Assessment of Rate of Decomposition and Nutrient Release from Leaf Residue of some Tree Species

By

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DEDICATION

I dedicate this work and its every consequence to the

one that I loved the most……..

To the soul of my mother

Amal Rostom Yassin
الإهداء

نهاية

والله حب علمتني

والحياة أهدتنا من يقين

الحياة هي كنث من الذي

الارض في حياة التدفق

بالإذن، تنتخب بذرية كل

أهديك جارية وصدق، جهدي فيها

الطاهرة أمي روع

رستم يس

رستم أمال

35 أعمال

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I would like to take the opportunity to express my great indebted to my ant Entisar Rostom, who bring me to the first step in my university study. Asking
god to bring her soul every peace and goodness.

I will not forget the patience of my husband, Abd El-azim, my lovely daughter Lena, whom I was so indebted to.
TABLE OF CONTENTS

DEDICATION ........................................................................................................I
ACKNOWLEDGMENT .....................................................................................II
TABLE OF CONTENTS ..................................................................................IV
LIST OF TABLES ..........................................................................................VIII
LIST OF FIGURES .........................................................................................IX
ABSTRACT (English) ......................................................................................XI
ABSTRACT (Arabic) .......................................................................................XIII

CHAPTER I

INTRODUCTION ................................................................................................1

CHAPTER II

LITREATURE REVIEW ..................................................................................3
* Decomposition and plant litter quality .......................................................3
* Factors affecting decomposition ...............................................................3
1. Chemical composition ..............................................................................4
  1.1 General .................................................................................................4
1.2 N content and C:N ratio........................................................................4
1.3 Lignin and polyphenol...........................................................................6
2. Environmental factors...........................................................................6
  2.1 Climatologically factors....................................................................7
  2.1.1 Temperature.................................................................................7
  2.1.2 Humidity.....................................................................................7
  2.2 Soil condition ..................................................................................8
  2.2.1 Soil texture................................................................................8
  2.2.2 Soil structure..............................................................................8
  2.2.3 Soil moisture content.................................................................9
  2.3 Soil reactions..................................................................................9
  2.4 Soil nutrients..................................................................................11
  2.5 Microbiological and fauna population.............................................12

Effect of litter on crop-soil system..........................................................13
1. Effect of plant residue on crop.............................................................14
2. Effect of plant residue on soil.............................................................15
CHAPTER III
MATERIALS AND METHODS.................................................................16

Site description.................................................................16

Plant material.................................................................18

Laboratory analysis..........................................................19

1 Carbon determination.................................................19

2 Nitrogen determination.................................................19

3 Phosphorous and Potassium determination........................19

Statistical analysis..........................................................20

CHAPTER IV
RESULTS AND DISCUSSION...........................................................21

Dry matter weight loss......................................................21

Nutrient release...............................................................26

Remaining C.................................................................26

Remaining N .................................................................30

Remaining P .................................................................35

Remaining K .................................................................39

CONCLUSION.................................................................44
LIST OF TABLES

Number........................................................................................................................................Page

1. Site description and properties of shambat soil series.......................................................17

2. Chemical composition of the plant material of the three tree species..................................18

3. Decomposition and nutrient release rate constants of the three species

   (W₀=Dry matter or nutrient pool, K= rate constant).........................................................43
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Number</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.a. Dry matter weight (% of initial content) remaining during decomposition of Leucaena, Ficus, and Eucalypt leaf residue.</td>
<td>24</td>
</tr>
<tr>
<td>1.b. Non-linear Dry matter weight decomposition rate curves of the three species during the period of 12 weeks of incubation.</td>
<td>25</td>
</tr>
<tr>
<td>2.a. Carbon (% of initial content) remaining during decomposition of Leucaena, Ficus, and Eucalypt leaf residue.</td>
<td>28</td>
</tr>
<tr>
<td>2.b. Non-linear Carbon decomposition rate curves of the three species during the period of 12 weeks of incubation.</td>
<td>29</td>
</tr>
<tr>
<td>3.a. Nitrogen (% of initial content) remaining during decomposition of Leucaena, Ficus, and Eucalypt leaf residue.</td>
<td>33</td>
</tr>
<tr>
<td>3.b. Non-linear Nitrogen decomposition rate curves of the three species during the period of 12 weeks of incubation.</td>
<td>34</td>
</tr>
</tbody>
</table>
4.a. Phosphorous (% of initial content) remaining during decomposition of Leucaena, Ficus, and Eucalypt leaf residue……………………………………………………37

4.b. Non-linear Phosphorous decomposition rate curves of the three species during the period of 12 weeks of incubation……………………………………………….38

5.a. Potassium (% of initial content) remaining during decomposition of Leucaena, Ficus, and Eucalypt leaf residue………………………………………………………41

5.b. Non-linear Potassium decomposition rate curves of the three species during the period of 12 weeks of incubation………………………………………………………42
Title: Assessment of Rate of Decomposition and Nutrient Release from Leaf Residue of some Tree Species

