LITTERFALL, DECOMPOSITION AND NUTRIENTS RELEASE IN *VITEX DONIANA* SWEET. AND *VITEX MADIENSIS* OLIV. IN THE SUDANO–GUINEA SAVANNAH

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Abstract

Vitex doniana and *Vitex madiensis* are among the most valuable wild fruit trees of the populations of northern Cameroon. They wish to see them growing in their farmlands. A good knowledge on the quality and quantity of their litter production is a prerequisite for their domestication in the area. Litters were collected under trees in one square meter in four locations of the Adamawa savannah. The experimental unit consisted of four trees. The design was a Randomized Complete Blok with four replicates. The leaf litter was incubated in natural savannah, then retrieved after one, three, six and twelve months and analyzed in the laboratory for organic and mineral mater contents. The maximum of litter fall was produced in November for *V. doniana* and in mid-December for *V. madiensis*. Litter decomposition was faster in *V. doniana* than *V. madiensis*. The total leaf litter represented 81.42 % of the organic matter. The interspecific comparison shows that the quantity of the dry annual litter produced by *V. doniana* (190,71g /m^2/year) was greater than that of *V. madiensis* (81.98g/m^2/year). The low litter production observed in *V. madiensis* compared to that of *V. doniana* was compensated by its richness in NPK elements. As far as these bioelements are concerned, *V. madiensis* yielded an important source of K (1153.84mg/100g of D.M), Mg (1539,01 mg/100g of D.M) and of Na (443,42 mg/ mg/100g of D.M. During the decomposition, there was an accumulation of neutral detergent fibbers compared to sugar and phenol. In farming systems, these species can contribute to the improvement of the soil fertility, and therefore can be recommended for a domestication programme in the region.

Keywords: Wild fruit trees, litter, bioelements, soil fertility, domestication, homegardens

Guinea Savannah'da (Adamawa, Cameroon) *Vitex donina* Sweet ve *Vitex madiensis* Oliv. Atıkları, Olgunlaştırılması ve Bitki Besin Maddesi İçerikleri

Özet

Vitex doniana ve *Vitex madiensis* Kameron'un kuzeyi için en değerli meyve türleri arasında yer almaktadır. Üreticiler, bu meyve türlerini kendi bahçelerinde görmek isterler. Bu çevrede, her iki yabani meyve türünün yaygın olarak kullanılabilmesi için bu türlerin atık üretim miktarı ve kalitesi üzerinde önceden bilgiye sahip olmak gerekir. Atıklar, Adamawa savannah'da 4 farklı lokasyondan ve ağaçların 1 m^2'lik alanından toplanmışlardır. Araştırma 4 yinelemeli ve her yinelemede 4 ağaç olacak şekilde Tesadüf Blokları deneme desenine göre kurulmuştur. Yaprak atıkları doğal ortamda inkübe edilmiş ve 1, 3, 6 ve 12 ay sonra laboratuar koşullarında organik madde, N, P ve Mg içerikleri analiz edilmiştir. *Vitex doniana* için maksimum yaprak dökümü kasım ayında ve *Vitex madiensis* için aralık ayında gerçekleşmiştir. Atıkların parçalanarak olgunlaşması, *Vitex doniana*'da, *Vitex madiensis*'den daha hızlı gerçekleşmiştir. Yaprak atıklarında bitkisel organik madde %81 olarak belirlenmiştir. Türler arasındaki kıyaslamada, *Vitex doniana*'da *yıllık organik madde, Vitex madiensis*'den daha yüksek, sırasıyla 190 g/m^2/yıl ve 81.98 g/m^2/yıl olarak saptanmıştır. Buna karşın, *Vitex doniana*'da yapraklarda kuru madde *Vitex madiensis*'dan daha düşük belirlenmiş, fakat bu durum besin maddelerinin (N, P ve K) zenginliği ile dengelemiştir. *Vitex madiensis*'de bu besin maddelerinin önemli miktarını K (1153.84 mg/100 g), Mg (1539.01 mg/100 g) ve Na (443.42 mg/100 g)'un oluşturduğu belirlenmiştir. N, P ve Ca ise *Vitex doniana*'da daha yüksek saptanmıştır. Ayrışma süresince, fenol ve şeker ile kıyaslandığında neutral detergent fibbers lifleri daha yoğun belirlenmiştir. Bu yetiştiricilik sisteminde atıklar, toprak verimliliğinin arttırılmasına önemli katkıda bulunmaktadırlar. Bu nedenle, bu iki türün bu bölgede yaygın olarak kullanılması önerilebilir.

Anahtar Kelimeler: Yabani Meyve Ağaçları, Atık, Bioelement, Toprak Verimliliği, Yaygınlaşma, Ev Bahçeciliği.

1. Introduction

The reduction of the period of fallow by peasants following the demographic explosion in most of the tropical zones has lead to soil fertility degradation. Some peasants circumvent this phenomenon by using resource chemical manures. Unfortunately most of these fertilizers are not always accessible to the poorest peasants. Obaton (1992) underlined that at high quantities these manures pollute the environment and reduce the agricultural outputs. To alleviate these constraints the agroforestry mostly appears as a spare solution. This approach has the advantage to contribute to the natural ecosystem safeguard, while increasing the agricultural production, thus insuring the food security.

