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SOIL NUTRIENT DYNAMICS AND LEAF LITTER FALL UNDER KOLA (*Cola nitida*) PLANTATIONS IN IBADAN, NIGERIA

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ABSTRACT
A study was carried out to determine the leaf litter fall, their nutrient content and soil nutrient status under different kola plantations in Ibadan, Nigeria. Leaf litter quantity and their contribution to soil nutrient status were assessed. Three kola plantations were used for the study. Each plantation was divided into four blocks where leaf litter was collected. Leaf samples were taken from the kola plant, while soil samples were taken at 0-20cm, 20-40cm depth soil depth at the point where litter leaf was collected. Results indicated that kola generated 5.83-7.38t/ha of leaf litter across the three kola plantation. Leaf litter had a nitrogen content of 81.55kg/ha – 107kg/ha. The nitrogen content of the soil ranged between 1.6g/kg to 4.8g/kg, which was well above the soil nitrogen critical level of 0.9g/kg required for kola production. The potassium content of the leaf litter was low, ranging between 2.91kg/ha – 3.66kg/ha for the three kola plantation. This was reflected in the low soil potassium content of 0.15-0.18 cmol/kg soil. Calcium and magnesium were also limiting. Though kola leaf litter contributes considerable amount of nutrient, there is need for nutrient supplementation through guided fertilizer application to supplement the limiting nutrient.

KEYWORDS: Kola, Leaf litter, soil nutrient status

INTRODUCTION

Tree cropping has been found to be ecological sound, environmentally sustainable and economically profitable (Singh *et al.,* 1990). It increases soil organic matter and ensures efficient recycling of plant nutrients through leaf litter and plant turnover (Buresh and Tian, 1990).Leaf litter is an important component of tree cropping system. This is because it builds up on the forest floor and creates a layer of nutrient and litter on the soil. It is a major source of soil organic matter as it returns nutrients back to the soil through nutrient recycling. It reduces nutrient loss through leaching and erosion (Sunita and Uma, 1991). It also increases biological activities by providing biomass and suitable microclimate for various micro-organisms responsible for the release of mineral nutrients in available form to trees. It improves soil structure, water infiltration and water holding capacity of the soil. Lai (2002) reported that planting of perennial trees on degraded land in the tropic helps mitigate green house effect through carbon sequence. Therefore, planting tree species with high biomass production rich in foliar and plant nutrient is important in maintaining soil organic matter (Young, 1977).

Tree crops such as cocoa has been reported to generate 6-8.5tons of leaf litter/ha Ogunlade and Iloyanomon, 2009). Similarly, Salako and Tian (2005) reported 5-14 tons/ha/yr of leaf litter under different tree species in Ibadan, Nigeria.

Kola is an important economic cash crop to a significant population of Nigerians who are involved in kola farming, trading and for industrial use . Nigeria produces 70% of the world kolanut (Jacob, 1973). Kolanut the product of kola tree is used as masticatory stimulant by Africans and for ceremonious functions. It is also used in pharmaceutical industries and for the production of soft drinks, wine and candles (Oguntuga 1975). It is used as a base in the production of kola chocolate and wine (Famuyuwa, 1987).The high potassium content of the kola pod husk has lead to its use in production of liquid soap and fertilizer. Kola pod husk has also been used to replaced up to 60% of maize in poultry feed (Hamzat and Babatunde*,* 2001. Olubamiwa *et a*l., 2002).

Kola tree generates a lot of leaf litter and the loss of leaves occurs mainly during the dry season. This serves as a survival mechanism to prevent loss of water through the leaves, thus conserving scarce water. Despite the benefits of leaf litter, the amount of leaf litter generated under kola plantation and its contribution to soil nutrient status has not been adequately studied and documented, hence the need for this study. The objectives of this study are:

(i.) To quantity leaf litter under kola plantation.
(ii.) To determine the nutrient content of kola leaf litter.
(iii.) To determine soil and nutrient status under kola plantations.

