milorganite	2	1	7.35	BCDEF	7.65	BCDE
Milorganite	2	3	7.65	ABCDE	7.65	BCDE
Milorganite	3	1	7.7	ABCD	8.2	ABCD
Milorganite	3	3	7.8	ABC	8.4	AB
LysteGro	1	1	6.3	GH	6.55	FG
LysteGro	1	3	6.25	H	6.2	G
LysteGro	2	1	6.9	EFGH	7	EFG
LysteGro	2	3	7	DEFGF	7.25	EF
LysteGro	3	1	7.2	BCDEF	7.55	CDE
LysteGro	3	3	7.05	CDEFG	7.4	DE

[1] Visual colour ratings are based on the NTEP 1-9 rating scale, 9 = Ideal green colour for putting green turf, 1= poorest colour/yellow and dead putting green turf, 6 = minimum acceptable turf colour for a golf course putting green.
[2] Ratings within each column followed by the same letter are not significantly different from each other (Tukey-Kramer method P > 0.05). Standard error 0.1594 for Kentucky bluegrass; 0.1689 for lawn mix; n=360; four replicates per treatment.

Table 4: Mean visual rating[1] of quality for Kentucky bluegrass and lawn mix plots.

Fertilizer	Rate (kg N/100m^2)	Application Frequency	Mean[2] Kentucky bluegrass		Lawn mix	
Multicote 4	1	1	7.25	ABCD	7.55	BCDEF
Multicote 4	1	3	7.15	ABCDE	7.05	DEFG
Multicote 4	2	1	8.05	A	8	ABCD
Multicote 4	2	3	7.55	ABC	7.9	ABCDE
Multicote 4	3	1	8	A	8.65	A
Multicote 4	3	3	8	A	8.5	AB
Milorganite[3]	1	1	6.42	DEF	7.25	CDEFG
Milorganite[3]	1	3	6.26	EF	6.55	FG
Milorganite	2	1	7.25	ABCD	7.7	ABCDE
Milorganite	2	3	7.6	AB	7.6	BCDE
Milorganite	3	1	7.35	ABC	8.2	ABC
Milorganite	3	3	7.7	AB	8.4	AB
LysteGro	1	1	5.55	F	6.4	GH
LysteGro	1	3	5.7	F	5.4	H
LysteGro	2	1	6.65	CDE	6.55	FG
LysteGro	2	3	6.9	BCDE	6.95	EFG
LysteGro	3	1	7.2	ABCD	7.3	CDEFG
LysteGro	3	3	6.9	BCDE	7.35	CDEFG

[1] Visual quality ratings are based on the NTEP 1-9 rating scale, 9 = Ideal quality for putting green turf, 1= poorest quality for a putting green, 6 = minimum acceptable turf quality for a golf course putting green.
[2] Ratings within each column followed by the same letter are not significantly different from each other (Tukey-Kramer method P > 0.05). Standard error 0.1661 for Kentucky bluegrass and 0.1802 for lawn mix (unless otherwise noted); n=360; four replicates per treatment.
3 Standard error 0.1700 for Kentucky bluegrass for these treatments

Table 5: Mean visual rating[1] of weed encroachment for Kentucky bluegrass and lawn mix plots.

Fertilizer	Rate (kg N/100m2)	Application Frequency	Mean[2] Kentucky bluegrass		Mean[2] Lawn mix	
Multicote 4	1	3	8.55	A	8.85	AB
Multicote 4	2	1	9	A	8.95	A
Multicote 4	2	3	8.55	A	9	A
Multicote 4	3	1	8.95	A	9	A
Multicote 4	3	3	9	A	9	A
Milorganite[3]	1	1	8.59	A	8.85	AB
Milorganite[3]	1	3	8.68	A	8.85	AB
Milorganite	2	1	8.55	A	9	A
Milorganite	2	3	8.65	A	8.95	A
Milorganite	3	1	8.65	A	9	A
Milorganite	3	3	8.85	A	9	A
LysteGro[3]	3	3	8.57	A	8.75	AB
LysteGro	1	1	8.05	A	8.45	B
LysteGro	1	3	8.1	A	8.85	AB
LysteGro	2	1	8.4	A	8.9	A
LysteGro	2	3	9.65	A	8.9	A
LysteGro	3	1	8.65	A	8.9	A

[1] Visual weed ratings are based on the NTEP 1-9 rating scale, 9 = no weeds, 1= all weeds, 6 = minimum level of weeds for a golf course putting green.
[2] Ratings within each column followed by the same letter are not significantly different from each other (Tukey-Kramer method $P > 0.05$). Standard error 0.1661 for Kentucky bluegrass and 0.08215 for lawn mix (unless otherwise noted); n=360; four replicates per treatment.
[3] Standard error 0.3167 for Kentucky bluegrass for these treatments.

Table 6: Mean percent turfgrass cover for Kentucky bluegrass and lawn mix plots.