In the Adamawa, homegardens constitute promising traditional agroforestry systems (Mapongmetsem et al., 2000). Some potential species have been identified in the region (Mapongmetsem, 1995). The systematic integration of these species in these traditional systems could reduce some of the constraints identified in the peasant environment. Unfortunately, little information exists on the decomposition process of the litters of these species and the nutrients released. The main objective of this study which is designed to determine the quantity and quality of litters produced by the two species is underlined by the following specific objectives:

-to determine the period of leaves shade off in the sudano–guinea savannah;
-to evaluate the effect of soil and litter bag on leaf litter decomposition;
-to evaluate the dynamic of nutrients released during the decomposition.

2. Materials and methods

2.1. Study station

The region of Ngaoundere spreads between the latitude 7°2 36′N and the longitude 13°34′72′. The climate type is soudano-guinean with one active dry season from October to March and a rainy season covering the remaining of the year. The yearly average total precipitation is 1315.6 mm with a yearly total mean evaporation of 1902.95 mm (Table 1). Two main winds blow in the region notably the monsoon during the rainy season from the South and the harmattan from the North responsible for the drought (Mapongmetsem et al., 2002). The soil of Ngaoundere is rich in ferruginous compounds derived from granites, granodiorites and of gneiss after rejuvenation and is composed of red ferralitic developpedancien basalts (Yonkeu, 1993). The vegetation is mainly composed of prairies and shrubby and/or woody savannah with marked predominance of *Daniellia oliveri* and *Lophira lanceolata* (Letouzey, 1968). Nowdays, the density of these species has strongly decreased under the influence of human actions (Mapongmetsem et al., 2000).

2.2. Studied species

Numerous agroforestry species have been identified in the Adamawa province (Mapongmetsem, 1995; Tchiégang-Megueni et al., 2001). They are grouped into fruit species, apicole species, fuelwood species, indicator species of the soil fertility and medicinal plants (Tchuenguem et al., 1998; Mapongmetsem *and al*., 2000). According to these authors fruit species constitute the important species to domesticate. *Vitex doniana and Vitex madiensis* represent among others the more valuable wild fruit trees to the local populations in the economic point of view. Moreover, the pulp of their fruits is rich in vitamin C and in sugars (Loura Benguella et al., 2002). The present work took place in four phases: Determination of the period of maximal fall of litters (leaf litter); the collection of the litter produced by the two species; decomposition of litters and determination of bioelements. Investigations were undertaken at Bini, Dang, Tison and Borongo each of which was georeferenced (Table 2). These coordinates were collected using the GPS (Global Position System). The thermohygrometer permitted to record the temperature and the relative humidity of the soil. The pH of soil was measured in the laboratory with a pH-meter. The texture and the structure of soil was described *in situ* from appropriate samples from the surface to a depth of 20 cm by a soil scientist.

2.3. Litterfall and collection

Table 1. Meteorological features of Ngaoundere (1995-2001).

	Month												
Feature	J	F	M	A	M	J	J	A	S	O	N	D	Total
P(mm)	0.00	0.70	27.5	117.58	121.81	185.05	242.98	272.08	204.94	138.83	4.13	0.00	1315.6
HR (%)	44.59	38.24	49.85	69.30	76.90	78.37	80.17	80.52	78.52	74.48	62.96	61.02	794.92
T(°C)	20.53	21.83	24.45	24.64	23.35	22.58	21.99	22.07	22.25	22.51	21.11	20.29	267.60
EP(mm)	199.39	230.58	231.87	177.30	140.84	117.76	107.34	106.26	108.26	123.53	157.53	202.29	1902.95
Sunstroke (h)	284.42	238.47	236.77	187.50	189.1	165.17	130.67	123.68	141.46	173.11	262.91	290.91	2424.17

Source: Meteorological station of Ngaoundéré airport (2002) ; P (mm) = pluviometre in mm; HR% = relative humidity in %; EP = evaporation in mm and Sunstroke in hours.

Table 2. Altitude and geographical different site coordinates.

Stational coordinates	Dang	Bini	Borongo	Tison
Altitude (m)	1106	1122.5	1134.75	1173
Latitude	7°25´119´´	7°26,6´390	7°26,54´427	7°16,6´246´
Longitude	13°33´414,83´´	13°29´748´´	13°34,5´458,75´´	13°34, 5´458,75´´

Phenological observations took place at Borongo, Bini, Biskewal and Tison. In each of these stations, 10 trees per species were labeled. The experimental design was a Randomised Complete Block with four replications. The treatments were represented by the two species, whereas the blocks corresponded to the stations. The experimental unit was made up of 10 trees. The frequency of observations was twice a month. Data collection from each observations concerned the number of trees defoliated, refoliated, bloomed and fructified. In the present work, only defoliation phenophase was taken into consideration. Based on these phonological data, litter was collected under completely defoliated trees (Mapongmetsem, 1998 ; Mapongmetsem, 2002 ; Baye-Niwah et al., 2001).

For the collection of the litter produced by a tree the method exploited was adapted from Mitchell et al., (1986) and Mapongmetsem (2002). This methodological approach is preferred to the seasonal evaluation because of the regular phenomenon of bushfire and grazing in the savannah that make difficult the follow-up of the trial. It consisted of delimiting at the foot of a tree a square of one meter of side, then to collect all the litter inside with discernment (leaves, flowers, wood, fruits). So, under each of evaluated trees an area of $1x1m^2$ was delimited with the help of double decimeter. Different litters were separated, weighed with the help of a portable balance and labeled. Every polyethylene bag carried a label with the following enrollments (name of the species, name of the locality, type of litter, date, diameter at the breast height (dbh) of the tree, fresh weight, replicate, reference of the site (latitude, longitude and altitude). The number of replication was four square under a tree. This evaluation of the litter was made according to requirements of the experimental protocol (healthy tree, without traumatism, none burnt plot and none grazed). The collection of litters was undertaken during the dry season between November and April.

