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Effect of Poultry Manure on Soil Physical and Chemical Properties, Growth and Grain Yield of Sorghum in Southwest, Nigeria

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ABSTRACT

The effect of poultry manure (PM) applied to sorghum at 7.5 t/ha was studied in the forest-savanna transition zone of Southwest Nigeria. There were 5 tillage treatments with or without PM making 5 x 2 (10) factorial combinations replicated three times at two locations (Isuada and Rugipo). The experiment was conducted using the same plots in three years. The PM significantly (P>0.05) reduced soil bulk density and temperature and increase porosity and moisture content. The manure increased significantly soil organic matter, soil and leaf N, P, K, Ca and Mg concentrations. The plant height, leaf area, stem girth and weight of roots, shoot and grain yield were significantly increased. The mean grain yield was increased by 39%. The PM had cumulative effect on soil properties, growth and yield parameters over the three years of study.

Key words: Poultry manure, Soil quality, Sorgham, yi

Introduction

Sorghum accounts for 43% of all major food staples in Sub-sahara Africa. It is an important crop for human and animal consumption in many parts of the world. Sorghum is mainly grown in dry tropical zones. In Nigeria, sorghum occupies 45-50% of land area under cereal. Of the total national hectarage, close to 99% is found in the savanna zone. However, due to the great need to increase hectarage and its yield level to meet increasing domestic and industrial demand, cultivation of sorghum has extended to humid forest and derived savanna zones of Nigeria. The success of such introduction depends on level of growth and yield of the crop. Hence there is need to accumulate data on these aspects. Also there is need to investigate suitable soil and crop management practices, moreso since sorghum yield is generally low at farmers level by 500-800 kg/ha (NAERLS, 1997). Among the factors responsible for this are low soil fertility and inadequate soil management and preparation (Abimiku *et al*., 2002).

The two cultural practices that can influence the performance of sorghum is organic soil fertility improvement and tillage. Appropriate tillage method is one of the factors for increasing hectarage and productivity of sorghum. In semi arid northern Nigeria, cattle dung at 7.5 t/ha are recommended for sorghum (Lombin and Abdullahi, 1977). Inorganic fertilizer is scarce and is really used by sorghum farmers since the crop is known to be hardy and adapted to adverse soil conditions. Also the use of inorganic fertilizers alone is not sustainable, apart from contributing to soil acidity and physical and chemical degradation. Due to absence of major cattle industries in forest-savanna transition zone, there is need to study the response of sorghum to poultry manure which is more commonly available. Hence the objectives of this work is to study the effect of poultry manure on soil physical and chemical properties, growth, grain yield and nutrient composition of sorghum in the forest-savanna ecology of Southwest Nigeria.

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Materials and methods

Field experiments were conducted at Rufus Giwa Polytechnic Owo and Isuada village in Owo area of Southwest Nigeria in late-season 2004, early-season 2005 and late-season 2006. The soil in Owo area is an Alfisol (Oxic Tropuldalf (USDA) or Luvisol (FAO) derived from quartz, gneiss and schist. There are two rainy seasons, one from March to July and the other is from mid-August to November. The rainfall values for 2004, 2005 and 2006 were 1135, 1015 and 1241mm respectively, the pan evaporation values were 1324, 1290 and 1339mm, while the mean value air temperature were 28^{0}C. The Owo area is in rainforest-savanna transition zone. The land at each location was planted to maize before being fallowed for 4 and 2 years at Isuada and Rugipo respectively.

The trial each year consisted of 5 x 2 factorial combinations of tillage (seedbed) and poultry manure (0, 7.5 t/ha). The treatments were (a) zero tillage, i.e. manual clearing followed by spraying with gramomoxone at 5 L/ha. Residue was left on soil., (b) zero tillage + poultry manure, (c) manual clearing with residue left on soil, (d) manual clearing + poultry manual, (e) disc ploughing after clearing, (f) disc ploughing + poultry manure, (g) disc ploughing + harrowing, (h) disc ploughing + harrowing + poultry manure, (i) disc ploughing + harrowing twice, and (j) disc ploughing + harrowing twice + poultry manure. The ten treatments were factorially arranged in a randomized complete block design and replicated three times. Each plot was 12 x 10m. Three sorghum seeds were sown per stand manually at 90 x 30 cm. Fully emerged plants were thinned to one per stand two weeks after sowing to give 37,037 plants per hectare. Poultry manure was applied by banding after manual weeding at 3 weeks after sowing at 7.5 t/ha. Weeding was done at 3 and 8 weeks after sowing.

Soil sampling and chemical analysis

Prior to commencement of experiment in 2004, surface (0-15 cm depth) soil samples were taken randomly from experimental sites (RUGIPO and ISUADA) and bulked, air-dried and 2 mm sieved for analysis. Soil samples were also collected at harvest in 2005 (second crop) and 2006 (for third crop) per plot basis. The samples were analysed as described by Carter (1993). Particle size analysis was done using hydrometer method, organic matter by dichromate oxidation method, total N by micro-kjeldahl approach, available P by Bray-1 extraction followed by molybdenum blue colorimetry. Exchangeable K, Ca, and Mg were extracted using ammonium acetate. Thereafter K was determined using flame photometer, and Ca and Mg by atomic absorption spectrophotometer. Soil pH was evaluated in soil-water (1:2) medium using digital electronic pH meter.

Determination of soil physical properties

One month after sowing sorghum, determination of soil bulk density, total porosity and gravimetric moisture content was done at monthly interval on five occasions. Five undisturbed core (4cm diameter, 10 cm high) soil samples were oven-dried at 100^{0}c for 24 hr. Total porosity was calculated from values of bulk density and particle density. Soil temperature was determined at 15:00 hr using a soil thermometer inserted to 5 cm depth. Five readings were made per plot at each sampling time and mean data computed.

Leaf and manure analysis

In 2006 (third crop) sorghum leaves collected from all plots in each location at 120 days (50% flowering stage) after sowing were chemically analysed. Leaf samples were oven-dried at 80^{0}C for 48 hr and ground. Leaf N was determined using micro-kjeldahl digestion method. Samples were dry ashed at 500^{0}C for 6hr in a furnace and extracted using 10 % HCL for determination of P, K, Ca and Mg (Tel and Hagarty, 1984). Leaf P was determined using vanadomolybdate method, K using flame photometer and Ca and Mg by EDTA titration (AOAC, 1970). Sub-samples of poultry manure used in the three years of study were air-dried and crushed through a 2 mm-sieve. The samples were analysed as described for leaf samples.

Determination of growth and yield parameters

Ten plants were randomly selected at the centre of each plot two weeks after poultry manure application for data collection. Plant height and leaf area per plant were determined 120 days after sowing, and leaf area was measured by graphical method. At crop maturity (6 months after sowing) selected plants were excavated, root severed and number of roots counted, stem girth was determined. Root and fresh matter was oven dried at 80^{0}C for 48 hr to determine their dry weights. Air-drying of grains was done to 12 % moisture content. The 100 seed weight was determined, and grain yield was calculated per hectare basis.

Data were subjected to analysis of variance and mean data on poultry treatment basis were compared using the Least Significant Difference (LSD) at P > 0.05.

Results and discussion

Results

The soil properties at Rugipo and Isuada sites (Table 1) indicate that the soil were slightly acidic, low in organic matter, N and available P, and high in bulk density. Therefore the soils required organic amendments to ameliorate their deficiencies.

Table 1: Properties of soils (0-15 cm) at Rugipo and Isuada in 2004 before experiment

Property	Rugipo	Isuada
Sand %	68	65
Silt %	14	16
Clay %	18	19
Texture	Sandy loam	Sandy loam
pH (H_2O)	5.73	5.58
Bulk density g/cm^3	1.50	1.48
OM %	1.81	1.76
Total N %	0.15	0.13
Available P mg/kg	11.3	9.2
Exchangeable K cmol/kg	0.55	0.21
Exchangeable Ca cmol/kg	1.70	2.76
Exchangeable Mg cmol/kg	1.50	1.30

The composition of poultry manure (PM) used in 2004, 2005 and 2006 experiments is shown in table 2. The organic carbon (OC), total N, P, K, Ca and Mg constituents are expected improve the fertility of experimental soils on decomposition of PM. The PM samples are relatively high in N, K and Ca. Table 3 presents data on soil physical properties as influenced by PM application. At both sites of study, PM improved soil physical properties significantly (P > 0.05) by reducing soil bulk density and temperature and increasing total porosity and moisture content in 2004, 2005 and 2006. Yearly application of PM had cumulative positive effect on soil physical properties. This is confirmed by the fact that means soil bulk density reduced from 2004 to 2006, while porosity and moisture content increased. The mean soil bulked density values for 2004, 2005 and 2006 were 1.29, 1.26 and 1.22 g/cm^3 and the values for total porosity were 50.9, 51.6 and 53.7%. Poultry manure increased soil nutrient status as indicated by increases in soil OM, N, available P, exchangeable K, Ca and Mg at Rugipo and Isuada (Table 4) in 2005 and 2006. The increases in pH were not significant (P> 0.05), whereas the increases in the nutrients content were generally significant. As in case of the physical properties, PM application had cumulative effect on soil nutrients content between 2005 and 2006. This attests to the positive effect of PM on the soil properties. Hence soil physical and chemical properties increased with addition of PM. The overall mean values of soil OM for 2005 and 2006 were 1.84 and 2.05 % respectively, the N values were 0.27 and 0.40 %, available P values were 13.5 and 15.4 mg/kg, exchangeable K values were 0.59 and 0.95, Ca values were 2.8 and 3.5, and Mg values were 1.66 and 2.43 cmol/kg.

Data collected in 2006 on the last sorghum crop (Table 5) indicate that PM increased plant N, P, K, Ca and Mg status significantly (P> 0.05) as indicated by leaf analysis. In no manure and manured plants, nutrients decreased in the order N, K, Ca, P and Mg at Rugipo and Isuada sites.

Table 6 and 7 contain data on growth (Table 6) and yield (Table 7) parameters of sorghum. Manure significantly (P>0.05) increased plant height, leaf area, stem girth, number of roots (Table 6), root weight, shoot weight, 100 seed weight and grain yield significantly in 2004, 2005 and 2006 and at both sites of study. The overall mean plant heights for no manure and manure were 5.30 and 5.72 m respectively, the values for leaf area were 1.12, 1.42 m^2, for stem girth 2.65 and 2.84cm, number of roots were 39.0 and 44.4, root dry weight 55.6and 62.7 g/plant, shoot dry weight 22.4 and 29.2 t/ha, 100 seed weight 2.95 and 4.05g, and grain yield 1.14 and 1.57 t/ha. Manure application over the three years of study had cumulative effect on growth and yield of sorghum. For 2004, 2005 and 2006, the mean root dry weight values were 53.6, 67.2 and 67.4 g/plant respectively, shoot dry weights were 23.5, 31.0 and 33.0 t/ha, and grain yields were 0.74, 1.98 and 2.06 t/ha. Considering grain yield per hectare, manure increased mean grain yield by 39 % over the three years of study. Sorghum grown in September 2004 did not produce appreciable dry matter and grain yields compared with second and third crops sown in April 2005 and August 2006 respectively. Also sorghum performance as

indicated by dry matter and grain yields was lower at Isuada compared with Rugipo. In 2005 and 2006 when rainfall was normal, the mean grain yield without manure was 1.41 t/ha, and with manure it was 2.02 t/ha.

Table 2: Composition of poultry manure used in 2004, 2005 and 2006 (%)

Nutrient	2004	2005	2006
Organic /C	12.7	14.9	14.5
Total N	2.10	2.23	2.13
C: N	6.0	6.7	6.8
P	0.53	0.37	0.28
K	2.35	2.02	1.88
Ca	1.42	1.35	1.27
Mg	0.58	0.43	0.39

Table 3: Effect of poultry manure on soil physical properties

Treatment	Bulk density g/cm^3		Total porosity %		Moisture content %		Temperature ^{0}c	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
No manure (2004)	1.43	1.40	45.9	46.4	10.1	7.6	30.2	30.9
Manure (2004)	1.31	1.26	50.1	51.8	13.8	9.7	27.9	28.7
LSD (0.05)	0.09	0.11	2.9	3.0	1.69	1.47	2.1	1.9
No manure (2005)	1.46	1.42	44.1	45.5	16.0	14.5	28.5	29.2
Manure (2005)	1.28	1.24	50.9	52.3	18.6	17.0	26.2	27.0
LSD (0.05)	0.08	0.07	2.01	2.72	1.47	1.33	1.2	1.1
No Manure (2006)	1.47	1.44	43.5	44.5	12.04	11.00	30.2	29.7
Manure (2006)	1.21	1.19	53.3	54.3	15.74	14.38	28.2	27.5
LSD (0.05)	0.07	0.06	3.89	3.44	1.28	1.81	0.9	0.8

Table 4: Effect of poultry manure on soil nutrient composition

Treatment	pH (H_2O)	OM%	N%	P (mg/kg)	K	Ca	Mg
					cmol/kg		
ISUADA							
No manure (2005)	5.5	1.32	0.10	8.4	0.12	1.99	0.96
Manure (2005)	5.6	1.79	0.25	12.5	0.41	3.41	1.52
LSD (0.05)	NS	0.06	0.02	0.2	0.02	0.12	0.04
No manure (2006)	5.3	1.27	0.08	8.20	0.11	1.95	0.92
Manure (2006)	5.6	2.01	0.37	14.4	0.78	4.02	2.01
LSD (0.05)	NS	0.04	0.01	0.18	0.02	0.11	0.05
RUGIPO							
No manure (2005)	5.7	1.35	0.11	10.2	0.45	1.24	1.28
Manure (2005)	5.8	1.88	0.29	14.4	0.77	2.10	1.80
LSD (0.05)	NS	0.08	0.01	0.25	0.01	0.09	0.06
No manure (2006)	5.6	1.31	0.11	9.6	0.39	1.20	1.28
Manure (2006)	5.9	2.09	0.43	16.4	1.12	2.94	2.46
LSD (0.05)	NS	0.06	0.02	0.24	0.04	0.09	0.08

Table 5: Effect of poultry manure on leaf nutrient composition of sorghum (%)-2006

Treatment	N		P		K		Ca		Mg	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
No manure	1.67	1.62	0.43	0.39	1.36	1.07	0.81	1.34	0.28	0.35
Manure	1.92	1.87	0.72	0.66	1.79	1.46	1.14	1.63	0.51	0.63
LSD (0.05)	0.10	0.07	0.19	0.15	0.24	0.21	0.20	0.18	0.14	0.12

Table 6: Effect of poultry manure on growth of sorghum

Treatment	Plant height (m)		Leaf area (m^2)		Stem girth (cm)		No of roots per plant	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
No manure (2004)	4.65	4.50	1.09	1.02	2.16	2.11	38.2	36.2
Manure (2004)	5.13	4.89	1.36	1.28	2.36	2.25	43.2	40.3
LSD (0.05)	0.21	0.23	0.06	0.08	0.15	0.09	1.24	1.15
No manure (2005)	5.81	5.75	1.23	1.15	3.44	3.08	46.2	38.2
Manure (2005)	6.29	6.18	1.51	1.36	3.62	3.27	53.1	44.7
LSD (0.05)	0.08	0.07	0.09	0.05	0.11	0.08	1.34	1.29
No manure (2006)	5.61	5.49	1.15	1.07	2.79	2.37	40.2	35.4
Manure (2006)	5.99	5.87	1.56	1.44	2.94	2.60	45.3	39.7
LSD (0.05)	0.18	0.16	0.09	0.07	0.04	0.03	3.2	2.9

Table 7: Effect of poultry manure on yield of sorghum

Treatment	Root dry weight g/plant		Shoot dry weight t/ha		100 seed weight (g)		Grain yield t/ha	
	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada	Rugipo	Isuada
No manure (2004)	49.5	47.0	19.12	18.42	1.56	1.48	0.62	0.58
Manure (2004)	54.4	52.8	23.91	23.07	1.94	1.81	0.77	0.71
LSD (0.05)	2.3	2.7	2.1	2.3	0.21	0.19	0.11	0.09
No manure (2005)	63.2	60.2	25.7	24.4	3.87	3.76	1.51	1.43
Manure (2005)	69.4	64.9	32.2	29.9	5.21	4.89	2.05	1.91
LSD (0.05)	1.9	2.1	2.2	2.4	0.22	0.20	0.21	0.18
No manure (2006)	57.9	55.7	24.1	22.6	3.56	3.44	1.39	1.31
Manure (2006)	69.1	65.6	33.9	32.2	5.43	5.01	2.14	1.97
LSD (0.05)	2.1	1.8	1.6	1.8	0.12	0.14	0.13	0.11

Discussion

Samples of PM used in 2004, 2005 and 2006 had slightly varying values of OC, N, P, K, Ca and Mg. On decomposition of OM and mineralization of organic nutrients, their release should have benefited the experimental soils that were low in OM, N and P. The OM should also have benefited the soil physical properties. Hence it was found that soil bulk density and temperature were reduced by PM, while total porosity and moisture content were improved. Because of the positive effect of OM, the physical properties were progressively improved between 2004 and 2006. The initial soil bulk density of 1.50 and 1.48 g/cm^3 recorded for Rugipo and Isuada respectively are somewhat high and or not conducive for cereal crops (Donahue *et al*., 1990). Hence the soils needed organic treatment to enhance root growth. The mean value of 1.5 g/cm3 for the sandy loamy soils is not conducive to good root growth of sorghum.

The OM contributed by the manure led to improvement of soil physical properties. The OM should have stabilized soil structure thereby reducing soil bulk density, increasing porosity, and infiltration rate and water retention. The letter reduced day time soil temperature. The favourable soil physical condition adduced to PM is consistent with earlier findings of (Weil and Kroontye, 1979; Khaleel *et al.,* 1981; Paglial *et al.,* 1987, Mbagwu 1987, 1992; Obi and Ebo, 1995, Akanni *et al.,* 2005).

The organic matter component of PM decomposed and nutrients were released to soil. Hence the finding that PM increased soil N, P, K, Ca, and Mg significantly. The increases in soil fertility is consistent with findings of previous studies that amendment of soil using poultry manure improved soil OM, N, P, K, Ca and Mg (Kingery *et al.,* 1993; Adeniyan and Ojeniyi, 2005; Akanbi *et al.,* 2005 ; Adenawoola and Adejoro, 2005). The increased availability of nutrients in soil due to application of the manure expectedly led to increased uptake of N, P, K, Ca, and Mg. The finding that PM significantly increased growth and grain yield of sorghum is attributable to improved soil physical and chemical properties. The increased porosity and moisture content should have enhanced root growth and water and nutrient uptake, apart from the fact that nutrients released from PM had direct effect on growth and grain yield. The importance of N and P in determining sorghum performance has been highlighted by Golosworthy (1967) and Tabo (1995). Arunah *et al.* (2006) in a field experiment in the northern guinea savanna zone of Nigeria found that PM was superior to applied N in promoting yield of sorghum. Earlier Yayock and Awoniyi (1974) compared effects of different animal manures including poultry, cow, pig and horse with inorganic fertilizers; they found that poultry manure, pig manure and inorganic fertilizers gave highest grain and stalk yield.

The least dry matter and grain yield recorded in 2004 compared with 2005 and 2006 can be adduced to a dry spell that set in 2004 during the latter part of vegetative and early reproductive phase. These stages fell between mid-December (2004) and mid-January (2005). Although sorghum is drought resistant, water supply is a critical factor for seed formation (Rachidi *et al.,* 1995). Sorghum performance was lower at Isuada compared with Rugipo. This could be adduced to lower soil OM, N, P and K status at Isuada.

The cumulative effect of PM on soil physical and chemical properties, crop growth and yield over three years corroborates the observation of Gupta *et al.* (1997) that PM is a very rich animal manures by given considerable increase in soil OM, available P and exchangeable cations. The cumulative effect supports the observation that PM added organic matter and nutrients to soil. Considering the observation that yield could be as low as 500-800 kg/ha on farmers' farms in the savanna belt (NAERLS, 1977), sorghum cultivation is a worthwhile venture in the forest-savanna zone. Under suitable environmental conditions and with manure, the average yield of sorghum is about 2.0 t/ha (Lombin and abdullahi, 1977) in the guinea savanna zone. With manure treatment, the average grain yield recorded in this work is 2.02 t/ha. Though the environmental conditions are more suitable in the guinea savanna zone where sorghum is mainly grown, its cultivation in the forest-savanna zone is justifiable if the soil is given poultry manure.

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Soil chemical properties, growth and fresh rhizome yield reduced with frequency/intensity of tillage imposed while application of OBA+PM increased them. Among the tillage practices, the highest fresh rhizome yield (15.0t ha-1) was produced by ZTM which was significantly different from other tillage practices.Â [26] T.M. Agbede and S.O. Ojeniyi, "Tillage and Poultry Manure Effects on Soil Fertility and Sorghum Yield in Southwestern Nigeria", Soil Tillage Research, 104:74-81, 2009. [27] S.O. Ojeniyi and F.O. Adekayode, "Soil Conditions and Cowpea and Maize Yield Produced by Tillage Methods in the Rainforest Zone of Nigeria", Soil Tillage Research, 51:161-164, 1999. Poultry manure, sometimes called chicken manure, is an excellent soil amendment that provides nutrients for growing crops and also improves soil quality when applied wisely, because it has high organic matter content combined with available nutrients for plant growth [5]. The chemical composition of poultry manure varies with factors such as source of manure, feed of the birds, age and condition of the.Â Poultry manure also contains useful soil nutrients that are needed for the growth of plants [18], but their composition is in the crude form that is released slowly to the soil [19].Â G. O. Agbaje and J. A. Olofintoye, â€œEffect of transplanting on yield and growth of grain sorghum (Sorghum bicolor (L.) Moench),â€ Tropicultura, vol. 20, no. 4, pp. 217â€“220, 2002. 2 (3):01-05 (December 2008) RELATIVE EFFECT OF WEED MULCH TYPES ON SOIL PROPERTIES AND YIELD OF YAM IN SOUTHWEST NIGERIA ADENIYAN, B.O. 1, OJENIYI, S.O. 2 AND AWODUN, M.A. 2 1 Ondo state agricultural development prgramme, 2 Department of Crop, Soil and Pest Management, Federal University of Technology, P.M.B. 704,, Nigeria Accepted for publicationÂ The type of residue mulching determines its impact on soil physical and chemical properties and crop yield (Awodun and Ojeniyi, 1999) and this is due to difference in biochemical quality of plant mulch material.Â Effects of tillage and mulching on the growth development and yield of late season tomato (Lycopersicon esculentum L.) in the humid south of Nigeria.