ADAN J. Agric. 2021, 2 (1): 82-89 **DOI:10.36108/adanja/1202.20.0180**

ISSN 2736-0385

Reclaiming Eroded Soil Using Sawdust – Poultry Compost for Agricultural production

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Abstract
The removal of top soil with high organic matter content is a critical threat to soil functions in most tropical agricultural lands and compost can be utilized in build up of organic carbon stocks and the soil nutrient. A two - year experiment was conducted to evaluate the effect of different rates of compost application on soil properties, yield and nutrient uptake of maize in an eroded soil. The treatments: control, 5, 10, 15 and 20 tonnes per hectares (t ha^{-1}) were laid out in Completely Randomized Design (CRD) and replicated thrice and data collected were statistically analysed. The soil was acidic and sandy in texture, the application of compost reduced the acidity and significantly ($p \leq 0.05$) increased organic matter and nutrient content of the soil. Maize grain yield of 3.08 and 2.56 t ha^{-1}were obtained in 2015 and in residual experiment of 2016 respectively with the application of 20 t ha^{-1} of compost. In conclusion, the application of 20 t ha^{-1} of sawdust – poultry compost significantly ($p \leq$ 0.05) improved the organic matter and nutrients status of the soil. Also, the yield and nutrient uptake of maize were significantly ($p \leq 0.05$) higher with the application of 20 t ha^{-1} of compost.

Keywords: *compost, growth, maize, remediation, soil nutrient, yield*

Introduction

Land degradation is any kind of alteration in the overall condition of soil that decreases its actual production capability which occurs slowly and cumulatively and has long lasting impact on rural people who become increasingly vulnerable. The impact of land degradation due to erosion reduces crop and pasture productivity, fuel wood and non-timber forest product which are closely linked to poverty and food security. According to Ogban and Edoho (2011), eroded soil are devoid of organic matter with very low nutrient content which render the soil unsuitable for agriculture. Due to this negative impact, it is therefore necessary to sort ways to reduce its effect. The use of compost to ameliorate degraded soil enhances the structure, microbial activities mostly fungal hyphae which help to bind soil aggregate together. The compost creates less environmental pollution than inorganic fertilizer due to their positive biological effect and modification of physical and chemical characteristics of soil (Farrell and Jones, 2009).

In many countries, a large proportion of municipal waste are not disposed properly thereby posing an environmental threat due to the presence of pathogens and toxic pollutants (Darby *et al.*, 2006; De Araujo *et al.*, 2009). Composting will help to manage the rate of waste disposal and environmental pollution. Efficient and optimal use of compost relies on a better understanding of the relationship between compost properties and their effects on soils. It is obvious that compost have a range of benefits on soils and cropping systems and in order to increase soil fertility, nutrients have to be added to the soil and this is often done by the application of chemical fertilizers.

Mineral fertilizers also do not improve the organic matter content of the soil; hence the use of compost in ameliorating degraded soil is inevitable. Its applications in sandy soils can facilitate moisture dispersion and more efficient water utilization. The incorporation of compost has the ability to buffer or stabilize soil pH of the final mix, depending on the pH of the compost and of the native soil. Compost will also improve the cation exchange capacity of soils, enabling them to retain nutrients longer and allow crops to efficiently utilize nutrients, while reducing nutrient loss by leaching.

Maize is an essential crop in the tropic and according to Majidian *et al.* (2005), the use of compost significantly ($p \leq 0.05$) increases its growth and yield in degraded soil due to its effect on the structure, bulk density and organic matter content of the soil. This study focused on improving eroded soil using compost. The study area Ekpoma and its environs are greatly affected by high rate of erosion. The objectives of the experiment are therefore to reclaim eroded soil, enhance the yield of maize and reduce the large proportion of municipal waste generated through compost.

