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Effects of Poultry Manure on Soil Fertility, Growth and Yield of White Yam and Yellow Yam

T. M. Agbede[1*] and A. O. Adekiya[2]

[1]Department of Agricultural Technology, Rufus Giwa Polytechnic, P. M. B. 1019, Owo, Ondo State, Nigeria
[2]Department of Crop, Soil and Pest Management, Federal University of Technology, P. M. B. 704, Akure, Nigeria
***Corresponding author: E-mail: agbedetaiwomichael@yahoo.com**

Abstract: Field experiments were conducted at Owo in the forest-savanna transition zone of southwestern Nigeria during 2007 and 2008 cropping seasons to study the effect of different levels of poultry manure (0, 10, 20, 30 and 40 t/ha) on soil fertility, leaf nutrient content, growth and tuber yield of two species of yam; namely, white yam (*Dioscorea rotundata* Poir) and yellow yam (*Dioscorea cayenensis* Lam). The treatments were factorially arranged in a randomized block design with three replications. The soil was deficient in organic matter (OM), total N, available P, exchangeable K, Ca and Mg. The results showed that poultry manure increased soil and leaf N, P, K, Ca and Mg, and soil OM, growth and tuber yield of the yams compared with the control treatments. White yam produced significantly higher yield than yellow yam. Compared with yellow yam, white yam increased tuber yield by 19%, 26%, 36%, 3% and 12%, respectively, for 0, 10, 20, 30 and 40 t/ha poultry manure. Application of poultry manure at 20 t/ha and 30 t/ha significantly improved growth and tuber yield of white yam and yellow yam, respectively, compared with the other treatments. These levels of poultry manure are, therefore, recommended for the two yam species in forest-savanna transition zone of southwest Nigeria. Recommendations of manure for yam production should be variety specific.

Key words: Poultry manure; soil fertility; yam; leaf nutrient content; Nigeria

INTRODUCTION

Root and tuber crops are an important food and source of calories for about one-third of the world's population. They are of particular importance for the people of Africa, who derive about 15% of their total dietary calories from tuber crops (Howeler *et al.* 1993). Yam is second to cassava as the most important cultivated tropical tuber crop. It is widely grown in Nigeria; and because of its multipurpose uses, it occupies a principal place in farming systems of the humid tropical region. While Africa contributes 90% of the world production of yams, Nigeria accounts for over 70% of the world production (Okoh 2004; Agbede 2006).

In Nigeria, yams are processed into various food forms, which include pounded, boiled, roasted or grilled, fried, slices and balls, mashed, chips and flakes. Yam is also an indispensable part of the bride dowry among Yoruba and Ibo tribes in southern Nigeria (Orkwor *et al.* 1998). Thus, there is dire need to investigate the sustainability of its production.

Due to their high demand for nutrients, yams are traditionally the first crops grown after fallow (Orkwor *et al.* 1998). The limitation imposed on the productivity of soil in the tropics, in term of loss of fertility and pressure of land use due to non-agricultural development, is forcing farmers to cultivate degraded or non-fertile soils. There is need to explore available means which could be used to improve the nutrient status of these soils. In a sustainable low input agricultural system, where nutrient depletion is a serious constraint to crop production, the use of organic manure is inevitable (Fagbola and Ogungbe 2007). In the past, mineral fertilizer was advocated for crop production. However, apart from being expensive and scarce, it is often associated with acidity (Agbede *et al.* 2008). Some farmers have claimed that tubers of yam grown with mineral fertilizers does not store long (Asadu 1995).

Poultry manure is an organic amendment that has been used successfully for centuries as a source of nutrient for crops (Brye *et al.* 2005). It is generally considered the most valuable of animal manure for use as a fertilizer due to its low water content and relatively high content of NPK and trace elements (Moore *et al.* 1995). Moreover, if managed properly, it can save farmers money and represent an environmentally safe means of waste disposal, considering the number of poultry farms in Nigeria.

In Nigeria, inspite of the importance of yam as a major staple food and its socio-cultural value in the lives of the people, research and documentation on the use of manure, especially poultry manure, for its production does not exist. There is no study on the effect of poultry manure on soil chemical properties and leaf nutrient composition and sustainability of yam production. Various yam varieties might react differently to different rates of application of poultry manure. Studies were, however, only carried out on the effect of poultry manure on other crops. For instance, maize (Adeniyan and Ojeniyi 2005), jute (Adenawoola and Adejoro 2005), ginger (Ayuba *et al.* 2005) and tomato (Adekiya and Agbede 2009).

