Maize Production with Manure-Amended Compost

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Abstract. Information from ECHO Network member Daryl Edwards from his work in Zimbabwe suggested that using quality compost containing 10% cow manure results in a maize harvest similar to that obtained with 100% cow manure. This could be significant to farmers who have small farm sizes and limited livestock and manure resources. The proposition was tested in the field on ECHO's demonstration farm in North Fort Myers, Florida. Four compost mixes (10%, 25%, and 100% cow manure, as well as 25% *Mucuna pruriens*; remaining portions of each compost mix were made up of equal parts of woody and leafy green plant material) were applied as pre-plant fertilizers to maize planting stations established according to a conservation farming system called Foundations For Farming (FFF). The compost was made in September (2010), and the trial was carried out between May and September of 2011. Data were collected on seed germination, tasseling, number of ears per plant and yield (dried on-cob and shelled weights of the harvested corn). Maize grain yield ranged from 4.4 to 5.4 t/ha. During the same season, a non-fertilized maize plot on another section of the ECHO Global Farm yielded 2.2 t/ha. Compost treatment had no effect on yield or any other crop growth parameter measured.   Results indicate that, with compost comprised of as little as 10% cow manure or 25% *Mucuna pruriens*, farmers can obtain similar maize yields as 100% composted cow manure.

Introduction

Maize is a very important crop for farmers in many parts of the world and is the staple and preferred food crop for many subsistence farmers in the developing world. The nutrient demands of maize are very high especially for Nitrogen. Inorganic fertilizers are commonly used to provide maize crops with the required nutrients; however, mineral fertilizers are often expensive, and heavy reliance upon them (to the exclusion of organic inputs) can have adverse effects on soil biology, leading to degradation of soil and a loss in the long-term capacity of those soils to sustain food production.

An alternative to inorganic fertilizers is cow manure, which provides fertility as well as soil organic matter content. Many smallholder farmers, though, have few cattle and are therefore limited in the amount of manure they can generate for their maize crops. Compost can make that cow manure go further. It has been proposed by Daryl Edwards, an ECHO network member working in Zimbabwe, that quality compost made using 10% cow manure is equally as effective as using 100% cow manure in terms of final crop yield.

The significance of Edward's observation, if replicable, would be that a small farmer with a limited amount of cow manure could extend their manure resource without sacrificing improved yields. This is important considering the realities subsistence farmers in many parts of the developing world face---such as small farm sizes, often between 1 and 2 ha and not owning much livestock. Compost can be cheaply made, as the components (e.g. weeds and crop residues) are often already available on the farm. Aside from a source of fertility, compost also improves soil structure, water- and nutrient-holding capacity, and help build up organic matter conducive to beneficial organisms that reduce pest and disease problems. These benefits, however, are likely to be observed over a longer period of time and not in just one growing season.

Generating enough compost to spread over an entire field is impractical. Thus, we tested Edward's hypothesis by applying compost in maize planting stations (small holes dug with a hoe) established according to Foundations For Farming (FFF), a system of conservation agriculture developed by Brian Oldreive in Zimbabwe and currently being used successfully in many parts of Africa. FFF is a holistic system which aims to address spiritual issues as well as agricultural and is "an initiative aimed at bringing transformation to individuals, communities & nations through faithful and productive use of the land." More information on this system is available online (www.foundationsforfarming.org/; www.farming-gods-way.org/). By applying the compost in small planting stations, fertility is concentrated near the maize plants. In this way, smaller amounts of manure can be used while still achieving yield increases. The FFF system also incorporates mulching and minimal tillage. Although we conducted this experiment using FFF, it should be noted that the zai pit system---that originated in Burkina Faso---also features the application of organic matter in small planting basins (zai pits are typically larger than FFF planting stations).

Materials and Methods

- Seed of *Zea mays* 'sol de manha' (~2200 seeds)
- 75,000 ml 100% cow manure
- 75,000 ml sifted 25% composted cow manure
- 75,000 ml sifted 10% composted cow manure
- 75,000 ml sifted 25% composted mucuna
- BT spray
- Spray applicator
- NPK fertilizer (8%N-2%P-8%K)
- Trowel
- Soil Sample Testing Equipment
- Mower

Field History

The experimental field was located on the ECHO demonstration farm in southwest Florida (17391 Durrance Rd. Ft Myers, FL 33917), north of the forage bank. The field was previously an area of grass and had been fallowed with Rye Grass during the Fall and Winter of 2010/11. The plot had to be cleared of several larger wooden scraps before planting could occur.