Materials and Methods

Experimental Site

A two - year experiment (2015 and 2016) was carried out at Teaching and Research Farm, Emaudo Annex, Ambrose Alli University, Ekpoma, Edo State. The site lies between Latitude North 6 degrees, 45 minutes, 34 seconds (6° 45' 34") and longitude East 6 degrees, 8 minutes 27 seconds (6° 8' 27" East),with an average annual rainfall of about 1500mm (Ighalo and Remison, 2010).

Procedure

The compost was prepared using sawdust and poultry manure; these wastes were collected from different locations; poultry manure was collected from poultry unit of the Teaching and Research Farm Ambrose Alli University, Ekpoma, eroded soil was collected at Emaudo erosion site, the wood sheaves and sawdust was collected from God's will sawmill at Emaudo. Composting of the organic waste was for a period of twelve weeks. Fifteen kilogram of sieved eroded soil was weighed into thirty kilogram pots and mixed with compost at the rate of 0, 5, 10, 15 and 20 tonnes per hectares transmitted into 0, 3.75kg, 7.5kg, 11.25kg and 15kg. The sieved soils were thoroughly mixed with the above kilograms of compost except the control, 10 litres of water was added weekly and the soil mixed with compost was allowed to equilibrate for t

Experimental Design and management

The experimental design was Completely Randomized Design (CRD) with five treatments replicated three times and the treatments were: control, 5, 10, 15, and 20 tonnes of compost per hectare. The soil mixed with compost was allowed to equilibrate for two weeks before planting; 3 maize seeds were planted and later thin to one plant per stand / pot, two weeks after germination. Hand weeding was carried out regularly by uprooting the weeds. After harvesting, the grain weight was taken.

Collection of Data

Plant height, girth and leaf area were measured at 3rd and 7th week after planting (WAP). The grain, dry matter weight and nutrient uptake were measured after harvest. The nutrient uptake was determined by multiplying nutrient concentration by the dry matter weight.

Leaf Area = L X W X 0.75 (Remison and Lucas, 1982).

Nutrient uptake = Dry Matter yield (Kg) x Nutrient content (%)

Data collected on growth, yield and yield components were analysed statistically using Analysis of Variance (ANOVA) and the means were separated using the Least Significant Difference (LSD).

Soil Analysis

Top soils (0-15 cm) were collected from the site prior to each planting, the soils were air dried, sieved and the samples were analysed for both chemical and physical properties. Particle size analysis was carried out using hydrometer method (Bouyoucous, 1962). The pH was determined in water (ratio1:1, soil: water). Organic carbon was determined by wet dichoromate method (Nelson and Sommer, 1975) and Available phosphorus by Bray extraction method (Anderson and Ingram, 1993). Total nitrogen was determined by Kjeldahl method (Bremner and Mulvaney 1982). Exchangeable cations (potassium, calcium and magnesium) were extracted with ammonium acetate, potassium was determined by flame photometer while calcium and magnesium by atomic absorption spectrophotometer (IITA, 1979).

Statistical Analysis: Data collected from the laboratory and field experiments were analyzed using analysis of variance (ANOVA) (SAS, 1995). Least significance difference (LSD) was used to separate the means.

Results and Discussion

Soil physico-chemical properties

The physical and chemical properties of the soil were determined for the two years as presented in Table 1. The initial pH of the soil ranged from 4.80 in control to 7.78 in soil amended with 20 tonnes per hectares of compost while in second year the pH ranged from 4.78 in control to 7.80 in soil amended with 20 tonnes per hectares of compost. The pH is elevated with increased volume of compost. The varying increase in pH at different levels of compost application was attributed to compost's ability to reduce acidity and 20 tonnes per hectare had the highest pH level compared to other treatments (Butler *et al.,* 2008; Johnson *et al.*, 2006). The increase in pH revealed that compost can be used as liming material to reduce acidity in soil.

