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Evaluation of Organic Manure on Growth and Yield of *Sorghum* (*Sorghum Bicolor*) in Makurdi, Nigeria

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ABSTRACT

Current a field trial was conducted at the University Commercial Crops Farm, University of Agriculture, Makurdi, Nigeria in 2014 and 2015 cropping seasons to evaluate yield response of *sorghum* to two manure sources. The study consisted of four levels of poultry manure (0, 2.0, 3.5 and 5.0) t/ha, and organic NPK® (0, 0.2, 0.4 and 0.6) t/ha and control. The treatments were laid out in a 4 × 4 factorial in Randomized Complete Block Design (RCBD) and replicated three times. The soil samples were collected processed and analyzed for soil nutrients before and after planting. The result of crop data collected indicated a significant increase in crop yield with manure application over control. The highest grain yield was obtained from organic NPK® at 0.6 t/ha. Soil pH, OM, N, P and CEC of the soil were improved by manure application indicating a positive effect of its continuous use as a soil amendment.
Current a field trial was conducted at the University Commercial Crops Farm, University of Agriculture, Makurdi, Nigeria in 2014 and 2015 cropping seasons to evaluate yield response of *sorghum* to two manure sources. The study consisted of four levels of poultry manure (0, 2.0, 3.5 and 5.0) t/ha, and organic NPK® (0, 0.2, 0.4 and 0.6) t/ha and control. The treatments were laid out in a 4 × 4 factorial in Randomized Complete Block Design (RCBD) and replicated three times. The soil samples were collected processed and analyzed for soil nutrients before and after planting. The result of crop data collected indicated a significant increase in crop yield with manure application over control. The highest grain yield was obtained from organic NPK® at 0.6 t/ha. Soil pH, OM, N, P and CEC of the soil were improved by manure application indicating a positive effect of its continuous use as a soil amendment.

Keywords: Organic NPK®; Soil nutrients; *Sorghumx*

Introduction

The introduction of high yielding crop varieties which demand high nutrient inputs led to adoption of mineral fertilizer as a reliable means of supplying crop nutrient elements. However due to the negative effects of this farm input on the soil environment, its continuous use on many farm land is becoming unfashionable. According to [1] mineral fertilizers have considerable negative consequence on both soils and the crop [2]. Reported that long term use of mineral fertilizer reduces organic matter, cause soil acidification leading to undesirable consequences on microbial and nutrients dynamics. The replenishment of soil nutrient losses to guarantee sustainable crop cultivation is a major challenge of Agriculture in many countries of the Sub-Saharan Africa; this is due to inherent poor nature of most soils and other environmental related constraints [3]. Therefore, solving the threat to declining food security is beyond the use of high yielding crop varieties. It is imperative to develop a strategy capable of protecting the soil against nutrients losses arising from continuous cropping and other forces of soil degradation. The use of organic materials in agricultural systems has continued to gain acceptance in meeting modern day soil fertility challenges. According to [4] the practice relies on compost, animal and green manure which are rich plant nutrients resource. The advantages derived from organic manure include; increase capacity of the soil to buffer changes in pH of the soil, increase the cation retention capacity (CRC), reduce phosphate fixation and serves as a reservoir of secondary and micro nutrients [5]. Other reasons in which the use of organic manure is been advocated include; food safety and sustainable use of soil as it can build up SOM, guarantees soil conservation [6]. Organic manure in the form of poultry manure and cow dung has been found to significantly increase CEC, SOM, N and P as well as ameliorates the acidifying effects of N-fertilizers [7,8]. According to [9] more than 95% of the N and S and up to 75% of surface soils are in organic form. Indeed, research findings have demonstrated the use of manure as a strategy to ameliorate soil degradation arising from continuous use of mineral fertilizer and poor cultivation practices. Although not many farmers have accepted manure as a convenient source of farm input particularly in Makurdi that is well known for the cultivation of *sorghum* where soil fertility status range from low to medium. The objectives of this study therefore, are to evaluate the effects of manure on soil properties and ascertain the rate of manure required for optimum production of *sorghum* in Makurdi, Nigeria.

