Evaluation of Greenbin Derived Municipal Compost to Improve Soil Health on Agricultural Cropland
(2013-2015 Final Report)

Purpose:

This project evaluated municipal compost use in agriculture by characterizing the nutrient and organic matter value on yield and soil quality. Economics and logistics of cost, transportation and handling these materials were also evaluated. Municipal compost includes combinations of leaf yard waste and food waste materials that have benefit for cash crop producers looking to increase organic matter levels in their soil.

Over 300,000 tonnes of organic waste gets diverted from Ontario landfills and provides over 55,000 T organic matter and over $5.25 million/year in crop available fertilizer equivalent. Greenbin compost provides nutrients and organic matter for crop land and can be an important component of improved soil resiliency especially when combined with crop rotations that include forages or cover crops and/or reduced tillage and residue management. This is similar to livestock farms that have access to manure. The agricultural trials were established to evaluate the nutrient and soil health benefits from adding municipal compost while determining if the logistics and cost of handling compost could be covered in yield and organic matter benefit.
The summary that follows highlights some of the observations and lessons learned.

Methods:

Side-by-side comparisons were set up at several sites across the province with municipal compost compared to commercial fertilizer and/or other organic amendments (biosolids).

During the growing season, soil fertility, soil nitrogen and plant tissue samples were taken to ensure adequate plant nutrition during the growing season. Soil organic matter and bulk density measurements were taken as part of the soil quality measurement.

- municipal compost (greenbin) is applied at a “once in the rotation” rate (target rate -5 to 10 tons/ac)
- replicated treatments included
    - normal fertility program
    - regular rate of compost
    - regular rate compost with additional N to meet corn crop needs
    - horticulture (site specific)
- Analysis of compost sample at time of application to determine the value of available nutrients, bulk density, OM and analysis of soil for nutrients and soil health. The analysis and estimate of available nutrients of the materials used are shown in the Table 2.
- Collect yield data at harvest from treatments for year of application and year(s) after application
- Collect crop input data, economics of compost use and observations/suggestions from process obtaining and using municipal compost

- Establishment of on-line network listing farmers/custom applicators with application equipment available to apply municipal compost and other organic amendments

Results:

In general the addition of organic amendments has increased the crop yield in the fields where they were applied. The resiliency of the soil in dry periods and wet periods is improved with the addition of compost, but soil quality improvements will take longer than 3 years to document. Table 1 gives a quick overview of the yield comparison for the treatments with compost compared to the treatments without compost. The average yield advantage for the side-by-side comparisons was 6.5% increased yield from application of compost.

Table 1: Yield Summarized by Location – With and Without Compost and % Yield Advantage from Compost

Location	Crop	With Compost (bu/ac)	Without Compost (bu/ac)	% Δ
Oakland (2011)	Corn	212.3	203	**4.4**
Winchester (2012)	Corn	191.3	191.5	**(0.1)**
Winchester (2013)	Corn	219.3	207.0	**5.5**
Winchester (2013)	Soybeans	48.5	50.1	**(3.2)**
Winchester (2014)	Corn	137.3	141	**(2.6)**
Jarvis (2013)	Corn	119.4	115.5	**3.3**
Jarvis (2014)	Corn	203	167	**17.7**
Jarvis (2015)	Soybeans	44.7	39.0	**12.7**
Plattsville (2013)	Corn	186.7	171.3	**8.2**
Strathroy (2013)	Corn	152.8	145.3	**4.9**
Strathroy (2014)	Soybeans	43.8	39.3	**10.3**
Strathroy (2015)	Corn	143.5	132.7	**7.6**
Strathroy (2014)	Corn	181.7	164.4	**12.4**
Strathroy (2015)	Soybeans	42.9	43.5	**(1.4)**
Castleton (2012)	Soybeans	33.5	31.0	**7.5**
Castleton (2013)	Wheat	78	72	**7.7**
Castleton (2014)	Corn	154.5	150	**3**
Castleton (2015)	Soybean	36.7	30.0	**18.3**
Orton (2012)	Corn	104.9	96	**8.4**
Wainfleet (2012)	Corn	139	147	**(5.4)**
Wainfleet (2013)	Soybeans	60.2	58.3	**3.1**
Meek (2012)	Corn	96.7	90.4	**6.5**
Meek (2013)	Soybeans	56	53	**5.3**
Meek (2014)	Wheat	74.5	67.9	**8.9**
Acton Field 1 (2013)	Forage	1.59 (ton/ac)	1.59 (ton/ac)	**0**
Acton Field 1 (2013)	Forage	1,344 (lbs milk/ac)	991 (lbs milk/ac)	**26.3**
Acton Field 2 (2013)	Forage	1.76 (ton/ac)	1.63 (ton/ac)	**7.8**
Thorndale (2013)	Strawberries	2.42 (kg)	2.08 (kg)	**13.9**

What have we learned so far:

- Transporting the compost is the most expensive part of the process and when combined with application cost often exceeds the nutrient value of the compost.
- Cost and benefits (increased yields and nutrient savings) of applied organic amendments or other soil-improving practices should be "costed" over the whole rotation as opposed to just the year of application.
- It is difficult to put a $$ value on organic matter – horticulture production puts higher value on OM.
- **Optimizing SOM helps improve soil resilience, aggregate stability, water holding capacity and water infiltration capacity**. Some of the participants of this study found that it take about 10 years of regular organic amendment (compost) additions combined with other soil management practices such as forage/cover crop rotations or residue management to see a The compost used at the project sites was municipal food waste mixed with high carbon materials (ie wood chips) and composted, most often in-vessel, under specific conditions to meet MOECC un-restricted compost guidelines. Analysis of materials varied depending upon the facilities' input ingredients, process used, and length of curing. With food waste compost (SSO or Source Separated Organics) the nutrient value is high which makes the logistics of transport and application easier. However, when the material is not fully cured, it falls into a category B compost which currently requires a NASM plan. Leaf and yard waste compost is more difficult to justify with short term economics when only looking at nutrient value. It takes close