Experiment design

The 40 x 42 ft (25.5 x 14.4m) field was divided into 12 plots to accommodate four treatments replicated three times. A generalized randomized block design (Figure 1) was used in which there were three blocks, one for each replication. The blocks consisted of four plots, with each one measuring 5.4 x 3 m. Treatments were randomly assigned to the plots within each block, resulting in a randomized complete block design.

Two guard rows were planted along all four edges of the experimental field plot in order to minimize

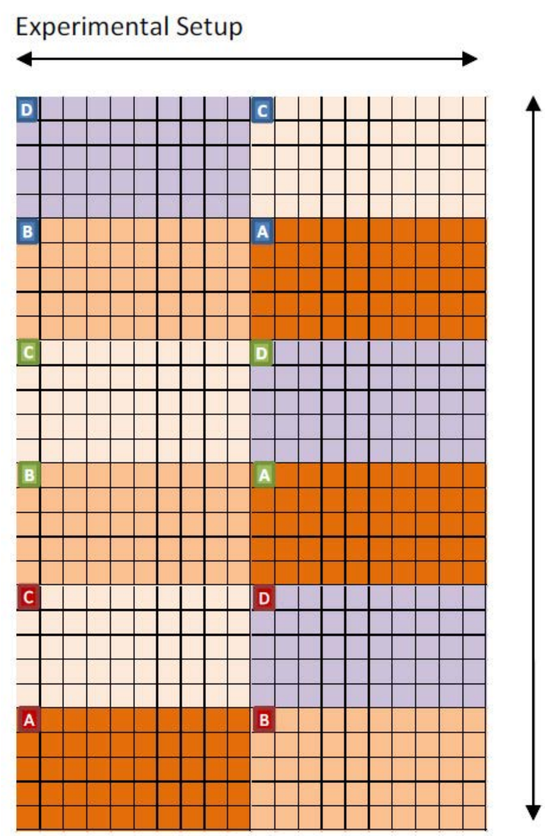

Figure 1. The experiment was set up with a total of three replications, each replication consisting of four plots. These plots are categorized by the type of compost inputted into the 100 planting stations found within each plot. The diagram to the left shows an aria view of the experimental setup. The red, green, and blue square outlines represent the placement of the three replications and colored areas within each square represent the type of composted used. The placement of each plot was the result of a random selection.

edge effect. The plots were marked out with PVC piping along the ground for easier management and more accurate recording of data.

Treatments

1. 100% cow manure
2. 25% Composted Cow Manure: Compost made from 25% cow manure, and equal parts green materials and brown woody materials
3. 10% Composted Cow Manure: Compost made from 10% cow manure, and equal parts green materials and brown woody materials.
4. 25% Composted Mucuna: Compost made from 25% mucuna, and equal parts green materials and brown woody materials

The compost was made in September 2010 by farm staff and interns near the end of the rainy season here in Florida, which is a good time for making compost as the greens have high water content. The four treatments were 100% cow manure, compost with 25% cow manure content, compost with 10% cow manure content and compost with 25% velvet bean (*Mucuna pruriens*) content. The remainder of each compost treatment comprised of an equal part of green waste content and brown woody content, all from the same source. These treatments were chosen to directly test Daryl's hypothesis and also see if there was a correlation of increasing the amount of cow manure content with the eventual maize harvest. The compost with 25% velvet bean content was added as an alternative to cow manure, as velvet bean has a high nitrogen content. Maize was used as the test crop due to its importance and because it is a very good indicator crop in terms of manifesting soil nutrient deficiencies.

Trial Establishment

The study was conducted during the rainy season of 2011 between May and September and the compost was started in September 2010. On May 12th the plot was laid out in FFF style and planting stations were dug at 75 cm between-row spacing and 60 cm in-row spacing. The stations were filled with 1/2 liter of compost. The guard rows had 1/8 cup (2 Tbsp) NPK (8%N-2%P-8%K) added. The stations were then planted with three seeds of *Zea mays* at a depth of 5 cm on May 17th. The plants were thinned to 2 plants per station on June 2nd and any losses/non germinated seeds were recorded.