The experimental design was a Randomized Completely Block, with two treatments represented by the two tree species. The experimental unit was constituted of four trees. The collected litters were brought to the laboratory for subsequent investigations. Since leaf litter was the most important of the collected litters, it was chosen for decomposition test *in situ*.

2.4 Litter decomposition

Three grams of fresh leaf litter were weighed and were bagged in two types of meshes: 1x1 mm^2 and $2x2mm^2$ mesh. Bags of litters were hatched in the month of June 1999 *in situ* on three types dominated soils of the region: soils developed on granite, soils developed on volcanic ash and in soils developed on basalt (Ibrahima et al., 2000; Mapongmetsem, 2002). To understand the evolution of the decomposition in savannah four bags were retrieved at different times: one, three, six, nine and eighteen months after incubation. In the laboratory the content of each bag was withdrawn carefully (sorted out of garbage) and weighed immediately to get the fresh weight. Then, it was dried at 65°C during 48 hours in order to determine the dry weight. After withdrawal of steams, its litter was passed through the desiccators for 10 minutes to consolidate the weight. The remaining litter was subjected to subsequent analyses.

To evaluate the ponderate evolution of litters, the mathematical functions was determined (Olson, 1963, Wieders and Langs, 1982) that fit best to our data among the following:

- Asymptotic function: W=A + brt ;
- Second degree function W=A + Bt +Ct2
- Simple exponential function: W=A x Bt or W=a log + bt;
- Double exponential: $W = t_0 e^{-k} + B e^{-ht}$
- Polynomial function: W=A x t b or W log = t blog

Where W is the remaining weight percentage, t the time in month, has the decimal logarithm of T_0 (labile fraction) and b the one of B (resistant fraction), K & h are constants of decomposition.

2.5. Chemical analysis

To determine the content of bioelements and to surround their dynamism in litters from their falling off from the trees to their incorporation into the edaphically complex, we proceeded to the measurements of the mineral and organic substances. The collected litters were analyzed for their mineral elements and their litters hatched in of Borongo, Biskawal and Tison, approximately during the same periods. The main measurements where those of nitrogen, phosphorus, potassium, calcium, magnesium and sodium as far as the mineral the mineral contents is concerned and sugar, phenol and neutral detergent fibbers for the organic matter.

The determination of the amount of dry matter and the ashes content was done according to the method of Afnor (1981). The dissolution of elements relies on the method of Maynard (1970). Mineralization for nitrogen content measurements was conducted according to Kjeldahl (Afnor, 1984) while the actual dosage was from the reaction of Hantz (Devani et al., 1989).

The phosphorus was analyzed by flame spectrophotometer method described by Rodier (1978). The sodium and the potassium by the photometer to flame of Rodier (1978). The calcium and magnesium were determined by titrimetric method (Afnor, 1986).

Sugar content was analysed following the method of Dubois et al. (195600 whereas that of phenol was done with that of Marigo (1973). For the Neutral detergent fibbers (NDF), the technique used was the one describe by Van Soest and Wine (1967).

The experimental design for the chemical analyses was a Split – split - plot with four replications. The main plot was represented by the two species whereas the sub and sub-sub- plots corresponded to type of soil and mesh respectively. The experimental unit was made up of four litter bags after one, three, nine and twelve months after decomposition.

2.6. Data collection and analysis

Data were collected during this experiment concerned the mean date of defoliation, the weight of the litters, the remain weight of the leaf litter. These data were subjected to analysis of variance, correlation and regression. The statistical programme used was Statgraphics plus. Comparison of the mean was done through Duncan Multiple Range Test (DMRT) whereas their separation uses LSD at 5 %.

3. Results and Discussion

3.1. Pedoclimatic characteristics of the stations

The soil structure of the three stations is generally polyedric. The texture was predominantly made of clay except in Biskewal where it was a mixture of sand and clay developed on granitic soils. Earth worms were more abundant at Tison than Borongo and Biskewal. The tickness of the litter found on these soils was variable. It was weak at Tison, very weak at Borongo and absent at Biskewal.

The colour of soil was brown reddish at Borongo, brown dark at Tison and brown at Biskewal. As far as the pH is concerned, there was a variation from 4.55 at Borongo, 5.20 at Biskewal, to 5.62 at Tison. The relative humidity at the soil level was closer to saturation with about 63% at Borongo, 76% at Biskewal and 93,6% at Tison. Temperatures were also variable with higher value at Tison 27 °C and very low values at Borongo (17°C) (Table 3). These features obtained from the field constitute important results for the follow up of the litter decomposition under heterogeneous local conditions. Higher temperature and higher humidity were reported to stimulate litter decomposition (Mangenot and Toutain, 1980). The action of decomposers whose activity depends on soil pH, with lower pH increasing their activity. The presence of lumps at the soil surface is an indicator of a strong biological activity.

3.2. Leaf shade off

From October to December, the leaves of *Vitex doniana* became yellow, but remained on the tree for about two weeks. The fall of leaves was brief. The defoliation peak was reached in November. The branches remained naked on the tree from two weeks to a month. Species with different biological states were observed in *V. doniana*. In the same niche, we noticed two individuals among which one was defoliated whereas the other was still in full green leaves. The lack of synchronization in tree species was reported in the humid lowlands of Cameroon (Mapongmetsem et al., 1998).