Strathmere Lodge Site:
The Strathmere Lodge (Middlesex Soil & Crop demonstration farm) site allowed in-depth evaluation of food waste compost at different rates in 2013. A high and low rate compared with commercial fertilizer resulted in nearly identical yields for both rates – an indication that the immature compost had higher available nitrogen than expected. The compost treatments boosted yield by an average 8 bu/ac. In 2014 the treatments grew soybeans, and average yield showed up to 5.5 bu/ac increase over the commercial fertilizer treatments. Compost was re-applied to this field in April 2015 and corn planted May

In 2014 on a different field, treatments compared an immature food waste compost applied before full curing (immature) with a cured leaf-yard waste based compost. The food-waste compost had a significantly higher nutrient content and higher level of ammonium nitrogen and seemed to have a higher amount of nutrients available when the crop needed them. With the leaf-yard based compost, even when the carbon to nitrogen ratio is below 20:1, it would appear that some additional commercial nitrogen is required. During the mid-June and July rapid corn growth period, many organic amendments can not release nutrients quickly enough the meet the crop needs. Where the leaf/yard based compost was supplemented with half the nitrogen needs, the yield was similar to the check plots. The food waste base compost with the higher nutrient (available nitrogen) content resulted in less to no advantage to additional nitrogen

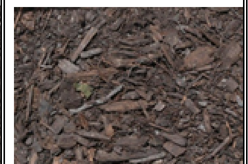
Table 2: Nutrient Analysis and Estimate of Available Nutrients for Organic Amendments Used in the Project

	OrgaWorld Compost-Ottawa		Orga World compost-London		Smith Falls Biosolids Pellets	
	Analysis	Available (lbs/ton)	Analysis	Available (lbs/ton)	Analysis	Available (lbs/ton)
						
Description:	Uncured - In-vessel ~ 30 days to finish - ↑yard waste than London		Uncured - In-vessel process ~ 30 days start to finish		Processed biosolids CIFA product	
Dry Matter %	81.9	1,638	76.6	1,532	89.1	1,782
Total Nitrogen %	1.54	8.6 + 1.7 = 10.3	2.78	14.9 + 4.5 = 19.4	2.78	16.6 + 0.14 = 16.7
NH_4-N (ppm)	1,143		3,003		96	
Phosphorus %	0.50	18.4 (P_2O_5)	0.62	22.8 (P_2O_5)	1.60	59
Potassium %	0.97	21.0 (K_2O)	0.77	16.6 (K_2O)	0.11	2.4
Organic Matter %	46.9	938	51.6	1,032	44.3	886
pH	8.4		7.6		7.1	
C:N ratio	17 : 1		13 : 1		9 : 1	
Bulk Density	351 kg/m^3	21.9 lbs/ft^3	455 kg/m^3	28.41 lbs/ft^3	563 kg/m^3	35.2 lbs/ft^3
Sulphur (ppm)	3,106	6.2	3,966	7.9	4,731	9.5
EC (conductivity) (ms/cm)	6.3	8.0	15.68	20.1	2.51	3.2
Sodium %	0.57	11.4	0.86	17.2	0.10	2
Aluminum (ppm)	3,785	7.6	1,726	3.5	150,171	300
Boron (ppm)	17.7	0.04	20.4	0.04	3.4	0.007
Calcium (%)	3.68	74	3.98	80	2.17	43.4
Copper (ppm)	37.4	0.07	41.3	0.08	259	0.52
Iron (ppm)	6,404	13	1,970	3.9	7,122	14.2
Magnesium (%)	0.61	12.2	0.43	8.6	0.74	14.8
Manganese (ppm)	199	0.40	90.9	0.18	128	0.3
Zinc (ppm)	109	0.22	385.5	0.77	640	1.3
	Available N - P_2O_5 - K_2O (lbs/acre)					
N-P_2O_5-K_2O @ 10 ton/ac	~ **103 – 184 – 210**		~ **194 – 228 – 166**		~ **167 – 590 – 24** **	
[1] assumes spring application to corn, incorporated within 24 hours			** Application limit (?) P availability with high Aluminum??			

Strathmere Lodge Site:

The Strathmere Lodge (Middlesex Soil & Crop demonstration farm) site allowed in-depth evaluation of food waste compost at different rates in 2013. A high and low rate compared with commercial fertilizer resulted in nearly identical yields for both rates – an indication that the immature compost had higher available nitrogen than expected. The compost treatments boosted yield by an average 8 bu/ac. In 2014 the treatments grew soybeans, and average yield showed up to 5.5 bu/ac increase over the commercial fertilizer treatments. In 2015 Foodwaste compost was re-applied at 7 tons/ac and planted to corn.

Table 2 (continued)

	AIM Environmental		Miller Compost		Try Recycling Compost		Peel Region Compost	
	Analysis	**Available (lbs/ton)**	**Analysis**	**Available (lbs/ton)**	**Analysis**	**Available (lbs/ton)**	**Analysis**	**Available (lbs/ton)**
								
