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Nutrient accretion to the soil via litterfall and throughfall in *Acioa barteri* stands at Ozala, Nigeria

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Introduction

Nutrient accretion to the soil is primarily through litterfall, litter decomposition and precipitation (rainfall, throughfall and stemflow). Although N, P and Ca accrue to the soil mainly through litterfall with some net — throughfall and rainfall contributions, net — throughfall, however, accounts for most of K and Mg inputs to the soil [Parker, 1983]. Nutrients in litterfall are more slowly released into the soil from organic matter than those from throughfall which are either easily absorbed by plant or quickly leached away in the soil [Gosz et al., 1976; Parker, 1983]. Rapid decomposition of plant litter at the onset of the rainy season, however, usually enhances major increases in nutrient accumulation over a relatively short period [Swift et al., 1981].

In view of the importance of nutrient dynamics in the tropics, studies were undertaken to quantify the turn over from litterfall and throughfall under *Acioa barteri* stands in a bush fallow at Ozala, Nigeria. The results of such studies would, therefore, stress the need for the present resurgent interest in the biologically enriched bushfallow system of agroforestry and its variant, alley cropping, largely because of the scarcity and high cost of inorganic fertilizers in Nigeria and also because of the stability of these systems against soil erosion. This paper, therefore, summarizes the results of the nutrient inputs within this agroecosystem.

Materials and methods

a. *Site description.* Litter production and throughfall deposition under a seven year old, predominantly *A. barteri*, bush fall were studied at Ozala, some 18 km south-east of Nsukka, Anambra State of Nigeria. Ozala, like Nsukka (6°52′N, 7°24′E), lies within the derived savanna zone [Keay, 1959] and on an elevation of 474 m in a humid tropical site on a fine, sandy loam (an ultisol) belonging to the Nsukka series. The annual rainfall within this ecozone is 1600 mm, 90% in April–October, while the mean annual maximum and minimum temperatures are 30 °C and 22 °C, respectively.

b. *Experimental procedures.* Leaves, twigs and flowers/fruits of *A. barteri* litterfall were collected at Ozala for 52 weeks (26th May, 1985–24th May, 1986) in three blocks, each 0.25 ha, using ten 1 × 1 m litter traps per block. Each litter trap had 20cm deep sides and perforated, transparent plastic floors on the bottom. The traps were raised 20 cm above the ground and randomly located in the study site.

Throughfall was also studied at the same site and period, using in each block, ten 20 × 20 mm plastic collectors with 20 cm diameter polythene funnels randomly positioned underneath the canopies of *A. barteri* stands. Rainfall was also sampled with two plastic collectors, each 1 m above the ground in an open field adjacent to the bush fallow. Rainfall and throughfall collections, measured at monthly intervals, were stored for two weeks in a deep freezer at the laboratory of the Department of Crop Science, University of Nigeria, Nsukka.

Samples of each litter component were oven-dried at 70 °C for 48h and milled while throughfall and rainfall samples were filtered through Whatman No. 46 filter paper. Both plant and water samples were analysed for N, P, K, Ca and Mg at the Soils Laboratory of the National Root Crops Research Institute, Umudike. Nitrogen was determined by the micro-kjeldahl method, P by Bray No. 1, K by flame omission photometry and Ca and Mg by the ethyleme diaminetetra-acetic acid (EDTA) titration.

Nutrient concentrations in the litterfall components, rainfall and throughfall were used to compute for gross nutrient accumulation each nutrient pathway. The data obtained in this study were analysed statistically according to Steel and Torrie [1980].

Results

Table 1 summarises the nutrient concentrations in the leaf litter, rainfall and throughfall samples. Throughfall generally had higher mean values for all the

Table 1. Mean nutrient concentrations* of the leaf litter, rainfall and throughfall in *Acioa barteri* stands at Ozala, Nigeria.