Trial Management

Watering: The plot was watered twice with overhead irrigation in the week preceding planting. This was to simulate a pre-planting rain. For the duration of the trial the plot was rain-fed.

Weeding: An initial weeding of the plot was undertaken with hoes, machetes and a mower. There was high weed pressure through the trial particularly from nutsedges (*Cyperus* sp.). Weeds were removed by hand and the use of hoes every 2-3 weeks throughout the trial.

Pest and Disease Management: The maize crop was monitored for pest and disease presence. BT (*Bascillus thuringiensis*) was sprayed every 7-14 days throughout the first three months of the trial for the control of the corn borer (*Ostrinia nubialis*) and this was effective to protect against damage to the maize crop.

Harvest: The maize was determined to be dry using the Black Layer method. When the corn is mature each grain is sealed off from the cob to stop the transfer of further nutrients and water, this can be seen by a black layer at the base of each grain. The plot was harvested on September 9th 2011 and the ears per plant were counted pre harvest with any underdeveloped ears being discarded. The cobs were then shucked and placed in a solar dehydrator for one week to accelerate field drying.

Timeline:

- September 2010: Made compost piles
- 10% Cow Manure, 25% Cow Manure, 100% Cow Manure, and 25% Mucuna
- April 8, 2011: Sifted 100% Cow Manure Pile
- April 15, 2011: Sifted 10% & 25% Cow Manure Piles
- April 21, 2011: Sift 25% Mucuna

- April 28-May 5, 2011: Prepped the land using Princess, a small cow (Note: Not successful)
- May 5, 2011: Used 6 people with hoes, machetes, and sitting mower to cut down weeds. The hope is that within a week the remaining rye grass will die back enough so that creating the stations won't be difficult.
- May 10, 2011: Begin laying out the experimental setup. Used statistically random method to select placement of compost input for each of the 3 replications.
- May 12, 2011: Dig planting stations and fill with ½ liter of appropriate compost type. Continue with land preparation, finish prepping planting stations and putting in compost amounts
- May 17, 2011: Planted three maize seeds per planting station in all stations May 26, 2011: Weeded
- June 2, 2011: Thinned and weeded June 9, 2011: Weeded and sprayed BT June 16, 2011: Light weeding
- June 17, 2011: Replanted no-germ stations
- June 20, 2011: Sprayed BT
- June 22, 2011: Longest Day of the Year, crop at full canopy September 9 2011: Harvested, shucked, and put into solar dehydrator September 16 2011: Weighed dried corn on the cob
- September 16-18 2011: Shelled maize and weighed corn without cob

Data collection

Different data were collected throughout the trial. An initial recording of plant mortality was recorded on June 17th. At two different times, the number of plants with tassels was recorded. The number of ears of corn per plant was recorded on September 9th the morning before the corn was harvested. The corn cobs were then dried in a solar dehydrator for 1 week and then weighed on September 16th. The dried cobs were then shelled over the next three mornings using a corn sheller and the shelled weight was recorded. Weather data from a data logging weather station at ECHO are shown in Figure 2 and Table 1.

Results and Discussion

By June 17, one month after seeding, at least 78% of the seeds had germinated (Table 2). Seed germination percentage and final plant population (data not shown) were quite uniform and not influenced by compost treatment. As of July 24, nearly 10 weeks after seeding, over 68% of the plants had tassled. Tassling was not affected by compost treatment.

Extrapolated grain yields ranged from 4.4 to 5.4 t/ha (Table 2). This shows what is possible with ½ L of compost per planting station. Although 4.4-5.4 t/ha is well under the maximum maize yield potential (over 10 t/ha are not uncommon), it is a significant improvement over the 2 t/ha yields that are common in many parts of Africa.   During the same season, a non-fertilized maize (same