Description:	Uncured - In-vessel process ~ 30 days start to finish		Leaf-yard + SSO? composted/ cured in windrows outdoors		Leaf-yard waste composted/ cured in windrows outdoors		In-vessel ~ 7 days then cured in covered windrows	
Dry Matter %	48.0	960	49.5	990	61.7	1,234	57.9	1,158
Total Nitrogen %	1.55	8 + 4 = 12	0.89	5.34 + 0.03 = 5.4	0.98	5.8 + 0.2 = 6.0	1.43	8.6 + 1.3 = 10
NH_4-N (ppm)	2,250		16		142		840	
Phosphorus %	0.33	12 (P_2O_5)	0.24	8.8 (P_2O_5)	0.21	7.7 (P_2O_5)	0.36	13.2 (P_2O_5)
Potassium %	0.47	10 (K_2O)	0.46	9.9 (K_2O)	0.53	11.4 (K_2O)	0.64	13.8 (K_2O)
Organic Matter %	38.0	760	21.2	424	30.2	604	42.3	846
pH	4.9		8.1		7.6		8.2	
C:N ratio	14 : 1		17 : 1		13 : 1		16 : 1	
Bulk Density	340 kg/m³	22 lbs/ft³	630 kg/m³	39.3 lbs/ft³	596 kg/m³	37.2 lbs/ft³	349 kg/m³	21.8 lbs/ft³
Sulphur (ppm)	3,106	2.5	1,073	2.1	1,171	2.3	1,313	2.6
EC (conductivity) (ms/cm)	6.25	8.0	3.83	4.9	3.15	4.0	5.86	7.5
Sodium %	0.21	4.0	0.09	1.8	0.07	1.4	0.34	6.8
Aluminum (ppm)	600	1.2	2,267	4.5	2,183	4.4	670	1.3
Boron (ppm)	11	0.02	10.4	0.02	15	0.03	24.7	0.05
Calcium (%)	1.65	33	3.45	69	3.70	74	2.48	50
Copper (ppm)	50	0.1	37.9	0.08	35.5	0.07	14.9	0.03
Iron (ppm)	1350	2.7	5,584	11.2	5,644	11.3	1,492	3.0
Magnesium (%)	0.2	4.0	0.29	5.8	0.79	15.8	0.23	4.6
Manganese (ppm)	100	0.2	218.5	0.44	219.2	0.44	68.6	0.14
Zinc (ppm)	50	0.1	93.9	0.19	251.0	0.50	51	0.10
	Available N - P_2O_5 - K_2O (lbs/acre)							
N-P_2O_5-K_2O @ 10 ton/ac	**~ 120 – 120 – 100**		**~ 54 – 88 – 99**		**~ 60 – 77 – 114**		**~ 48 – 132 – 138**	

[1] assumes spring application to corn, incorporated within 24 hours

Metric Conversions: (ton/ac x 1.11 = tonne/ha); (lbs/ac x 1.11 = kg/ha); (lbs/ton x 0.5 = kg/tonne)

In 2014 on a different field, treatments compared an immature food waste compost applied before full curing (immature) with a cured leaf-yard waste based compost. The food-waste compost had a significantly higher nutrient content and higher level of ammonium nitrogen and seemed to have a higher amount of nutrients available when the crop needed them. With the leaf-yard based compost, even when the carbon to nitrogen ratio is below 20:1, it would appear that some additional commercial nitrogen is required. During the mid-June and July rapid corn growth period, many organic amendments cannot release nutrients quickly enough the meet the crop needs. Where the leaf/yard based compost was supplemented with half the nitrogen needs, the yield was similar to the check plots. The food waste base compost with the higher nutrient (available nitrogen) content resulted in less to no advantage to additional nitrogen.

Table 3. 2013 Strathmere Lodge Compost Plot Yield Results

Treatment	**2013 Corn Yield** (bu/ac)	**2014 Soybean Yield** (bu/ac)
Corn - Planted May 3rd; re-planted June 15th after frost		
No Compost - Full N (135 lbs)	145.3	39.3
6.6 ton/ac rate of compost	152.5	44.8
13.3/ac ton rate of compost	153.1	42.7

- Greenbin Food Waste (OrgaWorld London) Compost applied April 23;
- May 3rd planted corn hit with frost at 5 leaf stage - Long plots were replanted June 15
- One section left and not re-planted but had very low population (<20,000 ppa) and no yield difference between treatments (~130 bu/ac)

Table 4. 2014 Strathmere Lodge Compost Plots – Harvest Data

Treatment No additional N	Moisture %	**Test Weight** lbs/bushel	**Protein** % DM	**Yield** bu/acre	**Yield Δ**
Check with 0 N (starter only)	19.9	53.4	6.14	146.2	---
Try Recycling + 0 N	19.7	53.6	6.07	145.3	**-1**
Orga compost + 0 N	19.4	55.8	7.26	198.3	**52.1**
Treatment with Recommended N	Moisture %	**Test Weight** lbs/bushel	**Protein** % DM	**Yield** bu/acre	**Yield Δ**
Check with 130 lbs N	19.4	53.9	7.42	182.5	---
Try Recyling + 72 lbs N	18.8	54.8	7.38	185.8	3.3
Orga World compost + 36 N	19.5	55.6	7.72	197.2	14.7

Compost applied: May 7, 2014

Orga World (London) @ 6.5 t/ac Greenbin (N - P_20_5 - K_20 =~ 126 – 148 – 108 lbs/acre)
TryRecycling @ 9.2 t/ac (mainly leaf-yard waste) (N - P_20_5 - K_20 =~ 55 – 71 – 105 lbs/ac)

Planted: May 19, 2014

- variety DKC 50-78 RIB (30,100 seeds put down set @ 1.75"depth)
- 22 litres G24 in furrow with seed
- Starter - 125 lbs 16-16-16 in 2 x 2 banded with planter
- Side dressing Nitrogen (28%) - June 19

Harvested: November 26, 2014

Rotation Economics

The Rotation Economics table (below) attempts to show the short-term/long-term economics where short term looks only at the cost and return of the current crop that the compost is applied to. The organic matter value is longer-term, therefore looking at current and subsequent crop yields tends to show OM value as opposed to just nutrient value. Costs and yield benefits calculated over the whole rotation gives a more realistic economic picture of the value of the organic amendment.