Elements	Nutrient concentrations		
	Rainfall ($mg\ l^{-1}$)	Throughfall ($mg\ l^{-1}$)	Leaf litterfall ($mg\ g^{-1}$)
N	20.4 ± 1.4	53.1 ± 1.7	10.5 ± 1.5
P	51.3 ± 1.2	70.1 ± 2.6	2.2 ± 0.2
K	2.1 ± 0.5	5.7 ± 0.5	1.1 ± 0.1
Ca	6.8 ± 0.7	12.0 ± 1.1	6.8 ± 0.6
Mg	3.5 ± 0.5	3.6 ± 0.5	4.3 ± 0.6

* Sample size: Rainfall = 60; Throughfall = 60, Leaf litterfall = 72.

elements except Mg which had the same results in both water pathways. However, K had the least mean values in both the litter and water samples.

The nutrient additions to the soil under *A. barteri* stands at Ozala, Nigeria are shown in Table 2. Total and leaf litterfalls contributed the bulk of all the elements except P which was greatest in rainfall. Negative net-throughfall values were, however, obtained for Mg. Total nutrient additions to the soil at Ozala through litterfall and throughfall, as kg ha^{-1} yr^{-1}, were 134 N, 93 P, 22 K, 69 Ca and 46 Mg.

Discussion

Nutrient accretion to the soil from the aerial portions of trees and shrubs are through several pathways such as litterfall, rainfall, throughfall and stemflow. Although stemflow was not studied at Ozala, it is a minor component (about 12%) of the water-borne materials, with widely varying amounts among species and between storms [Parker, 1983; Reiners, 1972].

The results (Table 2) of litterfall as a major nutrient pathway at Ozala are similar to those of Edwards [1982] and Parker [1983]. Besides, the negative net-throughfall deposition values for Mg in this work are also similar to those of Jordan et al. [1980]. Magnesium accretion to the soil at Ozala is mainly through rainfall and litterfall. The net-throughfall depositions of N(10%) and

Table 2. Contributions+ of various nutrient pathways to inputs of elements (kg ha^{-1} yr^{-1}) in the soil under *A. barteri* stands at Ozala, Nigeria.

Element	Nutrient input (kg ha^{-1} yr^{-1})				Nutrient input (kg ha^{-1} yr^{-1})		
	Total litterfall*	Net-throughfall	Rainfall	Total	Leaf litterfall	Throughfall deposition	Total
N	89.6 ± 4.3 (67)**	13.6 ± 1.2 (10)	29.9 ± 1.5 (23)	133.1 (100)	67.5 ± 2.7 (61)	43.5 ± 2.2 (39)	111.0 (100)
P	22.4 ± 1.5 (24)	9.4 ± 2.1 (10)	62.0 ± 2.2 (66)	93.8 (100)	16.8 ± 0.9 (19)	71.4 ± 3.7 (81)	88.2 (100)
K	17.3 ± 1.7 (79)	2.4 ± 0.5 (11)	2.1 ± 0.4 (10)	21.8 (100)	7.0 ± 0.5 (61)	4.5 ±0.3 (39)	11.5 (100)
Ca	56.1 ± 2.6 (81)	1.9 ± 0.3 (3)	11.0 ± 0.6 (16)	69.0 (100)	48.4 ± 1.8 (79)	12.9 ± 0.8 (21)	61.3 (100)
Mg	40.4 ± 2.4 (89)	−0.4 ± 0.1 (−1)	5.5 ± 0.4 (12)	45.5 (100)	34.3 ± 1.4 (87)	5.0 ± 0.4 (13)	39.3 (100)

+ Sample size = Rainfall = 60, Throughfall = 60, Litterfall = 72.
* Total litterfall (9.8t ha^{-1} yr^{-1}) = Leaf (7.2t ha^{-1} yr^{-1}) + twig (1.0t ha^{-1} yr^{-1}) + flower/fruit (1.6t ha^{-1} yr^{-1}) litterfall.
** Percentage of total nutrient input (shown in brackets).

Table 3. Comparison of the nutrient concentrations (mg g^{-1}) in the leaf litter of *A. barteri* stands at Ozala, Nigeria with those from some tropical sites.

