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Full Length Research Paper

Growth of cocoa (*Theobroma cacao L.*) seedlings on old cocoa soils amended with organic and inorganic fertilizers

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A greenhouse study was conducted for six months to investigate the response of cocoa seedlings to organic and inorganic fertilizers. The treatments were cocoa pod husk (CPH), kola pod husk (KPH), nitrogen (N), phosphorus (P), potassium (K), N + P, N, CPH +N, CPH +NP, CPH + NPK, KPH + N, KPH + NP, KPH + NPK and control. The mineral fertilizers were applied at the rate of 10 kg N ha^{-1} while the organic fertilizers (CPH and KPH) were at the rate of 2.5 t ha^{-1} and the combination of the two in 5 kg soil arranged in completely randomized design (CRD) replicated three times. The seedlings were regularly watered and data were collected on growth parameters. The performance of cocoa seedlings across the two locations as demonstrated by the results show that CPH and KPH could be used as sources of nutrient. However, these materials are not sufficient to meet the nutritional demand of the crop, hence, their is need for fortification with mineral fertilizer. CPH and/or KPH fortified with mineral fertilizers will aid the growth of cocoa seedling on old cocoa soil irrespective of the location. The percentage germination of the cocoa seedling was enhanced by the use of this organic material 73 and 95% for Ibadan and Mayo-Selbe, respectively. The treatment had a positive effect on the nitrogen level of the soil as CPH (8.14) and is slightly higher than NPK (6.99).

Key words: Cocoa pod husk (CPH), kola pod husk (KPH), cocoa plantation, cocoa seedlings, soil amelioration, fertilizers.

INTRODUCTION

Cocoa (*Theobroma cacao L.*) is one of the outstanding cash crops in Nigeria. Therefore, there is need to intensify its production through increased land area cultivated and per hectare yield through rehabilitation of old and non-producing cocoa plantations. In attempt to increase the hectarage of cocoa farms with the aim of increasing supply to the world market, farmers make do with the rehabilitation of old cocoa farms most of which are currently moribund. This is likely to continue since reserves of suitable soil no longer exist and future cocoa plantings are likely to be on soils which have already been exploited. Ogunlade (2008) suggested replanting of cocoa seedlings under old cocoa trees which serves as the shade for the young ones. However, soils under old cocoa plantation are depleted in nutrients as a result of continuous harvest without fertilizer application. Although, cocoa plants require adequate supply of N, P, K, Ca and Mg for optimal growth and good pod yield, they are often not supplied due to poor extension services and scarcity of fertilizers. This usually results to abandonment of most cocoa farms.

Cocoa pod husk which often constitutes a barrier to farm sanitation has been reported by many researchers (Adeyanju et al., 1975; Egunjobi, 1975; Oladokun, 1986) to be rich in nutrients. About 60% (wet basis) of cocoa pod is made up of husk. It is estimated that annually about 8,000,000 tons of cocoa pod husk are discarded

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during harvesting (Oguntuga, personal communication). With the work of Agbede and Kalu (1995), these husks have been suggested as possible source of fertilizer for the resource poor farmers. Therefore, the objectives of this study were to: (i) evaluate the possibility of rehabilitating declining cocoa soil for replanting of young cocoa plants, (ii) assess the possibility of using cocoa pod husk (CPH) and kola pod Husk (KPH) as fertilizer sources of raising young cocoa plants and, (iii) determine whether enrichment of these organic materials with mineral fertilizers (NPK) will strengthen their use as source of soil nutrients.