Table 5. Rotation Economics - Strathmere

Summary (2 reps) Recommended N Rate	**Yield bu/ac**	**Yield Δ**	**Short-term Benefit Corn value – Fertilizer/compost cost**		
			($/ac)		**Corn/Soy Rotation Benefit - Comments**
Check + 130 lbs N	182.5	---	821 – 111 =	710	(starter fertilizer + N) - Crop nutrient removal = (-$ 50)
Try Recycling + 72 lbs N	185.8	3.3	836 – 276 =	560	[$160 compost nutrient value + $76 fertilizer value) – $163 crop removal] + ($4.5 x 3.3) + $60 = $ 148
Orga World + 36 lbs N	197.2	14.7	887 – 244 =	633	[$212 compost nutrient value + $ 55 fertilizer value) – $173 crop removal] + ($4.5 x 14.7) + $60 = $ 220
Rotation benefit: [Fertilizer value of compost – (crop nutrient removal - starter fertilizer - commercial N applied)] +/- (corn yield increase over check plot x $4.50/bu) + (soy yield increase over check x $11/bu) = XX					

Strathmere Lodge Green Bin Plot informtion – 2015 Corn Plots

- Greenbin compost applied April 27 (immediate shallow incorporation)
- Corn planted May 2, 2015, Starter - 125 lbs 16-16-16 in 2 x 2 banded with planter
- Corn Replanted May 29, 2015 (due to frost)
- 140 lbs N applied to check plots (compost treatments already had adequate N)

Figure 2 shows the results of the Solvita test done to measure soil biological activity in mid-June. Solvita test measures soil respiration from biological activity and is an indicator of nitrogen mineralization. There is also a lab version, but the value of this test is mainly the opportunity to visually compare practices.

Figure 1. Compost Application – Summary of Applied available nutrients

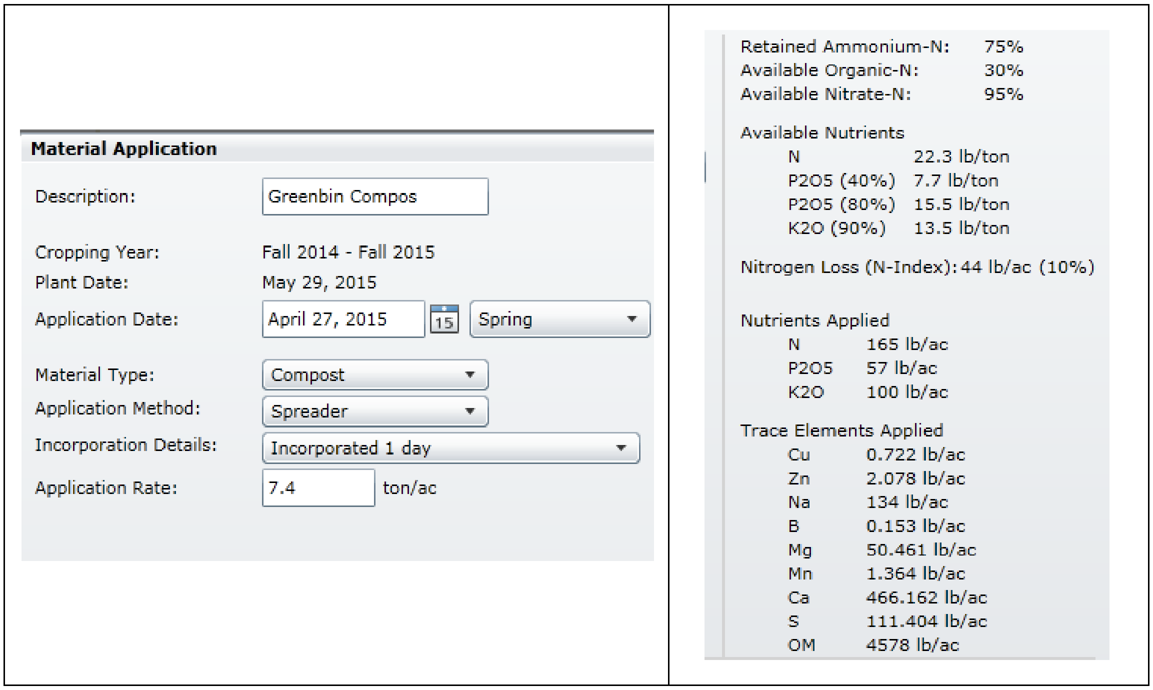
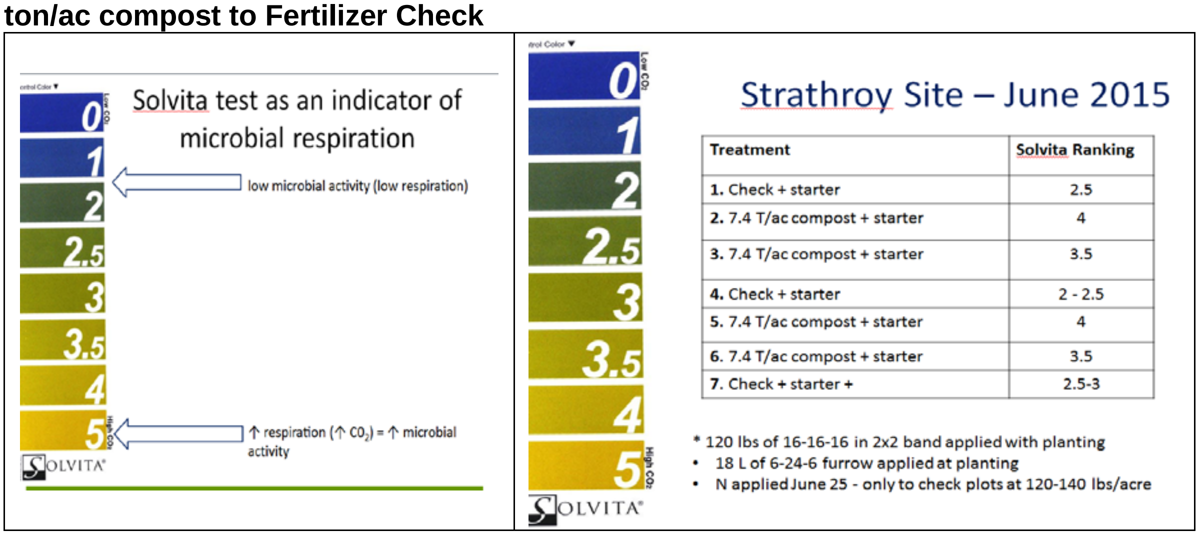