The ageing of leaves was noticed for *Vitex madiensis* towards the month of September in the soudano – guinea savannah of Ngaoundere. However, the fall of litter started in November and ended in January. Compared to *V. doniana*, the defoliation was progressive. The maximum number of defoliated trees was observed in Mild – December. The deciduous period ranged from three to five weeks. An understanding of the period of defoliation allowed the schedule of litter sampling in the Sudano – guinea savannah from October to January The decomposition of this litter favours the build up of the organic matter and the liberation of the mineral nutrients necessary for plant growth. The two Verbenaceae are deciduous.

3.3. Litter production

The total annual fresh litter produced by the two Verbenaceaes was 370.4 g/m^2/year again 337.32 g /m^2/year for the dry one. The foliar litter was the highest (301.6 g/m^2/year), whereas the litter derived from fruits was the lowest

Table 3. Characteristics of the stations.

Parameters	Dang	Biskewal	Tison
Type of soils	Soil developed on basalt	Soil developed on granite	Soil developed on volcanic ash
Color of soil	Brown reddish	Brown	Brown dark
Structure of soil	Average polyedrique	Fine polyedrique	Average polyedrique
Texture	Clayey	Argilo - Sandy	Clayey
Other observations	- Presence of lumps to the surface of the soil ; - Presence of microorganisms (toward earth, one thousand paws.)	Some lumps - Presence to the surface of soil	- Presence of lumps in the surface of soil; - Presence of microorganisms (toward earth, one thousand paws.)
Relative humidity (%)	63	76	93
pH	4.55	5.20	5.62
Temperature (°C)	17	23	27

(22.50g/m^2/year). Although the quantity of leaf litter was greater than that of the other organs, it represented 81.42% of the litter annually produced by the two species *in situ*. However there was a significant difference among the two species (0.000 < 0.001). The mean annual litter production varied from 107.3 g/m^2/year in *V. madiensis* to 230.29 g/m^2/year in *V. doniana* (Table 4). This difference could be attributed to the architecture of these species. Unlike *V.doniana*, *V. madiensis* is a shrub. Similar results were reported on the same species by Mapongmetsem (2002).

Table 4. Quantity of litters produced by the two Verbenaceaes in g/m^2/year.

Type of litters	*V. doniana*	*V. madiensis*
Leaves	190.71	81.98
Wood	29.16	12.03
Flowers and fruits	10.42	13.02
Total	230.29	107.03

There was a significant positive correlation between the diameter of trees and the litter production for *V. madiensis* at Bini station (r = 0.87; 0.001 < 0.007 < 0.01). The influence of the soil type was apparent since there was no significant difference between the blocks represented. This result suggests that litter production was similar in all three stations.

3.4. Litter decomposition

The litter dry weight of the control varied from 2.63 (*V. madiensis*) to 2.67g (*V. doniana*). Globally, the decomposition process in *V.doniana* and *V. madiensis* litter exhibited three phases, of which the first (a month after incubation) and the third (from 9 to 12 months) were very fast compared to the second (from one to 9 months) that was slow (Fig. 1). However, the first period corresponded to the raining season. Losses were more important after a month for *V.doniana* (41.33 %) than for *V. madiensis* (52.43 %). These results suggest that the loss in litter weight varied with the species. Similarly, Mangenot and Toutain (1980) reported that the quality of litters influences the process of decomposition. The most soluble element and the most easily assimilated substances by microorganisms were quickly degraded compared to less soluble and assimilable substances such as lignin and cellulose (Rapp and Leonardi, 1998). Litter was translucent after one month of incubation. The microorganisms involved in the decomposition of litter were found to be earth worms, lombrics and fungis. At the ninth month of incubation, the decomposition rate of *V. doniana* decreased (Fig. 1), but was still faster than that observed by Ibrahima et al., (2000). The authors reported that the decomposition was slow because of the dry season, which increased the hydric stress on the litter.

As far as the type of soil is concerned the degradation rate of the litter was similar to the decomposition and was very fast after a month. This result suggests that volatile substances were quickly liberated. However, after three months, the soil of Biskewal started to differ from the two others. At the end of the experiment, the decomposition was very fast in volcanic soil as compared to the two others (Fig. 1). This difference was established at 1% level after six, nine and 18 months. This result suggests that microorganisms were more active in Biskewal soil during this period. The tendency that the soil of Tison was separated from that of Borongo after nine months suggests that the rainfall stimulated the microbial activity in Tison. Whatever is the soil type, it appears that the litter of *V. doniana* was more rapidly degraded than that of *V. madiensis*. This result indicates that the heavy litter was rapidly degraded than the light litter. The effect of litter bag was also significant (0.000 < 0.001). Leaf litter decomposition is faster in 2x2 mm^2 (Fig. 1).

