Final Report

Going No-Till at City Roots Nov 2012-Dec 2015

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Introduction

This is the final technical report for the Conservation Innovation Grant called "Going No-Till at City Roots". This effort is a partnership between City Roots (CR), an urban organic farm located in Columbia, SC and the University of South Carolina (USC). The intention of this grant was to facilitate the conversion from conventional till to no-till on the operation in three years. The original plan was to convert one-third of the farm at a time to no-till. In reality, this strategy had to be abandoned after the summer of 2013, and City Roots had to go to a limited-till situation for all fields. We estimate that we reduced tillage from approximately seven times a year per subfield per year(7x18=126 tillage events) down to an average 2.2 per subfield per year (2.2x17[1]~37.4 events).

Over the 35-month period of monitoring of the project, we have amassed a vast amount of lab and field data and one of the challenges is to turn these data into information. This report seeks to provide a window into the data we collected and highlights some of what we deem as the more significant information. In addition, the design of this document is meant to be a repository for this information.

In the report we attempt to highlight the following:

1. As an overview of the body of work over the last three years we provide an executive summary from a technical standpoint, followed by the farmer's reflections on organic no-till.
2. The truly remarkable properties of City Roots soils - these are man-made, histic epipeda, made of municipal compost, perched on old gravel parking lots and old sand fill areas. The properties of these soils are compared to the average coastal plain soil in row crops.
3. Differences between fields are highlighted in terms of soil physical, chemical and biological properties as a function of their location or what substrate they are perched on. This information provides us with some clues as to how the changed under a reduced tillage regime.
4. The response of the soils (physical, chemical and biological properties) under a reduced tillage regime which was reduced from 5-7 times a year to less than 2 times a year on average.
5. A list of field and lab methods we used to acquire these data.

In addition to the above, we realize that very few people will actually read this document, so we have provided an executive summary that immediately follows this introduction.

[1] One subfield was removed from production in April 2014.

Executive Summary

City Roots, an urban, organic farm, located in Columbia, SC, has, through the CIG "Going No-Till at City Roots", managed to reduce its tillage by about two thirds and has successfully incorporated the practice of cover crops into its regular rotation. City Roots soils (originally 6"-8" municipal compost perched on sand fill or gravel parking lots) are unique when compared to typical mineral soils in the coastal plain. City Root soils boast 10 times more organic matter, 4 times more cation exchange capacity, and 25 times higher soil respiration. Apart from a small amount (<50 lb/ac) of potassium in the form of wood ash applied to several fields in March 2014 and some foliar applications, no amendments have been added to City Roots soils since the beginning of the project.

Observation over the last three years suggest that soil physical properties (root depth, depth to compaction, infiltration rates) improved significantly as a result of the reduced traffic from tillage – we saw a change in soil structure at the 4" mark which was characterized by platiness in 2012, but over time, this platy structure weakened to where we observed blockiness in this zone. On the top 4" of soil, we observed increasing amounts of granular soil structure. Bulk densities remained essentially unchanged.

From soil test lab analyses, soil organic matter, cation exchange capacity and soil pH were largely unchanged over the project period. This was good news for the most part as conventional wisdom would expect this much organic matter in a hot South Carolina environment to rapidly mineralize over time. In addition, we expected a reduction in soil pH as a result of rapid organic matter mineralization – this also did not happen.

In terms of the Haney (ARS) parameters, we saw a small increase in water extractable organic carbon (WEOC), a significant increase in Field 6 and 7, which we attribute to increased biological activity from more live root matter remaining in the soils. We observed a wholesale increase in water extractable organic nitrogen (WEON), and attribute this to less soil disturbance – we saw a concomitant decrease in soil test nitrate-N and hypothesize that the lower amount of tillage shifted the water-soluble soil nitrogen equilibrium from an inorganic (nitrate-N) pool to an organic pool.

One of our big surprises is that despite the lack of addition of phosphorus or potassium fertilizers, we experienced an increase in soil test phosphorus and a far smaller than expected reduction in soil test potassium based on crop removal rates for 13,000 lb/ac of produce per year. This has profoun dly affected our thinking in terms of the role of the soil's ability (especially soils with high organic matter content) to supply many of the nutrients the plant needs without the need for fertuilzer, commercial or otherwise.

We see the City Roots CIG project as the catalyst and ground zero of the soil health movement in South Carolina.

Final Reflections of Organic No-Till from the Farmer – Eric McClam

The transition of our farm into No-till vegetable production has been an enlightening yet challenging process over the last three years. We have seen great progress in our farm's overall soil health and fertility through the reduction of tillage and the introduction of multispecies cover crops into our management system. The greatest challenges however have come from the appropriate selection of cover crop mixes, the timing of their planting and subsequent termination. The proper equipment selection and usage has been difficult as well due to the lack of commercially available equipment appropriate for no-till vegetable production. As a result, we have had to custom design and fabricate some of the equipment we currently are using.

We had relatively good success with growing cool season cover crops such as rye and crimson clover to then terminate to plant summer cash crops such as squash or tomatoes into. With an appropriate density of cover crop and termination, the mulch produced by the cover crop is effective enough for the cash crop to establish canopy cover to shade out weed competition. However, if the stand of cover is rolled too early it typically will pop back up and continue to grow, hindering the cash crop's growth. Thus, the timing of termination, seeding rate and date are critical in this process. Further exploration of seeding rate, date and subsequent termination warrants further research. We have also found that the cover crop no till system has been able to provide adequate fertility to produce the cash crop, which has dramatically reduced our input costs. One of the other added benefits is the reduction of labor costs associated with this cropping system. Prior to shifting to No-Till, our planting cycle would have been to disk harrow the field, rotary till to prepare beds, plant the cash crop, cultivate approximately 3-4 times during the crops growth, mulch and harvest. We have significantly reduced those steps through No-till. We simply roll the cover crop and plant directly into it. The mulch produced by the rolled cover crop serves as a weed suppressant, and we do not have to continually cultivate throughout the season. The labor cost associated with producing the same crop has been reduced by approximately 20-25%. In addition to labor savings we have seen an increase in yield by 10-15% between conventionally tilled plots and our no-till plots. We were also able to reduce the amount of water usage for irrigation to the no-till areas due to the mulch's ability to keep in soil moisture and reduce soil temperatures in summer months.

Selection of appropriate cover crops to grow over the summer months to terminate for a fall planting has been challenging. We have been able to grow a great amount of biomass and produce fertility through cover crop and legume selection, however mechanical termination and planting has been difficult for fall cash crop plantings. For example, we have grown a mix of buckwheat for its quick germination and blossoms that attract beneficial insects along with sunn hemp, a legume that grows six to eight feet tall and produces a high quantity of biomass to roll down with the roller crimper. Unfortunately, the fibrous sunn hemp tends to bind our direct seeders for small vegetable crops such as root vegetables and leafy greens. However, our mechanical transplanter can successfully plant directly through it. Thus, we have found that certain selections of cover crops are appropriate for one method of planting may not be suitable for others. We have also found that incorporation of a legume such as sunn hemp has produced enough fertility for the following cash crop's needs, reducing our input and labor costs. The mulch produced by these rolled covers along with other cover crop stands in different stages of growth on the farm have had other benefits as well. They serve as a habitat for beneficial insects, which has reduced our usage of organically approved pesticides, saving us time and money.

One drawback to the no-till system is that in order to have a living mulch to roll down in the summer you need to have your fields cover cropped over winter and into the spring, which negates the spring season as a potential for a cash crop. We experimented with cover crops such as mustard and tillage radish that would winter kill to allow for a spring planting but had limited success due to early frost.

Overall, I would deem this project a great success. Through this project we have bolstered our soil fertility, improved our pest management strategies, and reduced labor, fertilizer, and pesticide costs. It may take a few more years of cover crop selection trials and equipment customization to completely integrate our farm fully with no till management practices. However I am fully confident no-till methodology holds a bright future as the best practice for vegetable crop farmers.

Site Description

City Roots is located in an industrial area close to the Rosewood neighborhood Columbia, SC and on the aptly named Airport Boulevard as the Columbia Owens airfield is literally across the road from City Roots. The farm (originally 3 acres of fields, warehouse/headquarters and greenhouse) is built on an old reclaimed industrial site.

The fields at City Roots were originally made up a layer of between 6 and 12 inches of city compost. A striking characteristic of the fields is that they contain between 8% and 24% organic matter in the top 6" of the soil and from a soils standpoint may be considered man-made, histic epipeda.

Field locations and subfield designations are shown in Figure 1. Field numbers had already been assigned to each field by City Roots management – these were split into a, b and c designations for the purposes of the project. At the beginning of the project (November 2012) we had 18 subfields and around April 2014, the number of subfields were reduced to 17 as a new greenhouse was erected over what was Field 6a.

Figure 1: View of CR fields and schematic representation of subfields.

According to the NRCS's soil survey fields 5, 6 and 7 lie on Dothan (loamy sand) soils while fields 1, 2, 3, and 4 lie on Lakeland (sand) soils. Subsequent field visits by soil scientists suggest that field 6 and 7 lie on a base of sand which may well have been deposited by the rehabilitation of the earlier brownfields site and would explain why fields 6 and 7 are generally better drained than the other fields even though Lakeland soils (profile is entirely sand) are far better drained than Dothan's. Fields 1, 2 and 4 are technically on the well-drained Lakeland soils but they are built on old gravel parking lots which effectively forms an aquatard and generally reduces infiltration. Finally field 3 is mostly perched on underlying wood chips and soils in this location are typically very well-drained and they have very low bulk densities.

About City Roots Soils

It is imperative to understand that City Roots soils, being a man-made, histic epipeda are vastly different from mineral soils, in this case, coastal plain soils (e.g., Lakeland or Dothan) in the surrounding area. Table 1 shows typical values for City Roots soils compared to a typical well-managed coastal plain soil in a well-managed, row-cropped field in South Carolina[2]. All of the row-crop soils are either no-tilled or strip-tilled and were cover-cropped at the time of sampling. Note that the rowcrop soils are active fields and they receive agronomic rates of N, P, K and micronutrients and lime.

Table 1: Average Soil Test Values from Haney Test Lab (ARS) and Clemson.

Lab	Test Parameter	City Roots Soils	Rowcrop Soils	Ratio CR/ Rowcrop Averages
Clemson	OM%	12.3	1.2	10.3
Clemson	CEC (meq/100g)	21.7	5.1	4.3
Haney	CO2-C (ppm)	450	18.8	5.6
Haney	WEOC (ppm)	406.9	91.6	4.4
Haney	WEON (ppm)	26.5	5.8	4.6
Clemson	pH	6.5	5.9	1.1
Clemson	Phosphorus (lb/ac)	134	105	1.3
Clemson	Potassium (lb/ac)	185	141	1.3
Clemson	Magnesium (lb/ac)	588	142	4.1
Clemson	Calcium (lb/ac)	6239	990	6.3
Clemson	Mn (lb/ac)	48.5	12	4.0
Clemson	Zn (lb/ac)	70	8.1	8.6
Clemson	Cu (lb/ac)	0.9	1.1	0.8
Clemson	B (lb/ac)	2.5	0.3	8.3

Note especially in the first five parameters (OM%, CEC, CO2-C, WEOC and WEON) how much higher the City Roots values are than the regular mineral soils. In the last column (Ratio CR/Row-crop Averages), note that CR soils have on average 10 times more organic matter and about 5 times more CEC, CO2-C, WEOC and WEON. The only element where on average the row-cropped fields were higher was copper (Cu). Table 1 is a prime illustration of just how unique City Roots soils are.

[2] These are soils samples off five farms in another Conservation Innovation Grant "Using CO2 Burst Tests to Measure on-farm Plant Available Nitrogen from Cover Cropped Soils in South Carolina"

Method

Field Data Collection

Our overall goal was to measure soil physical chemical and biological properties, both in the field and in the lab and they were as follows:

1. Sampling for Clemson and ARS (temple, TX) Labs

    We took composite samples at a depth of 0-6" in all subfields (18 total, after April 2014, 17 total), split the samples and sent them off to Clemson Soil test lab and the ARS labs in Temple, TX. From Clemson, we obtained mainly chemical properties namely soil pH, P, K, Ca, Mg, micronutrients, Cation Exchange Capacity (CEC) and % Organic matter (%OM). From temple, TX we were able to get additional readings that included soil respiration (24-hour CO2-C burst), Water Extractable organic carbon (WEOC) and water Extractable organic Nitrogen (WEON) which are better indicators of biological activity.

2. Field Nitrate and Soil pH tests

    These tests were done in the field with LaMotte NO3/NO2 Test Strips and pH paper.

3. Soil Moisture and Bulk Density tests

4. Infiltration Rates

5. Field Observations

    In addition to the above, we also conducted field observations (topsoil soil depth, root depth, depth to compaction), and took photographs of the topsoil profiles and field panoramas. Monthly field panoramas allowed us to calculate the number of tillage event in each subfield.

We developed sample and analysis protocols for each of the above methods and these protocols can be found in Appendix 1.

Deviation from Method in Original Scope of Work

We had initially stated that we would use a Draeger tube to measure soil CO_2-C. Early in the project, however, we were alerted to the work of Dr. Rick Haney who kindly agreed to analyze or samples for soil respiration using the 24-hour CO2-burst test. In addition Dr. Haney provided us with other biological soil test indicators in Water Extractable Organic Carbon and Nitrogen, or WEOC and WEON. These measurements were of inestimable value in helping us understand the City Roots soil system.

Analysis of Data

After three years of results and with nine full sampling events of 18 subfields (17 after April 2014), our main problem was to take data[3] and turn it into useful information. To do this we decided to ask two questions namely:

1. Can we detect significant differences between the fields, given the different underlying matrix namely gravel (Fields 1, 2 and 4), wood chips and Lakeland sand (Field 3) and sand (Fields 6 and 7)? To answer this question, we used a single – factor ANOVA using the Fisher Least Significant Difference method for multiple comparisons. We conducted the test for November 2013, the first sample run. Rather than analyze by subfield (one sample per sample event per subfield), we used the field as the unit of analysis

[3] At least 18 parameters [Soil pH, P, K, Ca, Mg, micronutrients, Cation Exchange Capacity (CEC) and % Organic matter (%OM), 24-hour CO2-C burst, Water Extractable organic carbon (WEOC) and water Extractable organic Nitrogen (WEON), topsoil depth, root depth, depth to compaction, infiltration rates, bulk density] x 17 subfields x 9 full sampling events ~ 2,700 data points.

where three subfield samples per field per sample event were combined. We therefore had six units of analysis (Fields 1, 2, 3, 4, 6 and 7).

2. Can we detect differences over time, i.e., was the reduction in tillage in act beneficial to the soils at City Roots. We used six units of analysis (Fields 1, 2, 3, 4, 6 and 7) for this analysis as well.

Results and Discussion

These results, especially those that look at soil properties over time, should be seen as observations in the context of reduced tillage. The original idea was to convert one-third of the farm from conventional till to no-till, but in practice what happened was that the entire farm went to a limited tillage situation in a period of less than a year. What this means that the intensive tillage estimated at 5-7 times a year per subfield (personal communications with Eric McClam, owner, manager of City Roots) was reduced to just over two times a year (we measured 2.2 tillage events per subfield per year from November 2013 to April 2015).

Differences Between Fields

For soil physical properties, we see the general trend that Fields 6 and 7 tend to be deeper and better drained than the others, while Field 4[4] is shallower and less well drained than all of the others (Table 2). No significant differences in bulk density were detected between fields, although it should be noted that bulk densities are extremely low because of the high percentage organic matter contained in the soil.

Table 2: For November 2013 (Beginning of Project) Analysis of Variance (ANOVA) Results for Soil Physical Properties. Table Denotes the Mean (or Average) Root Depth, Depth to Compaction, Infiltration and Bulk Density. Values marked with the same letter are not significantly different from one another.