Figure 2.Solvita Test Results (Strathmere Lodge Site – June 2015) Compares 7 ton/ac compost to Fertilizer Check



2015 Yield Results
Average:

No compost No N	104.7 bu/ac
No compost 120 lbs N	147.7 bu/ac
Compost no N	143.5 bu/ac

Table 6. Strathmere 2015 Yield Results

Treatment	Yield (bu/ac)	2013 compost (overlap?)	% Moisture	Test Weight (lbs/bu)	PSNT ppm NO_3 + NH_4-	PSNT N rec * (lbs N/ac)
No compost; 120 lbs N	154.8	no compost	20.8	54.9	3.3	184
Compost; no N	152.2	6.6 ton	20.1	55.0	4.0	175
Compost; no N	149.7	6.6 ton	19.5	56.2	5.2	170
No compost; no N	104.7	13 ton	21.2	53.8	3.8	180
Compost; no N	130.7	6.6 ton	20.5	55.1	8.4	150
Compost; no N	141.6	No compost	19.5	56.4	4.3	175
No compost; 120 lbs N	138.6	No compost	20.1	55.3	3.2	184
***** PSNT N recommendation based on 145 bu/ac yield goal						

Winchester Research Farm Site:
Research scale plots were established at the Winchester Research Farm in 2012 and have been established each year since to determine the impact of compost and biosolids pellets. Plots were established assuming the compost / biosolids pellets could provide zero nitrogen to assuming the compost could provide the full nitrogen needs for the crop to something in-between   Check plots with and without nitrogen were also established. . Soil fertility levels were adequate and soil organic matter levels between 3.5 and 4%.Results are shown below. There is a large range in plot yields, which results in less significant difference between treatments than what the numbers may indicate. What is clear, however, is that there is need for additional nitrogen when using leaf/yard-waste based compost. Although there is significant nitrogen content, the micro-organisms in the soil cannot mineralize the nutrients quickly enough to meet crop needs. What at "right" additional N rate is depends on the weather conditions each year.

Table 7. Compost on Corn - Winchester Research Farm 2012 and 2013

Treatment	2012 Yield (bu/ac)		2013 Yield (bu/ac)		2014 Yield	
					(bu/ac)	range
150 lbs/ac N (using Urea)	257	a	220	a	194	182-204
Biosolids Pellets + 125 lbs/ac N (Urea)	247	a	209	a	178	161-200
compost (10 ton/ac) + 150 lbs/ac N (Urea)	235	a	216	a	159	121-180
compost (10 ton/ac) + 75 lbs/ac N (Urea)	241	a	185	b	135	131-145
(20 ton/ac) compost	182	b	155	c	118	74-175
No compost, pellets or N fertilizer	157	b	163	c	88	51-102
Orga Compost – Ottawa (leaf/yard waste base) with a C:N ratio of 35:1 (2012); 17:1 (2013) 2012 analysis: DM 68%; N = 5 lbs; P_20_5 = 8 lbs; K_20 = 14 lbs; Biosolids Pellets applied @ 2.2 T/ha with C:N ratio of 9:1; 2012 analysis: DM 95%; N avail = 30 lbs; P_20_5 = 82 lbs; K_20 = 3 lbs						

Table 8. Subsequent Yields – Organic Amendments on Corn
Winchester Research Farm 2014

Treatment	Corn Yield (bu/ac)		Soybean Yield (bu/ac)	
	Compost Applied			
	2012		2013	
150 lbs/ac N (using Urea)	189	a[1]	50.1	a
Biosolids Pellets + 125 lbs/ac N (Urea)	205	b	51.7	a
compost (10 ton/ac) + 150 lbs/ac N (Urea)	201	b	48.8	a
compost (10 ton/ac) + 75 lbs/ac N (Urea)	201	b	47.3	a
(20 ton/ac) compost	204	b	49.6	a
No compost, pellets or N fertilizer	204	b	48.4	a

[1] small letters that are the same means there is no significant yield difference. Within-treatment variability was high.

Castleton Site
At the Castleton site (Pontypool sand) the goal was to build organic matter and moisture holding capacity to improve consistency of yield. Compost was added ahead of the soybeans and again ahead of the corn crop. Results for the corn year do not show a large difference and suggest that the 125 lbs of commercial nitrogen combined with relatively high fertility soil was adequate. The effort to build organic matter at this site has been on-going for about 10 years, and measurements indicate approximately 0.5 percent increase in soil organic matter. That represents approximately ½ inch extra water holding capacity with every rain event. Erosion (rills/ gullies) on this farm has decreased significantly and crop growth is more uniform.

Table 9. Castleton Site Yield Results over

2012 – Soybeans bu/ac	2013 – Wheat bu/ac	2014 – Corn bu/ac	2015 – Soybeans bu/ac
Check 31 10 t/ac 34 20 t/ac 33	Check 72 10 t/ac 76 20 t/ac 80	Check 150 10 t/ac 154 20 t/ac 155	Check 30.0 10 t/ac 37.4 20 t/ac 36.2

Miller compost applied fall 2011 and 2013
@ 10 ton/ac rate supplied: ~ 54 – 88 – 99 lbs/acre N - P_20_5 - K_20
2014 – Corn planted May 5, Liquid Starter: 3 – 12 – 0 - 3S – 0.3Zn - 0.1 Mn lb/ac with planter
Nitrogen: 125 lbs applied May 6 (as 28%)

Table 10. Acton Site – Compost Compared to Fertilizer on Forages (Beef Hay)

Field 5	Yield (t/ac)	% Δ	Quality Parameters				Milk lbs/ton	% Δ	Milk lbs/ac	% Δ
			CP	ADF	NDF	RFV				
Fertilizer	1.59	---	13	44	57	89.8	634	---	991	---
5 ton/ac	1.49	- 4.5	14	41	55	97.0	865	+26	1,263	+22
10 ton/ac	1.68	+ 3.2	14	42	54	97.3	871	+27	1,425	+31

Using MILK 91 – using default values except for quality parameters shown above)
Ideal quality for dairy alfalfa grass hay harvested at mid-bud is: CP 18; ADF 35; NDF 45; RFV 127
Fertilizer treatment had higher yield, but lower quality due to higher volume of grass & weeds
CP=Crude Protein; ADF= Acid Detergent Fibre; NDF=Neutral Detergent Fibre; RFV=Relative Feed Value

The forage site was chosen because of the extremely low soil fertility in the fields. Soil P ranged between 8 and 14 ppm, while K levels ranged between 29 and 67 ppm. The plant tissue samples taken during the growing season revealed that nutrient cycling was occurring since all tissue analysis was within the normal range; however fertilizer treatments were lower than treatments with organic amendments added.