The species by litter bag interaction was equally highly significant (0.000 < 0.001). This was induced by the particular pattern of *V. doniana* in the mesh of 2x2 mm^2. For a better understanding of the litter biodegradation process, the knowledge of the dynamic of nutrient liberation was necessary. The mathematical model which best adjusted the decomposition of the leaflitter in the sudano–guinea savannah was

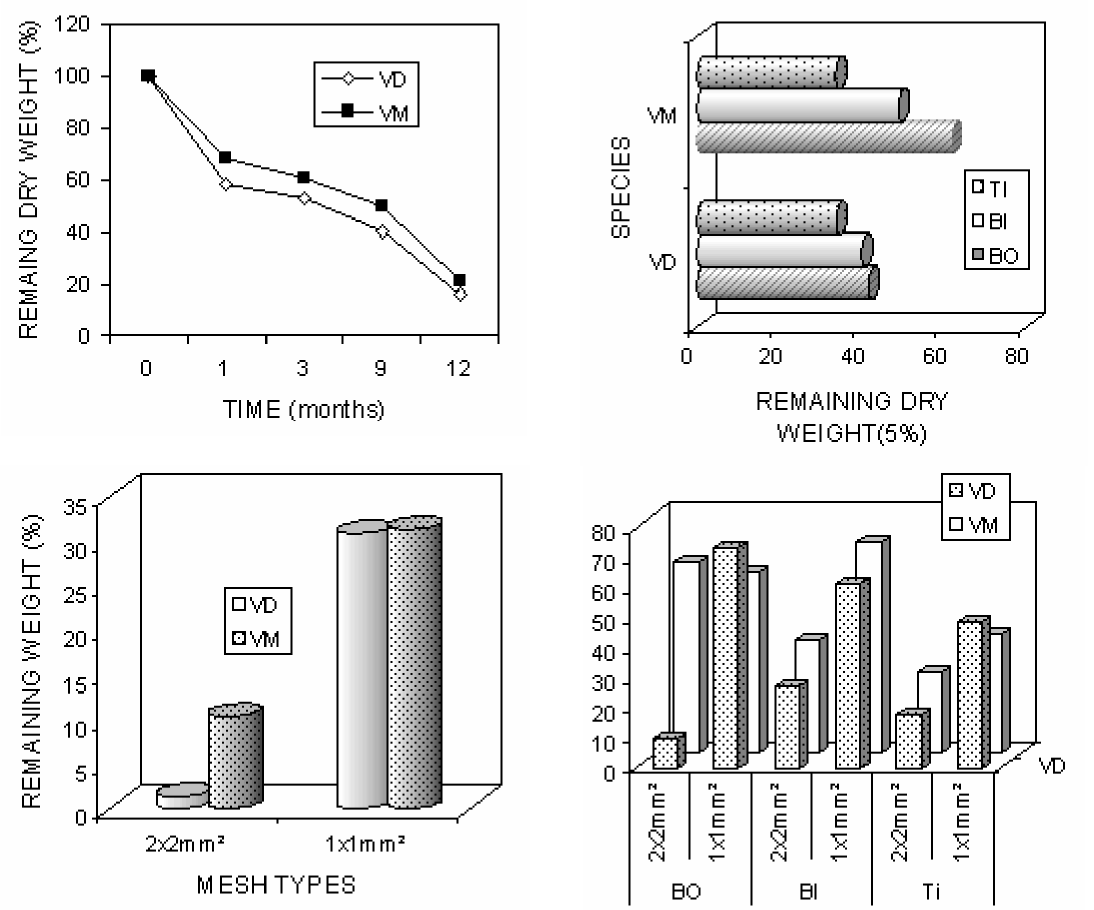

Figure1. Dynamics of the litter decomposition in the sudano-guinea savannah.

polynomial function (dry Weight remaining (%) = $A+Bt+Ct^2$). This is highly significant ($0.008 < 0.01$) and ($0.002 < 0.01$) in *V. doniana* and *V. madiensis* respectively (Table 5). The 75 th percentile of the decomposition ranged from 280.06 (*V. doniana*) to 375.77 days (*V. madiensis*) (Table 6).

3.5. Initial nutrients content of the litter

3.5.1. Mineral compounds

The initial nutrient content in nitrogen was more important in *V. doniana* (216,33 mg/100g of dry weight) than in *V. madiensis* (165.33 mg/100g dry weight). However the nitrogen content in *V. doniana* remained lower compared to those of Ericard (Mitchell et al., 1986), and *Bambusa bambus* (Shamugl and François, 1996). This value was greater than that of resinous population (18.3 g/m^2/year) (Glouaguen et Touffet, 1976). Seneviratne (2000) reported that microorganisms became very active when the ratio C/N is high. For the present case, the content of the C litter was not determined.

The phosphorus content of *V. doniana* (48.37 mg/100 g Dw) was greater than that of *V.madiensis* (33.55 mg/100 g dry weight). The fruits of these two species were rich in phosphorus than their litter (Loura et al., 2003).

The initial content of Ca was higher in *V. doniana* (3933.44 g/10 g/year) and lower in *V. madiensis* (2496.84 mg/100 g Dw). Despite these differences the litter of these species could be considered as the reservoir of Ca compound. These results are in agreement with those of Loura et al. (2000a) who reported that *V.doniana* is an important source of calcium.

The initial content of K in the litter was more important in *V. madiensis*

Table 5. Values of parameters (A, B and C) and of determination coefficient (R^2) of dry weight adjustments remaining next one three models des decomposition: dry Weight remaining (%) = $A+Bt+Ct^2$, AxBt and Axt^B ; with T_O = labile compartment, B and C, compartments resistant ; t = time of incubation in natural habitat.