Fertilizer	Rate (kg N/100m2)	Application Frequency	Mean[1] Kentucky bluegrass		Lawn mix	
Multicote 4	1	3	99.5	A	98.5	AB
Multicote 4	2	1	100	A	99.75	A
Multicote 4	2	3	100	A	99.5	A
Multicote 4	3	1	100	A	100	A
Multicote 4	3	3	99.75	A	100	A
Milorganite	1	1	99.75	A	99.75	A
Milorganite	1	3	98.44	A	99.5	A
Milorganite	2	1	99.75	A	100	A
Milorganite	2	3	99.75	A	99.75	A
Milorganite	3	1	100	A	100	A
Milorganite	3	3	100	A	100	A
LysteGro	1	1	98.5	A	99	A
LysteGro	1	3	99.5	A	96.25	B
LysteGro	2	1	100	A	99.5	A
LysteGro	2	3	95.1	A	98.25	AB
LysteGro	3	1	100	A	99.5	A
LysteGro	3	3	89.75	A	99.25	A

[1] Ratings within each column followed by the same letter are not significantly different from each other (Tukey-Kramer method $P > 0.05$). Standard error 1.9242 for Kentucky bluegrass and 0.5510 for lawn mix; n=360; four replicates per treatment.

Table 7: Normalized Difference Vegetative Index (NDVI) means for Kentucky bluegrass and lawn mix plots.

			Mean[1]			
Fertilizer	Rate (kg N/100m2)	Application Frequency	Kentucky bluegrass		Lawn mix	
Multicote 4	1	3	0.5303	BC	0.4649	EFGHI
Multicote 4	2	1	0.5929	A	0.5378	ABCD
Multicote 4	2	3	0.5885	A	0.5487	ABC
Multicote 4	3	1	0.585	A	0.5626	AB
Multicote 4	3	3	0.5942	A	0.5686	A
Milorganite	1	1	0.5177	BCD	0.4816	EFGH
Milorganite	1	3	0.5017	CDE	0.457	FGHI
Milorganite	2	1	0.5582	AB	0.5354	ABCD
Milorganite	2	3	0.5564	AB	0.5132	BCDE
Milorganite	3	1	0.5865	A	0.548	ABC
Milorganite	3	3	0.5893	A	0.5611	AB
LysteGro	1	1	0.482	DE	0.4175	I
LysteGro	1	3	0.4652	E	0.4274	I
LysteGro	2	1	0.5198	BCD	0.4449	GHI
LysteGro	2	3	0.5058	CDE	0.4364	HI
LysteGro	3	1	0.533	BC	0.4988	CDEF
LysteGro	3	3	0.533	BC	0.4884	DEFG

[1] NDVI measurements within each column followed by the same letter are not significantly different from each other (Tukey-Kramer method $P > 0.05$). Standard error 0.008286 for Kentucky bluegrass and 0.008755 for lawn mix; n=360; four replicates per treatment.

Conclusions – Field Study

There were few significant differences between the treatments, rates, and frequency of application. In general, the higher rates had higher ratings for the colour and quality. There were few significant differences in the area covered by turfgrass or by the amount of weeds found in the plots but overall there were almost no differences in weed encroachment or coverage. The few treatment combinations that were significantly different were still above the minimum acceptable level for turfgrass quality. Overall, the locally sourced biosolids product, LysteGro, did not perform as well as the industry standards but the average NTEP ratings were above the minimum acceptable level.

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?

Years 2 and 3:

For the 2nd and 3rd years of the study, we will be including an additional source of biosolids that is locally sourced. This will allow us to compare two local products to the inorganic and organic industry standards (Multicote and Milorganite, respectively).

We will also be starting work on the 2nd objective of the study, assessing soil health by fertilizer treatment. We will be establishing new plots in the spring of 2018 and assessing the turfgrass stand for a full two years, comparing the 4 different fertilizers. For the inorganic product, we will be applying a blended product to allow us to add phosphorus and potassium to more closely match the biosolids products.

Conclusions [Final Report]	Explain the key outcomes of the project, noting the success or obstacles of achieving the original objectives. Interpret the results and explain how the research and results will benefit the turfgrass industry. Recommendations for further studies may be included.

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

We have been unable to recruit a graduate student as we need secured funding to do so. In addition, the labour involved in the first year was greater than anticipated and as such, the funds requested would not be enough for a graduate student stipend and the operating cost of the project. Finally, with the removal of the 3rd objective from the original proposal, there is not enough in the study for a strong graduate student project. Should we be able to secure more funding and include the final objective that looks at disease suppression that results from biosolids application, we may be able to recruit a good student to complete the project.

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

The NSERC funding was primarily for the greenhouse study (which included ornamentals) and for establishment of the field study. The funding from OTRF went towards some of the materials and then primarly labour (both a technician and a summer student) as the project was a bit more labour-intensive than originally outlined.

Project Communication	List all industry and academic presentations and submitted publications
No communications have been made at this time but as the project progresses the findings will be reported at the Ontario Turfgrass Symposium in 2019.	

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