The organic carbon (OC) content for the first year ranged from 0.25g/kg in control to 39.9g/kg in 20 tonnes per hectare of compost and there was increase in organic carbon content due to the application of compost. This result was in agreement with the earlier work done by Odedina *et al.* (2003), they reported that organic fertilizer increased soil organic carbon of a degraded soil. Organic matter plays a crucial role in sustaining soil quality and crop production as it significantly improved the soil physical, chemical and biological properties (Bauer and Black, 1994). The organic carbon content increased from 0.19g/kg in control to 29.9g/kg and 32.6g/kg in 15 tonnes and 20 tonnes of compost application respectively in the second year. According to Zebarth *et al.* (2011), they reported increased soil organic matter content with the incorporation of compost and these can also help to limit the effect of erosion.

The available phosphorus and potassium in soil amended with 20 tonnes of compost was significantly ($p \leq 0.05$) higher with value 71.7mg/kg and 1.7 cmol/kg respectively compared to other treatments. Calcium and magnesium content was lower in control below threshold limit or critical levels. The low natural fertility of the soil indicated the need for external supply of nutrient to the soil to increase crop production. Compost applications increased soil K, Ca, and Mg due to a direct contribution of these nutrients from the compost itself, and the increase of CEC. The soil analysis carried out during the residual experiment showed the decline in organic matter, total N, exchangeable cation and available P in control and these could due nutrient uptake by maize. Akanbi and Togun (2002) reported that most African soils are impoverished and the application of compost increased the mineral content of the soil. Also, Soumare *et al.* (2003) affirmed that the application of compost increased the soil nutrient concentration. The ECEC increased from 3.04 Cmol/kg in control to 10.51Cmol/kg and 10.32Cmol/kg in 15 tonnes and 20 tonnes respectively due to the addition of compost to the soil. As earlier reported by Pedra *et al.* (2008), compost have a high cation exchange capacity and can therefore increase soil ECEC when incorporated. Addition of compost to sand or eroded soil had the potential of increasing the soil organic matter which act as a cementing agent, improved the nutrient content, water holding capacity and therefore can sustain crop production. According to Athur *et al.* (2013), they reported that all compost types significantly increased soil total carbon, total nitrogen, pH, electrical conductivity and significantly decreased bulk density compared to the control. Also, Monica *et al.*(2011) reported that amendment of soil with compost significantly ($p \leq 0.05$) increased the content of most nutrients including P, K, Ca, Mg, Mn, and Zn as well as organic matter (OM) and cation exchange capacity (CEC) compared to the control.

Table 1: Effects compost on the chemical and physical properties of the soil in 2015 and 2016 (2 years).

Treatment	pH 1:1 H_2O	OC g/kg	N g/kg	P (mg/kg)	Ca	Mg (Cmol/kg)	K	Na	Acidity	ECEC (Cmol/kg)	Mn	Cu (mg/kg)	Fe	Zn	Clay g/kg	Silt g/kg	Sand g/kg
FIRST YEAR																	
Control	4.80e	0.25c	0.30d	9.88e	2.25d	0.53d	0.51b	0.39e	0.40a	3.68c	12.25e	1.01c	698.73	13.12c	27	14	959
5 t ha^{1}	6.73d	31.10b	3.20c	18.75d	2.72d	1.28c	1.54b	0.66c	0.20b	6.20b	37.31d	0.90c	683.22	26.12b	27	14	959
10 t ha^{1}	7.00c	34.70a	3.60b	39.48c	6.91c	2.23b	1.52b	1.24a	0.20b	10.90ab	40.12c	2.23a	667.53	36.14a	27	14	959
15 t ha^{1}	7.57b	39.80a	4.10a	58.78b	8.48b	2.34b	1.67a	0.73b	0.21b	13.30a	49.76b	1.71b	646.54	34.15a	27	14	959
20 t ha^{1}	7.78a	39.90a	4.20a	71.75a	9.98a	4.10a	1.75a	0.58d	0.23b	16.31a	54.12a	1.12b	647.68	36.14a	27	14	959
LSD	0.08	0.87	0.86	6.56	1.02	0.06	0.10	0.04	0.05	3.30	0.14	0.38	NS	4.00			
SECOND YEAR																	
Control	4.78e	0.19e	0.13e	8.15e	2.16e	0.32c	0.09e	0.27c	0.20a	3.04e	13.22e	1.11d	697.72a	14.13d	27	15	958
5 t ha^{1}	6.80d	23.50d	1.40d	16.63d	2.64d	1.06b	0.11d	0.38b	0.10b	6.42d	39.31d	2.00b	664.22e	19.22c	27	17	956
10 t ha^{1}	7.10c	26.40c	2.14c	32.32c	5.04c	2.00ab	0.34c	0.35b	0.10b	7.95c	40.23c	0.98e	658.24d	20.55c	27	17	956
15 t ha^{1}	7.60b	29.90a	2.61b	44.34b	7.68b	2.44a	0.46b	0.56a	0.10b	10.51a	41.13b	1.85c	610.59c	27.66b	27	17	956
20 t ha^{1}	7.80a	32.60b	2.79a	53.06a	8.08a	2.76a	0.73a	0.57a	0.10b	10.32b	49.98a	2.04a	630.83b	32.87a	27	17	956
LSD	0.04	0.88	0.80	4.17	0.03	0.60	0.01	0.04	0.04	1.32	0.55	0.04	NS	3.04			