SPECIES	A	B	C	R^2	F	P	M
Vitex doniana (VD)	83.123 (10.696)	-0.019 (3.428)	0.299(0.0182)	0.847	8.292	0.059 ns	2
	83.931 (9.428)	0.886 (0.031)	-	0.850	22.700	0.008**	1
	40.947 (7.173)	-0.016 (0.004)	/	0.749	11.961	0.025*	3
Vitex madiensis (VM)	87.954 (7.632)	-7.667 (2.446)	0.222 (0.130)	0.911	15.385	0.026*	2
	87.794 (6,426)	0.914 (0.017)	-	0.912	41.700	0.002**	1
	49.712 (8.139)	-0.123 (0.004)	/	0.629	6.770	0.0599 ns	3

Mathematical models: 1 = $A+Bt+Ct^2$; 2 = AxBt; 3 = Ax t^B
* = $P < 0.05$; * * = $P < 0{,}01$; ns = $P > 0.05$; values in the parenthesis represent the standard error; R^2 = Coefficient of determination

Table 6. Number of days for a loss of weight of 25, 50 and 75% and loss of weight of the litter after one year of decomposition.

SPECIES	TPP 25% (days)	TPP 50% (days)	TPP 75% (days)	PPPA (%)
Vitex doniana	113.40	169.67	280.06	86.50
Vitex madiensis	148.50	262.14	375.77	80.00

TPP = Time for a loss of weight of 25%, 50% and 75 % S; PPPA = Loss of weight for one year.

(1153.84 mg/100 g Dw) than in *V.doniana* (543.33 mg/100 g Dw). Generally, the contents in K, Mg, Na were rather greater than that of N, P and Ca contents. However the K content of *V. madiensis* was higher than that found in the literature (Mitchell *et al*.,1986), and lower than that of *Pinus sylvestre* (Glouaguen et Touffet, 1976).

The initial content of Mg was lower in *V. madiensis* (539.01 mg/100g /year) than in *V. doniana* (945.24mg/100g/Dw). The litter of the two Verbenaceaes were rich in Mg than their fruits. The fruits of *V. madiensis* contained 102.67 mg/100 g Dw and those of *V. doniana* 267 mg/100 g Dw (Loura et al., 2003).

The initial content of Na of *V. madiensis* (443.42 mg/100 g Dw) was higher than that of *V. doniana* (160.79 mg/100g Dw) as well as that of *Picea abies* (Glouaguen et Touffet, 1976). The results of these global analysis indicate that the foliar litters of *V. doniana* have higher N, P, Ca contents whereas those of *V. madiensis* are rather higher in K, Mg and Na. *V. doniana* was rich in bioelements in different litters studied by various authors while phosphorus was the less represented element. In the order of decreased values, the nutrients contents restored to the soil was as follows Ca> Mg>K>Na>N>P.

In general there are two types of fertilizers: chemical and organic fertilizers. The former are directly assimilated by plants and are mainly concerned with N, K, P (Sebilotte, 1989). The potential of species as fertilizers is based on their content in N, P and k. Therefore, our results suggest that *V. madiensis* (450.90 mg/100g Dw) has the higher potentials as fertilizers than *V. doniana* (269.28 mg/100g Dw).

The phenomenon of compensation seems to be involved in each species as reported by Baye-Niwah et al., (2001) on other plants in the same region. Hence, like *Ximenia americana*, *Parkia biglobosa*, *Vitex maidiens*is produced fewer leaf litter, although they are rich in bioelements.

3.5.2. Organic compounds

The initial content of the two litter quality was similar in terms of sugar whereas their content in Neutral detergent fibbers differs. The *V. doniana* content was approximately the double (10089.29 mg/100g Dw/year) of what was found in *V. madiensis* (5694.42 mg/100g Dw/year). These results suggest that the initial content of the litter in these species was similar but as far as the decomposition goes on, their rate differed. Their phenol content was also different (Table 7).

Table 7. Initial Content (mg/100 g DW) of leaf litters in bioelements.

SPECIES	Quantities (mg/100 g DM)									
	C	N	P	K	Ca	Mg	Na	Sugar	Phenol	NDF
V. doniana	884.26	216.15	48.37	543.33	3933.44	945.24	160.79	1624.50	353.89	1008.29
V. madiensis	42.12	165.33	33.55	1153.84	2496.84	1539.01	443.42	1617.82	268.89	5694.42

3.6. Evolution of the bioelements in decomposing litter

One month after litter incubation at the soil level, the nitrogen content of the two species was enhanced and reached a maximum at 180%. This result is in agreement with that obtained in deciduous forest of Japan (Osono and Takeda, 2002) an in Apple orchards in New Zeland (Tutua et al., 2002). Between one and six months, the nitrogen content decreased. Nitrogen accumulation may be influenced by the raining season (between June and July). During this period the increment in nitrogen was brought about by atmospheric precipitations, animals and insects wastes as well as nitrogen fixing plants (*Entada abyssinica*, *Sesbania Pachycarpa* and *Mucuna pruriens*) commonly found in the savannah of Ngoundere (Mapongmetsem and Ibrahima, 1999). At the soil level, nitrogen of the litter forms an organic complex which become soluble. The nitrogen content in *Vitex doniana* changed from 210 to 375 mg/100g Dw, whereas that of *Vitex madiensis* was improved from 160 to 260 mg/100 g Dw after one month, then to 290 mg/100 g Dw after three months. After this period, nitrogen content was decreased in such a way that six months later, it was below the initial value in *V. doniana* compared to that of *V. madiensis* (Figure 2).

As far as the dynamic of the phosphorous in the decomposing litter is concerned, the phosphorous content increased during decomposition up to six months. Starting from six months, it decreased (Figure 2). According to Macleon and Wein (1978), this accumulation may be due to their low initial content. Three months after decomposition, the increment of P content in *V. doniana* reached 145 mg/100gdw. Generally the litter content of this element was always above that of *V. madiensis* all over the year. This result was in conformity with the above analysis on the initial litter content of the two species. Lechmann et al., (2001) reported that soil nutrients could play a determining role in the phosphorus mineralization.