Table 11. Acton Site – Compost & Biosolids Pellets on Forages (Beef Hay)

Field 6	Yield (t/ac)	% Δ	Quality Parameters				Milk lbs/ton	% Δ	Milk lbs/ac	% Δ
			CP	ADF	NDF	RFV				
Pellets	1.66	---	12.4	39	58	96	853	---	1,278	**---**
Pellets + Fertilizer	1.59	- 4.5	12.4	41	57	93	757	-12.7	1,203	-6.2
Pellets + Compost	1.72	+ 3.2	12.9	42	57	93	749	-13.9	1,289	0.9
Compost + Fertilizer	1.74	+ 4.5	12.2	40	61	88	645	-32.3	1,065	-20.0
Pellets + Compost + Fertilizer	1.83	+12.9	12.4	43	58	90	665	-28.1	1,182	-8.1

Using MILK 91 – using default values except for quality parameters shown above)

Ideal quality for dairy alfalfa grass hay harvested at mid-bud is: CP 18; ADF 35; NDF 45; RFV 127
Lower CP and RFV and higher ADF and NDF indicate greater maturity/lower quality

Another observation in comparing forage quality comes from the “activation” of the nutrients from compost compared to biosolids pellets. The biosolids pellets were coated with a fibrous material to help with storage and transport. The microorganisms in the soil have to break down the coating. The time difference in the availability of the nutrients between the pellets and the compost is evident in the yield and quality results. The treatments with the compost added grew and reached maturity more quickly than the treatments with the coated biosolids pellets. Since maturity affects quality, this difference is evident in milk/ton results for field 6.

Measuring the Impact of Soil Organic Matter from Organic Amendment Additions
Improvements in soil quality take time and are difficult to measure. Ideally the fertilizer benefit and the yield difference between the treatments for each crop in the rotation between applications will show the organic matter benefit from the organic amendment. A rotation that includes forages and/or cover crops in combination with organic amendments will show the soil quality advantage more quickly.

To try and show changes in moisture holding capacity, several different methods were experimented; however bulk density was chosen to determine if there were consistent differences. The graphs above show bulk density measurements for a Haldimand clay and a Burford sandy loam where the control treatments generally are denser (more compact) than for the treatments where compost was applied. This is more evident in the sandy loam than the clay soil. The higher the reading, the higher the bulk density. Lower numbers indicate more airspace and water holding capacity.

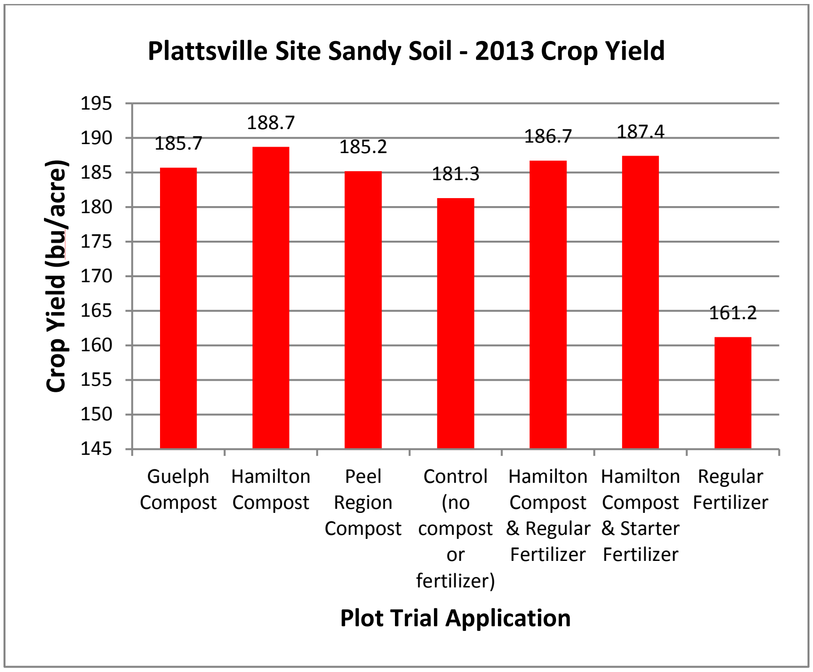
Long-Term Organic Matter Plots – Outdoor Farmshow site – Woodstock
At the Outdoor Farm show site long term rotation plots were set up in 2007, with organic amendments added once per rotation (per 3 yrs) and with one treatment receiving 100 tons of compost the first year only. The results shown below show the advantage in soil quality and yield.