Therefore, the objective of the present work was to study the effect of different levels of poultry manure on soil fertility, leaf nutrient composition and growth and yield of white yam and yellow yam grown in forest-savanna transition zone of southwest Nigeria.

MATERIALS AND METHODS

Trials were carried out at Owo ($7^0 12^/$N $5^0 35^/$E) in Ondo State of Nigeria during the 2007 and 2008 growing seasons. The soil at Owo is an Alfisol classified as Oxic Tropuldalf (USDA 1999) or Luvisol (FAO 1998) derived from quartzite, gneiss and schist (Agbede 2006). The land at the experimental site had been under rotational cropping for at least 8 years. There are two rainy seasons in the location, one from March to July and the other from mid-August to November. The average annual rainfall varies from 1000 to 1500 mm. The same site was used for the experiment in 2007 and 2008.

Each year, the experiment consisted of 2 x 5 factorial combinations of two yam species [white yam (*Dioscorea rotundata*) and yellow yam (*Dioscorea cayenensis*)] and five levels of poultry manure (0, 10, 20, 30 and 40 t/ha). The ten treatments were factorially arranged in a randomized complete block design with three replications.

Construction of mounds were done in April each year of the experiment (2007 and 2008) after manual clearing of debris away from the site. Soil mounds were formed at 1 x 1 m spacing and each mound was approximately 1 m wide at the base and about 0.75 m high. Each of the 30 plots was 5 x 5 m, giving a plant population of 25 plants per plot. Blocks were 1 m apart, and the plots were 0.5 m apart. Planting was done immediately after construction of mounds. One seedyam weighing about 0.4 kg of white yam (*Dioscorea rotundata* cv. Gambari) and yellow yam (*Dioscorea cayenensis* cv. Owo local) were planted per hole. Before treatment application, the poultry manure was air-dried and sieved with 2-mm sieve. It was applied in ring form, two weeks after planting. After sprouting, stakes were installed. Three manual weedings were done each year.

Ten plants were selected randomly from each plot, five months after planting, for the determination of the number of leaves and leaf area (by graphical method). Vine length and tuber weight were measured at harvest (8 months after planting for white yam and 10 months after planting for yellow yam).

Before the start of the experiment in 2007, surface soil (0-15 cm) samples were randomly collected from ten different points in the experimental site. After harvest in 2007 and 2008, soil samples were collected randomly from each plot up to 15 cm depth from five sampling points per plot. The soil samples were bulked, air-dried and sieved using a 2-mm sieve for routine chemical analysis as described by Carter (1993). The particle size analysis was done using hydrometer method. Soil pH was determined in soil-water (1:2) suspension using the digital electronic pH meter. The organic carbon was determined by the procedure of Walkley and Black dichromate wet oxidation method, total N by the micro-Kjeldahl digestion method and available P was determined by Bray-1 extraction followed by molybdenum blue colorimetry. Exchangeable K, Ca and Mg were extracted using 1 M ammonium acetate. Thereafter, K was determined using a flame photometer, and Ca and Mg were determined with an atomic absorption spectrophotometer (Okalebo *et al.* 2002).

Five months after planting, in each year, leaf samples were collected randomly from each plot, oven-dried for 24 hours at 80^0C and ground in a Willey-mill. Leaf N was determined by the micro-Kjeldahl digestion method. To determine P, K, Ca and Mg, ground leaf samples were dry ashed at 450^0C for 6 hrs in a muffle furnace and digested with nitric-perchloric-sulphuric acid mixture. Phosphorus was determined colorimetrically by the vanadomolybdate method, K by a flame photometer and Ca and Mg by the EDTA titration method (AOAC 1990). The oven-dried, ground poultry manure was similarly analysed.

The data were subjected to analysis of variance, using SPSS 15.0 and Microsoft Office Excel 2007 packages, and treatment means were compared using Duncan's multiple range test and the least significant difference (LSD) at P=0.05 probability level (Steel *et al.* 1997).

RESULTS

Table 1 shows the results of the soil chemical properties of the experimental site before the start of the experiment in 2007 and of the poultry manure used in the experiment. The soil was sandy loam, slightly acidic (pH=6.1). Based on the established critical levels for soils in ecological zones of Nigeria, the soil was low in organic matter (OM), total N, available P, exchangeable Ca and Mg, according to the critical levels of 3.0% OM, 0.20% N, 10 mg/kg available P, 2.0 cmol/kg exchangeable Ca, 0.40 cmol/kg exchangeable Mg recommended for most crops (Akinrinde and Obigbesan 2000). The exchangeable K was less than 0.15 cmol/kg critical level, considered as adequate for yam production (Okereke *et al.* 1987), thus, indicating poor soil fertility. Hence, it is expected that application of poultry manure would enhance soil fertility and performance of yam.

The effect of poultry manure on soil chemical properties at the end of the experiment in 2007 and 2008 cropping seasons are shown in Table 2. Application of poultry manure significantly increased soil OM, N, P, K, Ca and Mg in the white yam and yellow yam plots in both years; the value of these constituents increased with the increase in the poultry manure levels. However, K, Ca and Mg, only increased with increase in the poultry manure up to 20 t/ha for white yam and 30 t/ha for yellow yam. Thereafter, the nutrient status decreased. There were no significant differences between WY + 30 t/ha PM and WY + 40 t/ha PM for K, Ca and Mg contents.

The effect of poultry manure on leaf nutrient composition of the two species in 2007 and 2008 cropping seasons are shown in Table 3. Compared with the control treatments, all levels of poultry manure significantly increased leaf N, P, K, Ca and Mg in both species. Leaf N and P increased as the level of poultry manure increased in both species and years. However, K, Ca and Mg increased significantly up to 20 t/ha PM for white yam and 30 t/ha PM for yellow yam. At 0.0 to 20 t/ha PM, white yam produced significantly (P=0.05) higher values of leaf N, P, K, Ca and Mg than yellow yam, in both years.

Poultry manure application significantly (P=0.05) increased vine length, number of leaves and leaf area compared with the control, in both years (Table 4). Vine length, number of leaves and leaf area increased with manure level up to 20 t/ha PM for white yam and up to 30 t/ha PM for yellow yam. In both years, there were no significant differences in vine length, number of leaves and leaf area between 20 t/ha, 30 t/ha and 40 t/ha PM for white yam and between 30 t/ha and 40 t/ha PM for yellow yam. At 0.0 t/ha, 10 t/ha and 20 t/ha levels of poultry manure, growth parameters were significantly higher in white yam compared with yellow yam. Growth parameters tended to increase in 2008 than in 2007 (Table 4).

A similar trend was observed for tuber weight. In 2007 and 2008 cropping seasons, poultry manure significantly increased tuber yield of the two species compared with the control. Poultry manure increased tuber yield up to 20 t/ha in white yam and 30 t/ha in yellow yam (Fig. 1). Comparing the same level of poultry manure, tuber yield was significantly higher in white yam than in yellow yam, and white yam increased tuber yield by 19%, 26%, 36%, 3% and 12%, respectively, for 0, 10, 20, 30 and 40 t/ha

PM when compared with yellow yam. In both species, compared with the control, white yam plus 20 t/ha PM increased tuber yield by 73% in 2007 and 91% in 2008, while yellow yam plus 20 t/ha PM increased tuber yield by 27% in 2007 and 42% in 2008. Poultry manure treatments increased tuber yield in the second year, but decreased it in the control treatment.

Table 1. Soil physical and chemical properties (0-15 cm depth) of the experimental site before planting in 2007 and chemical composition of poultry manure used

Soil sample		Poultry manure	
Property	Value	Property	Value
Sand (%)	68.0	pH (H_2O)	6.8
Silt (%)	14.5	Organic C (%)	14.7
Clay (%)	17.5	Nitrogen (%)	2.23
Textural class	Sandy loam	C:N	6.6
pH (H_2O)	6.1	Phosphorus (%)	0.83
Organic matter (%)	1.49	Potassium (%)	2.3
Nitrogen (%)	0.18	Calcium (%)	1.5
Phosphorus (mg/kg)	7.1	Magnesium (%)	0.58
Potassium (cmol/kg)	0.14		
Calcium (cmol/kg)	1.21		
Magnesium (cmol/kg)	0.23		

Table 2. Effect of poultry manure on soil chemical properties at the end of the experiment in 2007 and 2008 cropping seasons