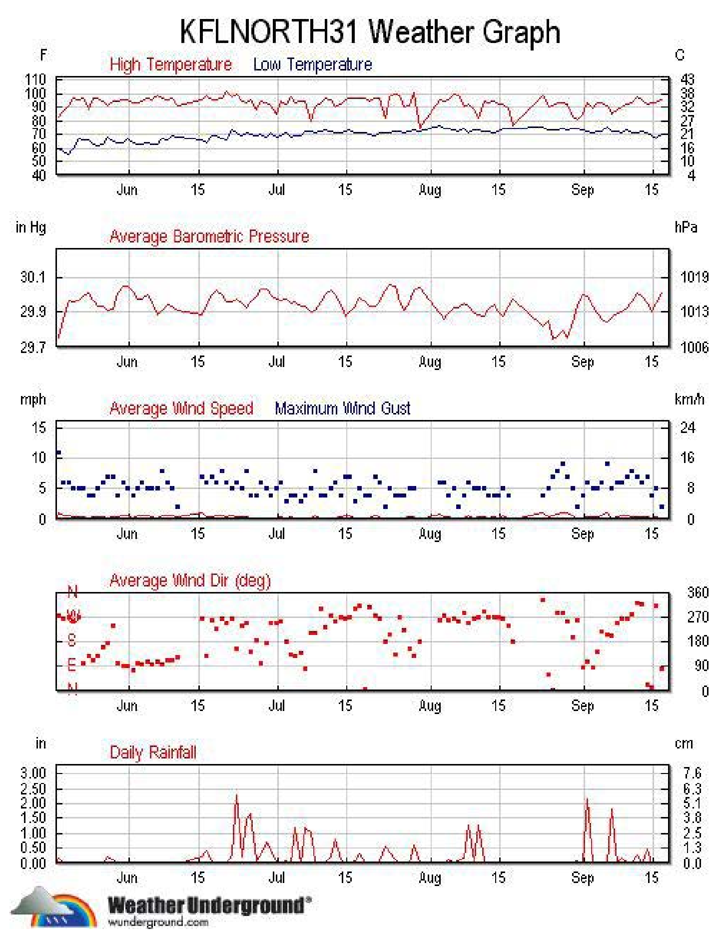

Figure 2. Weather data over the duration of the trial.

Table 1. Rainfall from seeding (17 May 2011) to harvest (16 Sept 2011) of maize.

	Rainfall		
Time period	Inches	Centimeters	Millimeters
May 17-31	0.53	1	135
June	8.15	21	2070
July	6.83	17	1735
August	3.08	8	782
September 1-16	4.94	13	1255
Total	**23.53**	**60**	**5977**

variety as in the experiment) plot on another section of the ECHO Global Farm yielded 2.2 t/ha; this plot was not replicated, but it does give an indication of the benefit of manure/compost in comparison with no fertilizer. Higher yields would likely have occurred with more compost or with NPK fertilizer; however, the cost of higher inputs would also need to be considered. Generally, ½ L per planting station is considered realistic for a smallholder farmer.

The rains were still heavy and frequent around the time of harvest (Figure 2), so yields might have actually been higher if the crop had been planted a bit later. The main objective in timing the planting of maize is to maximize the benefit from the sun. The websites on FFF contain more information on planting time.

The variables shown in Table 1, as well as other variables measured (data not shown for other variables), were not affected by treatment. Our results, therefore, are consistent with the observation by Daryl Edwards that it is not necessary for compost---applied to planting stations in the FFF system---to be comprised entirely of cow manure. Our results indicate that, in comparison to yield with 100% composted cow manure, similar maize yields can be obtained with 10% to 25% cow manure or 25% mucuna in plant-based compost piles.

We recognize that these data are from only one growing season. Future trials, at ECHO or by interested members of our international network, would benefit from:

(1) conducting the experiment over at least two growing seasons to allow for the buildup of soil organic matter and microbial life in the planting stations;

(2) if conducted over multiple seasons, leaving the maize stalks on the field as mulch; and (3) including a non-treated control plot in each of the three replication blocks.

Table 2. Effect of compost treatment on maize plant population, tassling and production of harvestable ears and grain (kernels shelled from cobs).

Compost Treatment[1]	Seed germination on June 17 (%)	Plants with tassles on July 24 (%)	Ears harvested (no/plot)	Grain yield
Cow-10%	80	68	63	4.53
Cow-25%	82	79	65	4.43
Cow-100%	81	88	66	4.92
Mucuna-25%	78	83	71	5.39
P value[2]	0.800	0.147	0.836	0.369

[1]Compost treatments shown in this column depict the percentage of the compost that was cow manure or mucuna. For each treatment, the remainder of the compost was made up of equal parts of browns (woody plant material) and greens (fresh, leafy plant material).
[2]Within a column, the effect of treatment on the corresponding measured variable is significant if P ≤ 0.05. The fact that all the P values exceeded 0.05 indicates that means did not differ with compost treatment.

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