MATERIALS AND METHODS

The experiment was conducted in the greenhouse of the Cocoa Research Institute of Nigeria (CRIN), headquarters, between latitude 07° 10' N and longitude 03°52' E lying on an altitude 122 m above sea level, kilometer 14, idi-Ayunre Ijebu-Ode road located at the South-eastern end of Ibadan city for six months. Soils under old cocoa plantation from two different locations: CRIN headquarters, Ibadan in Oyo State and CRIN substation at Mayo-Selbe in Taraba state (lat.07°8' N and long 11°E at about 130 m above sea level) were collected. The soils were air dried, crushed and sieved through a 2 mm sieve. Bulk soil in each location was properly mixed to ensure homogenous soil and 5 kg soil was weighed into each perforated plastic pot of six liters capacity leaving some space for watering and then placed on a plastic water retainer. Organic materials used included cocoa pod husk (CPH) and kola nut pod husk (KPH) from *Cola nitida*. They were collected from the fermentary unit of CRIN, Ibadan during the dry season, sun dried and milled into powder to pass through 4 mm sieve separately, added immediately and watered. Two beans of fresh Amazon cocoa were directly sown into each of the pots. Watering was done regularly early in the morning to filed capacity, the seedlings were later thinned to one plant per pot at one month after planting (MAP) and Urea (N) single super phosphate (P) murate of potash (K) which are inorganic fertilizers were applied. CPH and there combination with organic base material as CPH + N, CPH + NP, CPH + NPK, KPH + N, KPH + NP, KPH + NPK and absolute control making a total of 12 treatments and replicated three times for the two locations making a total of 72 pots. A complete randomized design with factorial arrangement with two factors fertilizer types (12) and locations (2) was used. The inorganic fertilizers were added at the rate of 10 kg/ha and 2.5 t/ha for the organic materials.

The following growth measurements were taken at one month interval for 6 months: height, stem girth, number of leaves and leaf area this was determined by measuring the leaf length and breath. At the end of six months, the plants were harvested by carefully removing the whole plant from the soil and separated into leaves, stem and root. They were oven dried at 70°C till constant weight was attained, milled and sieved (0.5 mm). The materials obtained were then analyzed for their macro and micro nutrient content. The soil before planted were air-dried, crushed and sieved to pass through a 2 mm sieve after which they were analyzed. The following analyses were carried out: particle size analysis was determined using the hydrometer method as described by Bouyoucos (1962). pH was determined in water (1: 1 soil: water ratio) using pH meter with glass electrode. Total Nitrogen was determined using macro Kjeldahl procedure as described by Jackson (1965). Organic carbon content was determined using the Walkley- Black method (Nelson and Sommers, 1982). Phosphorus determination was done by the Bray-1 method described by Bray and Kurtz (1945). Exchangeable K, Ca, Mg and Na were determined by extraction with 1 N ammonium acetate and the amount of K and Na in the filtrate were determined using flame photometer while Mg and Ca were determined using perkin elmer Atomic Absorption Spectrophotometer (AAS). Micro- nutrients- Cu, Fe, Zn and Mn were determined after extraction of the soil sample with 0.1N HCl and the filtrate read on AAS. Exchangeable acidity was determined by soil extraction with 1 N KCl and titration with 0.05 N NaOH using phenolphthalein indicator as outlined in IITA (1979). The plant materials were digested using the nitric and perchloric acids wet digestion method by weighing 0.5 g of plant samples into a digestion beaker and 5 ml of nitric and 2 ml of perchloric acid added. 2 ml of sulphuric acid was also added to ensure that the digest did not dry up under fume cupboard. After the digest had cooled down, it was transferred to a 100 ml volumetric flask and made up to mark with distilled water. From the digest: P was determined colomerically using the Vanado-Molybdate method, K was determined using flame photometer while Ca, Mg and Cu, were determined using AAS. Nitrogen in the plant samples was determined using Kjeldahl procedure.

RESULTS AND DISCUSSION

The soil sampled from Ibadan was classified as Alfisol (Obatolu, 1991) and formed from igneous rocks of the basement complex (Smyth and Montgomery, 1962) while the soil sampled from Mayo-Selbe was classified as an Ultisol and was formed from basement complex. The texture of both Ibadan and Mayo-Selbe soils were sandy loam and loamy sand, respectively. The soil of Ibadan has higher clay content than Mayo-Selbe soil (16.2 and 8.4 g/kg, respectively). Both soils were acidic, though, Mayo-Selbe is more acidic than Ibadan soil with the value of 6.4 and 5.3 for Ibadan and Mayo-Selbe respectively. This agrees with the findings of both Obatolu (1991) and Ogunlade (2008) who had separately worked with these soils before. Ibadan soil contained higher organic carbon and nitrogen than Mayo-Selbe soil though, both are relatively low. The soil of Mayo-Selbe was adequate in phosphorus while Ibadan soil has very low P (Table 1).