	Root depth (in)	Depth to Compaction (in)	Infiltration (in/hr)	Bulk Density (g/cm^3)
Field 1	6a	5a	6.0bc	0.58b
Field 2	4.5ab	4.5a	4.1c	0.66ab
Field 3	5.5ab	5.0a	77.6a	0.71ab
Field 4	4.3ab	5.1a	59.3ab	0.59a
Field 6	4b	5.8a	32.3	0.66ab
Field 7	2c	5.8a	38.9abc	0.82a

For the most part soil chemical and biological analyses are typically uniform across all fields (Table 3). The only significant differences between fields is the mean Cation Exchange Capacity (CEC) for Field 3 is significantly lower than the other fields.

Table 3: For November 2013 (Beginning of Project) Analysis of Variance (ANOVA) Results for Selected Soil Chemical and Biological Properties as analyzed by Clemson and ARS in Temple, TX. Table Denotes the Mean (or Average) values for each parameter and values marked with the same letter are not significantly different from one another.

	%OM	pH	P(lb/ac)	K (lb/ac)	CEC (lb/ac)	WEOC (ppm)	WEON (ppm)
Field 1	12.0b	6.9a	147a	364a	21.1ab	471ab	28.6a
Field 2	13.0ab	6.5b	125a	203b	23.2abc	402ab	12.2c
Field 3	13.3ab	6.5b	132a	275ab	21.3c	419ab	24.0ab
Field 4	17.7a	6.5b	141a	188b	25.9a	514a	27.4a
Field 6	10.7b	6.5bc	117a	203b	22.0bc	371b	19.8abc
Field 7	12.0b	6.3 c	151a	270ab	21.4bc	355b	14.5bc

[4] Field 4 results are influenced by 4b and 4c readings where soils are extremely shallow sometimes as shallow as 4", while 4a tends to be slightly deeper and richer in organic matter.

Differences Over Time

Table 4 provides an overall summary of the data where we observed the following general trends:

1. Soil organic matter for the most part did not change significantly and we believe that the reduction in tillage and addition of carbon to the system through cover crops, allowed very high organic matter values (average 11%) to be maintained. Similar comments may be made about trends in the Cation Exchange Capacity (closely related to organic matter) which remained largely unchanged.
2. In general depth to compaction, root depth and infiltration rates increased significantly as a result of the reduced traffic from tillage. We initially (in late 2012 and early 2013) saw a strong platy soil structure at the 4" mark; over time, this platy structure weakened to where we observed blockiness in this zone. On the top 4" of soil we observed a change from single-grain (structureless) soil to increasing amounts of granular soil structure (looking like BB's or cottage cheese). Bulk densities remained essentially unchanged.
3. Soil pH was steady throughout the project – no lime or similar pH amendments were added over the project's monitoring period.
4. Crop removal calculations (13,000 lb/ac produce at 0.3% P) suggest that if no phosphorus were added, we ought to have seen a drop in soil test phosphorus of 114 lb/ac. Soil test phosphorus in fact *increased* over the period of the project by an average of 29 lb/ac.
5. Crop removal calculations (13,000 lb/ac produce at 3% K) suggest that if no potassium were added, we ought to have seen a drop in soil test potassium of 1140 lb/ac. Soil test potassium in fact decreased over the period of the project by an average of 85 lb/ac a drawdown of only 7% of that predicted by the straight crop removal assumptions and calculations.
6. Water extractable organic carbon (WEOC), also related to soil organic matter stayed steady although we saw increases in Fields 7 and 8. We observed a wholesale increase in water extractable organic nitrogen (WEON), and attribute this to less soil disturbance. Table 16 shows that by March 2015 soil test nitrates decreased to about 30% of their average value in Nov 2012.

Table 4: Summary of all ANOVA's to Detect for a Significant Increase (I) or decrease (D) in soil properties between the beginning and the end of the project. Cells denoted by "I" indicate a significant increase, cells denoted by "D" indicate a significant decrease and cells denoted by "-" indicate no significant change.

	Average of All Fields	**Field 1**	**Field 2**	**Field 3**	**Field 4**	**Field 6**	**Field 7**
%OM	-	-	-	-	-	I	-
Root depth (in)	I	I	I	-	-	I	I
Depth to Compaction (in)	I	I	I	I	-	I	I
Infiltration (in/hr)	I	I	I	-	-	I	I
Bulk Density (g/cm3)	-	D	-	-	-	-	-
pH	-	D	-	-	-	-	-
P(lb/ac)	I	-	I	I	-	I	-
K (lb/ac)	D	D	-	-	D	-	D
CEC (lb/ac)	-	-	-	-	-	-	-
WEOC (ppm)	-	-	-	-	-	I	I
WEON (ppm)	I	I	I	I	I	I	I

Percent Organic Matter (%OM)

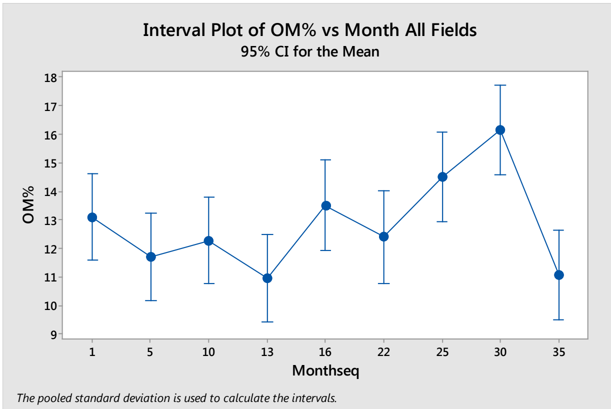
Percent organic matter (%OM) is measured by Clemson soil test laboratories using the loss on ignition (or LOI) method where 1% OM is typically equivalent to 20,000 lbs/ac. City Roots soils contain about 10 times more organic matter than a typical soil in the coastal plain and as of August 2015, the estimated amount of organic matter in the top 6" of soil was 220,000 lbs/acre.

Table 5: Results of ANOVA Test with Average Percent Soil Organic Matter by Field at the first sample date (Nov 2012) and the last sample date (Aug 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average %OM Nov 2012	**Average %OM Aug 2015**
All Fields	13.1	11.0
Field 1	12.0	10.9
Field 2	13	11
Field 3	13.3	13.4
Field 4	17.7	11.2
Field 6	10.7	**15.3**
Field 7	12	12.4

Table 5 shows that %OM did not vary much. We observed a statistically significant increase in %OM in only Field 6. A look at the time series of %OM by field (Figure 2) shows a drop-off for most fields %OM between March 2015 and August 2015. Had we stopped sampling in March 2015, we would have said there were significant increases in %OM in most of the fields. We believe the drop-off may have been due to a very hot summer which may have contributed to increased mineralization of the soil organic matter.

If we step back, however, we can say that for the most part, City Roots has in fact been able to maintain organic matter in the fields. Our initial expectations were that, because the organic matter content was so high, we would inevitably see decay of organic matter content over three years. We hypothesize that the maintenance of high organic matter levels has been achieved through less tillage and by adding carbon through the growing of large cover crops (>10,000 lb/ac).



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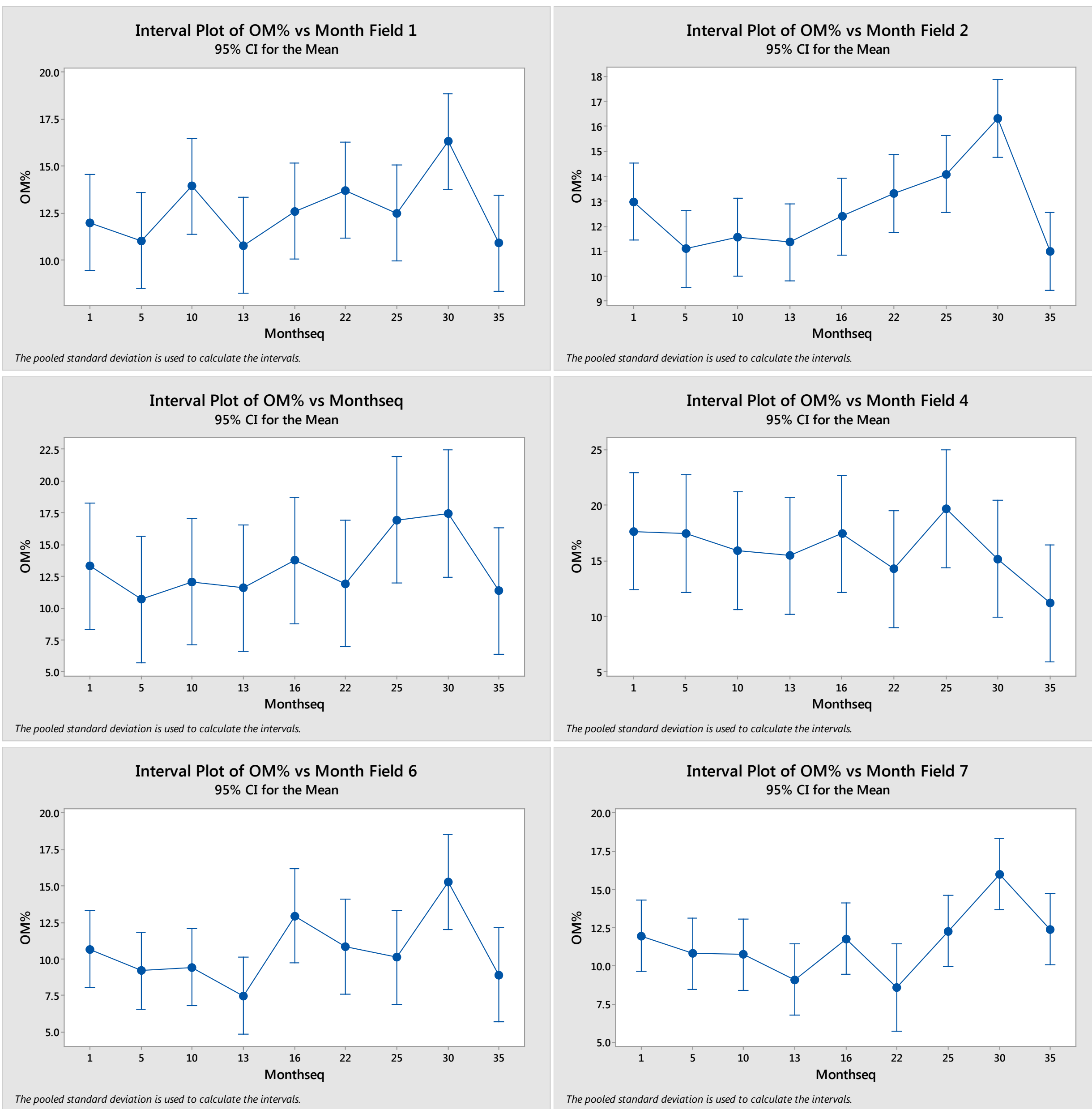


Figure 2: Time Series of Percent Soil Organic Matter by Field at City Roots.

Root Depth

Root depth is a physical observation along with topsoil depth and depth to compaction described by the Soil Quality Test Kit Guide (NRCS 2001) and as can be seen in Table 6, was influenced by the change to limited tillage and cover crops. We saw increases in root depth in all fields, but they were significantly different for Fields 1,2, 6 and 7. This increase was no more dramatic than in Fields 6 and 7 where 6-8" municipal compost which overlay a deep sand layer.

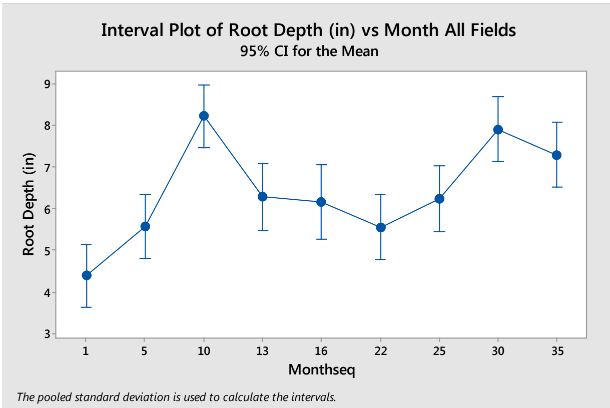
Table 6: Results of ANOVA Test with Average Root Depth by Field at the first sample date (Nov 2012) and the last sample date (Mar 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average Root Depth (in.) Nov 2012	**Average Root Depth (in.) Mar 2015**
All Fields	4.4	**7.3**
Field 1	6	**8.2**
Field 2	4.5	**8**
Field 3	5.5	7.2
Field 4	4.3	4.7
Field 6	4	**9.8**
Field 7	2	**7.7**

The dramatic increase in observed root depth simply came about because the reduced tillage was no longer shredding root growth. A good illustration of this may be show in Figure 3 where over five months, a dramatic difference in root depth and volume could be observed.

Figure 3: Field 7a root depth in November 2012 (left) and March 2013 (right).

Figure 4 suggests that once the switch was made to no-till or limited till, the increase in root depth was rapid and dramatic. We hypothesize that variation in root depth from that point on could be a function of (1) observation and where a sample was taken and (2) maturity of a crop or cover crop or (3) whether tillage had recently taken place. Again, this hypothesis was not tested in the field.



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13	Nov-13
16	Feb-14
22	Aug-14
25	Nov-14
30	Mar-15
35	Aug-15

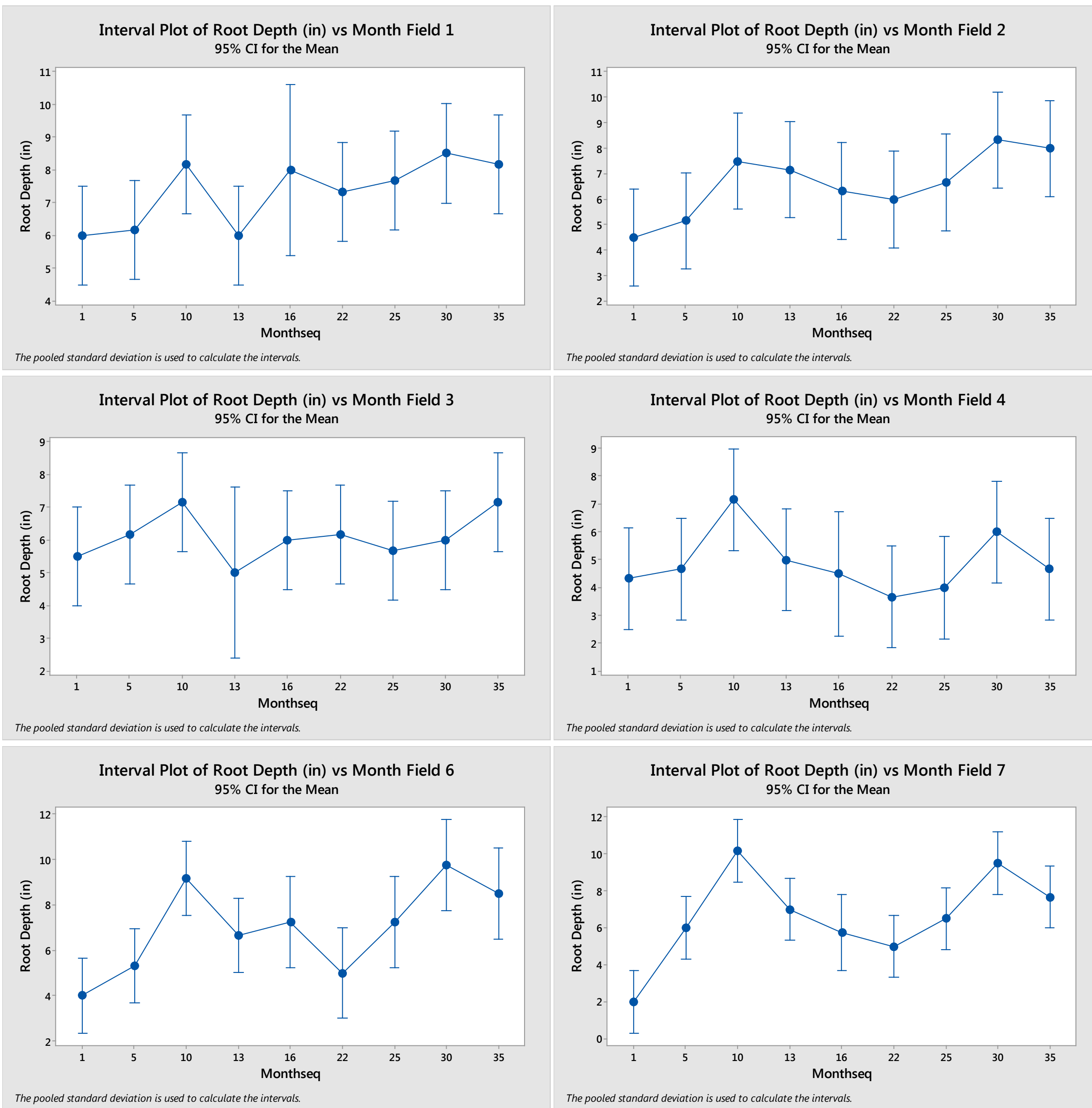


Figure 4: Time Series of Root Depth by Field at City Roots.