The evolution of K and Na followed a particular dynamic though the curves and were identical. There were, however, differences on the initial contents in both species. The content of K was higher in *V. madiensis* than in *V. doniana* (Figure 2). The decrease in contents was faster after six months of decomposition. Between six and twelve months of incubation, the evolution was rather attributed to their chemical potential. This result indicated that rainfall played an important role in the process of the mineralization of the two minerals or elements. The similitude between the decomposition and liberation curves of K and Na suggests that after one month of decomposition, K and Na were the first to be liberated from the litter of *V. madiensis* and *V. doniana*. For other elements, their accumulation during this period was due to the external outputs of diverse origins. There seemed to be a maximum level of liberation for these elements. It is obvious that their litter enriches the soil in nutriments (Dzwondo and Gawro, 2002).

Generally, the Ca curve looks like that of Mg. The recycling of these elements was faster one to two months after, leading to their fluctuation during the year. The behaviour of the mineral elements was opposite for the two species. The activity and alkalinity of the two types of litter may be responsible to this variability. Nevertheless, some similitudes were observed in these litters after three months. The physico–chemical characteristics of the litters may play an important role on the rate of litter decomposition (Koutika et al., 1999).

For the organic matter, it appears that during the first month of decomposition, the regressive trend of the release of phenol was

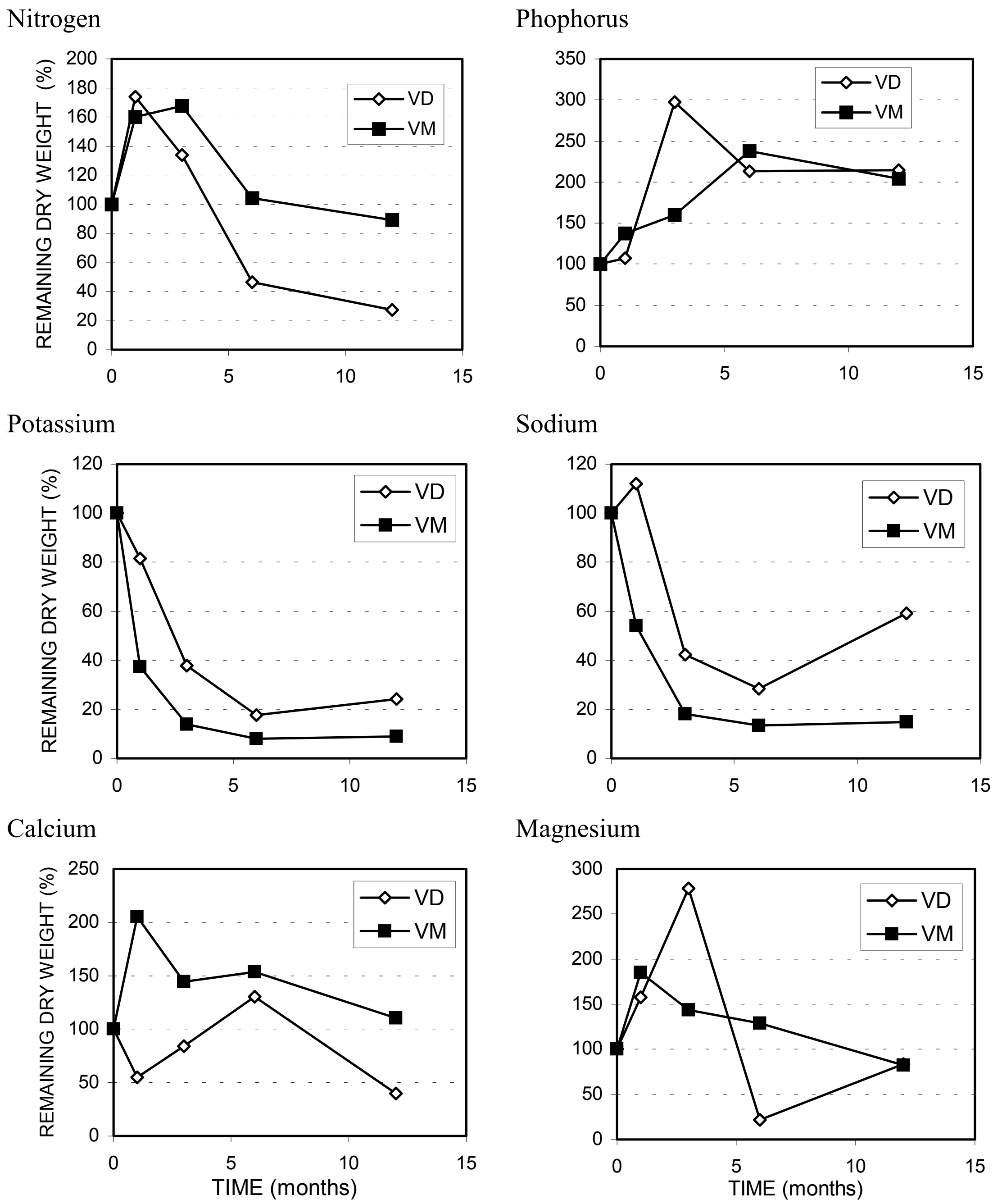

Figure 2. Dynamics of the nutrients in the decomposing leaf litter.

fast and identical between the two species. It decreased up to 50 %. From the third month, the percentage of the phenol started increasing differently in the litter till the end of the experiment. In *V. madiensis*, the phenol increased up to 160 % at the ninth month from which it decreased again to reach its initial value (Figure 3). During the first month of incubation the reduction of the phenol in the two litters was in the same proportion.