Table 2 shows that there was no significant difference in the use of inorganic fertilizers as compared with the control in height values. The use of CPH and KPH alone and its combination with inorganic fertilizer were generally superior to the control and inorganic fertilizer used alone. Also, both CPH and KPH combined with NPK fertilizer produced the tallest plants at 6 MAP. However, the first 2 months of the cocoa seedlings on the Mayo-Selbe soil shows that combined use of organic and inorganic fertilizer produced the tallest plants relative to sole use of inorganic and the control. At 6 MAP, Table 2 showed that plants with CPH were averagely taller than those with KPH 36.5 and 41.0 cm, respectively.

The stem girth of cocoa seedlings (Table 3) in both Ibadan and Mayo-Selbe soils were enhanced by various inorganic fertilizer treatments applied, especially, the mixture of organic and inorganic fertilizer. Cocoa seedling stem girth at 6 MAP was not statistically different in their response to fertilizer materials used for soil from the two locations. The relatively adequate phosphorus level in the

Table 1. Pre-cropping physical and chemical properties of soils at the two experimental sites.

Soil property	Ibadan	Mayo-selbe
pH	6.4	5.3
Organic carbon(g/kg)	15.2	11.7
N(g/kg)	0.7	0.5
Available P(mg/kg)	3.6	15.4
Exchangeable cation (cmol/kg)		
K	0.0	0.0
Ca	1.8	0.3
Mg	0.3	0.1
Na	0.0	0.0
Exchangeable acidity(cmol/kg)	0.3	0.5
Exchangeable micronutrient (mg/kg)		
Zn	8.6	0.8
Cu	11.2	1.6
Mn	450	91
Fe	142	157
Particle size distribution (g/kg)		
Sand	764	844
Silt	74	72
Clay	162	84
Texture (USDA)	Sandy loam	Loamy sand
Smyth and Montgomery (1962)	Alfisol	Ultisol

Table 2. Effects of organic and inorganic fertilizers on cocoa seedlings height (cm) for Ibadan and Mayo-Selbe soils.

Variable	2 MAP		4 MAP		6 MAP	
	Ibadan	Mayo	Ibadan	Mayo	Ibadan	Mayo
Control	13.2^{ab}	9.5^{ab}	29.5^{b}	21.0^{bc}	43.5^{a}	37.0^{bc}
N	14.0^{ab}	6.5^{ab}	30.5^{b}	15.5^{c}	39.5^{a}	17.0^{c}
NP	3.5^{b}	10.4^{ab}	13.5^{c}	20.0^{bc}	29.0^{a}	48.0^{ab}
NPK	22.5^{a}	5.5^{ab}	27.0^{bc}	15.0^{c}	30.0^{a}	41.0^{ab}
CPH	14.0^{ab}	3.4^{b}	26.3^{bc}	17.3^{bc}	41.0^{a}	27.5^{bc}
CPH+N	21.0^{ab}	22.0^{a}	30.0^{b}	37.0^{a}	40.0^{a}	48.0^{ab}
CPH+NP	19.8^{ab}	19.4^{ab}	29.4^{b}	31.0^{ab}	32.8^{a}	63.5^{a}
CPH+NPK	14.3^{ab}	18.5^{ab}	33.0^{ab}	28.5^{abc}	53.0^{a}	37.0^{bc}
KPH	17.0^{ab}	17.0^{ab}	24.8^{bc}	28.5^{abc}	36.5^{a}	46.5^{ab}
KPH+N	24.5^{a}	19.5^{ab}	47.0^{a}	10.0^{ab}	58.0^{a}	48.0^{ab}
KPH+NP	12.0^{ab}	14.5^{ab}	29.0^{b}	29.0^{abc}	41.0^{a}	35.3^{bc}
KPH+NPK	8.3^{ab}	8.5^{ab}	26.0^{bc}	30.0^{ab}	59.0^{a}	37.0^{bc}

N = Nitrogen, NP = Nitrogen + phosphorous, NPK = Nitrogen, phosphorous and potassium, CPH = Cocoa pod husk, KPH = Kola pod husk, NS = Not significant. Means in the same column followed by the same letters are not significantly different by DMRT at $P<0.05$.

Table 3. Effect of organic and inorganic fertilizers on the stem girth (cm) of cocoa seedlings on Ibadan and Mayo-selbe soils.