MATERIALS AND METHODS

Study site

The study was conducted in Cocoa Research Institute of Nigeria (CRIN) headquarter in Ibadan, Nigeria (latitude 07^0 10^1N and longitude 03^051^1E) and on an altitude of 122 meters above sea level. CRIN is located in Idi-Ayunre, the South Eastern end of Ibadan city. Ibadan is a forest ecological zone with a bimodal rainfall of about 1300mm per annum. The dry season runs from early November to March, while the rainy season runs from March to October or early November with two weeks of dry spell in August. The maximum temperature ranges between 26^0C to 35^0C with an average of 30.1^0C and the minimum ranges between 26^0C to 35^0C with an average from 15^{0}C to 24^{0}C with an average of 19.5^{0}C. The soil is classified as an alfisol (Smyth and Montgomery, 1962).

Leaf litter and soil collection

Three kola plantations A, B, C were selected for this study. Each plantation was divided into four blocks. Leaf litter was collected using litter traps of 1m x 1m at distances of 10m apart. Six such spots were demarcated per block.

The leaf litter collected in each demarcated area of 1m^2 was put in bags and oven dried at 60^{o}C for 72 hours and dry mater weight of the litter taken. Leaf samples were taken from the kola plant, while soil samples were taken at 0-20cm and 20-40cm depth using a soil auger at the points at where leaf litter was collected.

Leaf litter and soil analysis

Representative samples from the leaf litter was taken milled and analyzed for Total N, P, K, Ca, Mg, Na, Mn, Fe, Cu, and Zn. Soil samples collected were air dried passed through a 2mm sieve and analyzed for some of their physical and chemical properties. Soil pH was determined in soil/water solution of 1:2:5 ratio (Thomas, 1996). Particle size analysis was determined by hydrometer method (Gee and Or, 2002) and soil texture determined by using a textural triangle. Organic carbon was determined by dichromate wet oxidation method by Walkey and Black (1934). Total Nitrogen was determined by Kjeldahl method. Available P determined by Bray-1 method (Bray and Kuntz, 1945) and P in the extract determined colorimetrically by molybdenum blue method.

Exchangeable bases (K, Ca, Mg, and Na) were extracted by reacting with ammonium acetate and K and Na in the filtrate determined using a flame photometer. Ca and Mg were read using an Atomic absorption spectrophotometer Exchangeable acidity was determined by filtration titration method. Cation exchange Capacity (CEC) was determined by summation of all cation and effective cation exchange capacity (ECEC) was by summation of exchangeable bases and acids.

Data collected was subjected to analysis of variance (ANOVA). Least significant differences (LSD) was used for mean separation, where differences were significant, at 5% level of probability.

TABLE 1: Physical and chemical properties of soils of different kola plantations in Ibadan, Nigeria.

	Soil depth (cm)					
	Plantation A		Plantation B		Plantation C	
Parameters	0-20	20-40	0-20	20-40	0-20	20-40
pH	5.6	5.7	5.9	5.7	6.2	6.1
Organic carbon (g/kg)	20.0	14.5	18.2	14.9	11.8	6.7
N(g/kg)	4.8	3.50	4.40	3.60	2.90	1.60
P(mg/kg)	8.11	7.16	12.88	15.96	6.20	3.82
K (cmol/kg soil)	0.15	0.16	0.18	0.18	0.15	0.18
Ca(cmol/kg soil)	1.24	1.31	1.52	1.33	1.25	1.55
Mg (cmol/kg soil)	0.71	0.75	0.81	0.72	0.60	0.81
Na (cmol/kg soil)	0.10	0.12	0.12	0.11	0.10	0.11
Exchangeable acidity(cmol/kg)	0.4	0.2	0.4	0.4	0.4	0.4
CEC (cmol/kg soil)	2.60	2.54	3.03	2.74	2.50	3.05
Base saturation (%)	84.62	92.13	86.80	85.40	84.0	86.89
Zn (mg/kg soil)	9.71	10.43	10.69	8.89	7.54	11.09
Cu(mg/kg soil)	35.9	38.8	40.1	29.2	5.2	37.9
Mn (mg/kg soil)	36.89	41.53	47.22	35.18	27.79	48.28
Fe (mg/kg soil)	21.53	27.49	31.08	24.77	20.86	32.42
Sand (g/kg)	632.0	712	712	792	772	672
Silt (g/kg)	214.0	234	214	154	174	254
Clay (g/kg)	154.0	54	74	54	54	74
Textural class	Sandy loam	Sandy loam	Sandy loam	Loamy sand	Loamy sand	Sandy loam