Treatment	Organic matter (%)		Nitrogen (%)		Phosphorus (mg/kg)		Potassium (cmol/kg)		Calcium (cmol/kg)		Magnesium (cmol/kg)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
WY + 0 t/ha PM	1.30e	1.40e	0.13gh	0.16g	5.9e	6.6e	0.10e	0.12fg	0.15e	0.19e	0.73e	0.78e
WY + 10 t/ha PM	1.15d	1.20d	0.15f	0.18ef	7.0d	8.2d	0.49c	0.56cd	0.20d	0.22d	0.84d	0.89d
WY + 20 t/ha PM	1.45c	1.51c	0.19de	0.20d	8.2c	9.3c	0.73ab	0.77b	0.29b	0.31b	0.98b	1.03bc
WY + 30 t/ha PM	1.80b	1.89b	0.22c	0.24b	9.3b	10.4b	0.50c	0.53de	0.28b	0.30b	0.91cd	0.95cd
WY + 40 t/ha PM	2.20a	2.28a	0.27a	0.29a	11.3a	12.1a	0.49c	0.50e	0.24c	0.26c	0.89cd	0.91d
YY + 0 t/ha PM	1.32e	1.35e	0.12h	0.16g	5.7e	6.9e	0.11de	0.11g	0.14e	0.18e	0.74e	0.77e
YY + 10 t/ha PM	1.10d	1.21d	0.15f	0.17fg	7.1d	8.4d	0.50c	0.57cd	0.20d	0.22d	0.84d	0.90d
YY + 20 t/ha PM	1.50c	1.58c	0.18e	0.22cd	8.2c	9.1c	0.73ab	0.80b	0.29b	0.31b	0.99b	1.03bc
YY + 30 t/ha PM	1.83b	1.91b	0.23bc	0.24b	9.5b	10.6b	0.77a	1.00a	0.33a	0.35a	1.10a	1.15a
YY + 40 t/ha PM	2.19a	2.20a	0.26a	0.29a	11.1a	11.8a	0.51c	0.56cd	0.28b	0.30b	0.90cd	0.94cd
SE ±	0.14	0.19	0.01	0.02	0.95	1.06	0.06	0.07	0.03	0.03	0.0	0.11

Values with the same superscript in a column are not significantly different at P = 0.05, according to Duncan's multiple range test.

WY = White yam; YY = Yellow yam; PM = Poultry manure

Table 3. Effect of poultry manure on the chemical composition of the leaves white yam and yellow yam in 2007 and 2008 cropping seasons

Treatment	N (%)		P (%)		K (%)		Ca (%)		Mg(%)	
	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
WY + 0 t/ha PM	2.02f	2.10f	0.16i	0.17g	1.48f	1.51f	0.33f	0.35g	0.08h	0.09h
WY + 10 t/ha PM	2.60d	2.61d	0.21gh	0.21e	2.05c	2.08c	0.54bc	0.56cd	0.15ef	0.16ef
WY + 20 t/ha PM	2.89c	2.96c	0.27de	0.29c	2.91a	2.94a	0.76a	0.78a	0.25a	0.26a
WY + 30 t/ha PM	3.40b	3.45b	0.33bc	0.36b	2.06c	2.09c	0.54bc	0.56cd	0.22bc	0.23bc
WY + 40 t/ha PM	3.89a	3.90a	0.37a	0.41a	1.77d	1.80d	0.51c	0.53d	0.21c	0.22c
YY + 0 t/ha PM	1.78g	1.90g	0.13j	0.14h	1.29g	1.31g	0.23g	0.25h	0.06i	0.07i
YY + 10 t/ha PM	2.30e	2.30e	0.16i	0.18fg	1.58e	1.60e	0.42e	0.44f	0.11g	0.12g
YY + 20 t/ha PM	2.59d	2.61d	0.20h	0.23d	1.86e	1.89e	0.55bc	0.57cd	0.14f	0.15f

Table 3. Cont.

Treatment	N (%)		P (%)		K (%)		Ca (%)		Mg (%)	
	2007	200	2007	2008	2007	2008	2007	2008	2007	2008
YY + 30 t/ha PM	2.90c	2.99c	0.26ef	0.29c	2.18bc	2.20bc	0.75a	0.74ab	0.21c	0.22c
YY + 40 t/ha PM	3.30b	3.36b	0.31c	0.37b	1.61e	1.63e	0.47d	0.49e	0.18d	0.19d
SE±	0.31	0.32	0.02	0.02	0.21	0.22	0.05	0.06	0.02	0.02

Values with the same superscript in a column are not significantly different at P = 0.05, according to Duncan's multiple range test.