Treatments	2 MAP		4 MAP		6 MAP	
	Ibadan	Mayo	Ibadan	Mayo	Ibadan	Mayo
Control	2.1^{abc}	1.3^{a}	2.8^{a}	1.9^{bc}	2.8^{a}	2.5^{a}
N	1.2^{d}	1.3^{a}	1.5^{b}	1.3^{c}	2.2^{a}	2.1^{a}
NP	1.2^{d}	1.5^{a}	2.2^{ab}	2.4^{abc}	2.5^{a}	2.9^{a}
NPK	1.9^{abc}	1.5^{a}	2.5^{a}	2.3^{abc}	2.5^{a}	2.2^{a}
CPH	2.0^{abc}	1.6^{a}	2.3^{ab}	1.7^{bc}	2.8^{a}	1.9^{a}
CPH+N	2.6^{a}	2.0^{a}	2.4^{ab}	3.6^{a}	2.8^{a}	3.3^{a}
CPH+NP	1.9^{bc}	1.5^{a}	2.4^{a}	2.4^{abc}	2.0^{a}	3.1^{a}
CPH+NPK	1.7^{bcd}	1.8^{a}	2.3^{ab}	3.8^{ab}	3.1^{a}	3.2^{a}
KPH	1.9^{abc}	1.7^{a}	2.4^{ab}	2.8^{abc}	2.4^{a}	2.9^{a}
KPH+N	2.2^{ab}	1.8^{a}	2.4^{ab}	3.1^{ab}	3.1^{a}	3.3^{a}
KPH+NP	1.8^{bcd}	1.8^{a}	2.7^{a}	3.8^{ab}	2.9^{a}	2.6^{a}
KPH+NPK	1.5^{cd}	1.5^{a}	2.5^{a}	2.2^{abc}	3.1^{a}	2.0^{a}

N = Nitrogen, NP=Nitrogen + phosphorous, NPK=Nitrogen, phosphorous and Potassium, CPH=Cocoa Pod Husk, KPH = Kola Pod Husk, NS = Not significant. Means in the same column followed by the same letters are not significantly different by DMRT at P<0.05.

Table 4. Effects of fertilizer on macro nutrients uptake (mg/plant) of cocoa seedlings in Ibadan.

Treatment	Leaf					Stem					Root				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Control	7.78^{a}	0.14^{a}	1.28^{a}	1.24^{a}	0.33^{a}	8.56^{a}	0.13^{a}	1.9^{a}	2.12^{a}	0.43^{a}	7.78^{a}	0.14^{a}	0.94^{a}	0.29^{a}	0.4^{a}
N	7.00^{a}	0.20^{a}	1.76^{a}	0.81^{a}	0.47^{a}	7.52^{a}	0.37^{a}	1.94^{a}	3.04^{a}	0.91^{a}	6.64^{a}	0.29^{a}	1.13^{a}	0.46^{a}	0.45^{a}
NP	8.20^{a}	0.17^{a}	1.90^{a}	1.28^{a}	0.56^{a}	7.88^{a}	0.26^{a}	0.90^{a}	2.69^{a}	1.02^{a}	5.29^{a}	0.08^{a}	0.98^{a}	0.29^{a}	0.28^{a}
NPK	7.00^{a}	0.24^{a}	1.95^{a}	1.14^{a}	0.67^{a}	6.85^{a}	0.18^{a}	2.49^{a}	3.86^{a}	0.62^{a}	7.11^{a}	0.16^{a}	1.18^{a}	1.11^{a}	0.53^{a}
CPH	8.09^{a}	0.16^{a}	1.94^{a}	0.77^{a}	0.48^{a}	8.14^{a}	0.29^{a}	1.96^{a}	1.98^{a}	0.64^{a}	8.20^{a}	0.16^{a}	1.46^{a}	0.42^{a}	0.50^{a}
CPH+N	7.72^{a}	0.16^{a}	1.46^{a}	0.68^{a}	0.44^{a}	7.26^{a}	0.18^{a}	1.14^{a}	2.84^{a}	0.76^{a}	6.90^{a}	0.18^{a}	1.29^{a}	0.40^{a}	0.50^{a}
CPH+NP	5.76^{a}	0.66^{a}	1.55^{a}	1.28^{a}	0.85^{a}	6.22^{a}	0.38^{a}	1.37^{a}	2.90^{a}	0.94^{a}	6.74^{a}	0.26^{a}	1.21^{a}	1.22^{a}	0.61^{a}
CPH+NPK	6.22^{a}	0.21^{a}	2.04^{a}	0.79	0.55^{a}	5.81^{a}	0.14^{a}	1.76^{a}	2.63^{a}	0.59^{a}	6.90^{a}	0.14^{a}	1.98^{a}	0.57^{a}	0.57^{a}
KPH	7.37^{a}	0.14^{a}	1.22^{a}	0.68^{a}	0.44^{a}	7.26^{a}	0.23^{a}	1.08^{a}	2.44^{a}	0.58^{a}	5.03^{a}	0.06^{a}	0.94^{a}	0.44^{a}	0.39^{a}
KPH+N	6.33^{a}	0.26^{a}	1.84	0.80^{a}	0.46^{a}	6.33^{a}	0.11^{a}	1.84^{a}	0.71^{a}	0.63^{a}	7.05^{a}	0.13^{a}	1.47^{a}	0.59^{a}	0.54^{a}
KPH+NP	7.26^{a}	0.10^{a}	1.89^{a}	0.86^{a}	0.53^{a}	7.78^{a}	0.27^{a}	1.36^{a}	4.37a	1.11^{a}	7.78^{a}	0.13^{a}	1.95^{a}	1.81^{a}	1.21^{a}
KPH+NPK	7.21^{a}	0.15^{a}	1.13^{a}	0.80^{a}	0.35^{a}	6.17^{a}	0.14^{a}	1.08^{a}	1.91^{a}	0.52^{a}	6.90^{a}	0.12^{a}	1.74^{a}	0.35^{a}	0.43^{a}