Depth to Compaction (in)

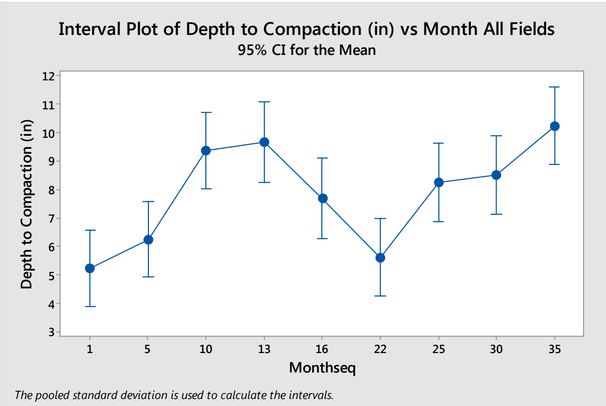
Depth to compaction is a physical observation along with topsoil depth, soil structure, and root depth described by the Soil Quality Test Kit Guide (NRCS 2001). Table 7 and Figure 6 show that depth to compaction to some extent mirrors root depth (Table 6 and Figure 4). Depth to compaction suggests the zone where roots can grow and on average the soil volume accessible by roots doubled in the last three years as seen by the average depth increase from 5.2" to 10.3". Average depth to compaction increased significantly in all fields but Field 4 where Fields 4b and c remain very shallow.

Table 7: Results of ANOVA Test with Average Depth to Compaction (inches) by Field at the first sample date (Nov 2012) and the last sample date (Mar 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average Depth to Compaction (in.) Nov 2015	**Average Depth to Compaction (in.) Mar 2015**
All Fields	5.2	**10.3**
Field 1	5	**11.8**
Field 2	4.5	**8**
Field 3	5	**7.5**
Field 4	5.2	5.2
Field 6	5.8	**16**
Field 7	5.8	**15.5**

In November 2012, what we observed in the field was that while the soils were light and "fluffy" in the top 2-3" – the fluffiness tended to be more single grain (i.e., no structure *per se*) than an actual granular soil structure. More often than not, at 3"-4", soils had a strong platy structure (e.g., Figure 5). Over time, we noticed that soil structure at the surface turned from a single grain to a granular (soil looks like cottage cheese or BB's) and that the platy structure weakened to where we noticed more blocky structure.

Figure 5: Soil Profiles of 6a, 6b and 6c (left to right) taken on November 2012. Note the platy soil structure (as a result of compaction by traffic) already begins at 3"- 4" in this image.



Key:

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35	Aug-15

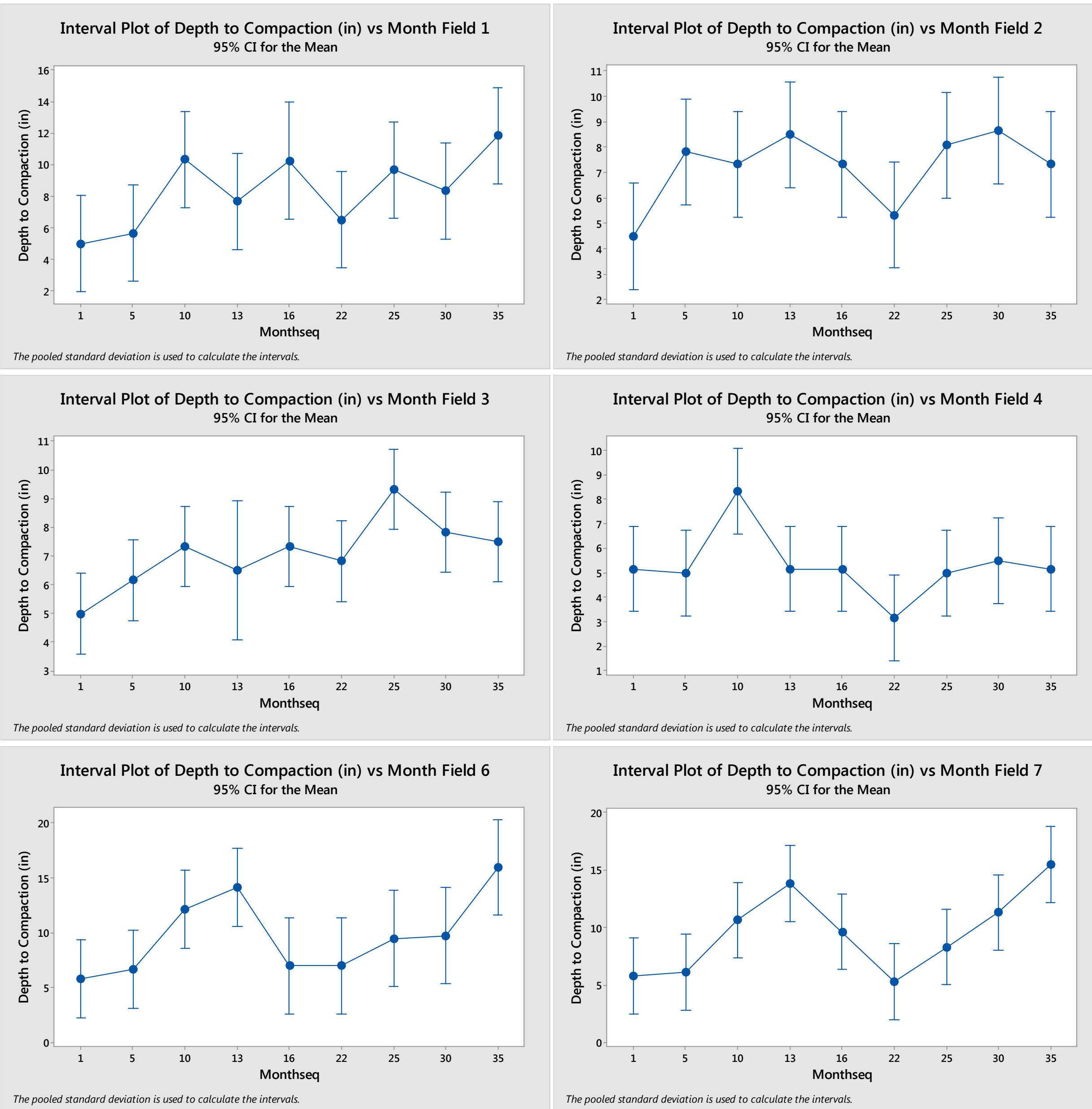


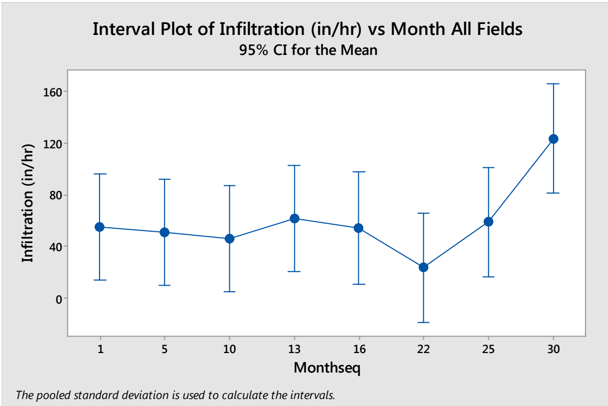
Figure 6: Time Series of Depth to Compaction by Field at City Roots.

Infiltration Rate

Infiltration rate is yet another physical observation described by the Soil Quality Test Kit Guide (NRCS 2001). The quicker water can go into the ground, the less likely runoff will occur and the better soil moisture will be replenished in the soil. In this sense, it is one of the primary indicators of the improvement of soil function. First of all, soil infiltration rates at City Roots are considered very high and rates above (say) 20 inches/her may be considered excessive. Table 8 shows that infiltration rates in Fields 1 and 2 (perched on the gravel parking lots) increased dramatically (and statistically significant increases were seen) while those in Fields 3, 6 and 7 increased numerically. Note that infiltration rates dropped in Field 4. If once compares these values to Depth to Compaction (Table 7, Figure 6) one can see the relationship at least on a qualitative level. In essence, as soil structure loosened up with less tillage, we saw, as a whole, more infiltration. While no image exists to illustrate this, we noticed in late 2013/early 2013 a persistent wet spot on Field 1 in cool, wet conditions, or after a significant irrigation event. This wet spot no longer exists today. Figure 7 provides one with a sense of the trends with infiltration rates – note that these are quite variable and are very dependent on soil moisture amongst other things. As a whole, we are satisfied that infiltration rates increased with a reduction in tillage.

Table 8: Results of ANOVA Test with Average Infiltration rates (inches/hour) by Field at the first sample date (Nov 2012) and the last sample date (Mar 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average Infiltration Rate (in/hr) Nov 2012	**Average Infiltration Rate (in/hr) Mar 2014**
All Fields	25	**71**
Field 1	6	**53**
Field 2	4	**117**
Field 3	77	123
Field 4	59	15
Field 6	32	107
Field 7	39	115



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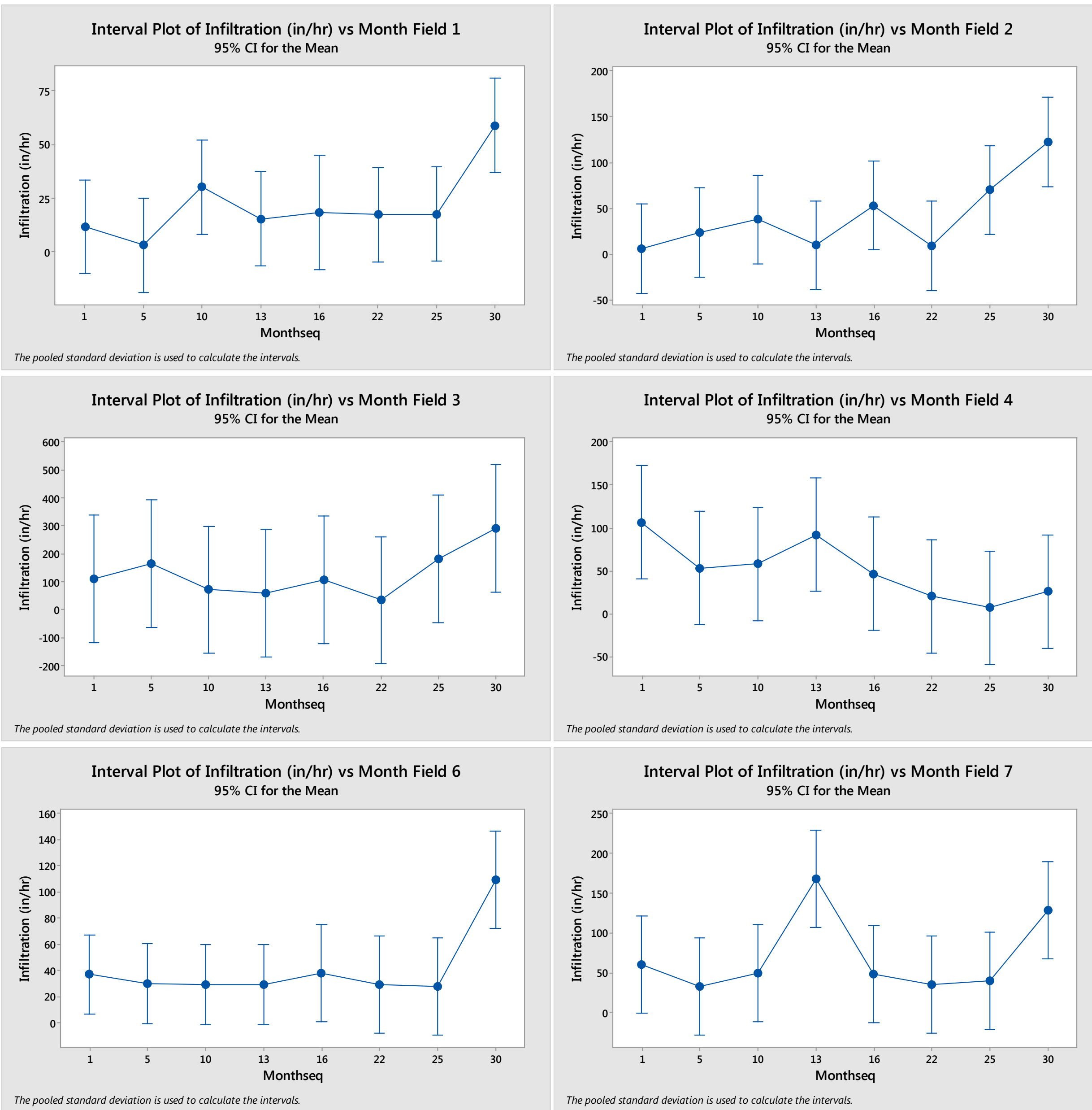


Figure 7: Time Series of Depth to Compaction by Field at City Roots.

Bulk Density

Bulk density (i.e., a measure of how much pore space is in the soil) is another physical observation described by the Soil Quality Test Kit Guide (NRCS 2001). The initial idea was that we would observe a reduction in bulk density over time. The surface bulk densities at City Roots are however typically less than half of the bulk densities found in a coastal plain soil. The very high organic matter content, contributing to an appreciably lower particle density than the average mineral soil, also contributes to this.

As a whole, bulk densities did increase, but only in Field 1 did they increase significantly (Table 9). A possible explanation for this is that over time, the mineral soil is mixing in with the man-made histic epipedon. Once again, an average bulk density of 0.7 g/cm^3 is extremely low and less than half of those observed in mineral soils.