Location	Species/vegetation	Nutrient concentrations (mg g^{-1})					Sources
		N	P	K	Ca	Mg	
Ozala, Nigeria	*Acioa barteri* stands	10.5	2.2	1.1	6.8	4.3	Present study
Cunning, Mulu, Sarawak	a. *Ficus dubium*	10.2	0.7	5.0	56.6	2.1	Anderson et al. [1983]
	b. *Parashorea macrophyllum*	8.1	0.3	2.1	16.5	1.2	"
New Guinea	Montane forest	12.4	0.1	0.2	1.5	0.2	Edwards [1982]

Table 4. Nutrient depositions in throughfall at Ozala, Nigeria and other tropical locations.

Location	Species/vegetation	Throughfall deposition (kg ha^{-1} yr^{-1})					Sources
		N	P	K	Ca	Mg	
Ozala, Nigeria	*A. barteri* stands	43.5	71.4	4.5	12.9	5.0	Present study
Puerto Rico	Rainforests	−+	136.8	13.0	4.3	26.0	Jordan et al. [1972]
Panama	Tropical moist forests	−+	1.0	77.5	58.1	15.1	Golley et al. [1975]
Cote d'Ivoire	Valley forest	81.9	9.8	174.5	46.5	48.5	Berhnard-Reversat [1975]
Kade, Ghana	−+	26.4	4.1	−+	4.1	29.1	Nye [1961]

−+ = No available information.

Table 5. Litter fall (t ha^{-1} yr^{-1}) and nutrient returns (kg ha^{-1} yr^{-1}) at Ozala, Nigeria and some tropical locations.

Location	Species/vegetation	Litterfall (t ha^{-1} yr^{-1})	Nutrient Returns (kg ha^{-1} yr^{-1})					Sources
			N	P	K	Ca	Mg	
Ozala, Nigeria	*A. barteri* stands	9.8	89.6	22.4	17.3	56.1	40.4	Present study
Gambari, Nigeria	*Tectona grandis* (Monoculture)	9.0	90.9	10.0	71.0	188.0	21.6	Egunjobi [1974]
Trinidad	a. *Mora excelsa*	6.8	61.3	3.3	11.0	68.1	15.0	Cornforth [1970]
	b. Evergreen	7.0	56.0	2.4	10.5	57.4	14.7	"
Cote d'Ivoire	a. Mixed moist evergreen forest	12.6	170.0	8.0	27.8	60.5	50.7	Berhnard [1970]
	b. "	9.5	158.0	13.6	80.5	85.1	25.5	"

P(10%) at Ozala fall within the ranges obtained by Parker [1983] for N(0–15%) and P(10–20%). However, the contributions for K(11%), Ca(3%) and Mg(−1%) in this study were lower than those of Parker [1983]. The differences could be due to the type and age of the species/vegetation, amount of precipitation, location and site quality. Nutrient depositions in throughfall are closely related to the trophic level in the stand or forest [Parker, 1983]. The low K values and the negative net-throughfall depositions of Mg might be indices of K and Mg deficiencies in the soil at Ozala, Nigeria.

Tables 3 and 4 compare the nutrient concentrations in the leaf litter of, and throughfall depositions under *A. barteri* stands at Ozala and some tropical locations. The differences between the results in the tables might again be due to the reasons adduced earlier for K and Mg.

Nutrient returns from the total litterfall of *A. barteri* at Ozala are also compared with those from other tropical sites in Table 5. The results at Ozala compare favourably well with those from other locations, perhaps due to the high rate of total litterfall of *A. barteri.*

Litter production and nutrient cycling in agroforestry are important in crop nutrition. Oligotrophic system, to which most of the forests and derived savanna zones in Nigeria belong, is, according to Jordan and Herrera [1981], characterized by extremely acid and nutrient-poor soils which depend largely on the release of nutrients held in the living biomass for efficient cycling. This study, therefore, has emphasized the continued importance of the bush fallow system for efficient and cheap form of nutrient cycling with minimal dependence on costly fertilizers in a low technology, and low resource agriculture characteristic of many developing countries.

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