N = Nitrogen, NP = Nitrogen + phosphorous, NPK = Nitrogen, phosphorous and Potassium, CPH = Cocoa pod husk, KPH = Kola pod husk. Means in the same column followed by the same letters are not significantly different by DMRT at P < 0.05.

soil of Mayo-Selbe suggests that the P fixing sites in these soils are saturated. The yearly burning that occurs in this area may be responsible for phosphorus accumulation in this soil. Although, K, Ca, Na and Mg content of Ibadan soil were higher than that of the Mayo-Selbe soil, they were both still very low in their exchangeable cations. Tables 4 and 5 showed that there was no clear difference in the rate of assimilation and partitioning of nutrient in the cocoa seedlings of soil from the two sites.

However, a close look at Table 4 reveals that the nutrients uptake was slightly aided by the mineral fertilizer especially, complete fertilizers and was better when the organic materials were fortified with these mineral fertilizers. The same trend was observed for their micro-nutrient content except for the Fe which is slightly higher in Mayo-Selbe soil than Ibadan soil. Tables 4 and 5 showed that there was no clear difference in the rate of assimilation and partitioning of nutrient in the cocoa seedlings of soil from the two sites. However, a close look at Table 4 reveals that the nutrients uptake was slightly aided by the mineral fertilizer especially complete fertilizers and was better when the organic materials were fortified with these mineral fertilizers.

Table 5. Effects of fertilizer on macro nutrients uptake (mg/plant) of cocoa seedlings in Mayo-Selbe.