Table 9: Results of ANOVA Test with Average Bulk Density (g/cm^3) by Field at the first sample date (Nov 2012) and the last sample date (Mar 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average Bulk Density (g/cm3) Nov 2012	**Average Bulk Density (g/cm3) Mar 2015**
All Fields	0.67	0.70
Field 1	0.58	**0.61**
Field 2	0.63	0.67
Field 3	0.71	0.71
Field 4	0.60	0.78
Field 6	0.66	0.69
Field 7	0.82	0.72

Soil pH

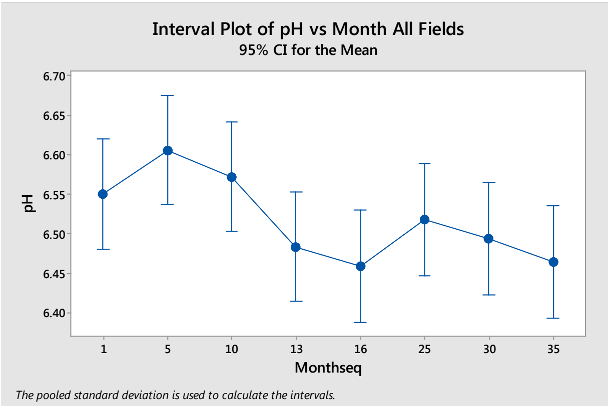
Soil pH (measured by Clemson soil test lab) is a critical component of measuring soil health, high and low pH can also govern the uptake or macro- and micronutrients. Firstly the range of soil pH's measured at City Roots (6-7) is ideal. Secondly, City Roots has never applied lime or any other amendment to the soil in the life of the operation. Note that average pH's on the whole have remained steady or dropped and it is only in Field 1 that pH has dropped significantly. Figure 8 suggests that the pH in fields perched on gravel or wood chips (Fields 1,2,3,4) appear to show a slight downward trend while those perched on a sand bed (Fields 6 and 7) appear if anything to be moving up. We have no working hypothesis for these differences (if indeed they are different).

Note also that City Roots buffer pH measurements are around 7.5 compared to a coastal plain soil that typically reads 7.8. This means that City Roots soils, with their high organic matter tend to resist changes in pH. This may be another contributing factor to the stable pH's.

These results suggest that the notion that all soils with high organic matter tend to acidify is in fact fallacious, at least, at City Roots.

Table 10: Results of ANOVA Test with soil pH by Field at the first sample date (Nov 2012) and the last sample date (Aug 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average Soil pH Nov 2012	**Average Soil pH Aug 2015**
All Fields	6.5	6.4
Field 1	6.9	**6.6**
Field 2	6.5	6.5
Field 3	6.5	6.4
Field 4	6.5	6.5
Field 6	6.5	6.5
Field 7	6.3	6.4



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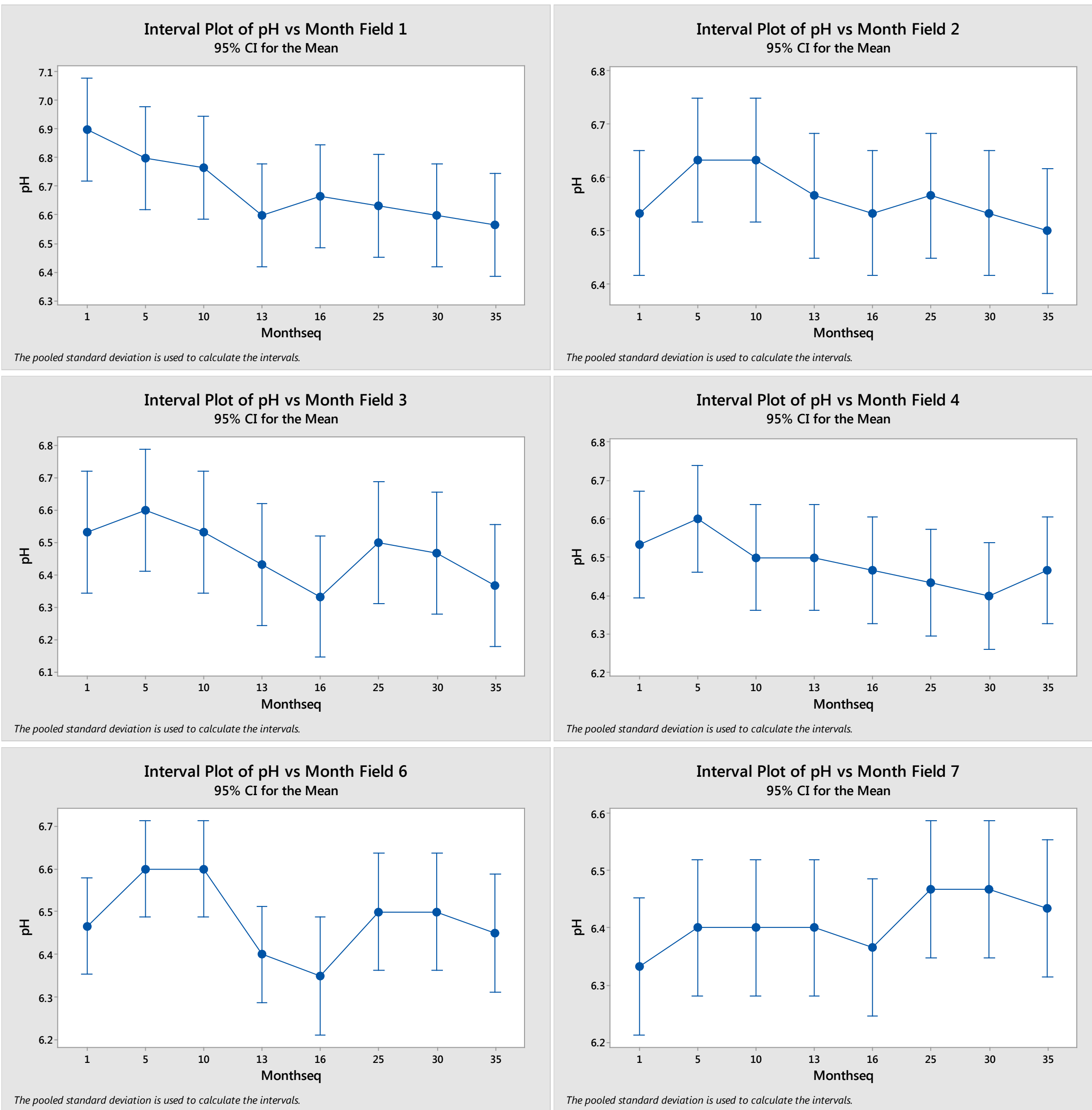


Figure 8: Time Series of soil pH by Field at City Roots.

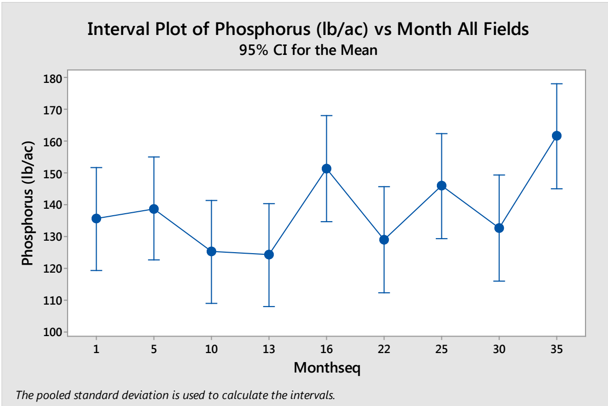
Soil Test Phosphorus

Soil test phosphorus (STP) is measured by Clemson soil test laboratories using the Mehlich 1 extraction method. What is remarkable from these numbers is that over time (Table 11, Figure 9), is that STP has *increased* (in the case of Fields 2, 3, 6 and 7, we observed a statistically significant increase) without the addition of any type of phosphorus fertilizer, organic or otherwise. Yet we estimate that with about 13,000 lbs of produce per acre per year, we are removing in the region of 0.3%[5] x 13,000 ~ 39 lb/ac P per year, or 144 lbs over 35 months - the data shows that on average, however, we actually *increased* soil test P by 29 lbs/ac over three years. We have observed the same phenomenon in our coastal plain soils in our NRCS-SC sponsored Conservation Innovation Grant. Initially we were concerned that we were not measuring correctly, later, when we presented these results, they were met with incredulity. Three years of data, however suggest that our measurements have been correct. Our working hypothesis is that the increased biological activity in the soils through less tillage and more root mass has allowed the plants (cash and cover crops) to access more pools of phosphorus, both in the organic and mineral phase an make them plant available.

Table 11: Results of ANOVA Test with Soil Test Phosphorus (STP) by Field at the first sample date (Nov 2012) and the last sample date (Aug 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average STP (lb/ac) Nov 2012	**Average STP (lb/ac) Aug 2015**
All Fields	135	**162**
Field 1	147	151
Field 2	125	**157**
Field 3	132	**226**
Field 4	141	115
Field 6	117	**133**
Field 7	151	**159**

[5] 0.3% is a conservative number.



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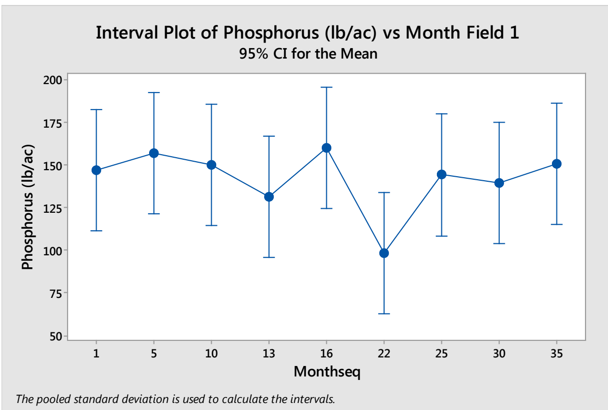
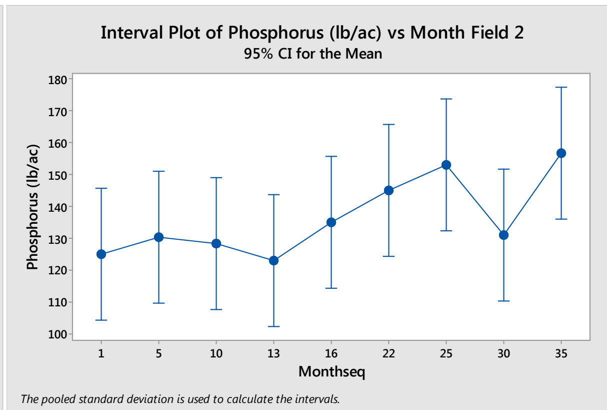
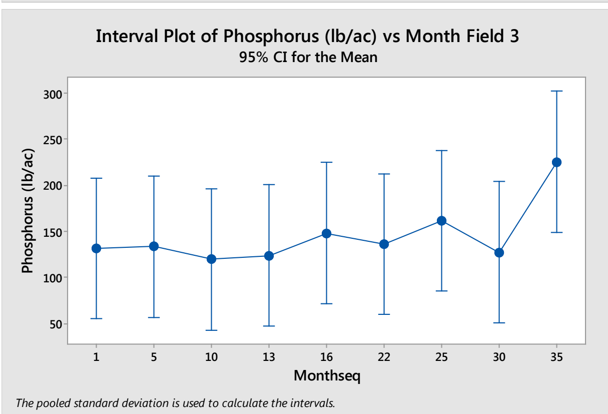
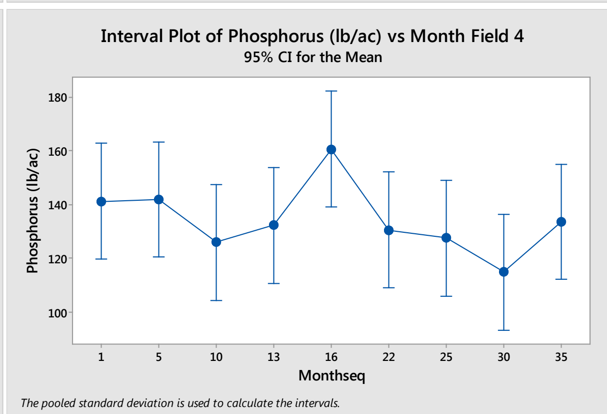
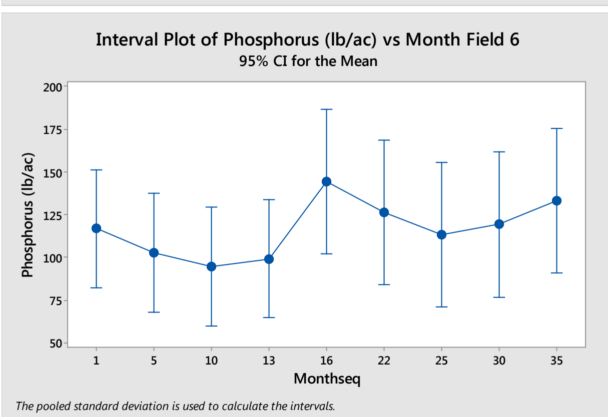










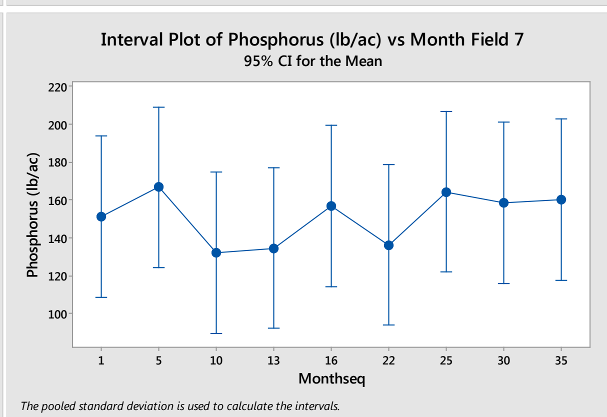


Figure 9: Time Series of Soil Test Phosphorus by Field at City Roots.

Soil Test Potassium

Soil test potassium (STK) is measured by Clemson soil test laboratories using the Mehlich 1 extraction method. On average, soil test potassium (STK) has dropped by 85 lbs/ac over the 35 months they were measured. In Fields 1, 4 and 7 these drops were significant. Note, however that STK in Fields 2 and 6 remained unchanged. Given 13,000 lb/ac produce at 3% K in the plant tissue we estimate that 390 lbs/ac per year or 1,140 lbs over 35 months should have been removed from the farm. We find that the actual drop in STK is in fact a fraction (7%) of that which has been removed. Once again we suggest that STK is becoming available from pools of both organic and mineral sources. In addition because we only measure the top 6" of soil, we believe that some of the crops are bringing STK up from the subsoil.

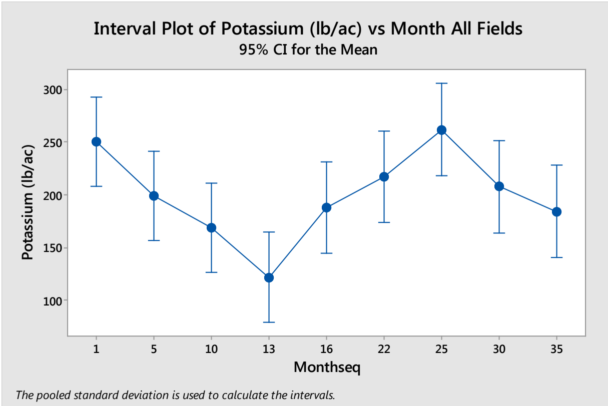
Table 12: Results of ANOVA Test with Soil Test Potassium (STK) by Field at the first sample date (Nov 2012) and the last sample date (Aug 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average STK (lb/ac) Nov 2012	**Average STK (lb/ac) Aug 2015**
All Fields	**250**	185
Field 1	**364**	172
Field 2	203	214
Field 3	275	217
Field 4	**188**	113
Field 6	203	202
Field 7	**270**	185

Evidence that the soil is replenishing soil test potassium[6] can be illustrated in fFigure 6. Note a downward trend (Figure 1) from months 1 – 13 (Nov 2012 – Nov 2013) in all fields – at this time, we experienced an exceptionally wet summer (summer of 2013) – the uniform downward trend was replaced by an equally uniform upward trend in February 2014, yet no potassium was added to the fields[7].

[6] We do not mean to suggest that the laws of the conservation of mass have been suspended, but we do suggest that the pools of potassium in the soil and the organic matter are fairly large and can be made plant available through increased biological activity

[7] A small amount of potassium <50 lb/ac in the form of wood ash was placed on some of the fields but this was after we had sampled the soils in February 2014.