Table 12. Outdoor Farm Show Site – Woodstock Ontario

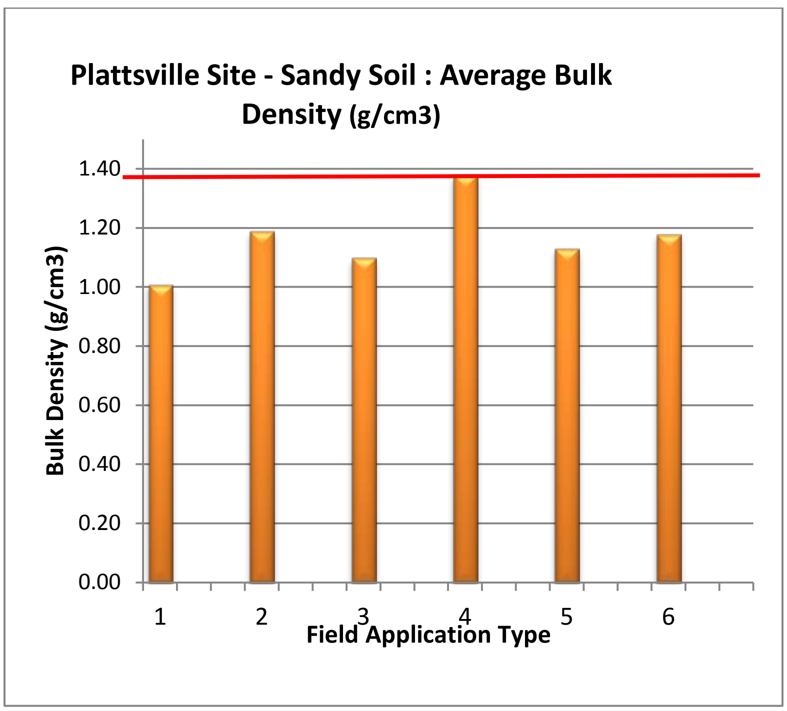
Treatments (rep average)	Soil Test			Moisture	Yield
	OM %	P ppm	K ppm	%	bu/ac
check	2.9	12	41	28.5	104
10 t/ac solid cattle	3.0	16	52	26.3	222
20 t/ac solid cattle	3.1	23	67	26.4	209
4 t/ac layer poultry	3.0	25	54	25.6	227
5 ton compost	3.3	21	51	26.2	229
100 t/ac dairy compost (2007)	3.4	24	46	25.8	213
4 t/ac DDGs	3.1	21	54	25.8	219

Organic Amendments were applied ahead of a corn crop in 2007, 2010 and 2013
Crop Rotation: Corn, Soybeans, Spring Cereals
OM = Organic Matter; DDGs = Dried Distiller Grains
Plots hand harvested October 2013 at COFS (Canada's Outdoor Farm Show Site – Woodstock)

Figure 3. Plattsville Site: Comparison of Food Waste Compost from Several Sources on Light Textured Soil

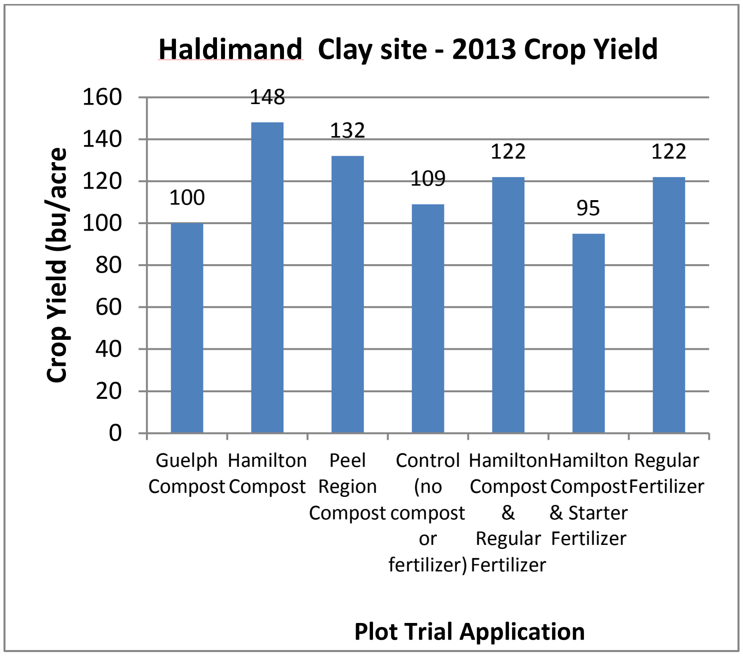


1. Guelph compost, 2. Hamilton compost, 3.Peel compost, 4. Contol (no compost fertilizer only), 5. Hamilton compost + fertilizer, 6. Hamilton compost + starter only, 7. Regular fertilizer only

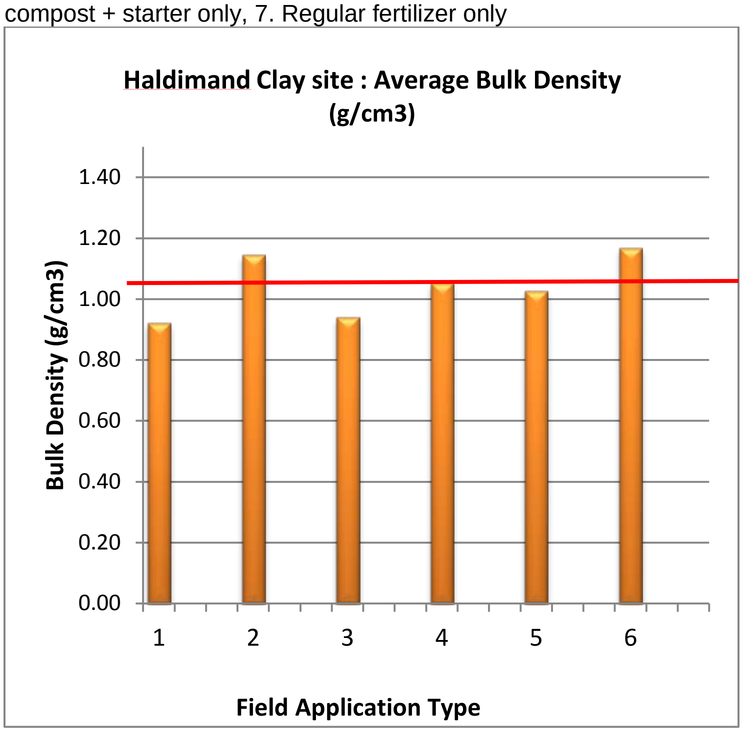


1. Guelph compost, 2. Hamilton compost, 3.Peel compost, 4. Contol (no compost fertilizer only), 5. Hamilton compost + fertilizer, 6. Hamilton compost+ starter only