Treatment	Leaf					Stem					Root				
	N	P	K	Ca	Mg	N	P	K	Ca	Mg	N	P	K	Ca	Mg
Control	7.78[a]	0.07a	1.22a	0.33[a]	0.34[a]	7.26[a]	0.32[a]	1.31[a]	1.77[a]	0.41[a]	8.09[a]	0.05[a]	2.44[a]	0.46[a]	0.55[a]
N	7.21[a]	0.17a	1.32a	0.96[a]	0.46[a]	7.99[a]	0.18[a]	0.61[a]	1.25[a]	0.56[a]	5.55[a]	0.19[a]	1.09[a]	0.26[a]	0.55[a]
NP	6.22[a]	0.21a	1.57a	0.51[a]	0.34[a]	6.22[a]	0.33[a]	2.73[a]	1.78[a]	0.44[a]	5.71[a]	0.23[a]	0.98[a]	0.22[a]	0.30[a]
NPK	6.74[a]	0.51a	1.93a	0.86[a]	0.57[a]	7.68[a]	0.51[a]	2.16[a]	1.43[a]	0.62[a]	7.88[a]	0.49[a]	1.41[a]	0.18[a]	0.44[a]
CPH	6.38[a]	0.12[a]	1.34[a]	0.48[a]	0.39[a]	6.33[a]	0.11[a]	0.86[a]	0.18[a]	0.34[a]	5.97[a]	0.54[a]	3.84[a]	0.55[a]	0.62[a]
CPH+N	6.48[a]	0.21[a]	1.10[a]	0.60[a]	0.42[a]	6.69[a]	0.22[a]	2.59[a]	1.65[a]	0.65[a]	6.48[a]	0.18[a]	1.29[a]	0.18[a]	0.46[a]
CPH+NP	8.92[a]	0.18[a]	1.55[a]	0.35[a]	0.34[a]	7.94[a]	0.23[a]	2.06[a]	1.74[a]	0.37[a]	7.57[a]	0.17[a]	2.00[a]	0.33[a]	0.46[a]
CPH+NPK	6.33[a]	0.16[a]	1.14[a]	0.70[a]	0.31[a]	5.39[a]	0.26[a]	1.90[a]	1.57[a]	0.65[a]	6.84[a]	0.21[a]	0.89[a]	0.11[a]	0.43[a]
KPH	7.52[a]	0.13[a]	1.04[a]	0.34[a]	0.26[a]	7.00[a]	0.16[a]	1.50[a]	1.04[a]	0.52[a]	7.52[a]	0.15[a]	0.94[a]	0.07[a]	0.25[a]
KPH+N	8.04[a]	0.20[a]	1.93[a]	0.46[a]	0.49[a]	6.69[a]	0.22[a]	1.95[a]	1.16[a]	0.57[a]	6.48[a]	0.19[a]	1.14[a]	0.25[a]	0.45[a]
KPH+NP	6.59[a]	0.16[a]	1.32[a]	0.40[a]	0.34[a]	6.48[a]	0.17[a]	1.54[a]	1.29[a]	0.54[a]	7.00[a]	0.13[a]	0.69[a]	0.05[a]	0.23[a]
KPH+NPK	7.52[a]	0.17[a]	4.66[a]	0.46[a]	0.48[a]	7.26[a]	0.27[a]	1.56[a]	2.30[a]	0.55[a]	5.24[a]	0.62[a]	0.98[a]	0.20[a]	0.51[a]

N = Nitrogen, NP = Nitrogen + phosphorous, NPK = Nitrogen, phosphorous and Potassium, CPH = Cocoa pod husk, KPH = Kola pod husk. Means in the same column followed by the same letters are not significantly different by DMRT at P<0.05.

REFERENCES

Adeyanju SA, Ogutuga DBA, Ilori JO, Adegbola AA (1975). Cocoa pod in maintenance rations for sheep and goats in the tropics. Nutri. Reports Int., 11: 351- 357.

Bouyoucos CJ (1962). Hydrometer method: Improved for mechanical analysis of soil. Agron. J., 54: 465-467.

Bray RA, Kurtz LT (1945). Determination of total organic and available forms of phosphorus in soils. Soil Sci., 59: 39-45.

IITA (1979). International Institute of Tropical Agriculture Annual Report for 1992. Ibadan, Nigeria. Series No 1 In. Soil Science and Plant Analysis, 15: 461-475.

Jackson ML (1965). A.S.A. Monograph Methods of soil analysis, 9: 45.

Nelson DW, Sommers LE (1982). Organic carbon and soil extracts. In: Methods of soil analysis. Part 2- Chemical and microbiological properties. Agronomy Monograph No.9 (2nd Edition). American society of Agronomy, Soil Science society of America. Madison, WI, USA., pp. 539-579.

Obatolu CR (1991). Growth and nutrient uptake of coffee (coffee spp) seedlings grown on different organic materials. PhD.thesis Dept. of Agronomy. University of Ibadan, Nigeria.

Ogunlade MO (2008). Seedling establishment under old cocoa plantation using neem-fortified cocoa pod husk fertilizer at Ibadan and Owena, South Western Nigeria. Ph.D. Thesis Dept. of Agronomy. University of Ibadan, Nigeria.

Oladokun MAO (1986). Use of cocoa pod husk as fertilizer for maize production. Niger. J. Agron., 1(3): 103-109.

Smyth AJ, Montgomery RF (1962). Soils and land use in central western Nigeria. Western Nigeria Government Press. Ibadan. Nigeria, pp. 18-62.