RESULTS

Soil physical and chemical properties are found in Table 1 The sand fraction of the soil ranged from 672-792g/kg (Table 1). The silt fraction ranged between 154-234g/kg, while the clay fraction ranged between 54-154g/kg .Except at 20-40cm and 0-20cm soil depth in plantation B and C respectively, which were loamy sand, all other soils are sandy loam. The soils of the kola plantations had a pH range of 5.6 - 6.20 , while organic carbon ranged between 11.8-20 g/kg for 0-20cm soil depth and 6.70-14.5 g/kg for 20-40cm soil depth.

Leaf litter generated ranged between 5.1-8.2tons/ha (Table 2)

TABLE 2: Weight of leaf litter (kg/ha) under different kola plantations.

Kola plantation	Mean weight tons/ha	Range tons/ha
A	7.3	5.1-8.2
B	7.4	7.2- 7.6
C	5.8	5.6-5.8
LSD	1.95	

with mean leaf litter production of 7.3tons/ha, 7.4tons/ha and 5.8tons/ha for plantations A, B and C respectively. Plantation B produced the highest amount of leaf litter, while plantation C produced the least. There was no significant difference between leaf litter generated in the different kola plantations.

The nitrogen content of the leaf litter ranged between 81.55-107.3kg N/ha (Table 3),

TABLE 3: Amount of nutrients (kg/ha) in kola leaf litter under different kola plantations in Ibadan, Nigeria

Plantation	N	P	K	Ca	Mg	Na	Mn	Fe	Cu	Zn
A	107.3	45.23	3.66	45.70	15.26	18.25	8.76	9.48	2.92	5.78
B	87.76	25.08	2.95	44.06	16.23	16,23	8.11	10.22	2.96	6.64
C	81.55	37.78	2.91	40.68	13.98	13.80	6.41	8.16	2.33	5.84
LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NS – Not significant

While the nitrogen content of the soil ranged between 1.61g/kg – 4.80g/kg (Table 1) with nitrogen content decreasing with increasing soil depth. The nitrogen content of the plant was 1.81-2.29% (Fig 1).

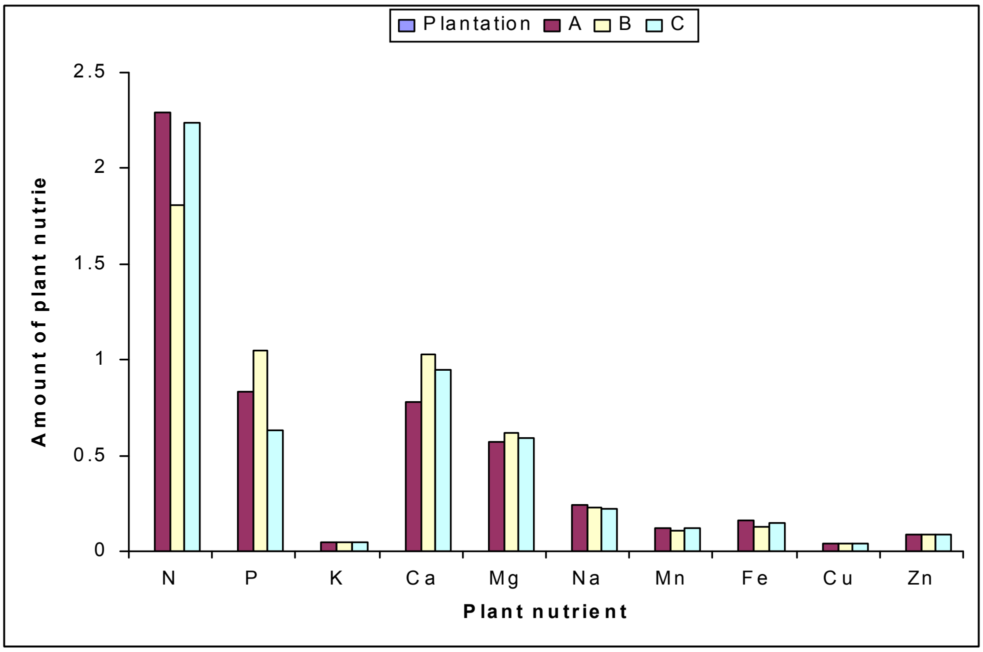

FIGURE 1: Amount of nutrient (%) in kola plant of different kola plantations in Ibadan Nigeria

There was no significant difference between nitrogen content of the soil (Table 1), kola plant (Fig 1) and leaf litter (Table 3) of the different kola plantations.

The phosphorous content of the leaf litter across the kola plantations ranged between 25.08-45.23kg/ha (Table 3), while the P content of the plant ranged between 0.63 – 0.83% (Fig 1). The P content of 0-20cm soil depth soil ranged between 6.2-12.88 mg/kg soil (Table 1) and the P content of the 20 – 40 cm soil depth ranged between 7.16 – 15.96kg/ha. There was no significant different between phosphorous content of leaf litter (Table 3), kola plant (Fig 1) and soil (Table 1) of the different kola plantations.

The potassium content of the leaf litter ranged between 2.91 -3.66 kg K/ha (Table 3), while the exchangeable K content of the soil ranged between 0.15-0.18cmol/kg soils for the different kola plantations (Table 1). The K content of the plant was 0.5% across the three kola plantations (Fig 1). There was no significant difference between potassium content of leaf litter (Table 3), kola plant (Fig 1) and soil (Table 1) of the different kola plantations.

Calcium and magnesium content of leaf litter in the kola plantations ranged between 40.68 – 45.70 kg/ha and 13.98- 15.26kg/ha respectively (Table 3), while soil calcium and magnesium content ranged between 1.24-1.55 Cmol/kg soil and 0.60-0.81 Cmol/kg soil respectively (Table 1). Similarly, calcium and magnesium content of the plant ranged between 0.04-1.03% and 0.57-0.62% respectively (Fig 1). There was no significant difference between the calcium and magnesium content of leaf litter (Table 3), kola plant (Fig 1) and soil (Table1) of the different kola plantations.

Sodium, manganese and iron content of leaf litter in the kola plantations ranged between 13.80 – 18.25kg/ha, 6.41-8.76kg/ha and 8.16-10.22kg/ha respectively (Table 3). Plant sodium, magnesium and iron content ranged between 0.22-0.24%, 0.11-0.12% and 0.13-0.16% respectively (Fig 1), while soil sodium, magnesium and iron content ranged between 0.1-0.12cmol/kg soil, 27.9-48.28mg/kg soil and 20.6-32.42mg/kg soil respectively (Table 1). There was no significant different between sodium, manganese and iron content of leaf litter (Table 3), kola plant (Fig 1) and soil (Table 1) of the different kola plantations.

Copper and Zinc in the leaf litter ranged between 2.3-2.96kg/ha and 5.70-6.64 kg/ha respectively (Table 3). Copper and Zinc content of the plant was 0.4% and 0.09% respectively (Fig 1). Soil copper and zinc content ranged between 5.2-40mg/kg soil and 7.54-11.09mg/kg soil respectively (Table 1). There was no significant different between copper and zinc content of leaf litter (Table 3), kola plant (Fig 1) and soil (Table 1) of the different kola plantations.

DISCUSSION

The soils of the kola plantations were slightly acidic with pH range of 5.6 - 6.20. This is within the acceptable pH range of 5-6 required for kola production. Organic carbon ranged between 11.8-20 g/kg for 0-20cm soil depth and 6.70-14.9 g/kg for 20-40cm soil depth. Except 20-40cm soil depth in plantation C the organic carbon of the soil was adequate for kola production.