Materials and Methods

Field trials were conducted at Commercial Crop Farms of the University of Agriculture, Makurdi, in 2014 and 2015 under rain-fed condition. The area falls within latitude 7° 411 N and longitude 8° 371 E, at an elevation of about 97 m above sea level in the Southern Guinea Savanna Agro-Ecological Zone of Nigeria. The area has two distinct seasons; wet and dry; the wet season starts from April and ends in October with mean annual rainfall of 1250 mm and mean temperature of 32°C. The soil at the site of the experiment classified as Alfisols. The experimental site was used for maize cultivation in the previous cropping season.

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Treatments and experimental design

The treatments were:

- Control
- Compost at 0.2 t/ha
- Compost at 0.4 t/ha
- Compost at 0.6 t/ha
- Poultry manure at 2.0 t/ha
- Poultry manure at 3.5 t/ha
- Poultry manure at 5.0 t/ha

The treatments were laid out in a 4 × 4 factorial in Randomized Complete Block Design (RCBD) and replicated three times. The manure was ploughed into the soil at land preparation before *sorghum* (local variety) was planted. Five seeds per hole were planted at 0.75 m × 0.5 m spacing and were later thinned to two stands per whole two weeks after planting.

Before planting, surface (0-15 cm) soil samples were collected at eight different points with the aid of a soil auger using random sampling method. The samples were bulked for analysis. The soil samples were air dried, ground and pass through 2 mm sieve and taken for routine soil analysis in the laboratory as follows; Soil pH was determined in a 1:1 soil-water suspension by the glass electrode method, particle size analysis by the hydrometer method of [10] in which sodium hexametaphosphate (calgon solution) was used as dispersing agent. Total organic carbon was by chromic acid oxidation procedure of [11] total nitrogen was determined using the procedure described by [12] the Molybdenum-blue method as described by [13] was used to determine available phosphorus. Exchangeable bases were determined by the neutral ammonium acetate saturation. Na and K in the extracts were determined by the flame photometer while Ca and Mg were determined using Atomic Absorption Spectrophotometer (AAS), exchange acidity by the 1 M KC1 extraction and 0.01 M NaOH titration. Effective cation exchange capacity was determined by summation of exchangeable bases and acidity.

The following crop data were collected; Leaf area, plant height, panicle length and grain yield. Leaf area (cm2) and plant height (cm) were collected at 3 weeks intervals. The panicle length (cm) and grain yield (kg/ha) were determined at harvest. Crop data collected were subjected to analysis of variance (ANOVA) and the means that were statistically different were separated using Fisher's least significant difference (F-LSD) at 5% level of probability [14].

Results and Discussion

Soil properties

The soil properties at the experimental site before planting indicated that the percentage of sand particles in the soil was dominant. This may be attributed to the fact that the soils were derived from sedimentary rocks which usually give rise to soils with high sand particle content [15]. The soil was described as sandy loam [16]. The soil was slightly acidic (6.66) based on soil acidity rating by Brady and Weil (2002). The soil pH falls within optimum range required for the production of *sorghum* [17] and optimum for the release of macro-nutrients required for plant growth [18]. The soil organic matter (SOM) was 1.80% (Table 1).

Soil parameters 0-15 cm	2015
Sand (%)	78.36
Silt (%)	10.04
Clay (%)	11.6
Textural class	Sandy loam
pH(H2O)	6.66
pH(KCl)	5.67
Organic matter (%)	1.8
Total nitrogen (%)	0.23
Phosphorus (mg/kg)	1.64
K (cmol kg-1)	0.23
Ca (cmol/kg-1)	4.76
Mg (cmol kg-1)	2.51
Na (cmol kg-1)	0.18
EA	1.01
ECEC (cmol kg-1)	8.69

Table 1: Soil properties of the experimental site before planting.

It was considered very low [19]. Low organic matter in the soil can also be due to rapid decomposition and mineralization of OM [20]. Attributed decline in SOM content to continuous cropping, burning of crop residue and natural vegetation by farmers among other poor soil management practices.

The total Nitrogen (N) which is the most limiting soil nutrients in the soil was 0.24 and was rated very low. The supply of Nitrogen (N) is partly a function of organic matter content of the soil [9] and often shows positive correlation with SOM. It's thus safe to consider the low content of OM in the soil as being responsible for the low concentration of total N in the soil of the study area. Phosphorus status of the soil (1.64 mg/kg) was considered low [19].

Similarly, the exchangeable cations (K, Ca, Mg and Na) and cation exchange capacity of the soil were low which revealed that the soil fertility status was generally low. The results of soil analysis as presented in Table 1 indicated that the soil was typical and require amendments in order to improve its fertility status. This soil was considered marginally suitable for cultivation of *sorghum* which can be grown on soils of low fertility status [21].

Sole application of compost NPK® and poultry manure led to increase in soil pH as presented. This increase in soil pH due to application of compost and poultry manure has been reported by several studies [22]. This might be attributed to release of base cations by compost and poultry manure which act as acid neutralizing agents and subsequently increases the soil pH level. This observation agrees that compost and manure in maize/legume inter crop in Pennsylvania raise the soil pH and also prevented leaching of nitrate ions. Soil organic matter was found to increase with levels of compost and poultry manure. This was possible because of the high organic matter composition in compost and poultry manure as revealed in the chemical analysis (Table 2).

Parameters	Poultry manure	Compost
Organic matter (%)	26.41	48.65

Total nitrogen (%)	2.25	8.2
Phosphorus (mg/kg)	12.1	6.12
K (cmol kg-1)	1.15	3.8
Ca (cmol kg-1)	10.81	13.28
Mg (cmol/kg-1)	0.53	8.13

Table 2: Chemical composition of poultry and organic NPK® (compost) used for the experiment. Table 2: Chemical composition of poultry and organic NPK® (compost) used for the experiment.

This attest to the fact that soil with low organic matter can be amended with addition of compost or poultry manure as have been reported by several Authors [23-25]. As can be deduced from (Tables 3-7), compost application gave the highest total nitrogen in soil when compared to poultry manure. This is an indication that organic NPK® could be an alternate source of plant nutrients. The significant increase in total nitrogen in response to compost application is consistent that compost increases the level of organic matter and subsequently supplies nutrients that are readily available to the plants. Available phosphorus was increased with compost and poultry manure treatments. This improvement in available phosphorus can be attributed to addition of compost and poultry manure. The addition of soil organic matter probably enhances microbial activities in the soil which might have decomposed the organic matter and consequently released available P amongst other nutrients.

Treatment	pH	OM	N	P	K	Ca	Mg	Na	EA	ECEC
		(%)	(%)	(mg/kg)	(cmol/kg)					
Control	6.28	1.1	0.16	0.8	0.21	2.46	2.43	0.13	1.06	6.29
0.2 t/ha CP	6.64	3.05	0.23	2.67	0.45	2.6	3.09	0.22	1	7.36
0.4 t/ha CP	6.65	3.89	0.23	3	0.6	2.69	3.33	0.28	1.03	7.93
0.6 t/ha CP	6.82	5.17	0.26	3.28	0.68	2.83	3.52	0.3	1.02	8.35
2.0 t/ha PM	6.67	2.88	0.22	2.99	0.25	2.69	2.46	0.2	0.83	6.43
2.0 t/ha PM+0.2 t/ha CP	6.86	3.4	0.24	3.03	1.05	2.8	3.2	0.28	1	8.33
2.0 t/ha PM+0.4 t/ha CP	7	4.3	0.25	3.09	1.69	2.85	3.65	0.33	1	9.52
2.0 t/ha PM+0.6 t/ha CP	7.02	4.85	0.3	3.45	1.8	2.88	3.8	0.34	1.01	9.83
3.5 t/ha PM	6.65	3.14	0.25	3	0.3	2.65	3	0.31	0.22	6.48
3.5 t/ha PM+0.2 t/ha CP	6.65	3.48	0.31	3.97	1.2	2.7	3.03	0.33	1	8.26
3.5 t/ha PM+0.4 t/ha CP	6.75	4.37	0.34	4.05	1.54	2.93	3.82	0.4	0.98	9.67
3.5 t/ha PM+0.6 t/ha CP	7.22	5.73	0.38	4.88	1.61	3	3.87	0.47	1	9.45
5.0 t/ha PM	6.68	3.34	0.34	3.4	0.66	2.9	3.4	0.35	0.27	7.58
5.0 t/ha PM+0.2 t/ha CP	6.91	5.7	0.4	3.6	1.29	2.99	3.7	0.49	0.99	9.41
5.0 t/ha PM+0.4 t/ha CP	7.04	6	0.51	5	1.45	3.05	3.91	0.55	1.1	10.06
5.0 t/ha PM+0.6 t/ha CP	7.3	6.39	0.57	5.5	1.96	3.3	4	0.6	1.12	10.98

Table 3: Effect of Organic NPK® (compost) and Poultry Manure on Soil Properties (2014).

Treatments	pH	OM	OC	N	P	K	Ca	Mg	Na	EA	ECEC
		(%)	(%)	(%)	(mg/kg)			(cmol/kg)			
Control	6.5	1.26	0.8	0.15	0.85	0.13	1.91	0.78	0.17	1.1	4.09
0.2 t/ha CP	6.67	3.73	1.81	0.23	2.05	0.24	2.2	1.6	0.2	1	5.24
0.4 t/ha CP	6.8	4	2.5	0.26	2.99	0.31	2.63	1.99	0.22	1.02	6.17
0.6 t/ha CP	6.9	4.85	2.8	0.33	3.21	0.43	3.15	2.01	0.34	0.99	6.92
2.0 t/ha PM	6.6	3	1.7	0.3	2.18	0.17	2.31	1.65	0.24	1	5.37
2.0t/ha PM+0.2 t/ha CP	6.68	4.05	2.53	0.39	3	0.28	2.76	2	0.36	0.5	5.9
2.0t/ha PM+0.4 t/ha CP	6.88	4.99	2.86	0.41	3.66	0.35	3.15	2.17	0.5	0.93	7.1
2.0t/ha PM+0.6 t/ha CP	6.9	5.17	3	0.46	4.4	0.48	3.88	2.3	0.52	1	8.18
3.5 t/ha PM	6.63	3.85	1.96	0.36	2.96	0.32	3.01	2.14	0.31	1.02	6.8
3.5t/ha PM+0.2 t/ha CP	6.7	4.4	2.57	0.4	3.07	0.44	3.22	2.72	0.49	0.99	7.86
3.5t/ha PM+0.4 t/ha CP	6.9	5.3	3.07	0.44	4.02	0.5	3.67	2.99	0.62	0.98	8.76
3.5t/ha PM+0.6 t/ha CP	6.99	5.95	3.6	0.48	4.89	0.57	4	3	0.73	0.81	9.11

5.0 t/ha PM	6.8	5.5	3.16	0.4	3.6	0.38	3.48	2.7	0.61	0.8	7.97
5.0t/ha PM+0.2 t/ha CP	6.9	5.2	3.07	0.49	3.99	0.49	3.63	2.73	0.65	0.85	8.35
5.0t/ha PM+0.4 t/ha CP	7.25	6.19	3.6	0.5	4.8	0.54	4.05	3.07	0.7	0.89	9.25
5.0t/ha PM+0.6 t/ha CP	7.36	6.55	3.12	0.53	5.1	0.61	4.41	3.12	0.81	0.81	9.76

Table 4: Effect of organic NPK® (compost) and poultry manure on soil properties.

Treatments	3 WAP	6WAP	9WAP	12 WAP				
	2014	2015	2014	2015	2014	2015	2014	2015
Compost (t/ha)								
0	63.1	64.9	117.7	113	225.5	234.2	287.3	302
0.2	64.6	59.7	120.8	113.9	234.3	240.3	314.2	317.6
0.4	61.3	58.5	124.6	121.1	242.2	244.8	319.8	323.7
0.6	60.2	61.3	127.3	134	247.8	249.5	326.3	331.1
LSD (0.05)	NS	NS	0.95	NS	1.1	2.1	0.96	1.62
Poultry manure (t/ha)								
0	60.1	60.3	118.7	114	231	232	298.3	304.6
2	65	62.8	122.2	114	236.1	233.9	313.5	314.5
3.5	61.6	61	123.4	120.8	239.4	236	318	318.7
5	62.4	60.2	126	123	243.2	241.9	321.5	327.5
LSD (0.05)	NS	NS	0.95	NS	1.1	2.1	0.96	1.62

Table 5: Mean effect of Organic NPK® (compost) and poultry manure on leaf area (cm2) of sorghum.

Treatment		3WAP		6WAP		9WAP		12WAP	
		2014	**2015**	**2014**	**2015**	**2014**	**2015**	**2014**	**2015**
Compost (t/ha)	Poultry manure (t/ha)								
0	0	66.8	65.3	89.3	115.7	220.2	219.5	217	295.4
	2	62	65.2	100	116.9	225	224.2	300.8	303
	3.5	62	59.2	103.5	118.3	241.6	227.3	305.8	307.6
	5	63.7	62.7	106	120	259.2	231	309.7	313.4
0.2	0	58.2	65.2	102	117.9	228.9	227.2	313	313.9
	2	55.5	65.7	103	120.2	232.3	233	316.3	312.4
	3.5	63.9	63.5	118	121.1	233.5	236.4	318.4	314.3
	5	61.2	63.7	120.9	123.7	239.8	240.3	322.7	319.3
0.4	0	58	58.2	103	119.7	237.5	240	313.2	315
	2	63.3	63.9	121.1	124.6	239.2	240.5	317.2	322.6
	3.5	53.6	59.6	123.3	126.1	243	244	321.7	326.5
	5	58.9	63.3	125.5	127.9	246.7	248.8	325.6	327.1
0.6	0	58	51.5	103	121.6	241.4	243.6	321.1	325.5
	2	70.3	65.4	122	127.1	243.5	248.2	323.5	328.9
	3.5	59.6	64.1	126	128.1	246	249.9	326	332.5
	5	56.8	59.7	131.7	132.3	246.6	252.8	331.8	337.3
	-0.05	NS	NS	NS	NS	NS	3.I6	4.14	1.91

Table 6: Interaction Effect of Organic NPK® (compost) and Poultry Manure on Leaf Area in 2014 and 2015.

Treatments	3 WAP		6WAP		9WAP		12 WAP	
	2014	2015	2014	2015	2014	2015	2014	2015
Compost (t/ha)								
0	16.5	15.4	84.1	87.1	180.6	181.6	244.8	248
0.2	17.6	14.8	106.2	116.2	184.6	207.1	257.7	259
0.4	16.8	16.6	126	132	212.4	224.2	259.5	262.3
0.6	17	15.9	129.8	136.5	220.4	226.8	265.3	268.8
LSD (0.05)	NS	NS	1.2	2.5	2.09	0.44	0.67	2.49
Poultry manure (t/ha)								
0	16.9	14.8	105.2	112.7	193.4	198.3	248.6	250.4
2	16.8	15.6	110.92	117.9	203.5	207.1	252.9	257.6
3.5	17.3	15.3	113.3	121.3	205.8	208.6	260.5	264.1
5	16.8	17.1	116.7	127.2	211.3	214	264.1	266.2
LSD (0.05)	NS	NS	1.2	2.5	2.09	0.44	0.67	2.49

Table 7: Mean effect of Organic NPK® (compost) and poultry manure on plant height (cm) of *sorghum*.

Exchangeable cations were increased in response to application of compost and poultry manure application. Compost retains the highest concentration of exchangeable cations. The release of nutrients to soil by both compost and poultry manure most probably explains the increases in Ca, Mg, K and Na. The improvement in concentration of exchangeable cations in the soil upon application of manure is widely reported [26].

Leaf area was significantly ($P<0.05$) increased by compost and poultry manure compare to control treatment. Combination of compost and poultry manure at 0.6 Kg/ha and 5.0 tonne per hectare respectively gave the highest leaf area. The leaf area increases with levels of compost and manure. This could be concluded that leaf area was dictated by the concentration of nutrients supplied in the soil from compost and poultry manure. This observation agrees with [27] who reported a significant ($P<0.05$) response of cassava and soil nutrients to application of animal manures. Plant height responded significantly to manure application similar to leaf area. This observation is consistent with observation made by [28] who reported that silica organic fertilizer at 20 Kg/ha significantly ($P<0.05$) affected the height of maize. This result is an indication of the efficacy of organic fertilizers in crop production. Grain yield was observed to significantly improve over control treatments when treated with organic NPK® fertilizer (compost). This was possible due to the release of nutrient elements (N, P, K, Ca, Mg etc.) in the soil with incorporation of organic NPK which was effectively utilized by *sorghum*. The increase in grain yield of *sorghum* as observed in (Tables 8-10) is a direct response to plant nutrients availability in the soil which is a consequence of mineralization of organic matter component of the applied compost. This phenomenon has been widely reported by several Authors [18,16,9].

Treatment		3WAP		6WAP		9WAP		12WAP	
		2014	2015	2014	2015	2014	2015	2014	2015
Compost	Poultry manure								
0	0	17.7	13.6	78.3	82.7	175.3	177.2	234.3	238.9
	2	14	16.3	82.9	86.3	181.6	180.8	243.1	247
	3.5	16.7	15.3	86.3	90.3	182.7	183.4	249.6	252.3
	5	17.7	16.4	88.7	98	182.8	185	252	253.9
0.2	0	16	13.5	97.9	103.6	178.7	180.1	248.5	246.4
	2	19	12.2	104.5	105.9	183.5	187	252	254.4
	3.5	19	16	109	119	186.3	189	263.9	266.8
	5	16.3	17.4	113.4	125.4	189.7	192	266.4	268.4
0.4	0	16.3	17.6	121.4	125.9	204.2	206.1	253.6	256.5
	2	17.7	17	126.3	128.7	221.6	225	255.6	259.7
	3.5	17.3	14.2	126.2	133.5	225.5	228.8	260.5	263.3

	5	15.7	17.8	130.3	136.3	234.4	233	268.1	269.8
0.6	0	17.7	14.3	123.1	138.1	215.5	217.6	258.1	259.6
	2	16.3	16.9	130	142	226.2	228.4	264.8	269.1
	3.5	16.3	15.7	131.6	148.1	229.7	233.2	268.2	272.6
5	17.7	16.7	134.3	156	238.5	241.9	270	273.8	337.3
LSD	-0.05	NS	NS	NS	2.34	1.98	1.79	NS	NS

Table 8: Interaction Effect of Organic NPK® (compost) and Poultry Manure on Plant Height in 2014 and 2015.

Treatments	**Panicle length (cm)**		**Yield (kg/ha)**	
Compost (t/ha)	**2014**	**2015**	**2014**	**2015**
0	26.1	28	280.1	378.7
0.2	28.4	29.2	287.2	483
0.4	29.6	30.6	323.3	730.9
0.6	30.5	31	458.1	864.1
LSD (0.05)	NS	NS	36.86	51.4
Poultry manure (t/ha)				
0	25.9	25	282.3	394.2
2	26	26.6	286.6	431.3
3.5	26.2	28	314.3	533.2
5	29.8	30	348	736.3
LSD (0.05)	NS	NS	36.86	51.4

Table 9: Mean effect of Organic NPK® (compost) and poultry manure on panicle length and yield of *sorghum*.

Treatment		Panicle length (cm)		Yield (kg/ha)	
		2014	2015	2014	2015
Compost (t/ha)	Poultry manure (t/ha)				
0	0	24.3	24	336	371.7
	2	24.7	24.1	338.1	378.6
	3.5	25	24.4	340.3	379.3
	5	25	25	346	385.1
0.2	0	24.7	25	343.7	379.5
	2	24.8	25.3	347.1	481.7
	3.5	25.6	25.3	348.3	548.4
	5	25.9	25.7	349.9	563.7
0.4	0	27	25.2	406.7	627.7
	2	27	25.3	408.5	630
	3.5	28.1	25.3	413.2	634
	5	28.3	25.7	414.7	934
0.6	0	28	26	459.2	934.9
	2	28.4	27	466.5	937
	3.5	28.7	27.4	469.1	948.7
	5	28.8	27.6	474.6	951.2
LSD	-0.05	NS	NS	NS	NS

Table 9: Mean effect of Organic NPK® (compost) and poultry manure on panicle length and yield of *sorghum*.

Conclusion

It can be inferred from the study that poultry manure and organic NPK® at varying rates improves soil fertility and enhanced yield of *sorghum*. Although combined application of the manure had no comparative advantage over sole applications of either manure source. It is therefore recommended that nontraditional manure resource as organic NPK® can be adopted for sustainable production of *sorghum* in the study area.

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