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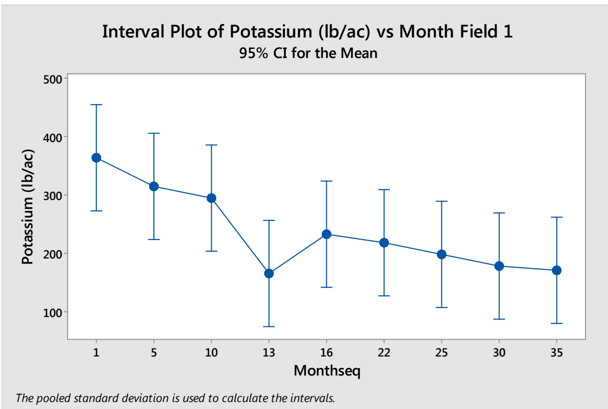
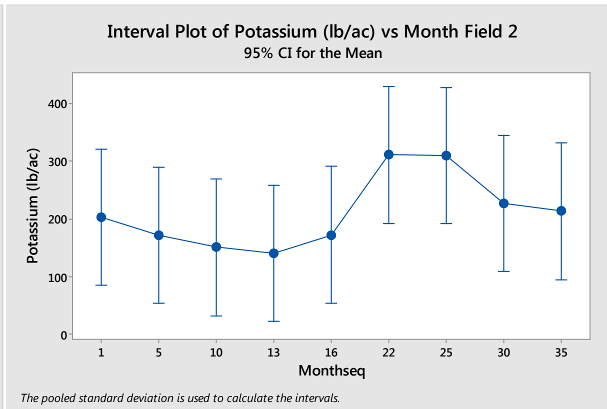
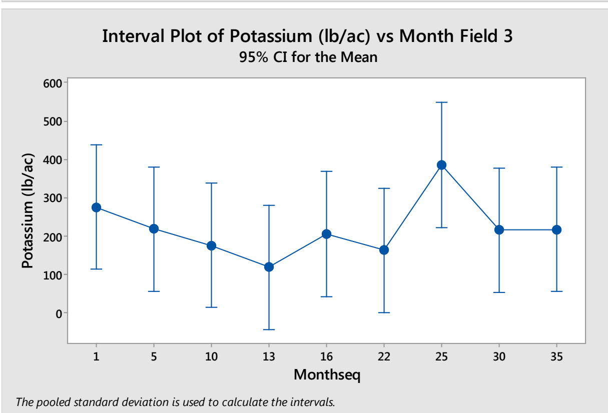
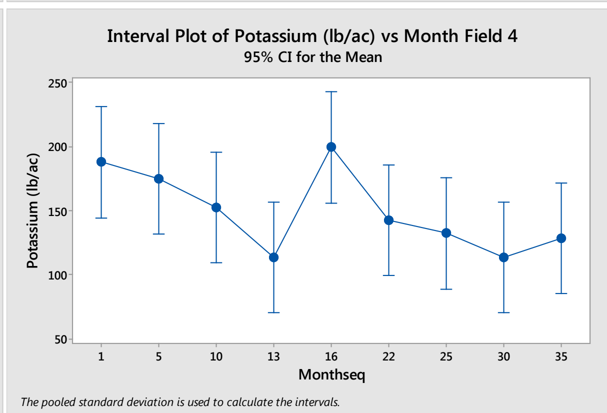
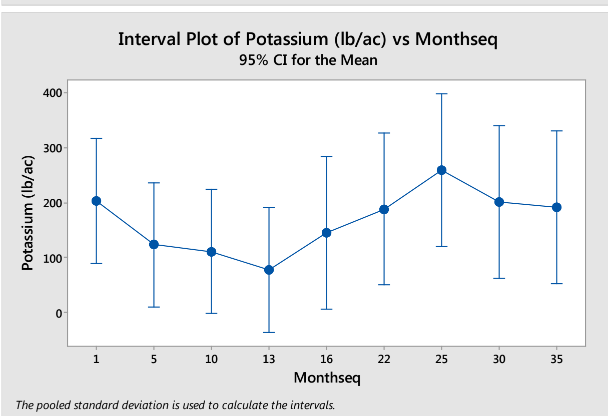










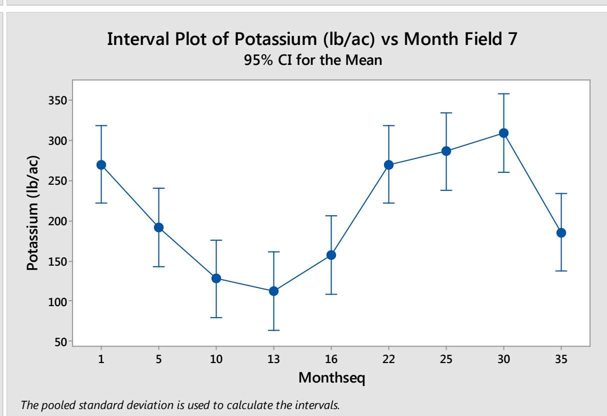


Figure 10: Time Series of Soil Test Potassium by Field at City Roots.

CEC

Cation exchange capacity (CEC) is a measure of the amount of negatively charged sites in a soil. Typically, a sand has a CEC of 2 meq/100 mg, a kaolinitic clay (like those found in the Carolinas) has a CEC of 5 meq/ 100 mg, however, the CEC of organic matter typically has CECs in excess of 300 meq/100 mg. We observe CEC's in a typical coastal plain soil of 5 meq/100 mg, so City Roots CEC's are about 4 times as high and are this high because of the organic matter contained. No significant change in CEC was observed – given that CEC and soil organic matter are closely linked, this is not surprising.

Table 13: Results of ANOVA Test with Cation Exchange Capacity (CEC) by Field at the first sample date (Nov 2012) and the last sample date (Aug 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average CEC (lb/ac) Nov 2012	**Average CEC (lb/ac) Aug 2015**
All Fields	23	24.2
Field 1	25.1	26.7
Field 2	23.2	24.7
Field 3	21.3	22.8
Field 4	25.9	25.3
Field 6	22.0	21.2
Field 7	21.4	23.7

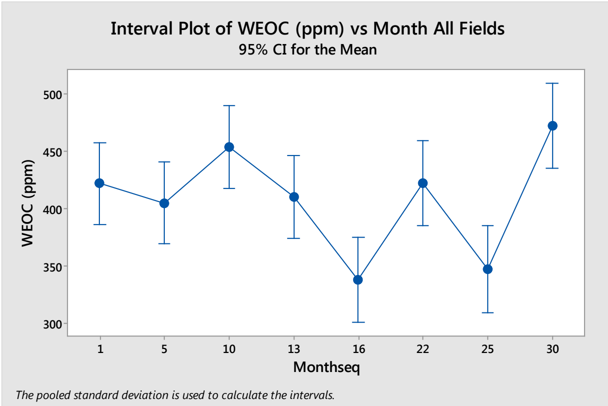
Water Extractable Organic Carbon (WEOC)

This parameter is analyzed at the ARS Haney labs in Temple, TX. The Haney Soil Health Tool Explanation V4.4. says the following : "This number (in ppm) is the amount of organic C extracted from your soil with water. This C pool is roughly 80 times smaller than the total soil organic C pool (% Organic Matter) and reflects the energy source fueling soil microbes. The organic C in the soil water extract reflects the quantity of the C in the soil that is readily available to the microbial population; whereas % SOM is reflective of the entire organic C pool that may become available over the lifetime of the soil. The amount of WEOC reflects the quality of the soil. In other words, % SOM is the house that microbes live in, but what Haney are measuring is the food they eat (WEOC and WEON)."

It ought to be once again noted once again that WEOC for City Roots is about four times higher than WEOC for the average coastal plain soil. On the whole, WEOC remained steady, but did increase significantly in Fields 6 and 7 (Table 14) this may be consistent with a small increase in %OM observed in these fields as well. The increase in biological activity (more root mass with root exudates) may be another factor in the increase in WEOC.

Table 14: Results of ANOVA Test with Cation Exchange Capacity (CEC) by Field at the first sample date (Nov 2012) and the last sample date (Aug 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average WEOC (ppm) Nov 2012	**Average WEOC (ppm) Mar 2015**
All Fields	422	472
Field 1	471	455
Field 2	402	473
Field 3	419	489
Field 4	514	470
Field 6	371	**482**
Field 7	355	**486**



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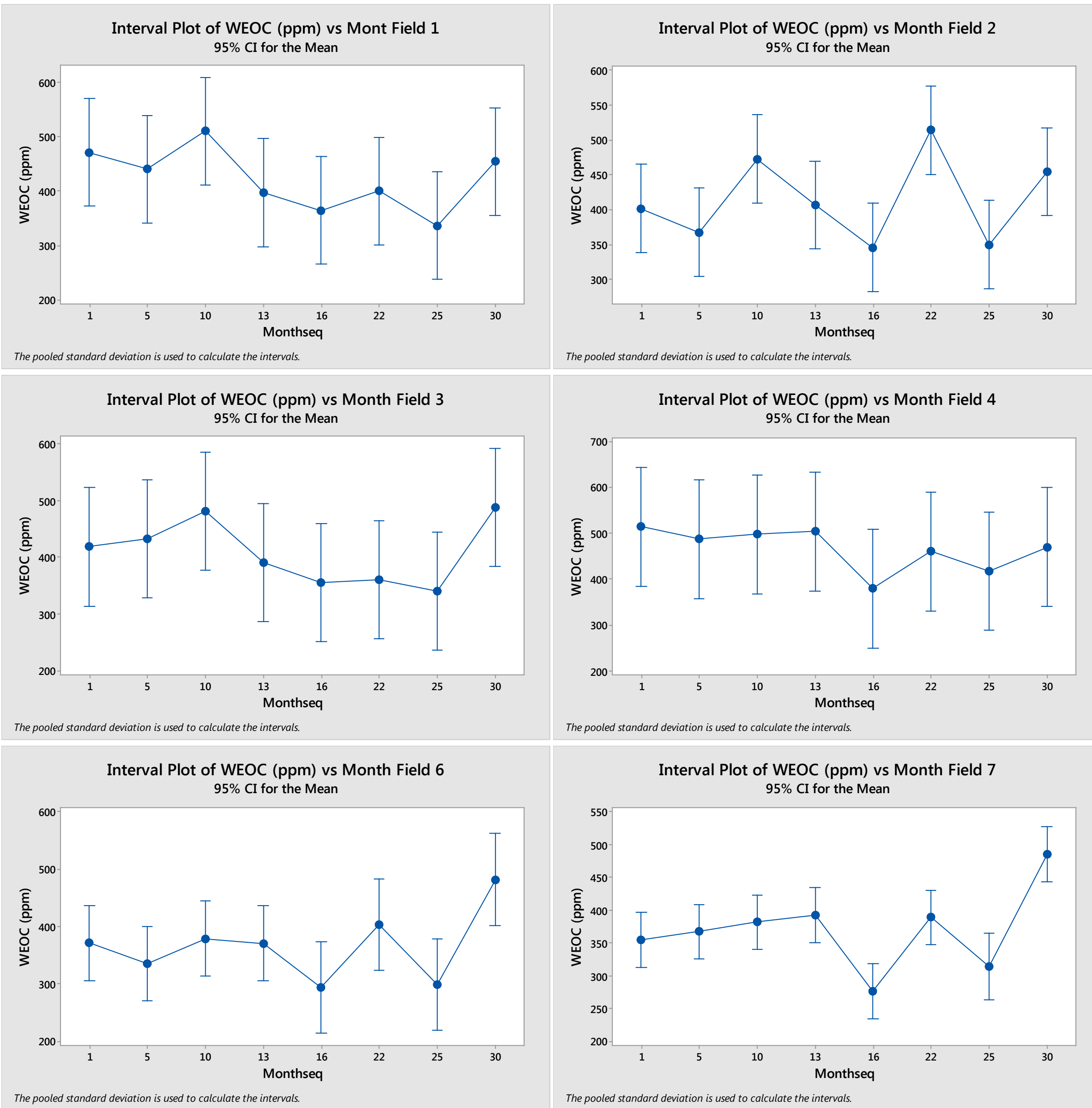

Figure 11: Time Series of Water Extractable Organic Carbon (WEOC) in ppm by Field at City Roots.

Water Extractable Organic Nitrogen (WEON)

This parameter is analyzed at the ARS Haney labs in Temple, TX. The Haney Soil Health Tool Explanation V4.4. says the following : "This number is the amount of the total water extractable N minus the inorganic N (NH4-N + NO3-N). The WEON pool is highly related to the water extractable organic C pool and will be easily broken down by soil microbes and released to the soil in readily plant available inorganic N." Note that we detected an across the board increase in WEON (table 15) and we attribute this to the reduction in tillage allowing the main water soluble nitrogen pool to be retained in the organic form. In examining soil test nitrates (also analyzed by Haney), it appears that the nitrate pool in the soil has decreased to around 30% of what it was in November 2012. Again, the working hypothesis suggests that tillage drives the microbial equilibrium to favor microbes that speed up organic matter mineralization (often known as "priming" the soil with tillage) thus releasing more CO_2 and more nitrates which are easily leached out of the soil profile if not taken up by the plant. Cutting back on tillage (if our hypothesis is correct), appears to have shifted the equilibrium in favor of an organic nitrogen (rather than a nitrate – nitrogen) pool.

Table 15: Results of ANOVA Test with Water Extractable Organic Nitrogen (WEON)by Field at the first sample date (Nov 2012) and the last sample date (Mar 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012).

	Average WEON (ppm) Nov 2012	**Average WEON (ppm) Mar 2015**
All Fields	21	**39**
Field 1	29	**37**
Field 2	12	**38**
Field 3	24	**39**
Field 4	27	**37**
Field 6	20	**41**
Field 7	15	**44**

Table 16: Results of t-test with Nitrate-N (lb/ac) by Field at the first sample date (Nov 2012) and the last sample date (Aug 2015). Numbers in BOLD for the last sample are significantly different from the numbers taken for the first sample (Nov 2012). Values denoted by a * indicate marginally significant differences (p-values >0.05 and <0.1) from the Nov 2102 samples.

	Average Nitrate-N (ppm) Nov 2012	**Average Nitrate-N (ppm) Mar 2015**
All Fields	38	**12***
Field 1	29	**19**
Field 2	40	**15***
Field 3	44	8
Field 4	40	9
Field 6	38	11
Field 7	38	**13**

Soil Respiration (Solvita 24 hour CO2-C)

This parameter is analyzed at the ARS Haney labs in Temple, TX. The Haney Soil Health Tool Explanation V4.4. says the following : "This result is one of the most important numbers in the soil test procedure. This value is the amount of CO2-C (ppm) released in 24 hr. from soil microbes after your soil has been dried and rewetted (as occurs naturally in the field). This is a measure of the microbial activity in the soil and is highly related to soil fertility. In most cases, the higher the number, the more fertile the soil."

Up until Month 16 (Feb 2014) the haney Labs used the Solvita paddle manufactured by Woods End Lab to measure soil CO_2-C. Readings were typically in the low 100's which is a very high reading and the interpretation from the reading means that there would be that the potential mineralizable nitrogen is high (75-105 lb/ac). However in August 2014 we saw a five-fold jump in soil respiration (Figure 12). What has happened was that the Haney lab changed their CO_2 reading method because the Solvita paddles were costing too much. The new method clearly read much higher and on further investigation, it was found that because these readings were so high, they saturated the Solvita paddles and the colorimeter at that time was simply not able to read them.

In this sense, City Roots soils broke the CO_2-C meter[8].

For reference, a coastal plain soil may read between 15 and 50 ppm CO_2-C – this gives one an appreciation of how biologically active these soils are. Given that we had no baseline at the beginning of the project, we were not able to draw any conclusions on the increase or decrease o soil respiration between the beginning and end of the project.