Kola generated between 5.83-7.34 tons/ha of leaf litter. Similar observation was made by (Ogunlade and Iloyanomon, 2009) in Ibadan, Nigeria, who reported 6-8.6tons/ha leaf litter from cocoa plantations. Reports from other forest ecologies in Nigeria, has shown 7.5-7.8kg/ha leaf litter for Sapoba forest (Onweluzo, 1970), while Ola-Adams (1978) reported 5.6tons/ha and 7.3tons/ha for Ibadan and Onigambari forest respectively and 5-15 tons/ha/yr for seven trees species in Ibadan (Salako and Tian, 2005)

Nitrogen content of leaf litter (81.55 – 107kg/ha) was high. The high nitrogen content of the leaf litter was reflected in the high nitrogen content of the soil 1.6g/ha – 4.8g/kg. This was well above the soil critical level of 1g/kg required for kola production (Egbe *et al.,* 1989). The nitrogen content of the kola plant 1.81-2.29% was also above the nitrogen foliar critical level 1.09% required for kola production (Egbe *et al.,* 1989). Nitrogen in the leaf litter was therefore adequate to meet the nitrogen needs of kola tree.

Schroth *et al.* (1995) noted that soil nitrogen availability was closely related to litter fall of seven of the nine tree species studied, while Sunita and Uma (1993) reported that trees showed preferential enrichment of soils in terms of N, P, Ca, Mg and Na. Shukla (2009) noted that nutrient accumulated in the leaves return to the ecosystem through litter fall

and this is a major pathway of nutrient and energy transfer with nutrient uptake, their

retention and release being the three components of nutrient dynamics.

The phosphorous content of the leaf litter across the kola plantations was high (25.08-45.23kg/ha). This was reflected in the high P content 6.2-12.88 mg/kg of the soil. This was well above the soil critical level of 6mg/kg P required for kola production (Egbe *et al.*, 1989). Similar high P content was observed in the kola plant which was 0.83-1.05% and was above the foliar critical level 0.08% required for kola production. Phosphorous in the leaf litter was therefore adequate to meet the phosphorous requirement of

This was in contrast to the findings of Ogunlade and Iloyanomon (2009) who reported that leaf litter was inadequate to meet the P requirement of cocoa plant. Similarly, Ogunlade and Aikpokpodion (2006) reported low phosphorous status in cocoa soils in South Western Nigeria. This contrast to the present findings could be attributed to the fact that leaves from kola plant decomposes faster than cocoa plant because cocoa leaves are lignified, they decomposes very slowly (Ekanade, 1990). The phosphorous in kola leaf litter was therefore more readily available than in cocoa leaf litter.

The potassium content in the leaf litter was low (2.91 – 3.66g/kg). This is reflected in the low K content of the plant 0.05% which is far below the foliar critical level of 1.2% K required for kola production. This may not be unconnected with the low available K in the soil 0.15-0.18 cmol/kg soil which was well below the soil critical K level of 1.2Cmol/kg soil required by kola as reported by (Egbe *et al.,* 1989). This could be attributed to mining of K through the harvesting of kola pod husk without nutrient replenishment. Kola pod husk contains about 3.5% K and where method of harvesting of kola involves discarding of this pod husk without nutrient replenishment, there is mining of K from the plantations. Kola in these plantations received no nutrient supplementation in form of fertilizer. This is typical of kola plantations in Nigeria. This is of concern because K is important in fruiting of Kola and its deficiency and leads to decrease kola quality and yield. There is therefore need to replenish K lost from the kola plantation.

The calcium and magnesium were low. They were both below the soil critical level of 3 cmol/kg soil and 1.2 cmol/kg soil required for calcium and magnesium respectively. Lombin and Fayemi (1979) reported that some highly leached soils are near deficiently levels and requires magnesium fertilization. Serious magnesium deficiency was anticipated in Nigeria in the near future. Ipinmoroti *et al. (*2009) reported low magnesium in soils of some cocoa plantation in Ibadan, Nigeria. Similarly, Obatolu and Chude (1987) reported Mg deficiency in cocoa soils.

CONCLUSION

Kola generated 5.83-7.3tons/ha of leaf litter. Leaf litter contained considerable amount of nutrients. The N content of the leaf litter was sufficient for kola production, while the potassium, calcium and magnesium content of the leaf litter was insufficient to meet the nutrient requirement of kola. There is therefore need for guided fertilizer application to supply the deficient nutrient and enhance kola production.

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