Textural class – Sand

Growth parameters

At 3 and 7 weeks after planting, compost had significant effect on the height of maize with the highest values recorded from the application of 20 tonnes of compost (Table 2). During the second year, the height of maize at 3 and 7 WAP were significantly ($P \leq 0.05$) improved with the application of 20 tonnes per hectare of compost.

The effect of different levels of compost on stem girth from 3 to 7 weeks after planting (WAP) is presented in Table 2. At 3 and 7 WAP, compost had significant effect on the stem girth of maize with the highest stem girth recorded from the application of 20 tonnes per hectare of compost. In the second year, the stem girth of maize from 3 to 7 WAP, were significantly ($P \leq 0.05$) higher with the compost (Table 3). The application of 20 tonnes of compost significantly ($P \leq 0.05$) increased stem girth throughout the growth season compared to other treatments.

The leaf area of maize at 3 and 7 WAP were significantly ($P \leq 0.05$) enhanced with compost and the highest leaf area value was recorded from the application of 20 tonnes of compost. In the second year, leaf area of maize at 3 and 7 WAP, were significantly ($P \leq 0.05$) increased with application of 20 tonnes of compost (Table 2 and 3).

The improvement in growth of maize observed with the application of compost compared to the control was attributed to the improvement of the soil physical and chemical properties. This was further supported by Singh *et al*. (2011), who reported that soil organic carbon content increased by compost application will in turn improved its aggregate stability, infiltration rates and decreased bulk density. Similarly, Annbi *et al*. (2007) reported that compost can help in the formation of a larger number of water stable aggregate through links between smaller particles strong enough to withstand the dispersing action of water. The increase in plant growth were earlier confirmed by Oworu *et al*. (2010) and Ogbonna *et al*. (2012), they reported that the application of organic fertilizer increased the growth of crops.

Yield and Nutrient Uptake

The grain, dry matter yield and nutrient uptake of maize were significantly ($P \leq 0.05$) increased with the application of compost compared to the control (Table 4). However, the application of 20 t $ha^{-1}$of compost had higher grain, dry matter yield and nutrient uptake compared to other treatments. This was in agreement with report of Dania and Fagbola (2013), application of pigeon pea leaves and mycorrhiza compost significantly ($P \leq 0.05$) increased the yield of maize in degraded soil. The dry matter yield of maize were significantly ($P \leq 0.05$) higher with application of 20 t ha^{-1}. According to Kawasaki *et al*. (2008), that humic substances which are the major component of soil organic matter in compost will increased shoot biomass via hormonal effects on root elongation and plant development.