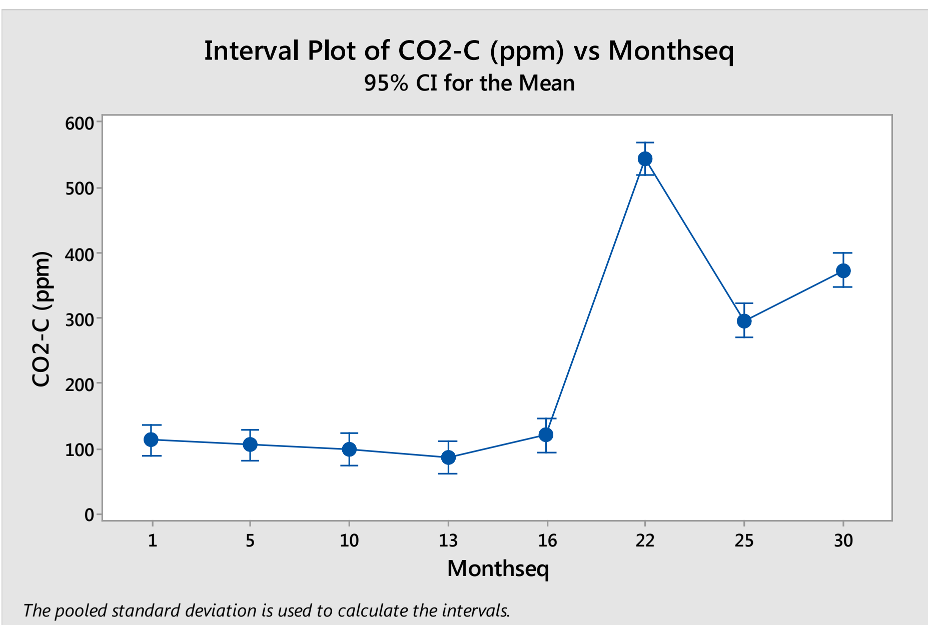

Figure 12: Soil respiration (ppm CO_2-C) as measured in the 24-hour CO_2 burst test.

[8] This limitation in the Solvita paddle has been addressed with a software update.

Field pH and Field Nitrates

We measured field pH and field nitrates with Machery-Nagel pH paper and Lamotte nitrate test strips for the first year.

The field test pH's tended to overestimate pH as measured in the lab by 0.3-0.4 units (average in Year 1 was 6.8). Precision for these colorimetric strips was a problem and increments were in 0.3 of pH unit. This tool was therefore useful to gain a general undertaking of whether the soil was acid or basic, but for the purposes of long term monitoring, this method is not recommended. Given that Clemson was measuring soil pH, we abandoned the field pH readings after a full year of monthly testing.

The Lamotte soil test nitrate strips came in increments of 0, 5, 10, 25 and 50, it was therefore difficult to get precise measurements. Once again, these strips may be useful comparing one system against another, but the purposes of long term monitoring, we did not find this method useful. Given that the Haney labs were measuring nitrates, we abandoned the field nitrate test after 12 months of testing.

The field pH an nitrate test data are available if requested.

Soil test Calcium, Magnesium and Micronutrients

The soil test data for these elements (all measured by Clemson soil test labs) are available, but will not be discussed in this report.

Earthworms

One of the more surprising observations that came out of this project is that we were never able to observe an significant earthworm populations throughout the project. Despite digging 17 holes (initially once a month for the first year) in each sample event, earthworms were few and far between. Our hypothesis is that the particle size distribution in City Roots soils both mineral and organic particles, is simply too large for earthworms to thrive.

Conclusions

All conclusions need to be seen in context of how unique the City Roots soils are compared to typical mineral soils in the coastal plain. City Root soils boast 10 times more organic matter, 4 times more cation exchange capacity, and 25 times more soil respiration. Soil pH's hold steady despite no lime or pH modifying amendments added. Apart from a small amount (<50 lb/ac) of potassium in the form of wood ash applied to several fields in March 2014 and some foliar applications, no amendments have been added to City Roots soils since the beginning of the project.

We can conclude that even though the City Roots farm is based on three acres, each field is unique in terms of its depth and the substrate (gravel parking lot, wood chips sand fill) upon which it is placed.

While we do not have a record of the number of tillage events per year prior to the project, the owners (Eric and Robbie McClam) estimate that the number of tillage events prior to the CIG project was between 5 and 7 a year. Based on field panoramic photographs, we calculated that the number of tillage events dropped to just below two a year from the inception of the project in November 2012.

Soil physical properties (root depth, depth to compaction, infiltration rates) improved significantly as a result of the reduced traffic from tillage. We saw a change in soil structure at the 4" mark which was initially characterized by platiness, but over time, this platy structure weakened to where we observed blockiness in this zone. On the top 4" of soil we observed increasing amounts of granular soil structure. Bulk densities remained essentially unchanged.

From soil test lab analyses, soil organic matter, cation exchange capacity and soil pH were largely unchanged over the project period. This was good news for the most part as conventional wisdom would predict this much organic matter in a hot South Carolina environment to rapidly mineralize over time. In addition, we predicted a reduction in soil pH as a result of rapid organic matter mineralization – this also did not happen.

In terms of the Haney (ARS) parameters, we saw a small increase in water extractable organic carbon (WEOC), a significant increase in Field 6 and 7, which we attribute to increased biological activity from more live root matter and attendant root exudates, remaining in the soils. We observed a wholesale increase in water extractable organic nitrogen (WEON), and attribute this to less soil disturbance – we saw a concomitant decrease in soil test nitrate-N and hypothesize that the lower amount of tillage shifted the water-soluble soil nitrogen equilibrium from an inorganic (nitrate-N) pool to an organic pool.

One of our big surprises is that despite the lack of addition of phosphorus or potassium fertilizers, we experienced an *increase* in soil test phosphorus and a far smaller than expected reduction in soil test potassium based on crop removal rates for 13,000 lb/ac of produce per year.

While original project design, namely the conversion of 1/3 of City Roots land per year to complete no-till, was deeply flawed at the experimental and operational level, the observational data from the last three years has been an unexpected boon to our understanduing of soils as living, dynamic ecosystems. Because we do not have side-by side data for tilled and no-tilled land, we cannot conclusively say that the no-till strategy had any influence on soil health, but from and observational standpoint, we have a fair degree of certainty that soil health, especially in terms of soil physical and biological properties, did improve as tillage was reduced.

To us, however, the most significant findings have been related to soil fertility, and at soil organic matter percentages in this range (average of 11% OM) the basic assumptions of soil fertilizer recommendations, namely that all fertility comes from organic or manufactured fertilizer, are violated. For example, the Clemson Extension fertilizer recommendations, Moore and Franklin (2002) recommend for a soil with (say) medium amounts of potassium and phosphorus that the fertilizer requirement for lettuce should be 150 – 100-120 lbs/ac of N-P_2O_5-K_2O per acre. Given the negligible amounts of organic fertilizer actually applied at City Roots and that the amounts of soil test P and K remain in the high and adequate range respectively, these data have caused us to question the validity of these recommendations., certainly in organic soils like City Roots. It must be kept in mind that the research that led to the yield response curves underlying the fertilizer recommendations was conducted on soils from 40 to 50 years ago where in all likelihood, tillage was excessive and organic matter and soil life was degraded. The advent of no-till and limited till has surely changed this dynamic. The findings in City Roots led to a new Conservation Innovation Grant sponsored by SC-NRCS *Using CO2 Burst Tests to Measure on-farm Plant Available Nitrogen from Cover Cropped Soils in South Carolina* which has in turn led to a 7 farmers in Richland, York, Dillon and Marlboro, collectively controlling 10,000 acres, committing fully to soil health.

We see the City Roots CIG project as the catalyst and ground zero of the soil health movement in South Carolina.

References

Moore, K., and R. Franklin. "EC 476 Nutrient management for South Carolina based on soil-test results." Clemson University Extension Service, Clemson, SC 80 (2002).

USDA-NRCS. 2001 Soil Quality Test Kit Guide. Section 1. Test Procedures, and Section 2. Background and Interpretive Guide for Individual Tests, USDA-NRCS. Ames, IA: Soil Quality Institute.

Appendix 1: Sample Protocols

Sampling for Clemson and ARS Soil Tests

Each of the three plots of each field (See Figure 2) – this will result in 18 samples.

Equipment:

Soil sample probe
Sharpie
Regular Pen
3 Sample buckets (cleaned out)
Hand trowel
½ quart ziplocks x 18
Clemson soil test bags x 18
USPS Boxes x n
Clipboard and sampling logsheet

Field Prep:

Label ziplocs before and Clemson bags before you get to the field

Sampling Procedure

Use the soil sampling probe to take 10 (ten) sample cores at random places for each Field division (e.g., 10 cores for Field 1 a, 10 for Field 1 b, etc.) Soil cores are to be taken at random (Figure 1) for each field plot division.

After each core is taken, place in a bucket. After ten cores are taken, use the trowel to mix the sample for one minute. Once mixing has been completed, use trowel to fill Clemson Soil test bag and a ½ quart Ziploc bag. When filling bags, use alternate scoops of soil for each bag. Once bags are filled label each bag.

A3. Random Duplicate

For each sample round select one Field plot at random (e.g., Field 4 b) and repeat sampling procedure. Label this field "RD" (Random Duplicate) and note which field the random duplicate was taken for quality control at a later stage.

A4. Fill Sample Log Sheet (Appendix 2) and file for records

A5. Boxing and Mailing

Box the samples and send them off to the following laboratories:

Clemson Bags	½ quart bags
Clemson Agricultural Service Laboratory	USDA-ARS
171 Old Cherry Road, Clemson, SC 29634	808 East Blackland Rd.
	Temple, TX 76502

References

Crozier, C.R., and R.W. Heiniger. 1998. Soil Facts: Soil sampling for precision farming systems. North Carolina Cooperative Extension Service Publication AG-439-36. North Carolina State University, Raleigh, NC.

Sampling and Material Handling for Soil NO_3/NO_2, pH and CO_2 Tests

To be done on each of the three subfields in each field and on a mineral soil outside of the fields (See Figure 2) – this will result in 19 samples.

Equipment

Soil sample probe
3 Sample buckets (cleaned out)
Hand trowel
½ quart ziplock bags x 19
Whatman 42.5mm circular glass microfiber filter paper
Solvita beakers x 19
Solvita jars x19
2mm sieve
Electronic balance
Sharpie

Prior to Sampling

Label the ½ quart bags, Dixie cups, and Solvita jars

Sample Method

For each of the subfields (6x3+1=19), take 10 random soil samples from the surface of the soil with the soil sample probe – be sure to clear any litter or other debris away from each site that is sampled. Mix the soil samples together and discard any large rocks or other large debris picked up. Fill each of the ½ quart ziplock bags with mixed soil samples labeled by subfield. Dry each sample in a glass jar in a 20°C oven overnight. When samples are completely dry, use a 2mm sieve to filter out larger particles in the soil.

Sample Splits

Split samples for CO_2 burst, NO_3/NO_2 and pH tests:

1) For the Solvita soil respiration tests, carefully measure ~40 g of the dry soil from each sample and place in the corresponding labeled Solvita beaker with a filter paper lining the bottom. Tap the jar very gently on the counter to ensure the correct density to the fill line, but do not over-pack.
2) Use the remainder of the dried soil samples to test for NO_3/NO_2 and pH.

Analysis for Soil NO_3/NO_2, pH Tests

Equipment

Spoon
11.0cm slow-speed filter paper
Container with deionized water
Timer
Labeled Dixie cups x19
Labeled Solvita jars x19
Solvita beakers with dried soil x19
LaMotte NO_3/NO_2 Test Strips
pH paper (Macherey Nagel pH fix 5.1-7.2)
Solvita Low level CO_2 color probe
Solvita Digital Color Reader
Electronic balance
Plastic spoon
Sharpie
Regular Pen
Clipboard and sampling logsheet
Paper towels

Method NO_3/NO_2, pH Tests

1. Fold the filter paper into a cone and place it on top of a clean, dry Dixie cup. Place Dixie cup with filter on top of electronic balance, and spoon 20 ± 3g of dried soil sample onto the filter paper. Add 20 ± 3g deionized water over the soil. Allow it to seep until filtrate is visible in Dixie cup.
2. For each container, pour 1-2 drops of filtrate that has formed at the bottom of the cup onto a Lamotte NO_3/NO_2 Test Strip. Place the strip on a dry paper towel where it will not get contaminated. Wait 1 minute and then read NO_3/NO_2 concentrations in ppm. Record on logsheet.
3. For each container, pour 1-2 drops of filtrate onto the pH paper – keep filtrate on color stick until color no longer changes. Then remove and read. Record on logsheet.

Method Solvita CO_2 Burst (Haney-Brinton) Test

1. Add 25g deionized water to the outside of the beaker, but inside of the Solvita jar. Note the time.
2. Tear open the foil pack labeled "Low-Level CO_2" and carefully remove the probe from the foil pouch. *Do not touch the gel surface, and don't allow soil to touch it.* At the start of the test the gel should be color #0 (bright blue).
3. Push the probe-stick point into the Solvita jar outside of the beaker with the gel facing out to be visible through the side of the jar. Be careful not to jostle or tip the jar. Screw the lid on tightly. Keep the jar at room temperature (68 - 75^{o}F/20-24^{o}C) or in an incubator *out of sunlight* for 24 hours.
4. At 24 hours, open the jar and remove the probe to read with the Digital Color Reader (DCR) in CO_2-low mode. If comparing colors on the regular color chart, read the probe next to the chart in the same plane and note that the visual color key has two charts — one for fluorescent/daylight, and the other for incandescent lighting. If using the DCR no precautions of lighting are needed. Record color and ppm CO_2 on logsheet.

Soil Moisture and Bulk Density Test

To be done on each of the three plots of each field (See Figure 2) and on a nearby mineral soil – this will result in 19 samples.

Equipment

Field

3" diameter sample ring
Hand sledge
Wood block
Garden trowel
1qt ziplock bag x 19
Sharpie
Ruler with SI units

Lab

Scale/balance
Labeled aluminum containers
Sharpie
Oven
Clipboard and logsheet
Pen

Prior to field trip

Ensure that ziplock bags are labeled for each subfield

In Field

1. Using the hand sledge and block of wood, drive the sample ring, beveled edge down, to a depth of 3 inches.
2. Measure from the soil surface to the top of the ring at 4 evenly spaced places and note the average.
3. Dig around the ring and, with the trowel underneath it, carefully lift it out to prevent any loss of soil.
4. Remove excess soil from the sample with the garden trowel. The bottom of the sample should be flat and even with the edges of the ring.
5. Touch the sample as little as possible. Using the trowel, push out the sample into the plastic sealable bag labeled with the correct subfield. Make sure the entire sample is placed in the plastic bag, and seal the bag.

In Lab

1. Weigh the labeled aluminum containers that will be used to dry the samples and note the weight of container on its underside and on the logsheet.
2. Pour the sample from the ziplock bag into container.
3. Weigh the soil sample and container; enter the combined weights into the logsheet.
4. Place the sample in the oven at 105 degrees for 24 hours.
5. After 24 hours, weigh the dry sample in its container and enter the weight in the logsheet.

Soil Water Infiltration Tests

To be done on each of the three plots of each field (Figure 2), plus on the mineral soil – this will result in 19 samples.

This exercise is not to be done on a field that is saturated (i.e., just after heavy watering or rain)

Equipment

6" diameter ring (ID of ring is 15.8 cm)
Wood block
Hand sledge
Water container
Timer/stopwatch
Graduated cylinder
Plastic wrap
Clipboard and logsheet
Pen

Method

Drive Ring into Soil

1. Clear the sampling area of surface residue, etc. If the site is covered with vegetation, trim it as close to the soil surface as possible. Ensure that the surface is reasonably flat.
2. Using the hand sledge and block of wood, drive the 6-inch diameter ring, beveled edge down, to a depth of three inches (line marked on outside of ring)
3. If the soil contains rock fragments, and the ring cannot be inserted to depth, gently push the ring into the soil until it hits a rock fragment.
4. To firm soil, use your finger to gently firm the soil surface only around the *inside* edges of the ring to prevent extra seepage. Minimize disturbance to the rest of the soil surface inside the ring.

Add Water and Measure Infiltration Rate

5. Line the soil surface with plastic wrap inside the ring so that both soil and ring are covered.
6. Add 498 ml[9] of water into the plastic in the ring.
7. Remove the plastic wrap very gently by pulling it out, and start the timer.
8. Stop the timer when the soil surface is just glistening.
9. Note the time to infiltrate one inch of water.
10. Repeat steps 5-9 for the second inch of water.

[9] Corresponds to one inch of water in the ring. Calculation is πr2h = $3.1417*(15.8/2)^2*2.54$ = 489 mL

Protocol for Soil Physical Observations

To be done on each of the three plots of each field (See Figure 2) and on the control mineral soil.

Equipment

Canon 7D + tripod
Tile spade (sharpshooter) or regular shovel if not available
Tape measure/ruler
Light-colored surface to place soil samples
Metal probe
Logsheet
Pen

Method

Topsoil depth, color, roots and structure

1. Dig a hole to a depth of about 1 foot.
2. Take a slice of the soil out with the sharpshooter and lay it on the light-colored surface – if plants are growing, dig down the side of a stem.
3. Measure and record the depth of the topsoil.
4. Measure depth to compaction layer by inserting metal probe vertically into soil as far as it will go without resistance. Use tape measurer to measure depth to compaction on metal probe.
5. Observe plant root growth – look for balled up roots or roots growing sideways
6. Examine soil structure – specifically the type (granular, blocky or platy), the size and the strength (weak moderate, strong) of the structure.

Photography

1. Pan of each field with Canon 7D on tripod
2. Soils slices for each subfield should be placed next to one another (3 per field) on the laminated poster and labeled to ensure a useful visual comparison of each plot. A tape measurer or ruler should also be placed by the soil samples to compare depths.

Protocol for Earthworm Observations

To be done on each of the three plots of each field (See Appendix 1) – this will result in 18 samples.

Equipment

Shovel/spade
Light covered surfaces e.g., box or laminated poster
Clipboard and logsheet
Pen

Method

1. Measure a 1ft x 1ft plot and dig down 12 inches (or to the original soil layer).
2. Using as few cuts as possible remove soil from the hole.
3. Sort the soil against a pale background to locate the earthworms.
4. Separate and count the earthworms.
5. Record number of earthworms found.

This form is available electronically.

(See Page 2 for Privacy Act and Paperwork Reduction Act Statements)

AD-1026
(10-30-14)

U.S. DEPARTMENT OF AGRICULTURE
FarmServiceAgency

HIGHLY ERODIBLE LAND CONSERVATION (HELC) AND WETLAND CONSERVATION (WC) CERTIFICATION

Read attached AD-1026 Appendix before completing form.

PART A – BASIC INFORMATION

1. Name of Producer	2. Tax Identification Number *(Last 4 digits)*	3. Crop Year
City Roots LLC.	2980	2015

4. Names of affiliated persons with farming interests. *Enter "None," if applicable.*

Eric McClam

Affiliated persons with farming interests must also file an AD-1026. See Item 7 in the Appendix for a definition of an affiliated person.

5. Check one of these boxes if the statement applies; otherwise continue to Part B.

A. ☐ The producer in Part A does not have interest in land devoted to agriculture. Examples include bee keepers who place their hives on another person's land, producers of crops grown in greenhouses, and producers of aquaculture AND these producers do not own/lease any agricultural land themselves. **Note:** Do not check this box if the producer shares in a crop.

B. ☐ The producer in Part A meets all three of the following:
- does not participate in any USDA program that is subject to HELC and WC compliance except Federal Crop Insurance.
- only has interest in land devoted to agriculture which is exclusively used for perennial crops, except sugarcane, and
- has not converted a wetland after February 7, 2014.

Perennial crops include, but are not limited to, tree fruit, tree nuts, grapes, olives, native pasture and perennial forage. A producer that produces alfalfa should contact the Natural Resources Conservation Service at the nearest USDA Service Center to determine whether such production qualifies as production of a perennial crop.

Note: *If either box is checked, and the producer in Part A does not participate in Farm Service Agency (FSA) or Natural Resources Conservation Service (NRCS) programs, the full tax identification number of the producer must be provided, but establishment of detailed farm records with FSA is not required. Go to Part D and sign and date.*

PART B - HELC/WC COMPLIANCE QUESTIONS

Indicate YES or NO to each question. *If you are unsure of whether a HEL determination, wetland determination, or NRCS evaluation has been completed, contact your local USDA Service Center.*	YES	NO
6. During the crop year entered in Part A or the term of a requested USDA loan, did or will the producer in Part A plant or produce an agricultural commodity (including sugarcane) on land for which an HEL determination has not been made?		✔
7. Has anyone performed (since December 23, 1985), or will anyone perform any activities to:		
A. Create new drainage systems, conduct land leveling, filling, dredging, land clearing, or excavation that has **NOT** been evaluated by NRCS? ***If "YES", indicate the year(s):*** _____		✔
B. Improve or modify an existing drainage system that has **NOT** been evaluated by NRCS? ***If "YES", indicate the year(s):*** _____		✔
C. Maintain an existing drainage system that has **NOT** been evaluated by NRCS? ***If "YES", indicate the year(s):*** _____ **Note:** *Maintenance is the repair, rehabilitation, or replacement of the capacity of existing drainage systems to allow for the continued use of wetlands currently in agricultural production and the continued management of other areas as they were used before December 23, 1985. This allows a person to reconstruct or maintain the capacity of the original system or install a replacement system that is more durable or will realize lower maintenance or costs.*		✔

Note: *If "YES" is checked for Item 7A or 7B, then Part C must be completed to authorize NRCS to make an HELC/WC and/or certified wetland determination on the identified land. If "YES" is checked for Item 7C, NRCS does not have to conduct a certified wetland determination.*

8. Check one or both boxes, if applicable; otherwise, continue to Part C or D.

A. ☐ Check this box only if the producer in Part A has FCIC reinsured crop insurance and filing this form represents the first time the producer in Part A, including any affiliated person, has been subject to HELC and WC provisions.

B. ☐ Check this box if either of the following applies to the producer and crop year entered in Part A:
- Is a tenant on a farm that is/will not be in compliance with HELC and WC provisions because the landlord refuses to allow compliance, but all other farms not associated with that landlord are in compliance. (AD-1026B, Tenant Exemption Request, must be completed).
- Is a landlord of a farm that is/will not be in compliance with HELC and WC provisions because of a violation by the tenant on that farm, but all other farms not associated with that tenant are in compliance. (AD-1026C, Landlord or Landowner Exemption Request, must be completed).

PART C – ADDITIONAL INFORMATION

9. If "YES" was checked in Item 6 or 7, provide the following information for the land to which the answer applies:

A. Farm and/or tract/field number: farm #3048 tract #10155
If unknown, contact the Farm Service Agency at the nearest USDA Service Center.

B. Activity: vegetable crops

C. Current land use *(specify crops)*: Tomatoes, squash, eggplant, lettuce, carrots, beets, cover crops

D. County: Richland

PART D – CERTIFICATION OF COMPLIANCE

I have received and read the AD-1026 Appendix and understand and agree to the terms and conditions therein on all land in which I (or the producer in Part A if different) and any affiliated person have or will have an interest. I understand that eligibility for certain USDA program benefits is contingent upon this certification of compliance with HELC and WC provisions and I am responsible for any non-compliance. I understand and agree that this certification of compliance is considered continuous and will remain in effect unless revoked or a violation is determined. I further understand and agree that:

- all applicable payments must be refunded if a determination of ineligibility is made for a violation of HELC or WC provisions.
- NRCS may verify whether a HELC violation or WC has occurred.
- a revised Form AD-1026 must be filed if there are any operation changes or activities that may affect compliance with the HELC and WC provisions. I understand that failure to revise Form AD-1026 for such changes may result in ineligibility for certain USDA program benefits or other consequences.
- affiliated persons are also subject to compliance with HELC and WC provisions and their failure to comply or file Form AD-1026 will result in loss of eligibility for applicable benefits to any individuals or entities with whom they are considered affiliated.

Producer's Certification:

I hereby certify that the information on this form is true and correct to the best of my knowledge.

10A. Producer's Signature (By)	10B. Title/Relationship *(If Signing in Representative Capacity)*	10C. Date *(MM-DD-YYYY)*
[signature]	Owner - Farm Manager	12/15/15
FOR FSA USE ONLY *(for referral to NRCS)* Sign and date if NRCS determination is needed.	11A. Signature of FSA Representative	11B. Date *(MM-DD-YYYY)*

IMPORTANT: If you are unsure about the applicability of HELC and WC provisions to your land, contact your local USDA Service Center for details concerning the location of any highly erodible land or wetland and any restrictions applying to your land according to NRCS determinations before planting an agricultural commodity or performing any drainage or manipulation. Failure to certify and properly revise your compliance certification when applicable may: (1) affect your eligibility for USDA program benefits, including whether you qualify for reinstatement of benefits through the Good Faith process; and (2) result in other consequences.

NOTE: *The following statement is made in accordance with the Privacy Act of 1974 (5 USC 552a - as amended). The authority for requesting the information identified on this form is 7 CFR Part 12, the Food Security Act of 1985 (Pub. L. 99-198), and the Agricultural Act of 2014 (Pub. L. 113-79). The information will be used to certify compliance with HELC and WC provisions and to determine producer eligibility to participate in and receive benefits under programs administered by USDA agencies. The information collected on this form may be disclosed to other Federal, State, Local government agencies, Tribal agencies, and nongovernmental entities that have been authorized access to the information by statute or regulation and/or as described in applicable Routine Uses identified in the System of Records Notice for USDA/FSA-2, Farm Records File (Automated) and USDA/FSA-14, Applicant/Borrower. Providing the requested information is voluntary. However, failure to furnish the requested information will result in a determination of producer ineligibility to participate in and receive benefits under programs administered by USDA agencies.*

This information collection is exempted from the Paperwork Reduction Act as specified in the Agricultural Act of 2014 (Pub. L. 113-79, Title II, Subtitle G, Funding and Administration). The provisions of appropriate criminal and civil fraud, privacy, and other statutes may be applicable to the information provided. ***RETURN THIS COMPLETED FORM AD-1026 TO YOUR COUNTY FARM SERVICE AGENCY (FSA) OFFICE.***

This form is available electronically.

CCC-941
(03-28-14)

U.S. DEPARTMENT OF AGRICULTURE
Commodity Credit Corporation

AVERAGE ADJUSTED GROSS INCOME (AGI) CERTIFICATION AND CONSENT TO DISCLOSURE OF TAX INFORMATION

Agricultural Act of 2014

1. Return completed form to:

(Name and address of FSA county office or USDA Service Center)

NOTE: *The following statement is made in accordance with the Privacy Act of 1974 (5 USC 552a - as amended). The authority for requesting the information identified on this form is 7 CFR Part 1400, the Commodity Credit Corporation Charter Act (15 U.S.C. 714 et seq.), the Food Security Act of 1985 (Pub. L. 99-198), and the Agricultural Act of 2014 (Pub. L. 113-79). The information will be used to determine eligibility for program benefits. The information collected on this form may be disclosed to other Federal, State, Local government agencies, Tribal agencies, and nongovernmental entities that have been authorized access to the information by statute or regulation and/or as described in applicable Routine Uses identified in the System of Records Notice for USDA/FSA-2, Farm Records File (Automated). Providing the requested information is voluntary. However, failure to furnish the requested information will result in a determination of ineligibility for program benefits.*

This information collection is exempted from the Paperwork Reduction Act as specified in the Agricultural Act of 2014 (Pub. L. 113-79, Title I, Subtitle F – Administration). ***PLEASE RETURN COMPLETED FORM TO FSA AT THE ABOVE ADDRESS.***

2. Name and Address of Individual or Legal Entity *(Including Zip Code)*

City Roots LLC

(Use the same name and address as used for the tax return specified in Part B.)

3. Taxpayer Identification Number (TIN) *(Social Security Number for Individual; or Employer Identification Number for Legal Entity)*

264732980

PART A – CERTIFICATION OF AVERAGE ADJUSTED GROSS INCOME

4. The program year for payment eligibility

A. **20**15 — **Enter the year for which program benefits are requested**. The period for calculation of the average AGI will be of the three taxable years preceding the most immediately preceding complete taxable year for which benefits are requested. For example, the 3-year period for the calculation of the average AGI for 2014 would be the taxable years of 2012, 2011 and 2010.

5. I certify that the average adjusted gross income of the individual or legal entity in Item 2 (*for the year included in Item 4*) was:

A. ☑ **Less than** *(or equal to)* **$900,000**

B. ☐ **More than $900,000**

PART B – CONSENT TO DISCLOSURE OF TAX INFORMATION

Pursuant to 26 U.S.C. §6103, I hereby authorize the Internal Revenue Service (IRS) to review the following items of "return information" ***(as defined in 26 U.S.C. §6103(b)(2))*** **from the returns** ***(as specified below)*** **of the individual or legal entity identified in Item 2 for the taxable years indicated in Item 4:**

Form 1040 and 1040NR filers; farm income or loss; adjusted gross income
Form 1041 filers; farm income or loss, charitable contributions, income distribution deductions, exemptions, adjusted total income; total income
Form 1065 filers; guaranteed payments to partners, ordinary business income
Form 1120, 1120A, 1120C filers: charitable contributions, taxable income
Form 1120S filers: ordinary business income
Form 990T: unrelated business taxable income

I understand the IRS will review these items of return information in order to perform calculations, the results of which I authorize to be disclosed to officers and employees of the United States Department of Agriculture (USDA) for use in determining the individual's or legal entity's eligibility for specified payments for various commodity and conservation programs. The calculations performed by the IRS use a methodology prescribed by the USDA. In addition, I am aware that the USDA may use the information received for compliance purposes related to this eligibility determination, including referrals to the Department of Justice.

Specially, the IRS will disclose to the USDA the individual's or legal entity's name and TIN, and inform the USDA if, pursuant to its calculations, the average Adjusted Gross Income (AGI) is above or below eligibility requirements as prescribed by the Agricultural Act of 2014. The IRS will also disclose to the USDA the type of return from which the information used for the calculations was obtained.

If the IRS is unable to locate a return that matches the taxpayer identity information provided above, or if IRS records indicate that the specified return has not been filed, for any of the taxable years indicated, the IRS may disclose that it was unable to locate a return, or that a return was not filed, for those years, whichever is applicable.

An approved Power of Attorney (Form FSA-211) on file with USDA cannot be used as evidence of signature authority when completing this form.

By signing this form:

- **I acknowledge that I have read and reviewed all definitions and requirements on Page 2 of this form;**
- **I certify that all information contained within this certification is true and correct; and is consistent with the tax returns filed with the IRS;**
- **I agree to authorize CCC to obtain tax data from the IRS for AGI compliance verification purposes by filing this form;**
- **I am aware that without this consent to disclosure, the returns and return information of the individual or legal entity identified in Item 2 are confidential and are protected by law under the Internal Revenue Code;**
- **I certify that I am authorized under applicable state law to execute this consent on behalf of the legal entity identified in Item 2 (for legal entity only).** Eric McClam signing for City Roots LLC

6. Signature (By)	7. Title/Relationship *of the Individual if Signing in a Representative Capacity for a legal entity*	8. Date *(MM-DD-YYYY)*
City Roots [signature]	Owner	12/15/2015

The U.S. Department of Agriculture (USDA) prohibits discrimination against its customers, employees, and applicants for employment on the basis of race, color, national origin, age, disability, sex, gender identity, religion, reprisal, and where applicable, political beliefs, marital status, familial or parental status, sexual orientation, or all or part of an individual's income is derived from any public assistance program, or protected genetic information in employment or in any program or activity conducted or funded by the Department. (Not all prohibited basis will apply to all programs and/or employment activities.) Persons with disabilities, who wish to file a program complaint, write to the address below or if you require alternative means of communication for program information (e.g., Braille, large print, audiotape, etc.) please contact USDA's TARGETCenter at (202) 720-2600 (voice and TDD). Individuals who are deaf, hard of hearing, or have speech disabilities and wish to file either an EEO or program complaint, please contact USDA through the Federal Relay Service at (800) 877-8339 or (800) 845-6136 (in Spanish).