Figure 4. Jarvis Site: Comparison of Food Waste Compost from Several Sources on Heavy Textured Soil

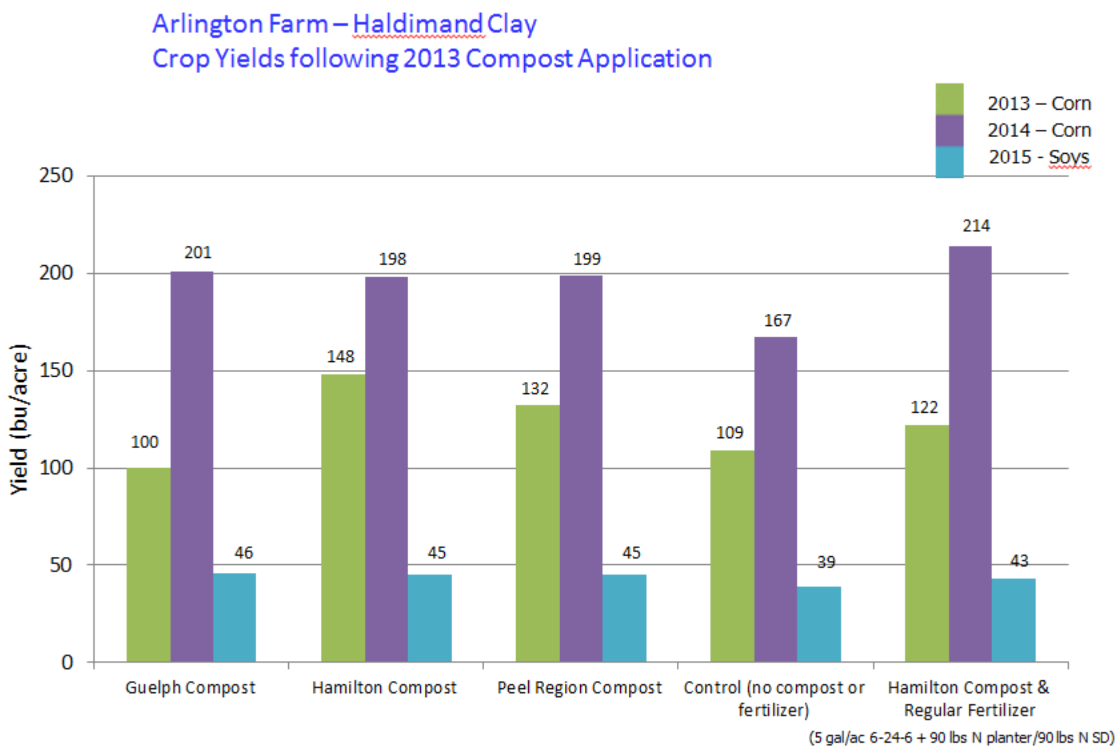


1. Guelph compost, 2. Hamilton compost, 3.Peel compost, 4. Contol (no compost or fertilizer), 5. Hamilton compost + fertilizer, 6. Hamilton compost + starter only, 7. Regular fertilizer only



1. Guelph compost, 2. Hamilton compost, 3.Peel compost, 4. Contol (no compost or fertilizer), 5. Hamilton compost + fertilizer, 6. Hamilton compost + starter only

Figure 5. Jarvis Site – Yield Summary 2013-2015



Summary:

Greenbin" waste diverted from landfill/yr:

Contributes over 55,000 T organic matter and over $5.25 million/year in crop available fertilizer equivalent

Logistics from production to field

- Product cost ~ $ 5 - 10/T
- Transportation= biggest expense - varies with distance
- Application cost $ 3 – 5/T
- Increased yield potential: **Yes – best when evaluated over a complete crop cycle**
- Improved soil quality: **yes; takes time**
- Maximum benefit: ~10 t/ac /rotation before corn (with good crop rotation/cover crops/and residue management)

Optimizing SOM helps improve soil resilience, aggregate stability, water holding capacity and water infiltration capacity. Some of the participants of this study found that it take about 10 years of regular organic amendment (compost) additions combined with other soil management practices such as forage/cover crop rotations or residue management to see a The compost used at the project sites was municipal food waste mixed with high carbon materials (ie wood chips) and composted, most often in-vessel, under specific conditions to meet MOECC un-restricted compost guidelines. Analysis of materials varied depending upon the facilities' input ingredients, process used, and length of curing. With food waste compost (SSO or Source Separated Organics) the nutrient value is high which makes the logistics of transport and application easier. However, when the material is not fully cured, it falls into a category B compost which currently requires a NASM plan. Leaf and yard waste compost is more difficult to justify with short term economics when only looking at nutrient value. It takes close

Benefits:

- Potential "manure" for cash crop farms
- High OM product with good balance of available N-P-K and micro nutrients
- Unrestricted designation – easier to access and handle than biosolids or manure
- Cured compost = low odour & low risk of N loss (leaching, volatilization)
- Uniform application is easier than with most solid manure types
- Ideally applied once in the rotation at ~ 10 ton/ac (after cereal harvest with cc ahead of corn)

Challenges:

- Low bulk density of some materials (~ 25-30 lbs/cubic foot) makes transport & handling expensive
- Temporary field storage can cause runoff/leaching & compaction damage
- Contaminants – plastics and glass (regulations -Jul 2015- should improve this)
- Timing of product availability and application
- Immature compost can have a distinct odour (and will be classified as a compost B material after July 2015). B Compost materials require a NASM plan.

Next Steps:

Analysis of the soil and bulk density data collected over the past year as well as continuation of project with greater emphasis on the economics of rotation and soil quality aspects as some sites enter the 2nd cycle of the rotation.

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- Ontario Soil & Crop Improvement Association

Project Contacts:

Christine Brown – OMAFRA, christine.brown1@ontario.ca

Location of Final Project Report: