AGRONOMIC VALUE OF LAND APPLICATION OF COMPOSTED ORGANIC WASTES TO POROUS SOIL OF NORTHERN GUAM

Mohammad H. Golabi
Ferdinand P. Galsim
Clancy Iyekar
Chieriel Desamito

College of Natural & Applied Sciences
University of Guam | Unibetsedåt Guahan

Western Pacific Tropical Research Center (WPTRC)

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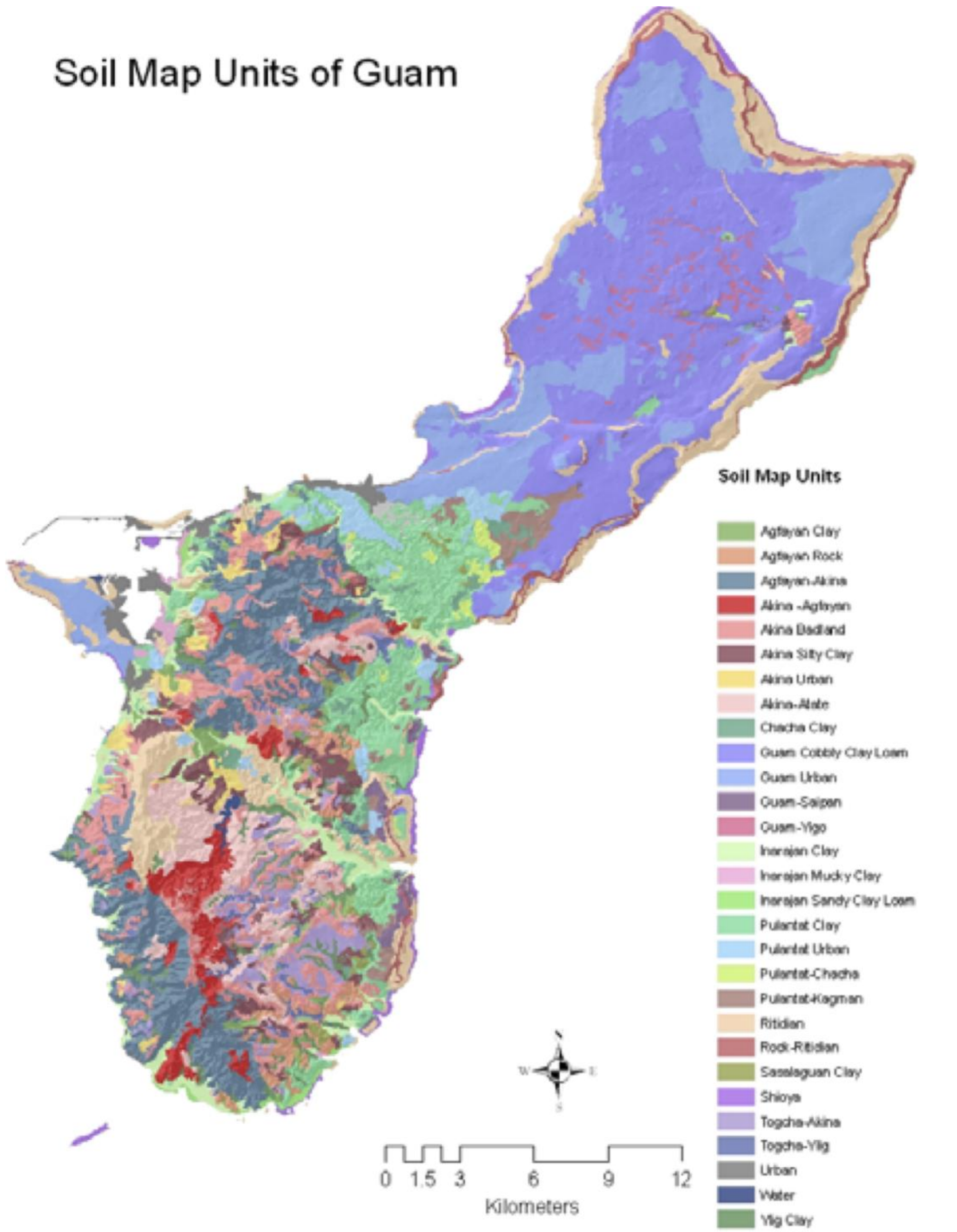
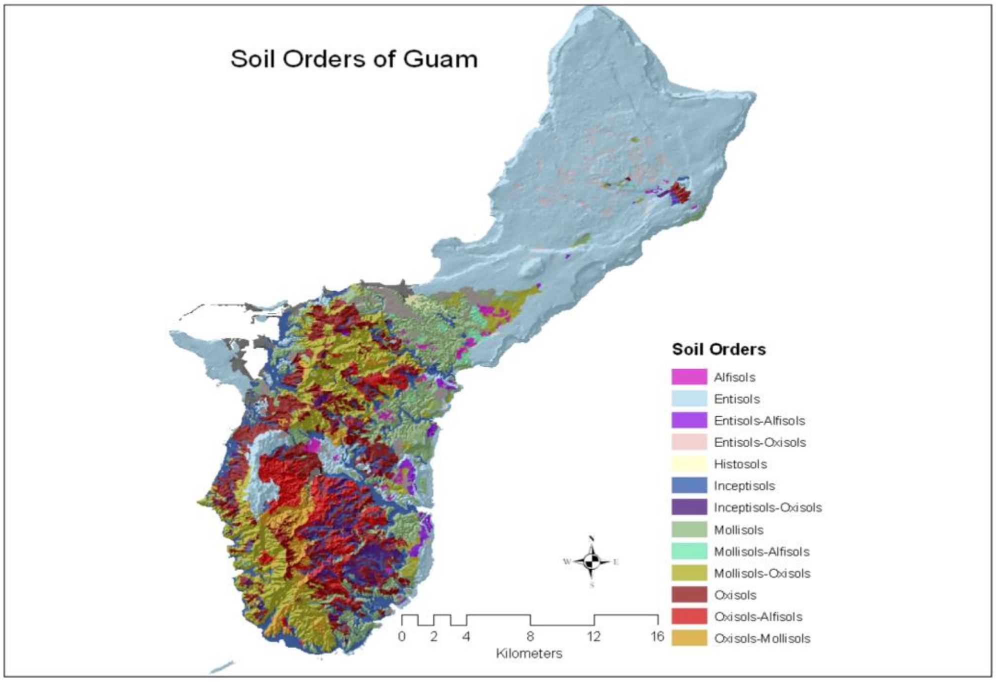


Map: courtesy Jonathan Deenik & NRCS



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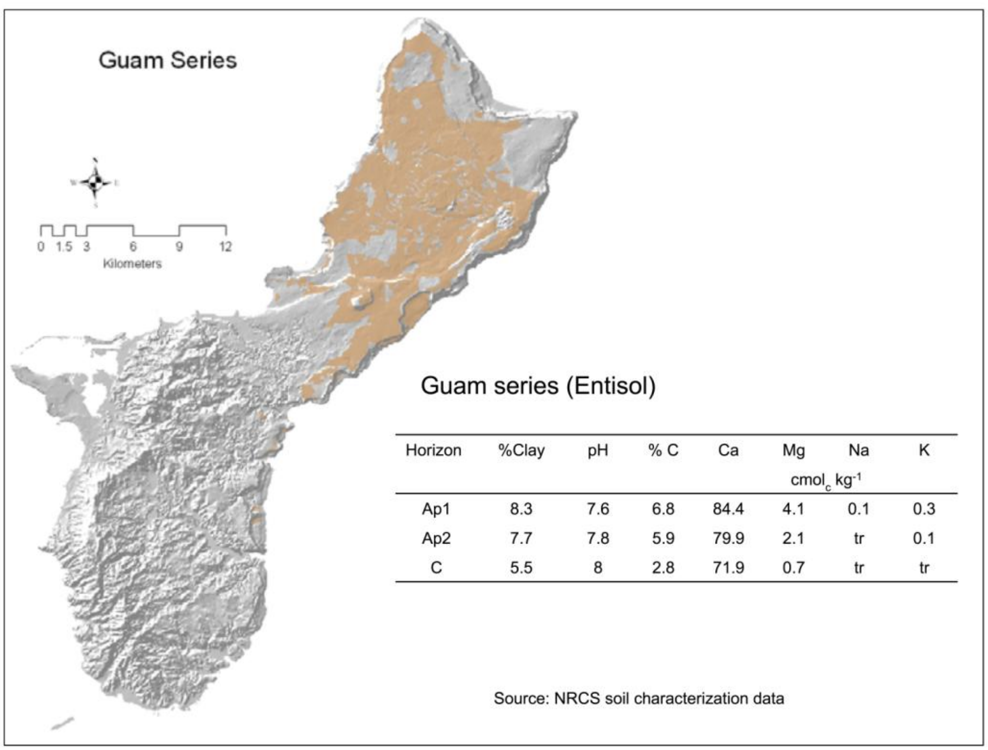

Horizon	%Clay	pH	% C	Ca	Mg	Na	K
					$cmol_c\ kg^{-1}$		
Ap1	8.3	7.6	6.8	84.4	4.1	0.1	0.3
Ap2	7.7	7.8	5.9	79.9	2.1	tr	0.1
C	5.5	8	2.8	71.9	0.7	tr	tr

Map: courtesy Jonathan Deenik & NRCS

ACKNOWLEDGEMENTS

We would like to express our special thanks to our field technicians Edwin Paulino, Ray Gumataotao, and Karl “Von” Nelson. Many thanks to Sheeka Tareyama who initiated the plot layouts and developed protocols for data collection. Also, to Sydonia Manibusan who helped with field works and sampling. We are thankful to Anderson Air Force Base for woodchip materials for our composting part of the project. Also we would like to extend our gratitude to Dr. Mari Marutani for providing composting materials and her employees for helping with the fieldworks.

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

LIST OF APPENDICES

ABSTRACT

Monitoring and protecting our natural resources is vital for the quality of life and the integrity of our ecosystem. The majorities of the farmlands in Guam are infertile and may not be suitable for farming. At the same time, almost 80 % of garbage generated in Guam's households is organic or compostable. This research evaluated the application of both composted organic waste and commercial fertilizer in northern Guam for increased crop yields. Furthermore, this project can help provide balance between a sustainable agriculture and waste management.

INTRODUCTION

Among the major concerns regarding the agricultural activities on Guam and other tropical islands of the Pacific is the low organic matter content of soils especially the calcareous soil of northern Guam (Golabi, 2004). The application and continued additions of organic matter create a soft, tillable soil, important for plant growth while adding nutrients, storing nitrogen, creating stronger aggregate that will enhance soil stability therefore reducing water erosion (Environmental Encyclopedia, 2011).

Golabi et al. (2007) conducted an experiment using composted organic matter in southern Guam that resulted in higher yield than inorganic fertilizer. Although the southern Guam soil was Akina series (Very fine, kaolinitic, isohypothermic Oxic Haplustalf) formed in residuum derived from the volcanic deposit (USDA-SCS, 1988), the significant improvement in bulk density, soil organic matter content, and nutrient distribution in the soil were attributed to compost application on the study plots (Golabi et al., 2007). The chemical and physical properties of the soil plots studied improved following the addition of compost, due to the increased in the organic matter content.

Goal:

Evaluate the agronomic value of land application of composted organic wastes in enhancing crop productivity for agricultural sustainability.

Objectives

The purpose of this experiment discussed herein were to:

Compare the crop yield of corn between commercial fertilizer and composted organic wastes at different application rates (0, 30, 60, and 90 t/ac)

a. Provide essential nutrients (N, P, K) for plant growth
b. Enhance organic matter content thereby improving physical and chemical properties of soils.

Guam farmers may use this scientific based research result to make informed decision for improving soil quality to enhance crop quality and yield while limiting municipal wastes on the island.

MATERIALS AND METHODS

Study Outline

The experimental work described herein focused on 2 aspects of study.

a. Crop yield comparison between composted organic waste and commercial fertilizer application.
b. Analyses of physical and chemical characteristics of compost and soil study plots.

Soil Background

Before the application of compost and commercial fertilizer, the soil plots were sampled and analyzed to determine soil background characteristics including: pH, soil organic matter (SOM), bulk density, electrical conductivity, and percentage of carbon and nitrogen content. Background soil pore water was also collected from lysimeters on January 9th and 21st, 2012.

Soil

Soil is a dynamic and possibly the most diverse ecosystem on earth. Living organisms in the soil such as bacteria, fungi, earthworms, etc., constitute an important component of the soil. These biological activities are the key ecosystem processes important in the cycling of essential elements for plants such as nitrogen, phosphorus, and potassium (Fitter et al, 2005). Soil is capable of recycling organic materials into water and CO_2 and has the capacity to degrade synthetic compounds foreign to the soil by microbial decomposition and chemical reactions.

Another major factor is the soil's capability to store and transmit water by controlling water availability to plants and possibly reducing environmental pollutants to surface and groundwater (Fitter et al, 2005). However, modern farming has changed the soil's dynamics due to excessive tillage and chemical applications. Innovation in plant nutrients such as the use of synthetic fertilizer, pesticides, improvement in irrigation, and advancement in farming machinery significantly increased crop production, but may have decreased soil resiliency.

As we become more dependent on using synthetic fertilizer to increase crop production, the negative impact of synthetic fertilizer to the environment can lead to the decline of other ecosystems such as arable land and forestry (Mhango and Dick, 2011).

Soil organic matter (SOM), also known as humus, is a well-decomposed and stable part of organic matter in mineral soils (SSSA, 2008). Soil organic matter serves as a reservoir of nutrients for crops, improves soil aggregation, increases nutrient exchange, retains moisture, reduces compaction and surface crusting, and increases water infiltration rate (USDA, 2017).
Soil is essential for life. First, it stores and serves as water filter and medium for plant growth and physical support. Second, it provides habitat for many organisms contributing

to biodiversity. Third, it can also filter solid waste in the environment. Finally, Lastly, it is an agroecosystem, which provide food, feed, fiber, and fuel (SSSA, 2002). Any disturbance to one of the key functions can change the soil's dynamic. The use of composted organic waste may help these preserve the soil functions as well as protecting living organisms involve in the soil life cycle.

When chemicals found in synthetic fertilizers such as nitrate and phosphates are overapplied, excess nutrients can easily leach into the groundwater or carried by surface runoffs into surface water body such as rivers, lakes and, ocean. There were many research works reporting that composted organic wastes minimize the level of nitrogen leaching because of its higher organic content increasing the abiotic sorption. Levanon, et al. (1993), has reported that the higher organic matter content in soils enhanced abiotic sorption as well as biotic degradation processes of synthetic chemicals, resulting in lower leaching of these chemicals.

Experimental Site

The composting production facilities as well as the experimental plots were located at the University of Guam Experiment Station in the village of Yigo of Northern Guam.

Guam has a mean annual rainfall of approximately 2540 mm with a distinct dry season from January to June during which rainfall averages approximately 800 mm (Lander, 1994). Mean annual temperature is 26^{0} C, and the monthly temperature range varies approximately $\pm 2^{0}$C from the mean (Karolle, 1991).

The soil underlying the study site is the 'Guam soil series' (clayey, gibbsitic, nonacid, isohypothermic lithic Ustorthents) formed in sediment over porous coralline limestone (Young, 1988). The bedrock underneath these soils is very porous therefore surface water can easily percolate into the groundwater aquifer, which supplies 80 % of the island's water supply (WERI, 2017).

Field Design

The 28 study plots (7 m x 6.9 m) shown in figure 1 were established for different compost application rates as well as equivalent rates of nitrogen by using synthetic fertilizers for comparison. The indicated study plots (figure 1) assigned were constant throughout for the 3 planting seasons. The application rates were setup as 3 treatment levels with 4 replications for each treatment plot, and randomized complete block design was used for statistical analyses. The composted organic wastes applied to study plots were processed in the University of Guam (UOG) station in Yigo. The compost mainly consisted of restaurant food and paper wastes, woodchips from Anderson Air Force base, and hog and chicken manures from local poultry and hog farms.

There were 8 water drip lines per study plot (d) that were set up approximately 91 cm apart. The water timers were set to turn on the water twice a day for 2 hours. As the corn ears neared the maturity stage, irrigation water was reduced to twice a day for 1 hr. Adjustments were also made during lengthy rains, storms, and dry or wet seasons to control erosion and guard against overwatering.

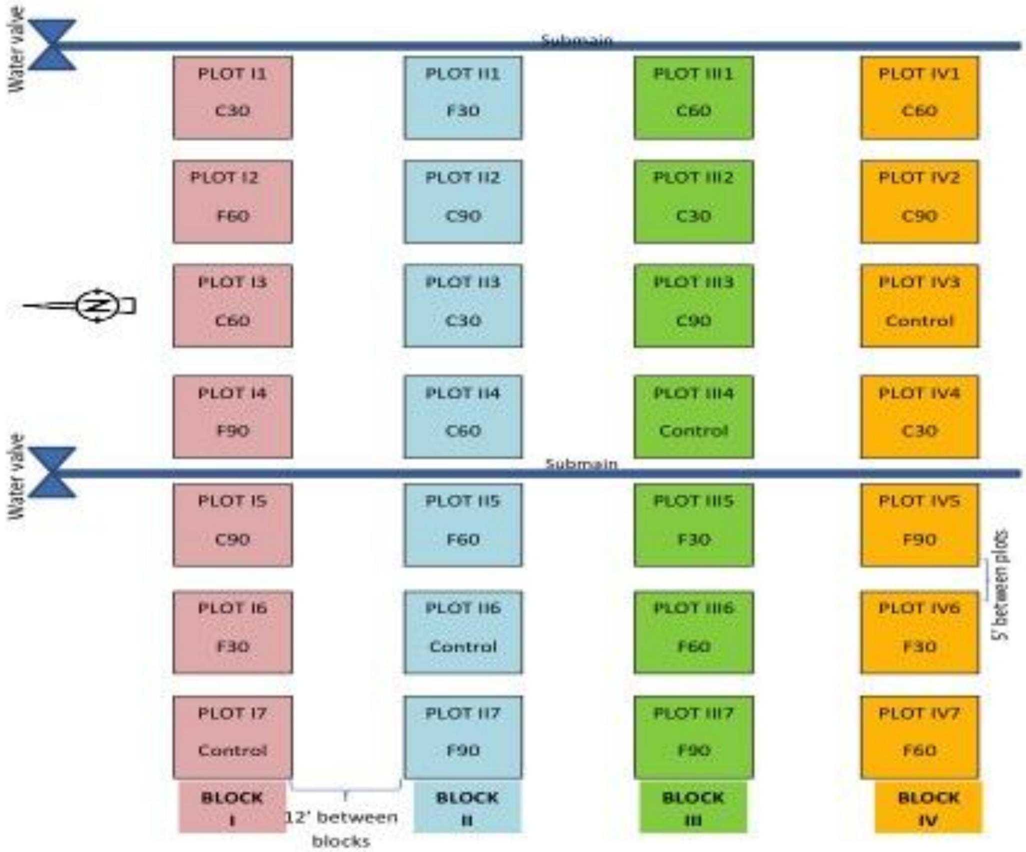

Figure 1: Illustrates the study plot design (4 replications)
Notes: C30 = 30 tons per acre of composted organic wastes
F30 = 30 tons per acre of inorganic fertilizer
Control = 0 tons per acre

<u>Nitrate From Crop Land</u>

Corn is the most widely planted feed crop in the United States and requires the most nitrogen per acre (Ribaudo, 2011). Since nitrogen is relatively inexpensive and easy to apply, farmers tend to overuse nitrogen fertilizers. However, excess nutrients can migrate down past the root zone and into the water aquifer.

As indicated by Hallberg (1987), nitrate is leached to ground water because the nitrogen input from synthetic fertilizers applied on crop land, as well as on managed grass lands are generally in excess of N requirement. Moreover, composted organic materials provide a source of slow release nitrogen and other essential nutrients (Golabi et al, 2004), hence reducing the use of commercial fertilizer by farmers. In this project, we are introducing composted organic wastes as an alternative for source of nitrogen as well as other nutrients for crop (corn) production. As shown in our research results, the use of composted organic wastes reduced the leaching of nitrogen below the root zone in our study plots in northern Guam.

Figure 2: Study Plot Showing 8 rows of drip lines with 20 drip emitters per row at 1 ft. intervals

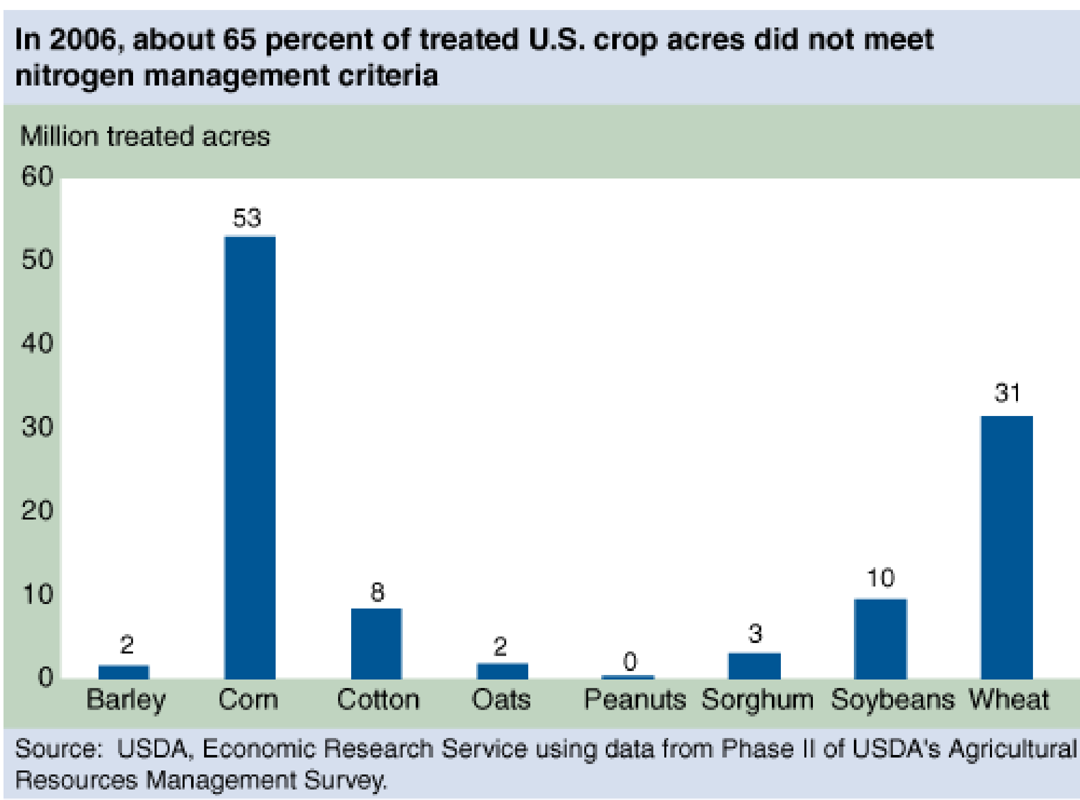

Figure 3: Corn and wheat having one of the highest nitrogen requirements

Laboratory Investigations

Carbon and Nitrogen in Soil and Compost

Soil and compost samples were analyzed using the carbon and nitrogen instrument (FlashEA 1112 series by Thermo Electronic Corporation) shown in figure 4. Data obtained include percentage of the carbon and nitrogen of the soils from the study plots as well as the carbon and nitrogen ratio of the compost applied to the study plots.

Figure 4: Nitrogen and carbon analyzer (FlashEA 1112 Series) used for soil and compost analyses

Soil samples from study plots and compost samples from compost windrow were air-dried and sieved through a 2.00 mm mesh screen. The samples were then milled using a coffee grinder and sieved again with a 0.023 mm mesh screen to prepare for carbon and nitrogen analysis using FlashEA 1112 series.

Soil pH Analysis

A soil pH is the measure of acidity and alkalinity and is important in many chemical processes such as plant nutrient availability and overal soil health. Because of the calcareous soil of northern Guam and the effects of crop residues to the soil's chemical property, pH testing was performed for overall soil quality determination (Butterly et al., 2012, Golabi et al., 2004).

The soil pH was analyzed using an Oakton glass eletrode pH meter and was calibrated before testing of samples. Generally, a 1:1 of soil to water ratio is performed but was adjusted to 1:2 due to the texture of the soil and the compost (Sparks, 1996).

Soil Organic Matter (SOM) Analysis
Walkley-Black Method (Sparks et al., 1996) was used to test for soil organic matter (SOM) in the soil study plots as well as the composted organic wastes windrow that was applied to the study plots. Soil organic matter can increase soil water-holding capacity, lower bulk density, and act as a reservoir for plant nutrients which an indicator for crop yield and soil water leaching.

Corn Crop
The corn seeds purchased from University of Hawaii that were used from 2012 and 2014 were hybrid sweet # 8 while hybrid supersweet #10 was used in 2015 and 2016. Three corn seeds were planted for each drip line emitter.

Harvested "husk of corn" were placed in burlap bags, weighed, and dried using a SMO28G-2 SHEL LAB Forced Air Drier (27.5 Cu Ft) at a temperature of 55^{o} C (Figure 5) for 72-hour duration. The corn dry-weight was used for the final yield analysis.

Figure 5: Shel-lab drier for obtaining harvested corn dry weight

<u>Application of Compost and Inorganic Fertilizer</u>

Compost was applied to study plots with corresponding 30, 60, and 90 tons per acre. The content of nitrogen (%) in the compost corresponds to the equivalent rates of synthetic fertilizer triple 16 (N, P, K) which was applied in two half applications. The compost was applied 1 week before planting while the inorganic fertilizer was applied 2 weeks after planting. First half application of commercial fertilizer (16-16-16) was applied to corresponding plots two weeks after planting at the following rates (Table 1):

Table 1: Compost and Fertilizer Application Rates Per Plot

Rate (t/ac)	Fertilizer (kg)/plot	Compost (kg)/plot
30	6.35	287.40
60	12.70	574.80
90	19.30	862.19

Note: (t/ac is tons per acre which is mass of compost equivalent to N from fertilizer (triple 16)

Composting

The idea of organic wastes having agronomic values as a "resource recovery" management strategy sounds appealing and, in fact, has been shown to be of great benefit to soil quality and crop productivity in the island of Guam (Golabi et. al., 2003). As reported by Jackson, et al. (2003), application of compost had beneficial impacts of increasing soil microbial biomass, increasing total soil carbon and nitrogen, reducing soil bulk density, and decreasing the potential for groundwater pollution that would otherwise result from nitrate leaching below the root zone upon the application of commercial fertilizers.

Composting in Large-scale

In order to obtain enough organic compost, a large-scale composting was used in this project. An 'Active aeration' windrow (figure 6a) was used which required a 'pull-behind compost turner' called 'AEROMASTER.' This compost turner has the capability of turning large piles of compost, and provides maximum blending and aeration (Midwest Bio-System, 1997). The turner can thoroughly mix windrow materials without pulverizing the humus crumb structure that develops during the build-up phase of the composting process (Midwest, 2017).

A garden water hose was attached to the compost turner for the purpose of applying water into the compost. Composting precedes best at moisture content of 40-60% by weight. At lower moisture levels, microbial activity is limited. At higher levels, the process is likely to become anaerobic generating foul smelling (Monitoring Compost Moisture, 1996). Moisture content of the compost is also critical to maintain ideal temperature to support microorganisms' metabolic process such as bacteria and fungi. Other Factors affecting the composting process include carbon to nitrogen ratio, oxygen concentration, pH, surface area, temperature, and retention time (Sherman, 1999). The compost windrow (Figure 6b) was turned once a week (figure 6a and 6b) for at least 2 months before it was applied to study plots (figure 6c).

Figure 6a: Early stage of composting (0 – 3 weeks)

Figure 6b: Matured stage (after 2 months)

Figure 6c. Application of composted organic waste on study plots)

Table 2: Plot numbers based on application rates and number of replications

Treatment #	Application Rates (ton/acre on dry basis)	Replications	Number of Plots	Grand Total of Plots #s
Treat. # 1 (control)	0	4	4	4
Treat. # 2 (compost)	30, 60, 90	4	12	12
Treat. # 3 (commercial fertilizer)	With equivalent nitrogen content to: 30, 60, 90 of compost	4	12	12
Total treatments				28

Composts were applied based on N rates (Table 2) only during 2014 and 2016 planting season while inorganic fertilizers where applied during 2014, 2015, and 2016 seasons. Composts were applied to the study compost plots 3 days before planting of corn seeds and fertilizers were applied 2 weeks after planting. Two-way analysis of variance (ANOVA) based on randomized complete block design. Minitab version 17 was used for statistical analysis of crop yield.

RESULTS

Carbon to Nitrogen Ratio

Table 3: 2014 Compost Carbon to Nitrogen Ratio (C:N) Results

	2014 Compost C:N Result		
	% N	% C	% C:N
North	0.73	16.36	22.41
Northwest	0.72	16.17	22.46
Northeast	0.66	16.18	24.52
	Avg. C:N		23:1

Table 4: 2016 Compost Carbon to Nitrogen Ratio Results

	2016 Compost C:N Result		
	% N	% C	% C:N
North	0.37	8.51	22.92
Northwest	0.31	6.82	21.68
Northeast	0.22	10.65	48.25
	Avg. C:N →	31:1	

The composted organic wastes windrow that was applied to the study plots was tested for the percentage of N, C, and carbon to nitrogen ratio content. In 2014, the compost windrow had an ideal C:N of 23:1 (Table 3) for better soil fertility. However, in 2016, the C:N ratio of the compost was elevated at 31:1 (Table 4), which may have affected the crop yield in the 30 and 60 tons per acre application rates.

Soil pH

Table 5: pH Levels of Soil Study Plots

		8/14/2013	2/10/2014	6/13/2014	2/2/2015
Plots	Treatments				
I-1	C30	7.05	7.01	7.27	6.77
I-2	F60	6.83	6.87	7.01	6.88
I-3	C60	6.89	6.72	7.00	6.83
I-4	F90	6.90	6.93	6.89	6.81
I-5	C90	6.89	6.63	7.24	6.76
I-6	F30	6.92	6.88	7.06	6.85
I-7	Control	6.98	6.87	6.99	6.99
II-1	F30	7.06	7.05	7.20	6.83
II-2	C90	6.82	6.83	7.03	6.80
II-3	C30	6.88	6.81	7.02	6.98
II-4	C60	6.96	6.75	7.03	6.92
II-5	F60	7.02	6.93	7.08	6.99
II-6	Control	6.93	6.90	6.98	6.98
II-7	F90	6.99	6.93	7.06	6.93
III-1	C60	7.15	7.10	7.03	6.98
III-2	C30	6.94	6.92	6.97	6.87
III-3	C90	6.89	6.82	7.10	6.74
III-4	Control	6.99	6.96	7.02	6.94
III-5	F30	7.00	6.91	7.11	6.93
III-6	F60	7.01	6.90	7.09	6.88
III-7	F90	6.99	6.83	7.10	6.87
IV-1	C60	6.88	6.76	7.38	Missing
IV-2	C90	6.96	6.75	7.19	Missing
IV-3	Control	6.95	6.92	6.99	7.02
IV-4	C30	7.02	6.95	7.00	6.90
IV-5	F90	7.17	7.01	7.06	7.01
IV-6	F30	7.20	7.01	7.05	7.00
IV-7	F60	7.26	7.11	7.09	7.17

The soil with pH above 7 can be characterized being as calcareous (Motavalli, Marler, 1998). Most of the soil plots in this study had pH levels above 7 due to the presence of calcium carbonate ($CaCO_3$) in the soil. Because the optimum pH range for planting sweet corn is 5.5 – 7.5 (Motavalli, Marler, 1998), it was not necessary make any adjustments in the soil pH levels.

Crop Yield

In 2014, crop yields (Table 6) (Figure 7a-b) from compost were greater than fertilizer but were not statistically different. There was no significant increase from 60 tons per acre to 90 tons per acre indicating that adding higher than 60 tons per acre may not be necessary during the dry season. The 30 tons per acre of composted organic waste yielded 3 times more than the control and higher yield than the 30 tons per acre fertilizer applied study plots.

In 2015 crop season, compost was not applied to the plots. According to Reeve *et al,* (2012) composts and manures have residual effects that may last for many years and when properly evaluated, has cost benefits. According to the data (Table 5), in 2015, C30 yielded 11.4 lb./plot compared to 6 lb./plot from the control. On the other hand, C90 yielded 17.1 lb./plot (dry season) and when compost was re-applied the following rainy season (2016), the yield was 23.5 lb./plot.

In 2016, the corn seeds were planted at the beginning of the rainy season thus problems with insects and weeds affected the plant growth and crop yield. However, corn benefited from the compost application despite inconsistencies on planting.
Despite the effects of high rainfall during the rainy season on plant growth and crop yield in 2016, C90 (Figure 8) performed better than F90 yet F60 has higher yield than C60. Even more significant was the drop of yield from 14.3 lb. /plot to 6.4 lb./plot from F30 and C30 consecutively. The crop yield during the rainy season was not consistent possibly due to the effects of excess rain and the high carbon to nitrogen ratio of the compost applied.

Table 6: Crop Yield (lb./plot)

Treatment	2012	2014	2015 *	2016
Control	4.4	10.2	6.0	2.6
F30	21.2	25.8	16.5	14.3
C30	19.6	29.3	11.4	6.4
F60	19.8	33.5	18.3	18.1
C60	22.5	36.6	12.4	14.4
F90	33.3	36.3	22.0	17.7
C90	37.9	40.5	17.1	23.6

Notes: * No compost applied, only inorganic fertilizer to soil plots. 2012 data was complied by a previous graduate student and used only as a reference

Dry Season (Jun 2014)

Figure 7a: “Corn Husks” From Inorganic fertilizer and Composted Waste Application
Note: (C = compost; F = fertilizer)

30 tons per acre 60 tons per acre 90 tons per acre

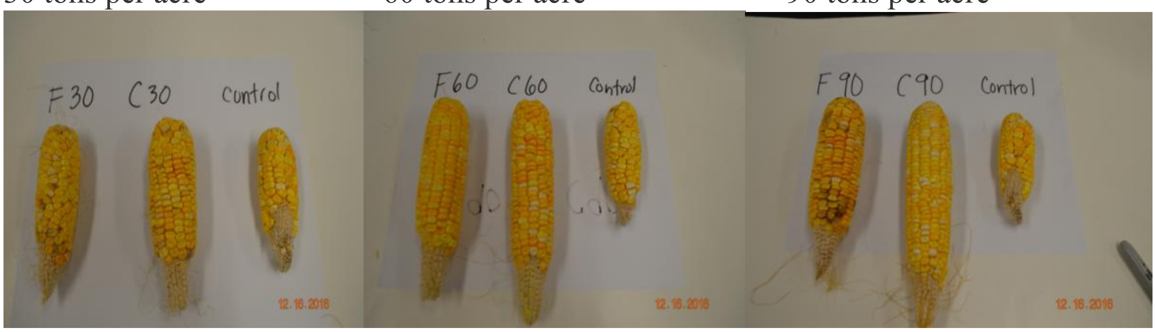

Figure 7b: Effects of high rainfall, weed competition, and increased insect population on crop yield (2016 – rainy season)

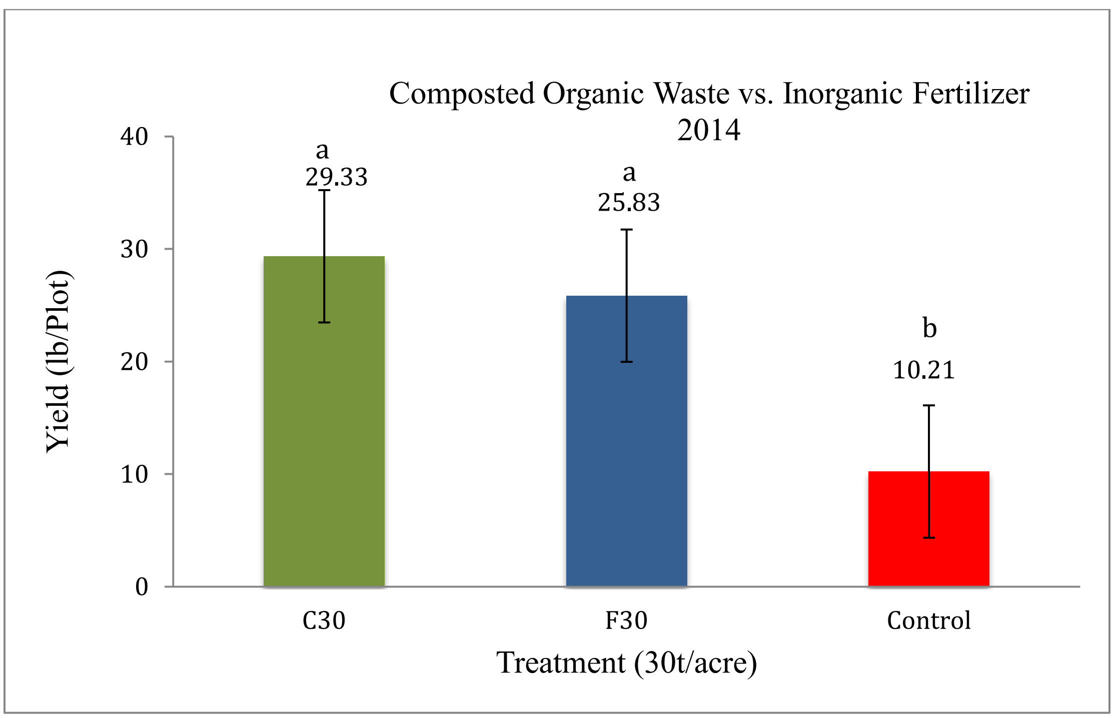

Figure 8: Crop yield (Corn) comparison between composted organic waste (C30) and inorganic fertilizer (F30) at 30 tons per acre application in 2014 (dry season)
Notes: Letters above bar graph (Treatments sharing the same letters are not statistically different)

Statistical analyses

Table 7: 2014 Corn Yield Data (30 tons per acre (2-way ANOVA Randomized Complete Block Design)

C30 vs. F30					
Source	DF	Adj SS	Ms	F-Value	P-value
Blocks	2	51.75	17.25	2.54	0.23
Treatment	1	24.5	24.5	3.61	0.15
C30 vs. Control					
Source	DF	Adj SS	Ms	F-Value	P-value
Blocks	3	40.26	13.42	21.51	0.02
Treatment	1	731.53	731.53	1172.62	<<0.01
F30 vs. Control					
Source	DF	Adj SS	adj MS	F-Value	P-value
Blocks	3	35.95	11.99	1.37	0.40
Treatment	1	488.28	488.28	55.96	< 0.01

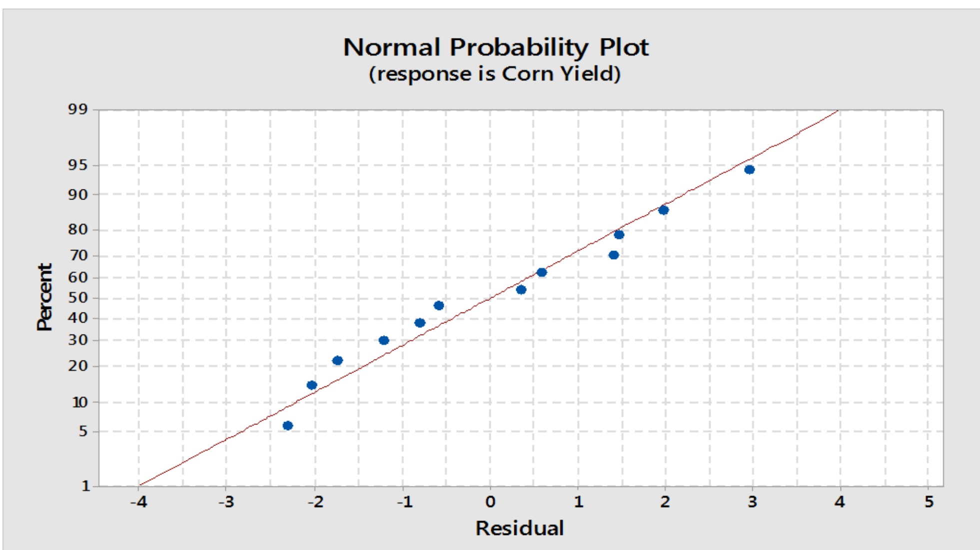

Figure 9: Normality test (Using Minitab 17)

The composted organic waste plots of 30 tons per acre (C30) yielded higher crops (Figure 8a) (29.33 lb. per plot) than the inorganic fertilizer studies plots (F30) but were not statistically significant (dry season)(Figure 9). However, using the 2 – way analysis of variance (ANOVA) randomized block design statistic, comparing C30 and F30 to control plots showed not statistically significant (0.15) using significance level of 0.05. Furthermore, both C30 and F30 were statistically different to control study plots.

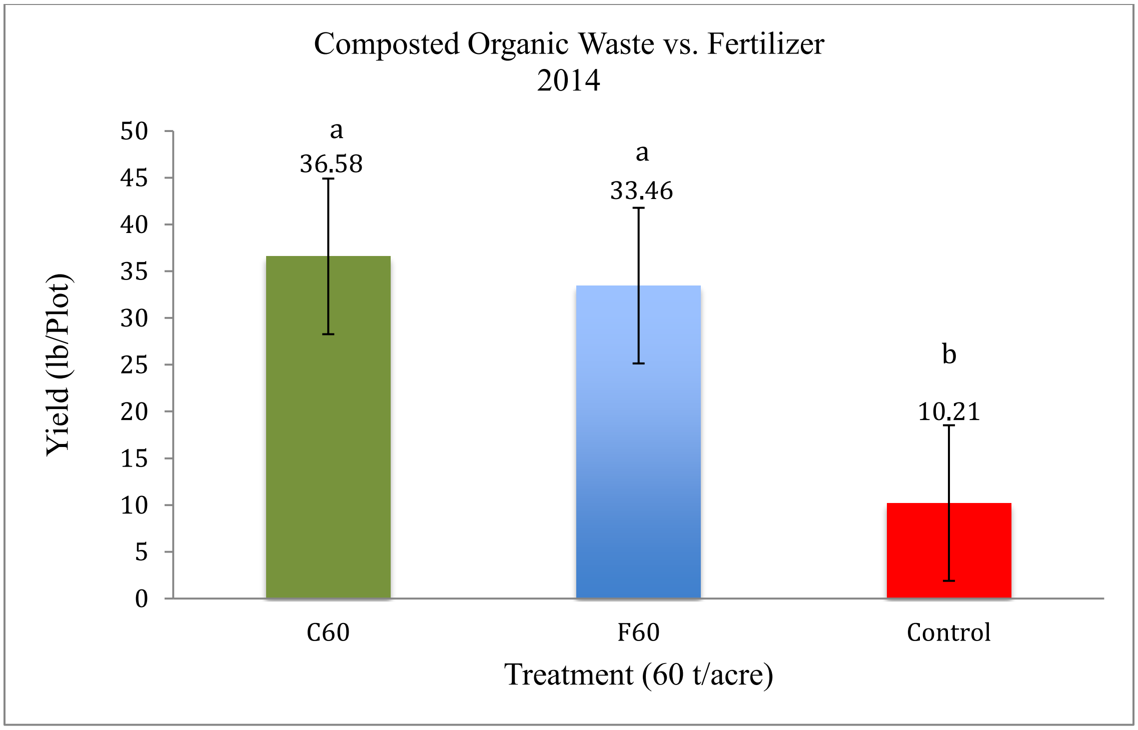

Figure 10: Crop Yield (Corn) Comparison between Composted Organic Waste (C60) and Inorganic Fertilizer (F60) at 60 tons per acre Application in 2014 (Dry Season) Notes: Letters above bar graph (Treatments sharing the same letters are not statistically different)

For the 60 tons per acre of equivalent N application, the composted organic waste plots (C60) were not statistically different from the inorganic fertilizer plots (F60) (Figure 10,11) and only significant when compared to the control plots (p-value <0.01). Still, compost plots had higher yield than inorganic fertilizer plots.

Table 8: 60 tons/acre 2-Way ANOVA Randomized Block Design Results

C60 vs. F60					
Source	df	Adj SS	Adj MS	F-Value	P-value
Blocks	3	89.07	29.69	3.93	0.145
Treatment	1	19.53	19.53	2.59	0.206
C60 vs. Control					
Source	df	Adj SS	MS	F-Value	P-value
Blocks	3	68.87	22.96	9.17	0.051
Treatment	1	1391.28	1391.28	555.74	<<0.01
F60 vs. Control					
Source	df	Adj SS	adj MS	F-Value	P-value
Blocks	3	50.11	16.7	2.88	0.20
Treatment	1	1081.13	10.81.13	186.67	<0.01

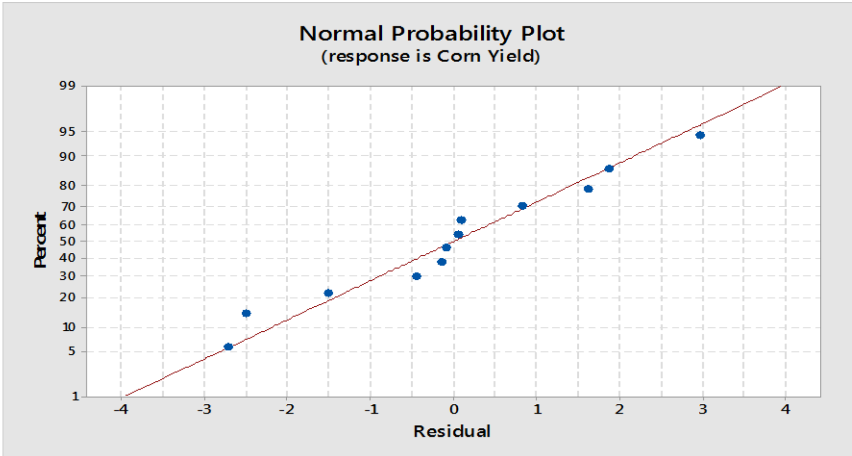

Figure 11: 60 tons per acre normality test using Minitab 17 statistical software

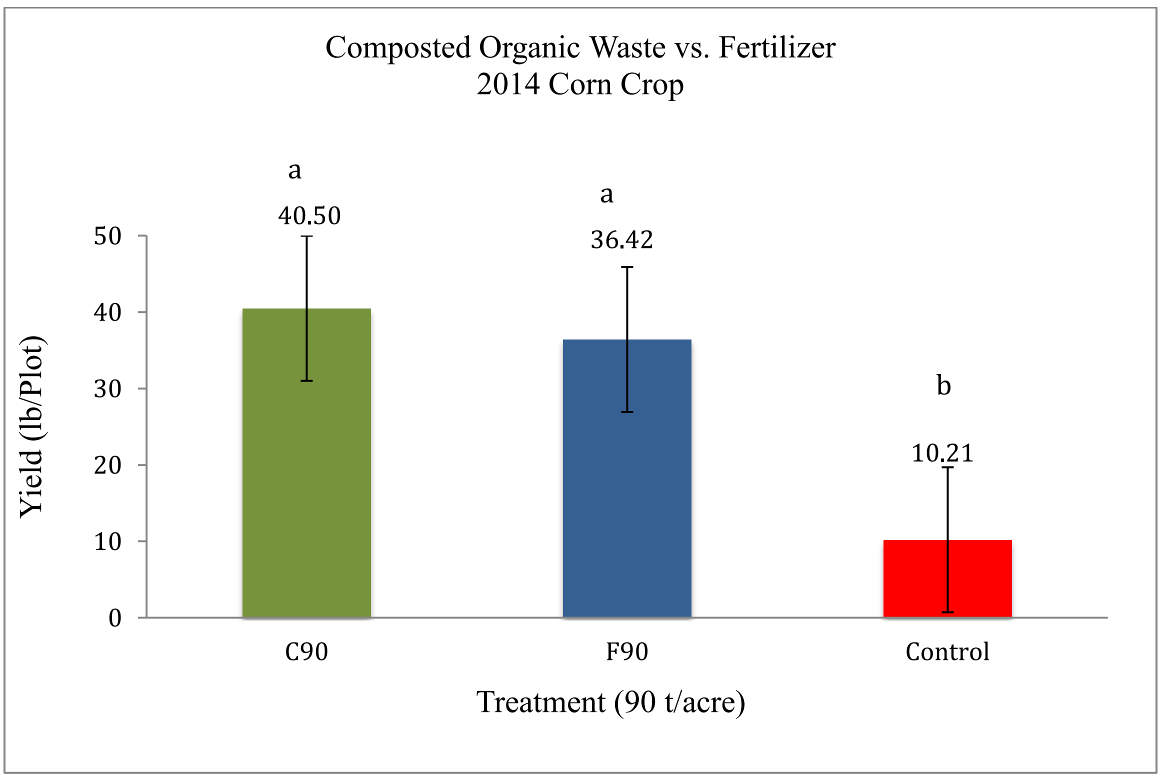

Figure 12: Crop yield (corn) comparison between composted organic waste (C90) and inorganic fertilizer (F90) at 90 tons per acre application in 2014 (dry season)
Notes: Letters above bar graph (Treatments sharing the same letters are not statistically different)

Table 9: 90 tons/acre 2-Way ANOVA Randomized Block Design

C90 vs. F90					
Source	DF	Adj SS	Adj MS	F-Value	P-value
Blocks	3	78.74	26.25	1.63	0.35
Treatment	1	33.35	33.35	2.07	0.25
C90 vs. Control					
Source	DF	Adj SS	MS	F-Value	P-value
Blocks	3	19.76	6.59	6.06	0.09
Treatment	1	1835.17	1835.17	1688.59	<<0.01
F90 vs. Control					
Source	DF	Adj SS	adj MS	F-Value	P-value
Blocks	3	63.95	21.32	0.89	0.54
Treatment	1	1373.75	1373.75	57.12	<0.01

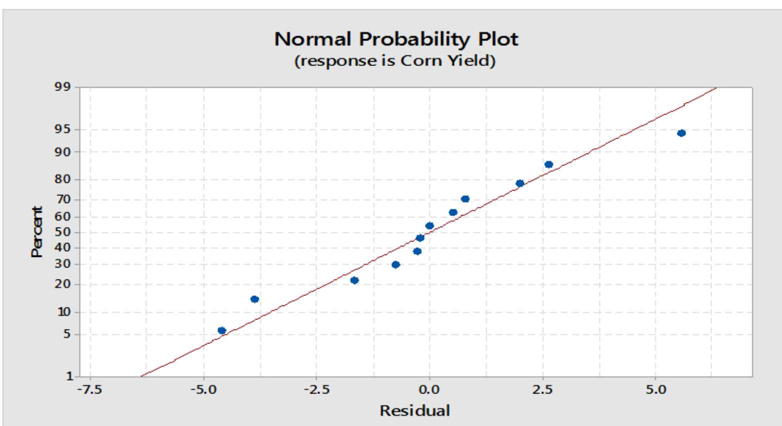

Figure 13: 90 tons per acre normality test using Minitab 17 statistical software

For the 90 tons per acre of equivalent N applications (Figure 13), composted organic waste plots (C90) had higher yield than inorganic fertilizer plots but were not statistically different. Still, both were statistically different to control plots.

2015 Crop Yield Data

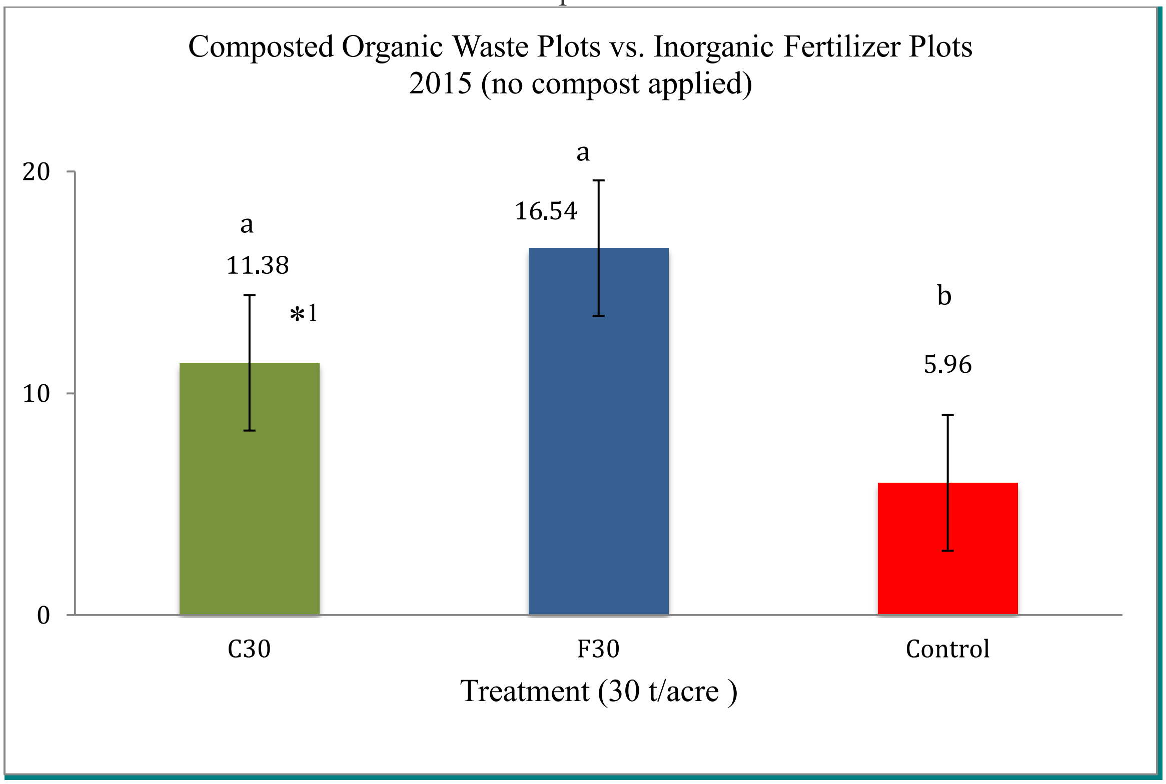

Figure 14: Crop yield (corn) comparison between composted organic waste (C30) and inorganic fertilizer (F30) study plots at 30 tons per acre of equivalent N (*[1] = 0 tons/acre of compost was applied on C30 study plots)
Notes: Letters above bar graph (Treatments sharing the same letters are not statistically different)

Table 10: 2015 Crop Yield 30 tons per acre 2-way Analysis of Variance (ANOVA) at 95 % confidence interval

C30 vs. F30					
Source	DF	Adj SS	Adj MS	F-Value	P-value
Blocks	3	118.39	39.46	2.27	0.26
Treatment	1	53.41	53.41	3.07	0.18
C30 vs. Control					
Source	DF	Adj SS	MS	F-Value	P-value
Blocks	3	14.29	4.76	2.36	0.25
Treatment	1	58.65	58.64	29.12	0.01
F30 vs. Control					
Source	DF	Adj SS	adj MS	F-Value	P-value
Blocks	3	120.38	40.13	2.2	0.27
Treatment	1	223.98	223.98	12.27	0.04

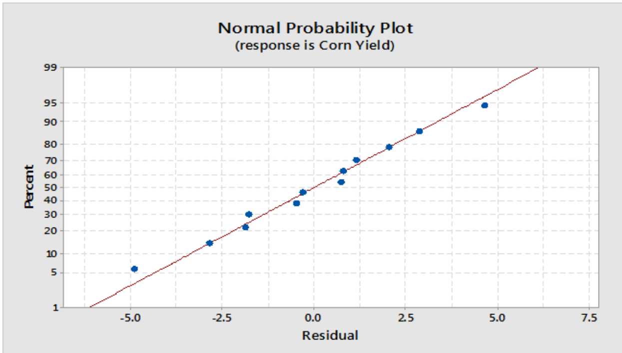

Figure 15: 30 tons per acre normality test using Minitab 17 statistical software

During the second planting season (dry season) (figure 14), 30 tons per acre of inorganic fertilizers were applied on fertilizer plots only (no compost applied on composted plots). Compost plots (C30) yielded (11.38 lb./plot) of corn compared to control plots (0 tons per acre of equivalent N)(5.96 lb./plot). Compost plots was statistically different from the control plots (p-value = 0.01)

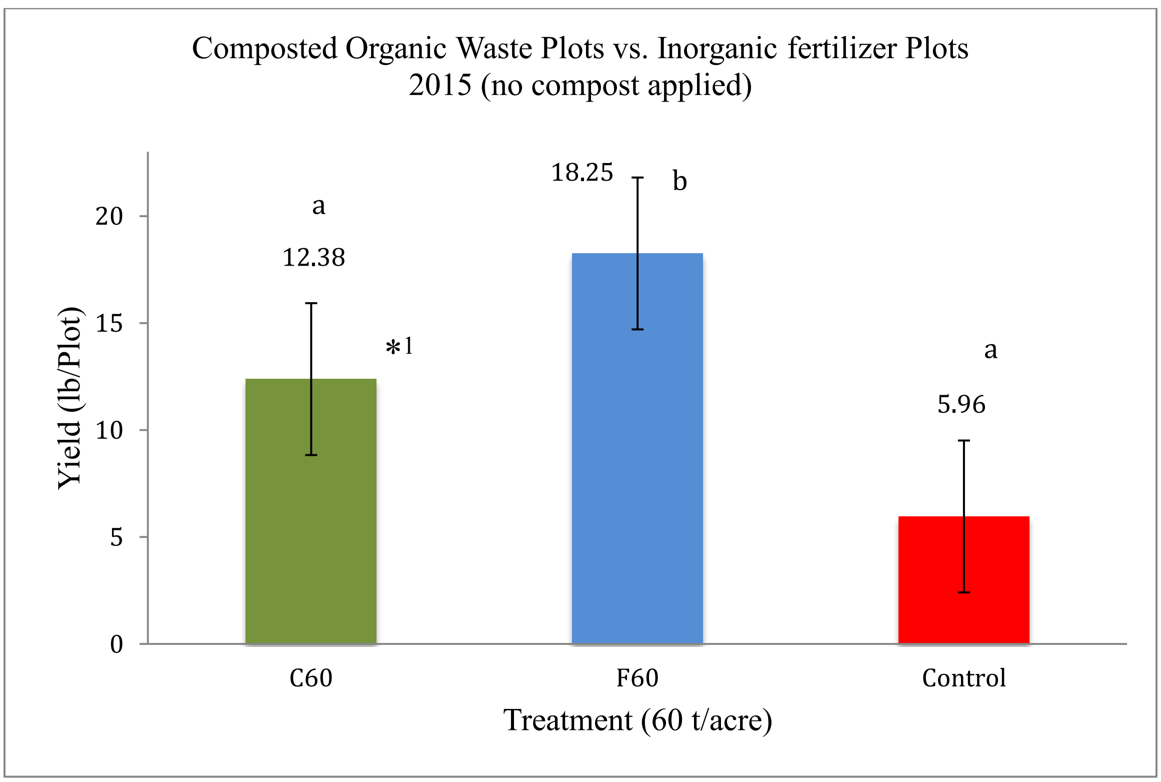

Figure 16: Crop yield (corn) comparison between composted organic waste (C60) and inorganic fertilizer (F60) plots at 60 tons per acre of equivalent N ($*^1$ = 0 tons/acre of compost was applied on C60 study plots)
Notes: Letters above bar graph (Treatments sharing the same letters are not statistically different)

Table 11: 2015 Crop Yield 60 Tons Per Acre 2-way Analysis of Variance (ANOVA)

C60 vs. F60					
Source	DF	Adj SS	Adj MS	F-Value	P-value
Blocks	3	214.74	71.58	17.89	0.02
Treatment	1	68.97	68.97	17.24	0.03
C60 vs. Control					
Source	DF	Adj SS	MS	F-Value	P-value
Blocks	3	71.74	23.91	2.54	0.23
Treatment	1	82.37	82.37	8.75	0.06
F60 vs. Control					
Source	DF	Adj SS	adj MS	F-Value	P-value
Blocks	3	101.24	33.75	2.01	0.29
Treatment	1	302.09	302.09	17.96	0.02

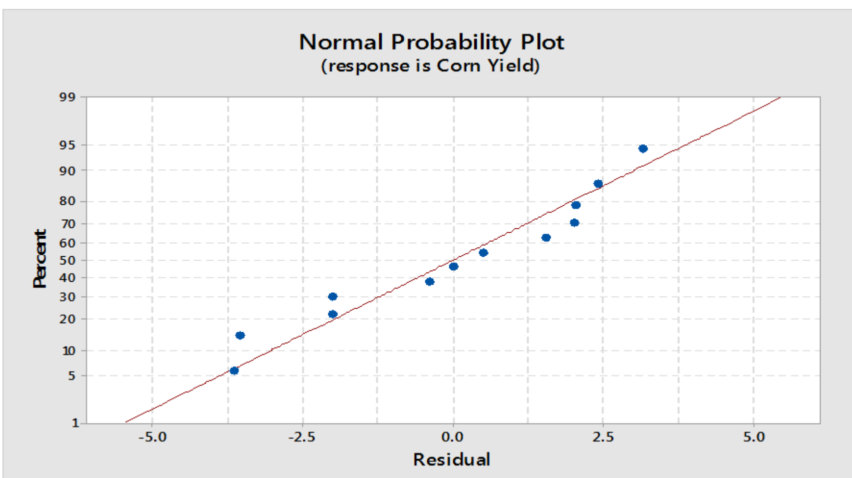

Figure 17: 60 tons per acre normality test using Minitab 17 statistical software

At 60 tons per acre of equivalent N application of inorganic fertilizer with no compost added to compost plots, compost plots yielded 2 times greater than control plots despite not statistically different. It showed that compost has carryover effects after 1 year. The fertilizer plots (F60) had higher crop yield than compost plots (C60) and were statically different (P-value 0.03).

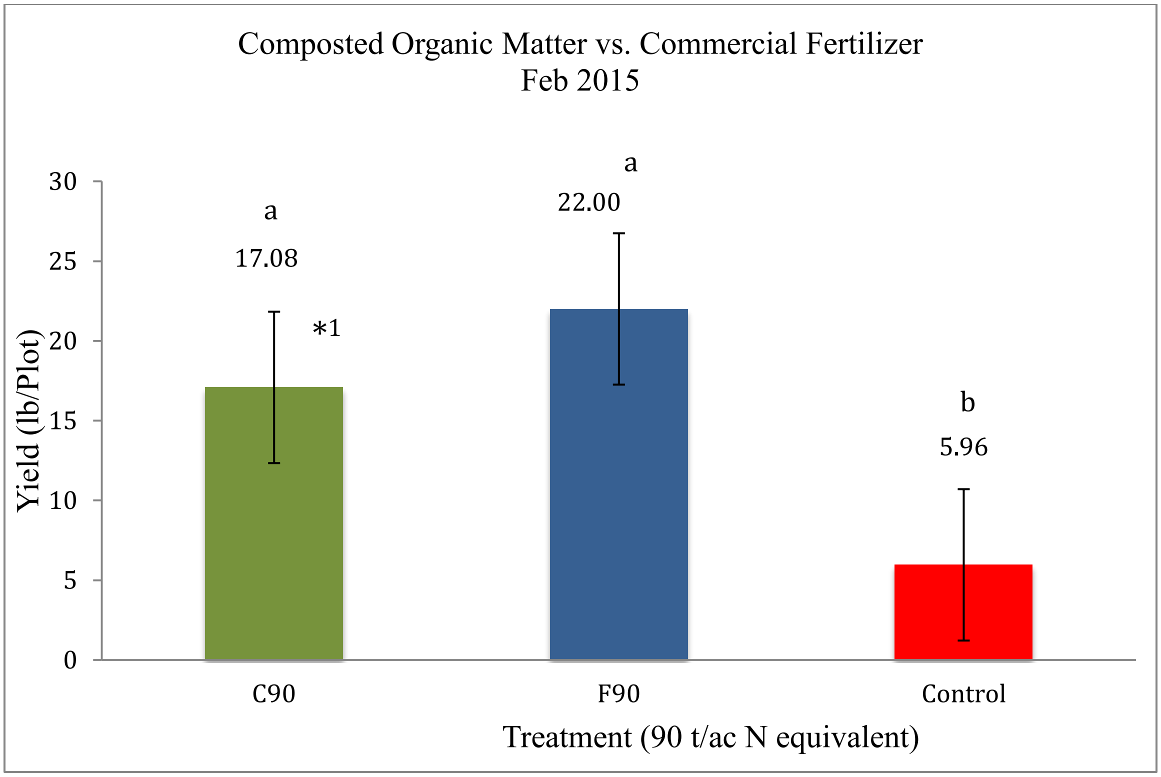

Figure 18: Crop yield (corn) comparison between composted organic waste (C90) Plots and inorganic fertilizer (F90) at 90 tons per acre of equivalent N (*[1] = Compost was not applied on C90 study plots)
Notes: Letters above bar graph (Treatments sharing the same letters are not statistically different)

Table 12: 2015 Crop Yield 90 Tons Per Acre 2-way Analysis of Variance (ANOVA)

C90 vs. F90					
Source	DF	Adj SS	Adj MS	F-Value	P-value
Blocks	3	107.96	35.99	0.76	0.59
Treatment	1	48.41	48.41	1.03	0.39
C90 vs. Control					
Source	DF	Adj SS	MS	F-Value	P-value
Blocks	3	69.25	23.08	2.29	0.26
Treatment	1	247.42	247.42	24.54	0.02
F90 vs. Control					
Source	DF	Adj SS	adj MS	F-Value	P-value
Blocks	3	114.68	38.23	1.9	0.31
Treatment	1	514.72	514.72	25.58	0.02

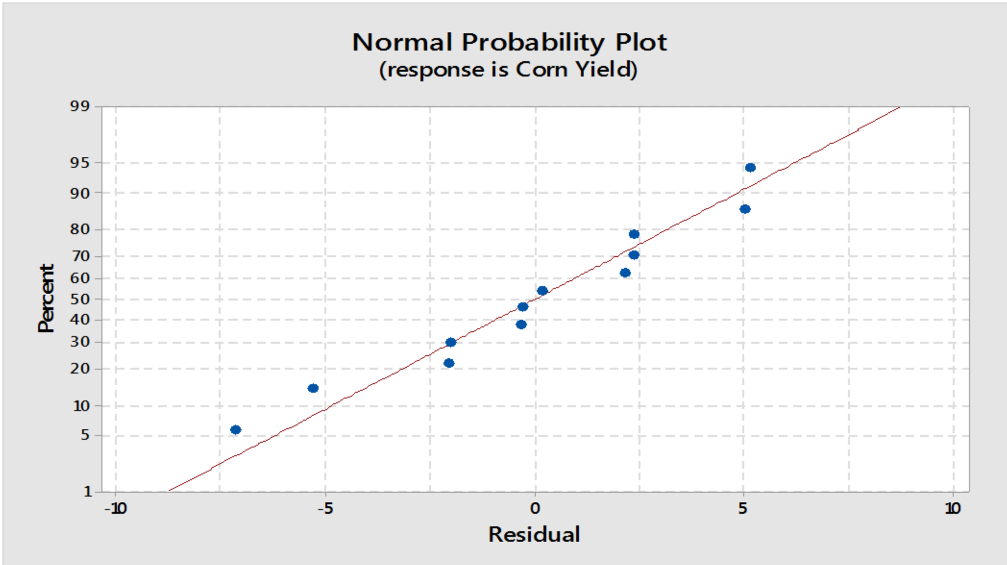

Figure 19: 90 tons per acre normality test using Minitab 17 statistical software

At 90 tons per acre of equivalent N application of inorganic fertilizer on fertilizer plots (F90), there was significant difference in crop yield ($p < 0.01$) between compost and control. Although fertilizer plots (F90) has higher crop yield than compost plots (C90), they were not statistically different (P-value = 0.39).

2016 Crop Yield Data

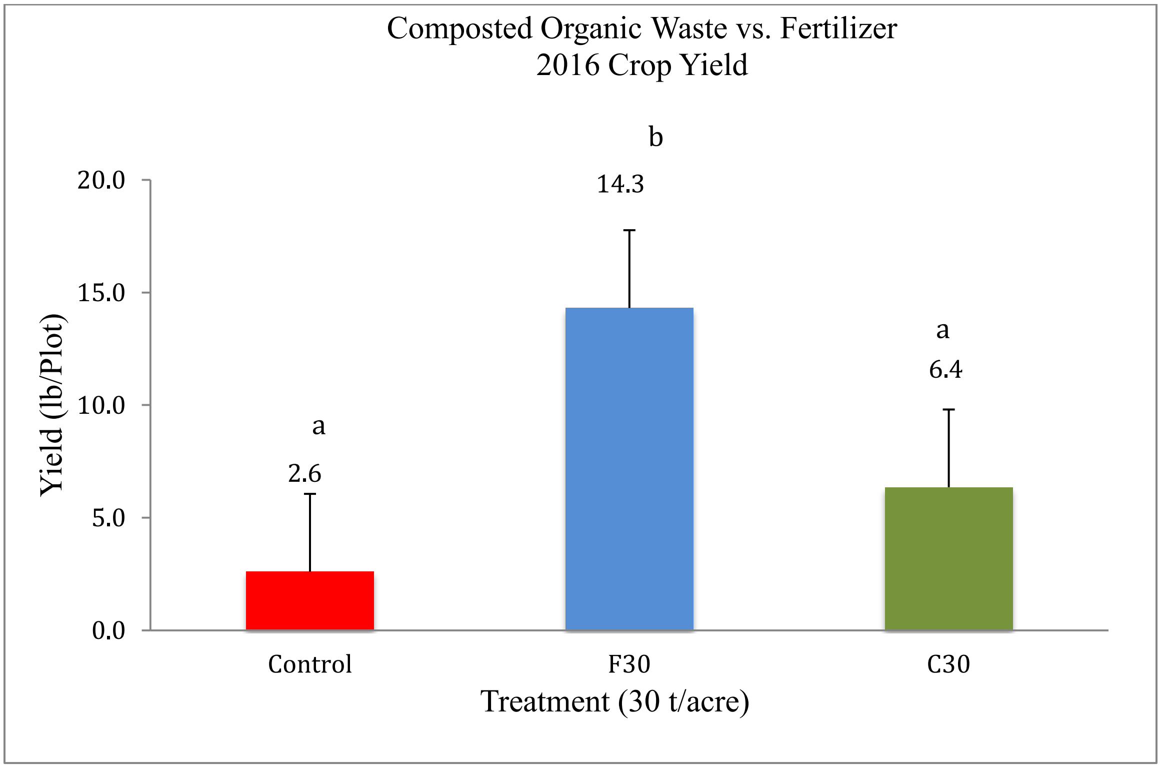

Figure 20: Crop yield (corn) comparison between composted organic waste (C30) and inorganic fertilizer (F30) at 30 tons per acre application in 2016 (rainy season)
Notes: Letters above bar graph (Treatments sharing the same letters are not statistically different

Table 13: 30 tons per acre crop yield (2-way ANOVA complete block design)

C30 vs. F30					
Source	DF	Adj SS	Adj MS	F-Value	P-value
Blocks	3	120.25	40.08	1.34	0.41
Treatment	1	126.8	126.8	4.24	0.13
C30 vs. Control					
Source	DF	Adj SS	MS	F-Value	P-value
Blocks	3	34.39	11.46	1.02	0.5
Treatment	1	274.37	274.37	13.63	0.21
F30 vs. Control					
Source	DF	Adj SS	adj MS	F-Value	P-value
Blocks	3	87.52	29.17	1.45	0.38
Treatment	1	274.37	274.37	13.63	0.03

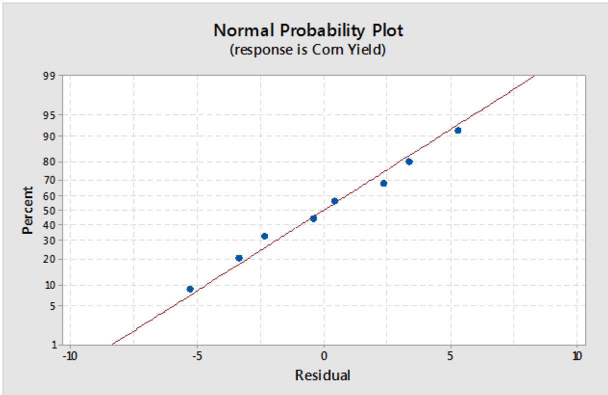

Figure 21: 30 tons per acre normality test using Minitab 17 statistical software

During the 2016 (wet season), the inorganic fertilizer plots (Figure 20) had higher crop yield compared to the composted organic plots and were statistically significant when compared to the 30 tons per acre treatment (p-value = 0.13). This was possibly due high C:N ratio 31:1 from the compost applied to study compost study plots (Table 19). The low nitrogen content is immobilized in the soil depleting plants from nitrogen.

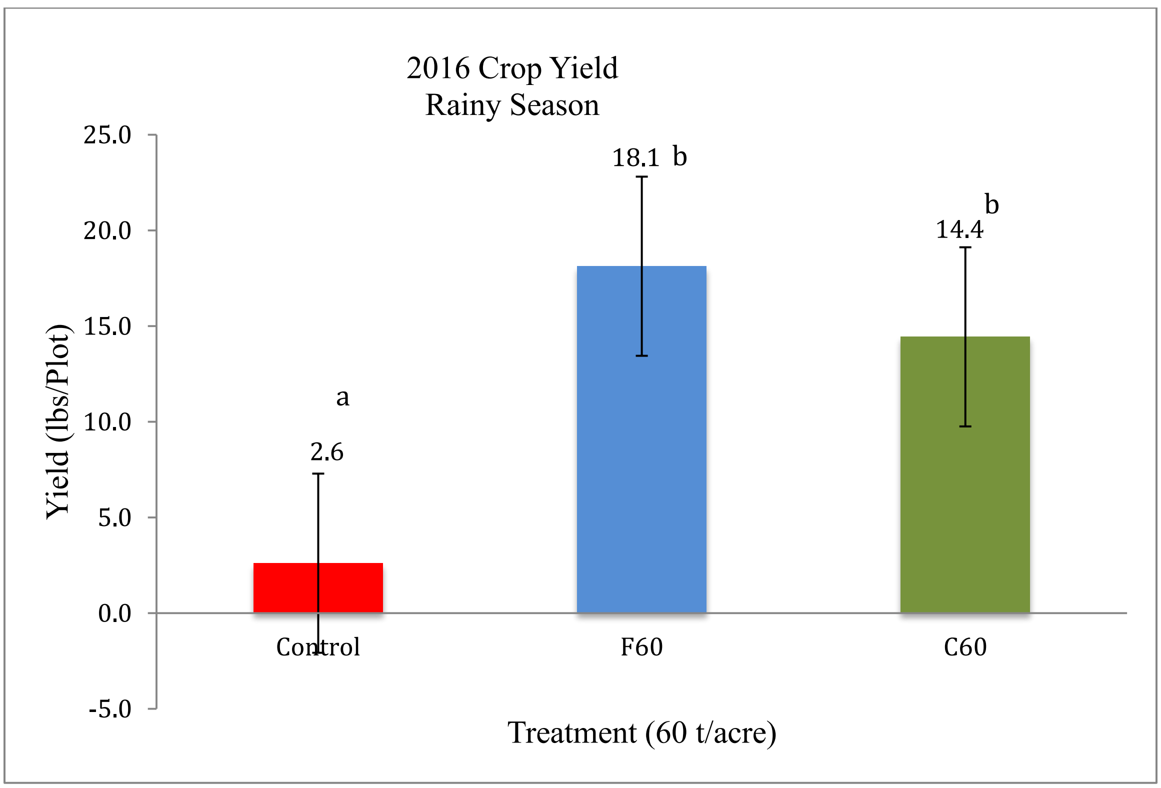

Figure 22: Crop yield during the rainy season based on 60 tons per acre application
Notes: Letters above bar graph (Treatments sharing the same letters are not statistically different)

Table 14: 60 tons/acre (2-way ANOVA – Randomized Complete block design)

C60 vs. F60					
Source	DF	Adj SS	Adj MS	F-Value	P-value
Blocks	3	74.85	24.95	1.06	0.48
Treatment	1	27.23	27.23	1.16	0.36
C60 vs. Control					
Source	DF	Adj SS	MS	F-Value	P-value
Blocks	3	19.28	6.42	4.61	0.12
Treatment	1	279.9	279.9	200.77	< 0.01
F60 vs. Control					
Source	DF	Adj SS	adj MS	F-Value	P-value
Blocks	3	60.17	20.06	0.89	0.54
Treatment	1	481.74	481.74	21.38	0.02

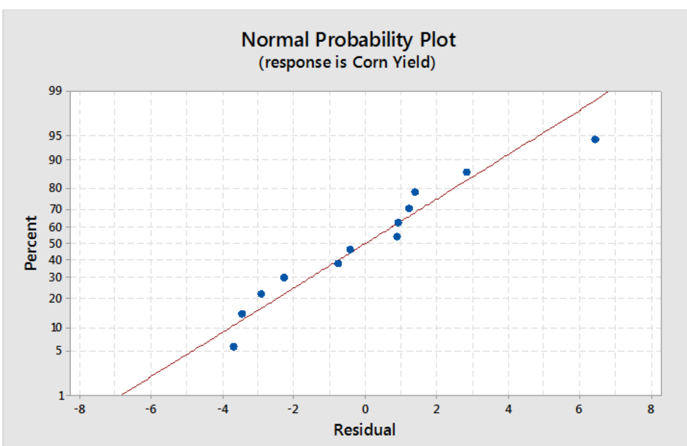

Figure 23: Normality Test of Control, C60, F60 using Minitab 17 statistical software

Fertilizer study plots (F60) (Figure 22) yielded higher corn crop (18.1 lb./plot) than compost plots (C60) at 14.4 lb./plot but were not statistically different (p = 0. 36). The effects of high C:N of the compost used and the high rainfall have affected the crop yield of the composted plots (Figure 22).

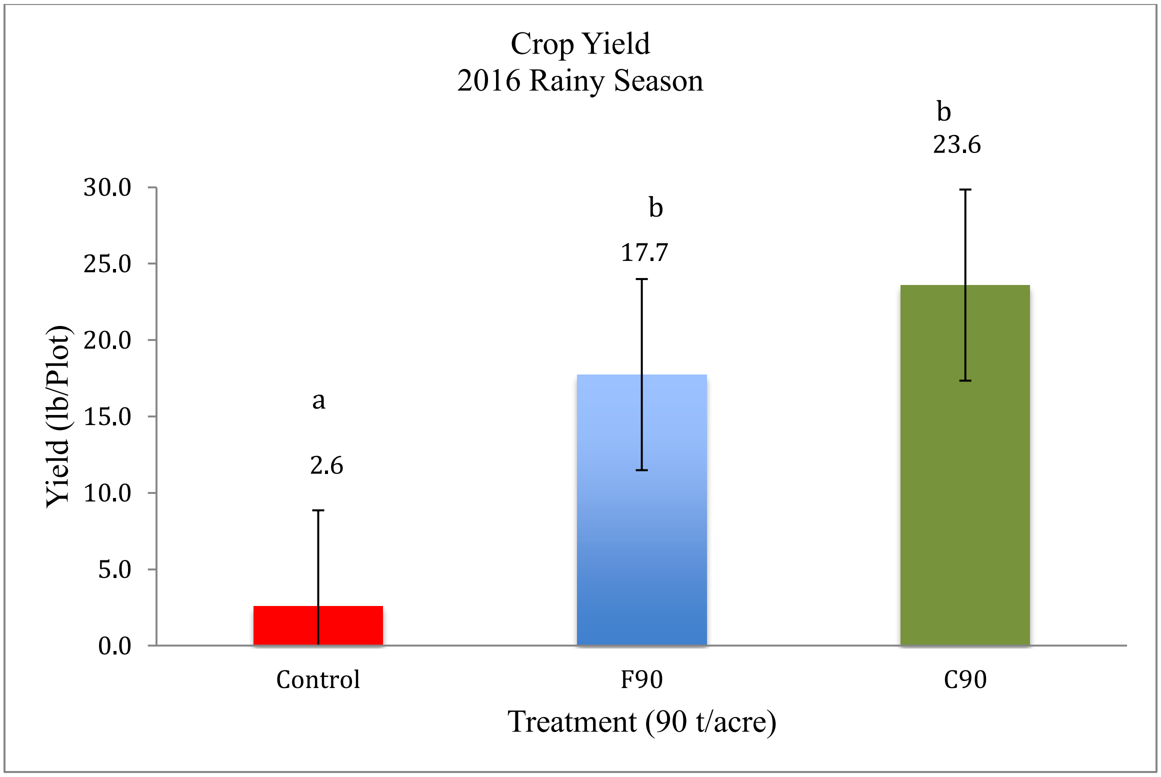

Figure 24: Crop yield (corn) comparison between composted organic waste (C90) and inorganic fertilizer (F90) at 90 tons per acre equivalent N application in 2016 (rainy season)
Notes: Letters above bar graph (Treatments sharing the same letters are not statistically different.

Table 15: 90 Tons Per Acre 2-Way ANOVA Randomized Block Design

C90 vs. F90					
Source	DF	Adj SS	Adj MS	F-Value	P-value
Blocks	3	79.61	26.54	1.32	0.41
Treatment	1	68.68	68.68	3.41	0.16
C90 vs. Control					
Source	DF	Adj SS	MS	F-Value	P-value
Blocks	3	52.2	17.4	1.26	0.43
Treatment	1	881.33	881.33	63.58	< 0.01
F90 vs. Control					
Source	DF	Adj SS	adj MS	F-Value	P-value
Blocks	3	25.73	8.57	0.97	0.51
Treatment	1	457.95	457.95	51.57	< 0.01

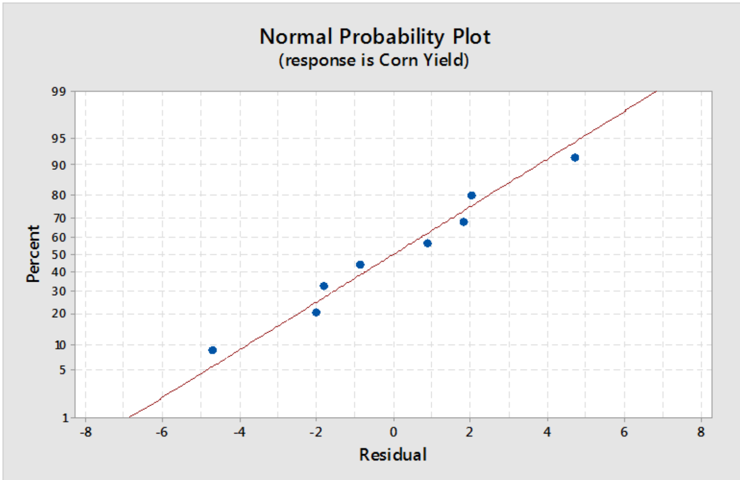

Figure 25: 90 tons per acre normality test using Minitab 17 statistical software

Based on the 90 tons per acre equivalent N application compost plots (C90) had higher crop yield than fertilizer plots (Figure 23) but were not statistically different. However, C90 plots were statistically different from the control plots.

Soil Organic Matter (SOM)

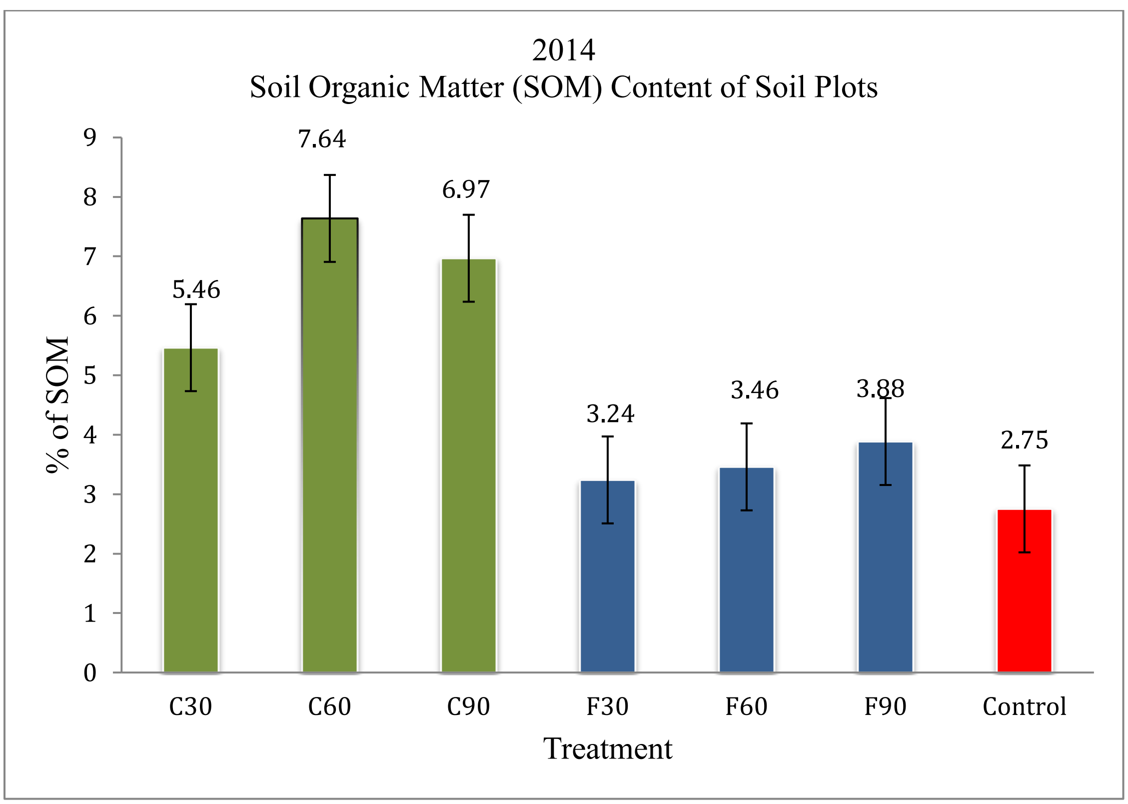

Figure 26: 2014 Soil organic matter (SOM) content (%) based on all treatments

Based on the 2014 of collected SOM sampled from all study plots, compost applied study plots were significantly higher soil organic matter content than inorganic fertilizer applied plts and control plots. Both C60 and C90 (compost plots) were significantly higher (SOM) than 30 tons per acre (C30) plots.

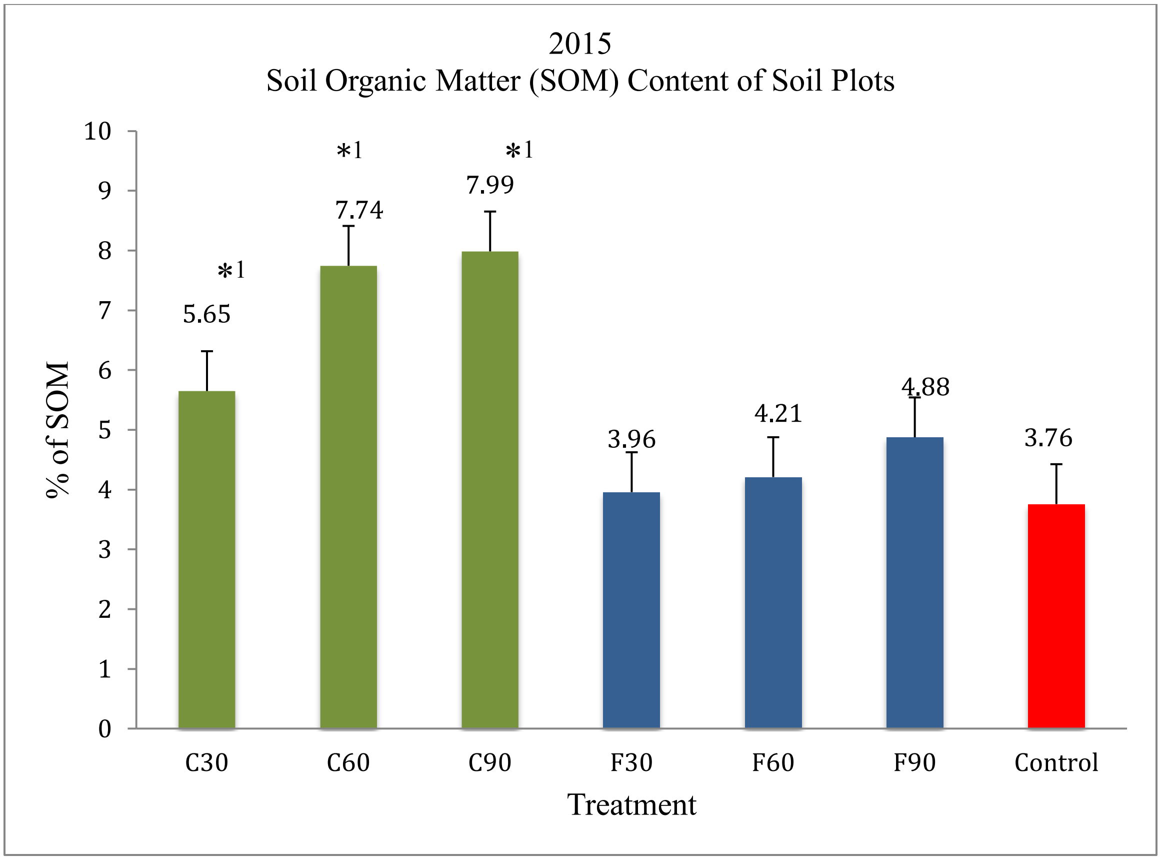

Figure 27: 2015 Soil organic matter (SOM) content (%) based on all treatment rates
Notes: *[1] = compost was not applied on these study plots

In 2015, compost was not applied on all compost plots (C30, C60, C90) but inorganic fertilizers were applied on all fertilizer plots (F30, F60, F90). All compost study plots had higher SOM than fertilizer and control plots. The SOM content of compost plots remained the same in 2015 despite the non-application of composts.

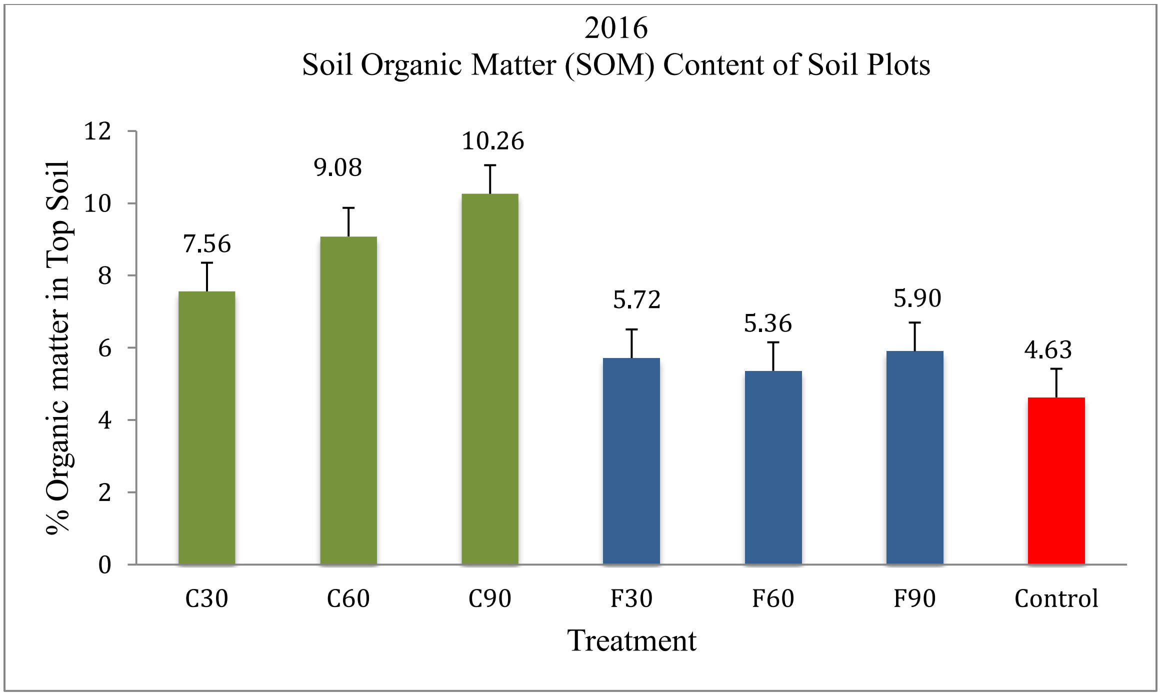

Figure 28: Soil organic matter (SOM) content (%) based on all treatments

In 2016 (rainy season), compost was re-applied again to all compost plots (C30, C60, C90) with the same rate as in 2014. SOM content in the compost study plots increased due compost reapplication. Despite the high rainful and high carbon to nitrogen ratio (C:N) of 30:1 that was obtained from the compost, the SOM increased.

Bulk Density

The critical value of bulk density for restricting root growth varies with soil type (Hunt and Gilkes, 1992) but in general, bulk densities greater than 1.6 g/cm^3 tend to restrict root growth (McKenzie et al., 2004). In this study, the soil plots were tilled prior to compost and fertilizer application. Also, majority of the soil plots had high amount of sodium carbonate rocks, which increased the bulk density of the samples. However, inorganic fertilizer and control study plots showed higher bulk density (BD) had a mean of 1.36 g/cm^3 while composted organic plots mean was 1.16 g/cm^3. This showed that composted organic waste applied as soil amendment improved the soil physical property due to the increased of soil organic matter. It also showed that control soil plots and fertilizer soil plots bulk density were not significant based on the error bars.

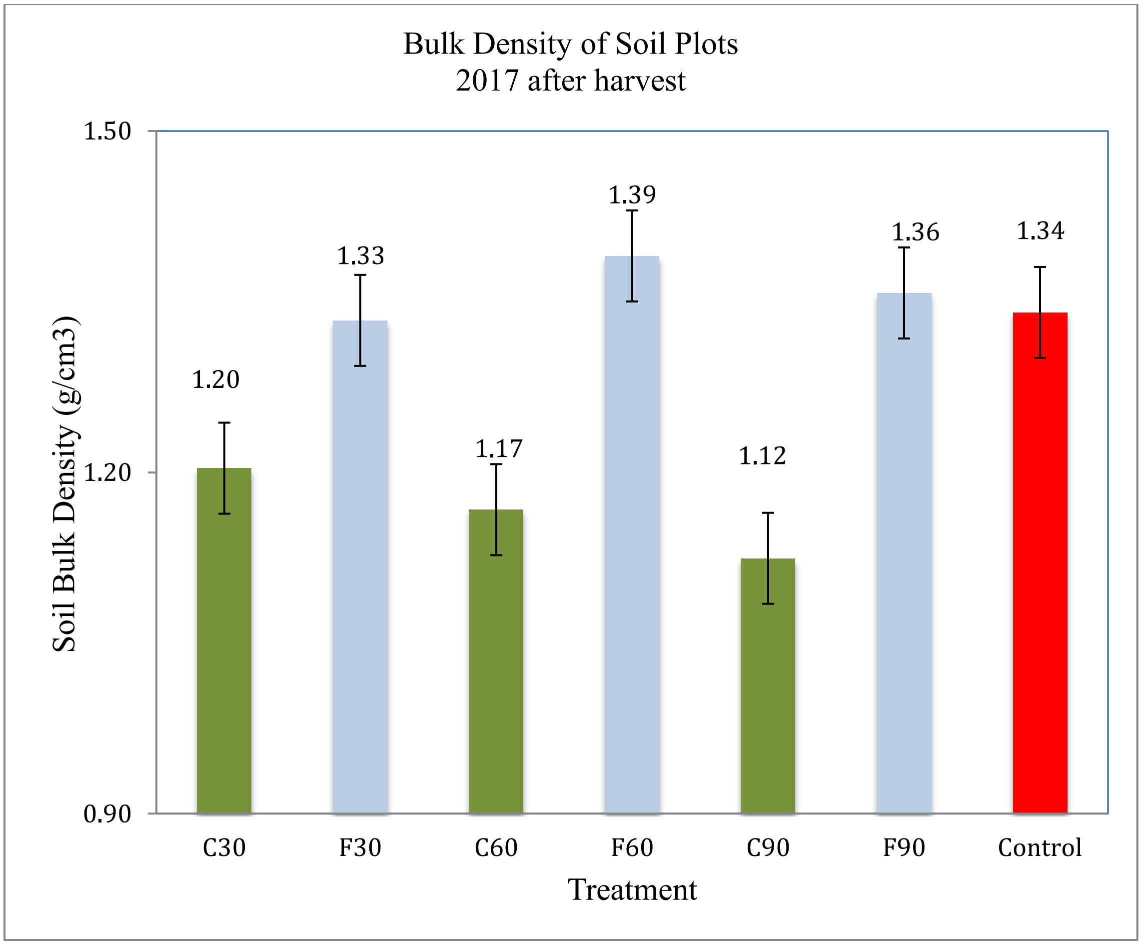

Figure 29: Bulk density of soil plots after harvest
Notes: Top soil sampled only, approximately 2.5 cm deep

Nitrogen and Carbon Percentage

Table 16: Total Nitrogen Content of the Soil Plots Under Study

Level	Total Nitrogen (%)
Very low	< 0.1
Low	0.1 - 0.2
Medium	0.2 - 0.5
High	0.5 - 1.0
Very high	> 1

Total nitrogen (%) in the composted organic plots were higher than inorganic fertilizer plots (Table 17 & 18) during the first year (dry season), second year (dry second), and the third year (rainy season). Compost plots were in the range of medium to high nitrogen percentage while inorganic fertilizer plots were in the low to medium. Despite the non application of compost during the second year, the nitrogen percentage in the soil was still high.

Table 17: Total nitrogen and carbon and carbon to nitrogen ratio in the soil plots 2014 (dry season)

Yigo Soil Plots	2014					
	Pre-plant (8/1/2013)			After Harvest (2/10/2014)		
Treatment	% N	% C	C:N	% N	% C	C:N
C30	0.26	6.60	26:1	0.34	9.48	28:1
F30	0.26	10.18	39:1	0.26	10.51	41:1
C60	0.44	11.59	26:1	0.51	11.46	23:1
F60	0.23	10.16	45:1	0.27	13.17	49:1
C90	0.33	8.02	25:1	0.33	6.66	20:1
F90	0.28	11.46	42:1	0.29	12.14	42:1
CONTROL	0.21	8.56	42:1	0.20	8.18	40:1

Table 18: Total nitrogen and carbon and carbon to nitrogen ratio in the soil plots (2015 - dry season)

Yigo Soil Plots	2015 (no compost applied)					
	Pre-plant (6/13/2014			After Harvest (2/2/2015)		
Treatment	% N	% C	C:N	% N	% C	C:N
C30	0.38	8.70	23:1	0.39	8.97	23:1
F30	0.25	10.18	41:1	0.30	11.00	37:1
C60	0.51	11.91	23:1	0.48	12.89	27:1
F60	0.28	10.01	36:1	0.31	11.74	38:1
C90	0.50	11.50	23:1	0.45	11.26	25:1
F90	0.29	11.31	40:1	0.33	12.15	37:1
CONTROL	0.24	8.76	37:1	0.23	9.62	42:1

Table 19: Total nitrogen and carbon and carbon to nitrogen ratio in the soil plots (third year – rainy season)

Yigo Soil Plots	2016					
	Pre-plant (9/9/2016)			After Harvest (12/21/2016)		
Treatment	% N	% C	C:N	% N	% C	C:N
C30	0.44	9.21	21:1	0.40	9.85	24:1
F30	0.38	11.40	30:1	0.30	10.88	36:1
C60	0.53	11.77	22:1	0.47	12.50	27:1
F60	0.39	12.10	31:1	0.28	11.49	42:1
C90	0.53	10.72	20:1	0.50	12.62	25:1
F90	0.40	12.07	30:1	0.29	11.82	41:1
CONTROL	0.33	9.58	29:1	0.25	9.33	37:1

Carbon to Nitrogen Ratio

Carbon to nitrogen ratio (C:N) is the ratio of carbon to nitrogen in a substance. For examples, a C:N of 5:1 means there is 5 units carbon for each unit of nitrogen. The carbon to nitrogen ratio in the soil less than 24:1 can lead to nitrogen surplus while anything greater than 24:1 can lead to nitrogen deficiency. The composted plot were in ideal range of less than 24:1 while most of the inorganic fertilizer plots are beyond 30:1 carbon to nitrogen ratio.

Phosphorus

Another major essential nutrient needed by plants and also found in fertilizers is Phosphorus. Phosphorus (P) is needed for plant's growth and maturity and plays a key role in photosynthesis (Conley et al., 2009). Although phosphorus is not considered toxic to humans, high concentration in fresh water can lead to rapid growth of algae. This leads to decreased in water visibility and reduced oxygen in the water that is detrimental to the fish population. Surface runoffs containing excess phosphorus can also reach beach areas increasing algae in the water; this can affect tourism, a major contributor to Guam's economy.

Phosphorus (P) used in agriculture is in a form of phosphate. Most phosphatic fertilizers are made of highly pure monocalcium or dicalcium orthophosphate, $Ca(H_2PO_4)2$ and $CaHPO_4$ (Van Wazer, 2014). Although phosphorus is essential for plant growth, in some agriculture the availability of phosphorus is often limited (Richardson, et al., 2011). The availability of P to plants for uptake and use is reduced in alkaline and calcareous soil such as in northern Guam due to the presence of calcium phosphate minerals**.**

The application of organically complexed P from humic substances such as compost can enhance P nutrition and result in higher yield (Hopkins, Ellsworth, 2005). As an alternative, slow release and cation complexed fertilizer P may also increase crop yield. The phosphates captured from the lysimeters in this study are mostly undetectable and rarely reached 1.5 ppm. The analysis and impact of Phosphate was not reported since the emphasis was on nitrogen.

Electrical Conductivity

Electrical conductivity (EC_a) is a measurement of soil salinity, which is often associated with irrigated farmlands, or shallow water tables in arid-zone regions (Corwin, Lesch , 2005). Although plants absorb nutrients in the form of soluble salts, excessive salinity can affect plant growth (Shrivastava, Kumar, 2015). Since the northern Guam soil is highly porous and regularly receives high amount of rain, any increase in salinity can be attributed to excess application of composted organic wastes.

Though composted organic wastes can improve soil fertility, there are concerns of the salt contents in the soil. Research indicates that composts that have high salt content without leaching may affect plant growth rate (Reddy, *et al*., 2012). However, in this study, the effects of composted organic wastes in the soil salinity were minimal (table 21b). Soil plots were tested again after harvest (Table 17c) for soil salinity and the composted organic study plots resulted in lower electrical conductivity thus water suitability became excellent based on the standard (EC) Range (Table 20a).

Table 20a: Electrical Conductivity (EC) Range as Related to Water Suitability

Class of Water	Specific Conductance dS/m
Excellent	<0.25
Good	0.25 to 0.75
Permissible	0.76 to 2.00
Doubtful	2.01 to 3.00 (may contain salt)
Unsuitable for irrigation	> 3.00 (contains salts)

Table 20b: Year 3 (Rainy Season) Electrical Conductivity (EC) Test of Study Plots Before Planting 9/9/2016

Treatment	Avg. dS/m	^oC	Class of Water
C30	0.26	22.2	good
F60	0.24	22.2	excellent
C60	0.26	22.2	good
F90	0.24	22.2	excellent
C90	0.27	22.1	good
F30	0.22	22.1	excellent
Control	0.20	22.2	excellent

Table 20c After Harvest 12/21/2016

Treatment	Avg. dS/m	Class of water
C30	0.20	excellent
F30	0.16	excellent
C60	0.20	excellent
F60	0.16	excellent
C90	0.21	excellent
F90	0.17	excellent
Control	0.14	excellent

DISCUSSION

Crop Yield

Composted organic wastes applied to study plots (2014, dry-season) consistently produced higher yield than in the fertilizer-applied plots although they were not statistically significant. However, compared to control plots, both fertilizer and compost applied study plots had significantly higher yield statistically.

In 2015, the compost study plots did not receive compost but fertilizer was applied on fertilizer plots. This was conducted to study the carryover effects of compost applied on poorly structured soils of northern Guam. Based on the results, compost applied study plots had significantly higher yield statistically than control plots (0 tons/acre). On the other hand, C90 plots with zero compost applied were statistically not different compared to F90, which 90 tons per acre equivalent N to compost was applied. This showed that compost has carryover effect of nutrients contributed to statistically significant increased crop yield.

During the wet season (2016), there were inconsistencies with the crop yield. This was possibly due high C:N of the compost applied. The rapid growth of weeds in the soil from the compost plots and the poor weed management are factors that also affected the crop yield. Since the corn variety is short, they were more susceptible to competition with weeds. Effective weed management, one of the key factors impacting crop yield may be applied for any future composted organic application research (Knight et al, 2017).

Organic Matter

Compost application on study plots maintained higher soil organic matter (SOM) even when compost was not reapplied in 2015 (dry season). This showed that organic matter from compost has carryover effects of nutrients. By increasing organic matter, soil in northern Guam may increase soil water and nutrient holding capacity (cation exchange capacity), which can also reduce the unnecessary leaching of nutrient (N, P) chemicals in the underground water supply. Soils that were low in organic matter however experienced low crop yield.

Soil organic matter contributes for improved soil structure for better root penetration and proliferation. The lack of soil organic matter leads to increase in soil bulk density therefore affecting plant growth and development.

Nitrate Leaching

The application of composted organic waste in the porous soil of northern Guam not only increased soil fertility but also has lower leaching of nutrients such as nitrate. Inorganic fertilizer on the other hand percolated nitrate rapidly beyond 30.5 cm. especially during the rainy season.

CONCLUSION AND RECOMMENDATION

Increasing organic matter in the soil using composted organic wastes may be beneficial to farmlands located above groundwater system. Since the application of soil organic matter can slow down leaching by retaining the nutrient in the water that would otherwise drain down beyond the root zone allowing sufficient residence time within the root zone for plant uptake of available nutrients (Golabi et al., 2007). The poorly structured soils on Guam and other tropical islands in the western Pacific may benefit with the land application of composted organic wastes to increasing crop production and improving soil quality while preserving environmental quality of the groundwater system (Golabi et al., 2004).

RECOMMENDATIONS FOR IMPROVEMENT

The methodology used in this study

1. Use of rain gauges to improve the accuracy of leachate data based on the cumulative rainfall that may have affected the movement of vertical migrations of chemicals in the soil profile.
2. Study denitrification measurement in northern Guam's subsoils for any decrease of NO_3^- contamination in the groundwater.

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APPENDIX I

Corn Yield Data

2014 Yield From 30 Tons/Acre

Blocks	Treatment	Corn Yield
I	C30	30.67
I	F30	29.17
I	Control	11.33
II	C30	32.83
II	F30	25.83
II	Control	12.83
III	C30	27.33
III	F30	28.00
III	Control	7.67
IV	C30	26.50
IV	F30	20.33
IV	Control	9.00

2014 Yield From 60 Tons/Acre

Blocks	Treatment	Corn Yield
I	C60	37.67
I	F60	34.33
I	Control	11.33
II	C60	42.33
II	F60	37.50
II	Control	12.83
III	C60	32.00
III	F60	34.33
III	Control	7.67
IV	C60	34.33
IV	F60	27.67
IV	Control	9.00

2014 Yield From 90 Tons/Acre

Blocks	Treatment	Corn Yield
I	C90	40.83
I	F90	36.83
I	Control	11.33
II	C90	42.33
II	F90	37.50
II	Control	12.83
III	C90	40.17
III	F90	43.33
III	Control	7.67
IV	C90	38.67
IV	F90	28.00
IV	Control	9.00

2015 Yield From 30 Tons/Acre

Blocks	Treatment	Corn Yield
I	C30	12.83
I	F30	25.50
I	Control	8.50
II	C30	11.00
II	F30	16.00
II	Control	6.67
III	C30	12.42
III	F30	17.17
III	Control	4.00
IV	C30	9.25
IV	F30	7.50
IV	Control	4.67

2015 Yield From 60 Tons/Acre

Blocks	Treatment	Corn Yield
I	C60	20.00
I	F60	26.33
I	Control	8.50
II	C60	8.67
II	F60	16.17
II	Control	6.67
III	C60	12.42
III	F60	20.33
III	Control	4.00
IV	C60	8.42
IV	F60	10.17
IV	Control	4.67

2015 Yield From 90 Tons/Acre

Blocks	Treatment	Corn Yield
I	C90	24.00
I	F90	26.25
I	Control	8.50
II	C90	12.33
II	F90	27.67
II	Control	6.67
III	C90	13.33
III	F90	22.67
III	Control	4.00
IV	C90	18.67
IV	F90	11.42
IV	Control	4.67

2016 Yield From 30 Tons/Acre

Blocks	Treatment	Corn Yield
I	control	2.37
I	F30	16.36
I	C30	13.08
II	control	2.88
II	F30	21.4
II	C30	2.88
III	control	1.38
III	F30	4.81
III	C30	3.59
IV	control	3.79
IV	F30	14.7
IV	C30	5.87

2016 Yield From 60 Tons/Acre

Blocks	Treatment	Corn Yield
I	control	2.37
I	F60	27.79
I	C60	14.74
II	control	2.88
II	F60	14.74
II	C60	14.23
III	control	1.38
III	F60	15.25
III	C60	11.20
IV	control	3.79
IV	F60	14.72
IV	C60	17.57

2016 Yield From 90 Tons/Acre

Blocks	Treatment	Corn Yield
I	control	2.37
I	F90	21.12
I	C90	17.57
II	control	2.88
II	F90	21.36
II	C90	30.84
III	control	1.38
III	F90	14.57
III	C90	22.21
IV	control	3.79
IV	F90	13.90
IV	C90	23.77

APPENDIX II

PHYSICAL AND CHEMICAL DATA

Organic Matter (SOM) Content of Soil Study Plots

Treatment	2013	2014	2016
C30	5.11	5.54	6.68
F30	4.06	3.92	5.66
C60	7.99	8.28	8.63
F60	4.51	3.79	5.61
C90	6.58	10.05	8.02
F90	4.51	4.46	5.56
Control	3.14	3.54	4.52

Bulk Density of Soil Study Plots

Treatment	D_b avg.
C30	1.20
F30	1.33
C60	1.17
F60	1.39
C90	1.12
F90	1.36
Control	1.34

2016 Soil Salinity Test

Plots	Treatments	µS/cm	dS/m	°C
I-1	C30	274	0.27	21.9
I-2	F60	276	0.28	21.9
I-3	C60	243	0.24	21.9
I-4	F90	260	0.26	21.8
I-5	C90	282	0.28	21.7
I-6	F30	224	0.22	21.7
I-7	Control	213	0.21	21.8
II-1	F30	211	0.21	22
II-2	C90	270	0.27	22
II-3	C30	285	0.29	22
II-4	C60	273	0.27	21.8
II-5	F60	232	0.23	22.2
II-6	Control	208	0.21	22.2
II-7	F90	244	0.24	22.1
III-1	C60	233	0.23	22.4
III-2	C30	258	0.26	22.3
III-3	C90	253	0.25	22.3
III-4	Control	187.6	0.19	22.2
III-5	F30	200	0.20	22.2
III-6	F60	231	0.23	22.1
III-7	F90	235	0.24	22.2
IV-1	C60	293	0.29	22.5
IV-2	C90	262	0.26	22.5
IV-3	Control	171.8	0.17	22.5
IV-4	C30	206	0.21	22.4
IV-5	F90	209	0.21	22.5
IV-6	F30	231	0.23	22.4
IV-7	F60	207	0.21	22.4

Soil Carbon and Nitrogen Content

	Tested	% N	% C	
I-1 Yigo Corn Project 12/21/16	02/07/2017	0.45	8.50	C30
I-2	02/07/2017	0.37	6.81	F60
I-3	02/07/2017	0.48	13.44	C60
I-4	02/07/2017	0.28	10.93	F90
I-5	02/07/2017	0.49	13.99	C90
I-6	02/07/2017	0.26	10.63	F30
I-7	02/07/2017	0.24	10.82	CONTROL
II-1	02/07/2017	0.35	6.37	F30
II-2	02/07/2017	0.54	12.38	C90
II-3	02/07/2017	0.40	11.37	C30
II-4	02/07/2017	0.45	13.65	C60
II-5	02/07/2017	0.23	12.04	F60
II-6	02/07/2017	0.27	10.67	CONTROL
II-7	02/07/2017	0.28	10.18	F90
III-1	02/07/2017	0.42	11.44	C60
III-2	02/07/2017	0.41	9.67	C30
III-3	02/07/2017	0.47	12.12	C90
III-4	02/07/2017	0.28	11.50	CONTROL
III-5	02/07/2017	0.24	13.21	F30
III-6	02/07/2017	0.29	12.95	F60
III-7	02/07/2017	0.30	13.37	F90
IV-1	02/07/2017	0.54	11.47	C60
IV-2	02/07/2017	0.51	11.99	C90
IV-3	02/07/2017	0.23	4.32	CONTROL
IV-4	02/07/2017	0.36	9.86	C30
IV-5	02/07/2017	0.31	12.80	F90
IV-6	02/07/2017	0.37	13.33	F30
IV-7	02/07/2017	0.22	14.14	F60