If you wish to file a Civil Rights program complaint of discrimination, complete the USDA Program Discrimination Complaint Form, found online at ***http://www.ascr.usda.gov/complaint_filing_cust.html****, or at any USDA office, or call (866) 632-9992 to request the form. You may also write a letter containing all of the information requested in the form. Send your completed complaint form or letter by mail to U.S. Department of Agriculture, Director, Office of Adjudication, 1400 Independence Avenue, S.W., Washington, D.C. 20250-9410, by fax (202) 690-7442 or email at* ***program.intake@usda.gov****. USDA is an equal opportunity provider and employer.*

This form is available electronically.

CCC-941 (03-28-14)

U.S. DEPARTMENT OF AGRICULTURE
Commodity Credit Corporation

AVERAGE ADJUSTED GROSS INCOME (AGI) CERTIFICATION AND CONSENT TO DISCLOSURE OF TAX INFORMATION

Agricultural Act of 2014

1. Return completed form to:

(Name and address of FSA county office or USDA Service Center)

NOTE: *The following statement is made in accordance with the Privacy Act of 1974 (5 USC 552a - as amended). The authority for requesting the information identified on this form is 7 CFR Part 1400, the Commodity Credit Corporation Charter Act (15 U.S.C. 714 et seq.), the Food Security Act of 1985 (Pub. L. 99-198), and the Agricultural Act of 2014 (Pub. L. 113-79). The information will be used to determine eligibility for program benefits. The information collected on this form may be disclosed to other Federal, State, Local government agencies, Tribal agencies, and nongovernmental entities that have been authorized access to the information by statute or regulation and/or as described in applicable Routine Uses identified in the System of Records Notice for USDA/FSA-2, Farm Records File (Automated). Providing the requested information is voluntary. However, failure to furnish the requested information will result in a determination of ineligibility for program benefits.*

This information collection is exempted from the Paperwork Reduction Act as specified in the Agricultural Act of 2014 (Pub. L. 113-79, Title I, Subtitle F – Administration). **PLEASE RETURN COMPLETED FORM TO FSA AT THE ABOVE ADDRESS.**

2. Name and Address of Individual or Legal Entity *(Including Zip Code)*

Eric McClam

(Use the same name and address as used for the tax return specified in Part B.)

3. Taxpayer Identification Number (TIN) *(Social Security Number for Individual; or Employer Identification Number for Legal Entity)*

2647329880

PART A – CERTIFICATION OF AVERAGE ADJUSTED GROSS INCOME

4. The program year for payment eligibility

A. 20 15 — **Enter the year for which program benefits are requested.** The period for calculation of the average AGI will be of the three taxable years preceding the most immediately preceding complete taxable year for which benefits are requested. For example, the 3-year period for the calculation of the average AGI for 2014 would be the taxable years of 2012, 2011 and 2010.

5. I certify that the average adjusted gross income of the individual or legal entity in Item 2 (*for the year included in Item 4*) was:

A. ☑ **Less than** *(or equal to)* **$900,000**

B. ☐ **More than $900,000**

PART B – CONSENT TO DISCLOSURE OF TAX INFORMATION

Pursuant to 26 U.S.C. §6103, I hereby authorize the Internal Revenue Service (IRS) to review the following items of "return information" *(as defined in 26 U.S.C. §6103(b)(2))* from the returns *(as specified below)* of the individual or legal entity identified in Item 2 for the taxable years indicated in Item 4:

Form 1040 and 1040NR filers; farm income or loss; adjusted gross income
Form 1041 filers: farm income or loss, charitable contributions, income distribution deductions, exemptions, adjusted total income; total income
Form 1065 filers; guaranteed payments to partners, ordinary business income
Form 1120, 1120A, 1120C filers: charitable contributions, taxable income
Form 1120S filers: ordinary business income
Form 990T: unrelated business taxable income

I understand the IRS will review these items of return information in order to perform calculations, the results of which I authorize to be disclosed to officers and employees of the United States Department of Agriculture (USDA) for use in determining the individual's or legal entity's eligibility for specified payments for various commodity and conservation programs. The calculations performed by the IRS use a methodology prescribed by the USDA. In addition, I am aware that the USDA may use the information received for compliance purposes related to this eligibility determination, including referrals to the Department of Justice.

Specially, the IRS will disclose to the USDA the individual's or legal entity's name and TIN, and inform the USDA if, pursuant to its calculations, the average Adjusted Gross Income (AGI) is above or below eligibility requirements as prescribed by the Agricultural Act of 2014. The IRS will also disclose to the USDA the type of return from which the information used for the calculations was obtained.

If the IRS is unable to locate a return that matches the taxpayer identity information provided above, or if IRS records indicate that the specified return has not been filed, for any of the taxable years indicated, the IRS may disclose that it was unable to locate a return, or that a return was not filed, for those years, whichever is applicable.

An approved Power of Attorney (Form FSA-211) on file with USDA cannot be used as evidence of signature authority when completing this form.

By signing this form:

- **I acknowledge that I have read and reviewed all definitions and requirements on Page 2 of this form;**
- **I certify that all information contained within this certification is true and correct; and is consistent with the tax returns filed with the IRS;**
- **I agree to authorize CCC to obtain tax data from the IRS for AGI compliance verification purposes by filing this form;**
- **I am aware that without this consent to disclosure, the returns and return information of the individual or legal entity identified in Item 2 are confidential and are protected by law under the Internal Revenue Code;**
- **I certify that I am authorized under applicable state law to execute this consent on behalf of the legal entity identified in Item 2 (for legal entity only).**

6. Signature (By)	7. Title/Relationship *of the Individual if Signing in a Representative Capacity for a legal entity*	8. Date *(MM-DD-YYYY)*
Eric McClam	Owner	12/15/2015

EQIP Organic Initiative Self-Certification Worksheet for Fiscal Year 2015

This self-certification form must be used by each producer applying for EQIP Organic Initiative assistance. The goal of the Organic Initiative is to ensure that conservation technical assistance and EQIP benefits are allocated to address resource concerns related to organic production. In order to qualify for the Organic Initiative, a producer must self-certify that they meet one of the following three categories.

1. Certified Organic

I, City Roots Eric McClam, hereby acknowledge that I am a certified organic producer and I will provide NRCS with a copy of my current USDA NOP organic certificate or proof of good standing from a USDA-accredited certifying agent. I understand that I am required to maintain organic certification throughout the life of the EQIP OI contract. If certification is not maintained, the contract may be subject to termination.

Signed: [signature] Date: 12/15/15

2. Exempt from Certification (Organic Producers Selling Less Than $5,000 in Organic Products Annually)

I, ______________________, hereby acknowledge that in order to receive technical and financial assistance through EQIP Organic Initiative as an exempt producer, I agree to develop and implement an OSP that meets standards established in the National Organic Programs (NOP) Act (7 U.S.C. Sections 6501-6522) for the life of this contract. I understand my application will be ranked with transitioning organic producers provided I meet eligibility requirements. I certify that I sell less than $5,000 in organic products annually and I have provided the required documentation as specified in 440-CPM. I agree to notify NRCS should my exempt from certification status change during the life of this EQIP OI contract.

Signed: ______________________ Date: ______________________

D.C. Approval: ______________________ Date Approved ______________________

3. Transitioning to Organic

I, ______________________, hereby acknowledge that in order to receive technical and financial assistance through EQIP Organic Initiative as a transitioning to organic producer, I agree to develop and implement an organic system plan to standards established in the National Organic Programs (NOP) Act (7 U.S.C. Sections 6501-6522).

I understand that if I do not meet this requirement during the period while transitioning to organic production, my EQIP contract may be subject to termination.

Signed: ______________________ Date:______________________

CONSERVATION INNOVATION GRANTS
Semi-annual Progress Report

Grantee Name: City Roots	
Project Title: Going No-ill at city Roots	
Agreement Number: 69-3A75-12-210	
Project Director: Eric McClam	
Contact Information:	Phone Number: 803-543-7007 E-Mail: eric@cityroots.org
Period Covered by Report: May 2014-December 2015	
Project End Date: 12/31/2015 (changed with no cost extension from 8/31/2015)	

A) Summarize the work performed during the project period covered by this report:

City Roots, an urban, organic farm, has managed to managed reduce its tillage by about two thirds and has successfully incorporated the practice of cover crops into its regular rotation. As a result of the reduced tillage, marked and significant increases in depth to compaction, root depth and infiltration have been observed. During the project period of three years, with the exception of less than 50 lb/ac K_2O addition in March 2014, no amendments have been added to the soil, yet % organic matter, pH, cation exchange capacity and water extractable organic carbon (WEOC) have stayed steady while soil test phosphorus has actually increased. Soil test potassium has decreased but at a rate that is a fraction of the reduction predicted by pure crop removal calculations. A shift in soluble nitrogen from inorganic (nitrate-N) to organic (water extractable organic nitrogen or WEON) has also been observed.

A miniseries of seven videos of about 22 minutes of materials has also been produced as a result of this funding. The video series documents the transition that the owners (Eric and Robbie McClam) faced in transitioning to no-till.

Outreach has been significant in terms of visitors that come to City Roots, interns, and field days. Observations at City Roots, especially soil respiration observations, provided a solid empirical basis for a new GIG project sponsored by NRCS SC, which in turn has changed that was six farmers, planting about 10,000 acres, manage their soils.

B) Describe significant results, accomplishments, and lessons learned. Compare actual accomplishments to the project goals in your proposal:

Conversion of one third of the property per year to no-till:

City Roots has reduced tillage by more than one third from an estimated average of 7 tillage events per subfield per year (126 total tillage events) to an average of 2.2 events year per subfield (or ~ 38 events per year). This was not achieved in one-thirds as originally planned, but for operational reasons was already in place for the growing season of 2013. Over this period, the planting cool season and warm season cover crops was prioritized and each field saw at least one cover crop per year, if not more.

Set-up and upkeep on a permanent rainfall simulator

Due to the necessity to acquire custom no-till implements appropriate for a no-till cropping system we were unable to purchase a rain-fall simulator within the budget constraints.

Separate annual technical (soil health) report:

Please find attached a separate final technical report. The most significant results of our findings on effect of tillage reduction on soil health are summarized as follows:

1. Over the project period we observed physical indicators Root Depth, Depth to Compaction and Infiltration rate increase by 66%, 98% 184% respectively. These numeric results were accompanied by qualitative soil observations that showed a reduction in platy structure at the 3-4" mark and a marked increase in granular structure at the 0-3" layer.
2. Soil organic matter (%OM), pH, cation exchange capacity, water extractable organic carbon (WEOC) and bulk density remained unchanged for the project period. No lime amendments (to adjust pH) were added over the project period.
3. We observed a significant reduction in soil test potassium but this was less than 10% the reduction predicted by a pure crop removal calculation – less than 50 lb/ac of potassium was added to the soils in March 2014. We observed an *increase* in the amount of soil test phosphorus, yet no phosphorus amendments were added.
4. We observed an 85% *increase* of water extractable organic nitrogen (WEON) along with a 68% decrease in soil test nitrates over the project period, suggesting a shift in equilibrium soluble nitrogen pools from inorganic (nitrate-N) to organic (WEON).

Five minute mini-documentary

Given the abundance of good interview and visual material we had from the last three years, we ended up producing a series of seven videos totaling 22 minutes. This has been structured in the following way:

1 of 7 Intro - to Going No-Till at City Roots
2 of 7 Interview in 2012, Anticipating the Transition to No-Till
3 of 7 A Look Back at 3 Years of Going No-Till
4 of 7 Cover Crops and Mixes in the Organic System
5 of 7 Hiccups When going No-Till on an organic farm
6 of 7 Outreach at City Roots

7 of 7 Final Reflections of Going No-Till at City Roots

This series can be found on line at:
https://www.youtube.com/watch?v=PBYaTXrg_LI&index=1&list=PL7vSXSqSbkkDVUtteuvToYSbM0EmNHTRd

- **Copy of visitor outreach event logbook documenting additional outreach activities –**
  As an urban farm, City Roots has a very large volume of people coming through the farm each year. In 2015 alone, the farm has had approximately 4,500 attendees to farm related festivals, 500 on farm dinner participants, 500 customer walk ins, 150 CSA members, 200 volunteers, 100 workshop attendees and over 850 school tour participants ranging from kindergarten to college students. No-till methodology can be seen upon arriving on the farm and is described in detail on our self-guided tour maps that are available upon entry to the farm.
- **A list of those who are adopting no-till because of what they have seen at City Roots**

  We view City Roots as ground zero for the soil health movement in South Carolina. Without some of the initial observations at City Roots, especially those regarding the influence of organic matter, the use of soil respiration and the retention/recycling of nutrients, there would have been no empirical basis or initial data for subsequent proposals.

  Most significantly, the City Roots project initially inspired another South Carolina NRCS project (*Using CO2 Burst Tests to Measure on-farm Plant Available Nitrogen from Cover Cropped Soils in South Carolina*). Through insights gained from this, and the City Roots GICG over time, we know of seven farmers who plant about 10,000 acres who have now wholeheartedly invested in soil health. Along with the planting of increased acreage of cover crops (we estimate at least 3,000 acres in SC in the fall of 2015 for these farmers alone) farmers have observed and reported the following:
    - Reduction in soil compaction, unexpected retention of soil test P and K, steady, and in some cases increased soil pH's, appearance of earthworms, elimination of soil erosion, reduction in weeds on cover-cropped fields even a year after the field has been cover cropped
    - Farmers have literally parked their subsoilers, cut back by 50-100% on P and K fertilizer, cut back by 50% or more on lime, cut back between 20% and 50% on nitrogen fertilizer, cut back on pesticides and herbicides.

We understand that these claims appear to be outlandish, so feel free to contact the following South Carolina farmers:

Aubrey Cooper (Lee County) - 803-427-0527
Carl Coleman (Dillon County) – 843-841-7373
Alan Gaddy (Dillon County) – 843-495-0949
Sonny Price (Dillon County) – 843-845-0650
John McInnis (Marlboro County) – 843-862-3657

Jason Carter (Richland County) – 803-429-3481
Jim Crowder (York County) – 803-209-0555

C) Describe the work that you anticipate completing in the next six-month period:

Project complete as of Dec. 31 2015.

D) Provide the following in accordance with the Environmental Quality Incentives Program (EQIP) and CIG grant agreement provisions:

1. A listing of EQIP-eligible producers involved in the project, identified by name and social security number or taxpayer identification number;

City Roots LLC. EIN 264732980

Eric McClam 247659880

2. The dollar amount of any direct or indirect payment made to each individual producer or entity for any structural, vegetative, or management practices. Both biannual and cumulative payment amounts must be submitted.

NRCS EQIP funds received by City Roots for 2015 was $21,405.65

3. A self-certification statement indicating that each individual or entity receiving a direct or indirect payment for any structural, vegetative, or management practice through this grant is in compliance with the adjusted gross income (AGI) and highly-erodible lands and wetlands conservation (HEL/WC) compliance provisions of the Farm Bill.

See Attached