There was a significant fast degradation of the sugar during the first three months of the litter decomposition. The quantity of sugar was reduced to 20 % in *V. doniana* and to 40 % in *V. madiensis*. From this period till the end of the experiment, the quantity of sugar slightly increased up to 40 and 60 % in *V. madiensis* and *V.doniana* respectively. The increment observed at the end of the experiment could be attributed to the rain leaching which

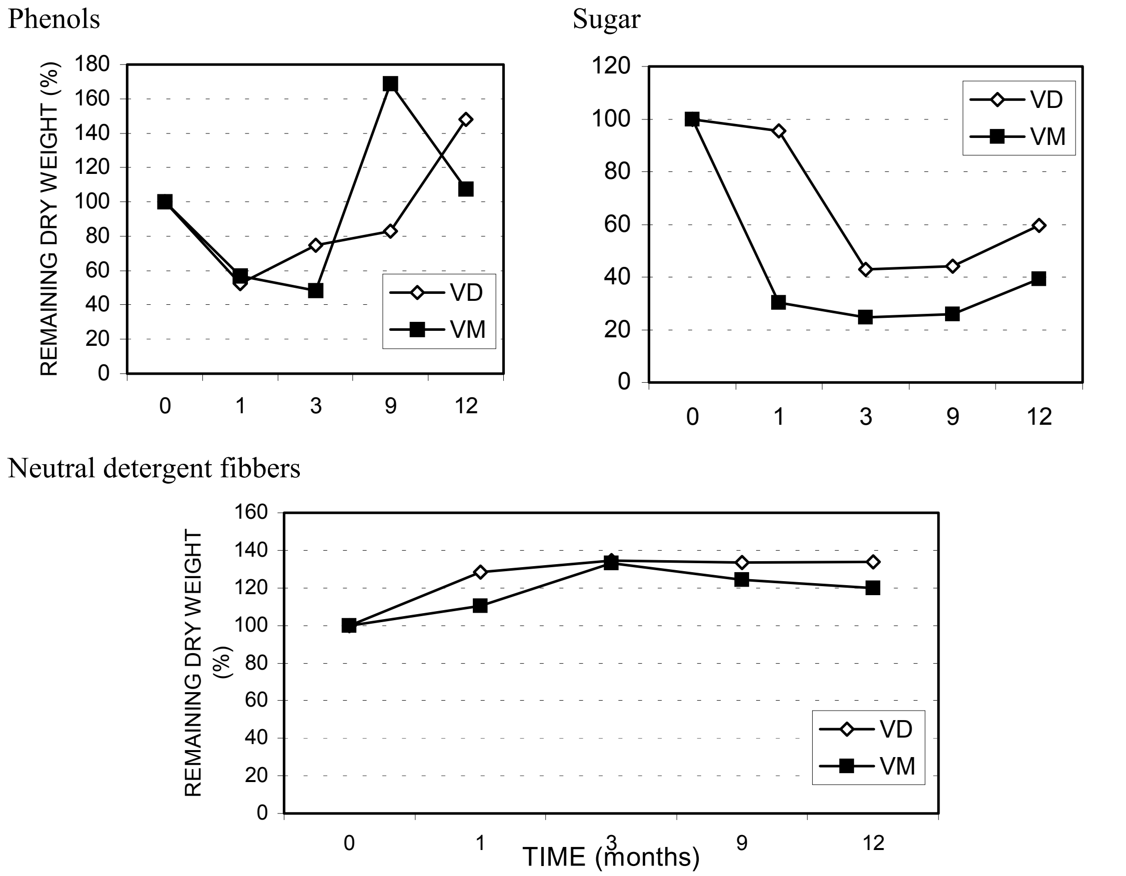

Figure 3. Dynamics of the organic compounds in decomposing litters.

brought in external sugar and phenol.

Compared to the previous organic matter, there was an accumulation of the Neutral Detergent Fibbers (NDF) from the beginning to the end of the trial (Figure 3). The NDF was made up of recalcitrant compounds among which lignin and cellulose do not decomposed easily by microorganisms. They need specific microorganisms to degrade them.

4. Conclusion

The period of maximum shade off of the litter varied between the two species. The peak of defoliation in the Adamawa savannah was located in mid-December for *V. madiensis*, and November for *V. doniana*. The decomposition of these species was influenced by the quality of their foliar litter, the type of soil and its pedoclimate. The litter of *V. doniana* decomposed faster than that of *V. madiensis*. Generally the decomposition was faster during the raining season due to water availability. For all the litter evaluated, the leaf litter was the most important. The foliar litter production varied according to species and was generally rich in Ca and poor in P in the Ngaoundere savannah. *V. doniana* produced more litter than *V. madiensis* but it was rich in fertilizer elements. The type of soil did not influence the litter production. The association of the two Verbenaceaes provides a fertilizer rich in N, K and Ca. Ca is known to play an important role in roots development. K was the most mobile element and its mineralization was enhanced during the raining season. We noticed that phenol and sugar were released rather than the neutral detergent fibbers which were accumulated.

In addition to the contribution of these two species in the improvement of the local population diet, they could play an important role in soil fertility. We intend to: (i) measure the C content and evaluate the C/N ratio for a better estimation of nitrogen in the litter; (ii) extend the study on other species; (iii) evaluate the effect of biomass on the behaviour of some annual crops. The expected results will increase our knowledge on the domestication of these two species in the region.

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