WY = White yam; YY = Yellow yam; PM = Poultry manure

Table 4. Effect of poultry manure on growth parameters of white yam and yellow yam in 2007 and 2008 cropping seasons

Treatment	Vine length (m)			Number of leaves per plant			Leaf area per plant (m^2)		
	2007	2008	Mean	2007	2008	Mean	2007	2008	Mean
WY+0 t/ha PM	2.60d	2.71e	2.66	1530de	1656d	1593	1.64cd	1.75c	1.70
WY+10 t/ha PM	2.90c	3.10cd	3.00	1890c	1992c	1941	1.89b	1.96b	1.93
WY+20 t/ha PM	3.30a	3.55a	3.43	2245a	2359a	2302	2.25a	2.34a	2.30
WY+30 t/ha PM	3.28a	3.40ab	3.34	2220a	2351a	2286	2.20a	2.27a	2.24
WY+40 t/ha PM	3.15ab	3.34ab	3.25	2202a	2221ab	2212	2.19a	2.22a	2.21
YY+0 t/ha PM	2.45e	2.35f	2.40	1335f	1401e	1368	1.39e	1.50d	1.45
YY+10 t/ha PM	2.61d	2.75e	2.68	1610d	1703d	1657	1.55d	1.72c	1.64
YY+20 t/ha PM	2.88c	3.02d	2.95	1962bc	2002c	1982	1.85b	1.99b	1.92
YY+30 t/ha PM	3.20ab	3.33ab	3.27	2201a	2304a	2253	2.18a	2.20a	2.19
YY+40 t/ha PM	3.00bc	3.22bc	3.11	2113ab	2215ab	2164	2.15a	2.19a	2.17
SE ±	0.27	0.32		217.3	227.2		0.21	0.23	

Values with the same superscript in a column are not significantly different at P = 0.05, according to Duncan's multiple range test.

WY = White yam; YY = Yellow yam; PM = Poultry manure

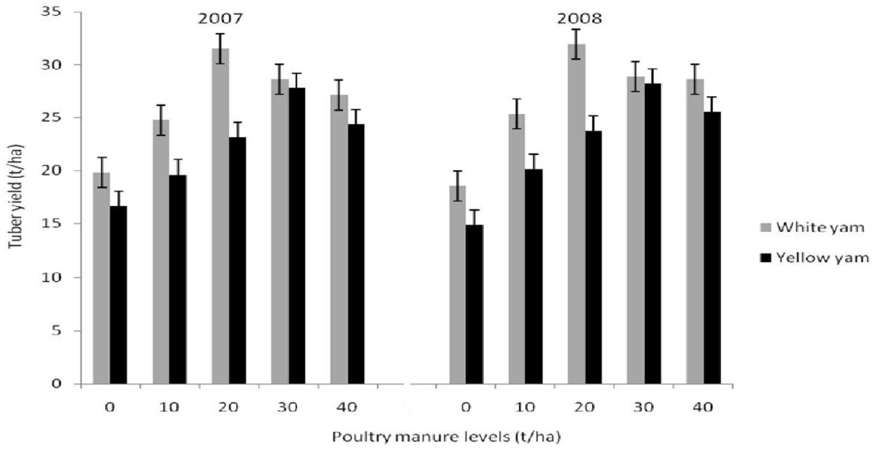

Fig. 1. Effect of poultry manure on tuber yield of white yam and yellow yam in 2007 and 2008 cropping seasons. Vertical bars show standard errors of paired comparisons

DISCUSSION

The increase in soil and leaf N, P, K, Ca and Mg and soil OM contents, due to the application of poultry manure, was consistent with the use of poultry manure for improving soil nutrient status and crop production (Adeniyan and Ojeniyi 2005; Agbede and Ojeniyi 2009; Adekiya and Agbede 2009). Soil and leaf N and P contents increased with increase in the amount of poultry manure up to 40 t/ha in both species, while soil and leaf K, Ca and Mg only increased up to 20 t/ha PM in white yam and up to 30 t/ha PM in yellow yam and thereafter decreased. The decrease in soil and leaf K, Ca and Mg above 20 t/ha PM for white yam and 30 t/ha PM for yellow yam could be due to nutrient imbalance. It was suggested that the application of poultry manure rich in N and P above crop requirements could cause a build up of N and P in the soil and thereafter reduce the uptake of other nutrients (Eghball 2002; Adekiya and Agbede 2009).