Nitrogen uptake of maize was significantly ($P \leq 0.05$) increased with the application of 20 t ha^{-1} of compost compared to other treatments. Also, there was an increase in potassium and phosphorous uptake with the different treatments than the control, though not significantly. Boateny *et al.* (2006) reported that compost significantly ($P \leq 0.05$) increased the nutrient uptake of maize. Compost application can increase soil nutrient availability and the nutrient uptake by the plant, as earlier reported by Walker and Bernal (2008).

Table 2: Effects of different rates of compost on the growth of maize in an amended eroded sandy soil at the third and seventh weeks after planting (2015).

Treatments	Height (cm)		Stem girth (mm)		Leaf Area (cm^2)	
	3	7	3	7	3	7
Control	17.03b	55.47b	3.41	8.73b	75.34	116.40c
5 tha^{-1}	24.07a	100.70a	3.65	12.13a	79.07	415.80ab
10 tha^{-1}	24.10a	103.20a	3.82	12.53a	83.08	478.40a
15 tha^{-1}	25.09a	114.67a	4.02	13.66a	87.66	492.90a
20 tha^{-1}	26.67a	117.77a	4.22	16.24a	90.64	520.00a
LSD	2.89	43.01	NS	5.05	NS	60.55

The mean values with the same letter in the vertical column are not significantly ($P \leq 0.05$) different using LSD

Table 3: Effects of different rates of compost on the growth of maize in an amended eroded sandy soil at the third and seventh weeks after planting (2016)

Treatments	Height (cm) 3	7	Stem girth (mm) 3	7	Leaf Area (cm^2) 3	7
Control	14.07	50.10c	2.34	6.78c	38.25c	83.86c
5 t ha^{-1}	15.05	80.30b	2.35	11.48ab	49.65b	354.38b
10 t ha^{-1}	15.66	99.67ab	2.33	12.93a	51.84b	386.76b
15 t ha^{-1}	16.01	103.67a	2.95	12.96a	68.44a	411.75b
20 t ha^{-1}	16.51a	111.30a	2.96	14.83a	75.88a	588.59a
LSD	NS	15.60	NS	3.40	9.80	60.40

The mean values with the same letter in the vertical column are not significantly ($P \leq 0.05$) different using LSD

Table 4: Effects of compost on the yield components of maize (t/ha^{-1}) in an eroded soil in two seasons (2015 and 2016)

Treatments	First year (2015)					Second Year (2016) (Residual)				
	Yields	wt. of biomass	nutrient Uptake N	P	K	Yields	wt. of biomass	nutrient uptake N	P	K
Control	0.00d	0.80c	0.26c	0.10b	0.06d	0.00e	0.41c	0.20d	0.12d	0.08e
5 t ha^{-1}	1.02c	1.64b	1.09b	0.47b	0.31d	0.41d	0.86c	1.21d	0.31c	0.16d
10 t ha^{-1}	1.67c	2.89b	2.85b	1.04a	0.56c	1.04c	1.98b	1.46c	0.53ab	0.28c
15t ha^{-1}	2.34b	4.56a	3.98a	1.46a	0.77b	1.74b	2.60b	2.36b	0.66b	0.48b
20 t ha^{-1}	3.43a	5.43a	4.78a	1.98a	1.03a	2.08a	3.54a	3.41a	1.27a	0.98a
LSD	0.66	1.34	1.21	0.45	0.21	0.23	1.01	0.15	0.13	0.14

The mean values with the same letter in the vertical column are not significantly ($P \leq 0.05$) different using LSD

Conclusion and Recommendation

Compost application improves the quality and nutrient status of degraded soil. Eroded soil can be productive with adequate application of compost, as it improves the soil biological, chemical and physical properties. The growth and yield of maize was significantly ($p \leq 0.05$) improved with application 20 t ha^{-1} of compost compared to other treatments. The application of 20 t ha^{-1} of compost is recommended for the improvement of the nutrient status, growth and yield of maize in an eroded soil.

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