The increase in vine length, number of leaves, leaf area and tuber yield in the two species, caused by poultry manure treatments over the control could be attributed to increased availability of soil OM, N, P, K, Ca and Mg contents due to the manure. All these nutrients are known to enhance yam productivity. The increase in growth and tuber yield of the two species in the second year by the poultry manure treatments, compared with their control treatments, could be adduced to their high residual effects on soil fertility and structure which were able to sustain two successive crops of yam in this study. The increase in growth and yield up to 20 t/ha PM for white yam and 30 t/ha PM for yellow yam was consistent with their leaf nutrient contents at these manure levels, suggesting that the application of poultry manure above these amounts will be a waste. These results could be due to relatively high soil K recorded for the two species at these poultry manure levels. Yam performance is known to be strongly influenced by K (Obigbesan 1981; Akanbi and Ojeniyi 2007). Sobulo (1972) reported that a yam yield of 29 t/ha removed 133, 10 and 85 kg/ha of N, P and K, respectively, from the soil. An average yam yield of 11 t/ha removed 38.6 kg N, 3.0 kg K and 0.7 kg Ca per ha in another location (Okigbo 1980). These results showed that N and K are critical elements highly demanded by the yam crop.

The attainment of optimum level of poultry manure at 20 t/ha by white yam and 30 t/ha by yellow yam suggested that yellow yam required a higher rate of poultry manure for the attainment of economic production compared with white yam. The significantly higher growth and yield of white yam than yellow yam indicated the higher efficiency of white yam in using the soil nutrients than the yellow yam.

CONCLUSION

Poultry manure applied at 10-40 t/ha increases soil and leaf N, P, K, Ca and Mg and soil OM, growth and yield of both white yam and yellow yam. Within the same conditions of growth, white yam produces significantly higher yield compared with yellow yam. Poultry manure applied at 20 t/ha and 30 t/ha improves growth and tuber yield of white yam and yellow yam, respectively, when compared with other poultry manure levels. Higher rates of poultry manure applied above these levels have no significant yield advantage. These levels of poultry manure are, therefore, recommended for sustainable production of the two yam species on both small-scale and commercial basis. Recommendations of manure for yam production should be variety specific.

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تاثير سماد الدواجن على خصوبة التربة ونمو وانتاجية اليام الأبيض والأصفر

ت.م.أجبيدى[1]* و ا.و. اديكيا[2]

[1]قسم التكنولوجيا الزراعية معهد رفوس غيوا ص.ب1019 أوو،ولاية أندو- نيجيريا

[1]*البريد الاكترونى agbedetaiwomichael@yahoo.com

[2]قسم المحاصيل والتربة وادارةالافات،الجامعة الفدرالية للتكنولوجيا، ص.ب 704 أكورى- نيجيريا

المستخلص : اجريت تجربتان حقليتان فى اوو جنوب غرب نيجيريا خلال موسمى 2007 و2008 لدراسة تاثير خمسة مستويات(صفر،10، 20،30، 40 طن/هكتار) من سماد الدواجن على خصوبة التربة والمحتوى الغذائى للورقة والنمو والانتاجية من الدرنات لنوعين من اليام. وزعت المعاملات عامليا فى نظام كامل العشوائية بثلاثة مكررات. كانت التربة فقيرة فى المادة العضوية والنيتروجين الكلى والفوسفور المتاح والبوتاسيوم الكالسيوم والمغنسيوم. أوضحت النتائج أن سماد الدواجن ادى إلى زيادة نيتروجين التربة والورقة والفوسفور والبوتاسيوم والكالسيوم والمغنسيوم والمادة العضوية في التربه إضافة للنمو والإنتاجية من الدرنات. أعطى اليام الابيض انتاجية أعلى معنويا من اليام الأصفر حيث بلغت أعلى زيادة فى عدد الدرنات 19% 26% 36% و3% و 12% عندما سمدا بصفر و10 و20 و30 و40 طن/هكتار من سماد الدواجن، على التوالى. إضافة السماد بمستوى 20 و30 طن/هكتار ادت الى تحسين معنوى فى النمو والانتاجية من الدرنات فى نوعي اليام الاصفر والابيض، على التوالى، مقارنة بالمعاملات الاخرى. لذلك يوصى باضافة هذين المستويين لتحسين إنتاجية نوعي اليام في جنوب غرب نيجيريا، كما يوصى بأن يكون مستوى الإضافة حسب الصنف.