By

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A field experiment was carried out with the main objective of determination of decomposition and nutrient release of leaf litter of the three-selected tree species based on their C/N ratios. Low C/N ratio was represented by *Leucaena leucocephala*, medium C/N ratio was represented by *Ficus benegalensis*, and high C/N ratio was represented by *Eucalyptus camaldolensis*. Fresh leaf samples (40g) of the mentioned tree types were buried 20 cm in the soil under Shambat semi-arid tropics condition, over a period of three months. Samples were drawn at intervals of 1, 2, 3, 4, 6, 8, 10, and 12 weeks. Samples were analyzed for remaining dry matter weight, carbon, nitrogen, phosphorus, and potassium.
Results showed that Leucaena decomposed significantly (P<0.05) faster than Ficus and Eucalyptus. Also, it released C and N faster than Ficus and Eucalypt; C released was significantly (P<0.05) higher than that of the other species tested. While N accumulated in Ficus and Eucalypt, only 66.8% of the N content in Leucaena was remained after the first week. Ficus released P significantly (P<0.01) higher than Leucaena at the beginning stages. And Eucalyptus released K significantly (P<0.01) higher than Ficus and Leucaena at the end of the period of incubation. The dry matter decay and C release rate were similar in the three species. However, N accumulated near double in Eucalyptus (180.7%) and one third percentage in Ficus (136.3%) in the first stages. This showed that the C/N ratio is not the only indicator to decide the rate of decomposition and nutrient release. The K and P releasing rates were rapid in the first stages ($R^2$ 0.73-0.92) in the three species.

This study suggests that Leucaena constitutes a readily available source of N, and could be consider a high leguminous tree resource quality to micro-organisms, however it is important to add N fertilizers in agroforestry management systems that include Ficus and Eucalyptus species.
ABSTRACT (Arabic)

كما، تأثير

البحث

العنوان:

الأشجار العينات ببعض الأوراق من الناحية الغذائية.

الدراسة:

محمد أحمد أحمد

التي و الأشجار ببعض الأوراق تحرر و التحلل لتحديد الحقلية.

التجربة هذه أجرت اختيار الكربون بالنسبة إلى النتروجين.

الكربون المعدل كان حيث الكربون يمثل النتروجين المنخفض النتروجين الكربون المعدل و اللوسينة إلى بذرة الأشجار كل

تتم إلى النباتات.

الغذاء للفترة و الأكل شبه الاستوائي في الأشجار.

التخصيص، و الأشتراء من أحد الأشجار رأسه (1.2.3.4.5.6.7.8.9.10.11.12)

الكربون و الأصابع الغذاء الأراضي في الأشجار.

الكمية

الكربون و الأصابع الغذاء الاستوائي في الأشجار.

66.8 (اللوسينة الأوراق في النتروجين يحتوي على الأسرع في تحلل النتائج أظهرت) 

p ≤ 0.05 (الأسترلين الأصابع الجذرية تضئين) 

p ≤ 0.05 (الأسترلين الأصابع الجذرية يتضمن في الأشجار) 

p ≤ 0.05 (الأسترلين الأصابع الجذرية ينمو الأشجار) 

p ≤ 0.05 (الأسترلين الأصابع الجذرية)
للمقارنة، أن بعض الأعراض تتجاوز بشكل ملحوظ أثناء الحالة في البطارقة، وتحدد الفحوصات على الأطباء بعابضات من العين في الكارثة، وتتجاوز فائضًا، أثناء الحالة في البطارقة، وتحدد الفحوصات على الأطباء بعابضات من العين في الكارثة.

 ...

 ...
CHAPTER I
INTRODUCTION

Most soils in arid and semi-arid regions have low organic matter (OM) content, the use of organic residues as fertilizers and soil amendments is very old (Bartholomew, 1965; Allison, 1973). Soil organic matter (SOM) in these regions, could either be built up and sustained through controlled agronomic practices by adding green manures, animal dung, compost and other organic amendments and chemical organic synthesis, or by planting trees, which will add organic matter to the soil naturally through their litter and residue.

Generally, organic matter is highly variable in quality; sometimes it is rich with N (low C/N) and composed of easily digestible compounds (cellulose, saccharides. Others are poor in N (high C/N) and composed of hardly digestible compounds (lignin, waxes, tannins and resins). So, to get good results from organic matter use, both for soil improvement and crop production, many factors have to be taken into consideration: form of organic matter (crude material, chopped crushed, ground, and processed (compost), age of litters (fresh, or old), quantity and frequency of application, method of application (surface mulch, or incorporation), soil type and conditions (texture, CEC, pH, moisture content, toxic factors (saline, acidic, pollution by heavy metals) and general climatic conditions (temperature (arid, humid,..), water logged).
Most studies and works concentrated on the effect of field application of green manures and amendments indicated that organic matter supplies constitute a source of readily available N which is the most limiting nutrient in many agricultural systems of the arid and semi-arid tropics (Crowther and Vanschreven 1955, Weeraratna 1979). Also many studies estimated that substrates with high N content (>1.7%) are considered to be easily digestible by micro organism (Crowther and Vanschreven, 1955; Berg and Staaf, 1987; Laskowski et al., 1994; Siddig, 2002; Somaya, 2002).

In the Sudan, tree litter causes a real disposal problem. It can be used or recycled to add nutrients and improve soil properties. The pattern of decomposition and nutrient release are needed to be known prior to its use. Such study is greatly lacking in the Sudan. Therefore, this study was designed to determine the following:

1) The rate of decomposition of fresh leaves of some tree species buried in the soil under field conditions.

2) The changes in nutrient contents (C, N, P, and K) of the decomposed plant material and their rate constants.
CHAPTER II
LITERATURE REVIEW

Decomposition and plant litter quality:

The nutrients contained in plant litter are held as organic molecules, when the litter decomposes, these nutrients are released to the soil solution. They then become available for uptake by plants. Decomposition requires decomposer action and takes place when soil microorganisms increase. Traditionally, soil scientists and ecologists have focused on the upper soil profiles when examining controls over organic matter dynamics (Parton et al., 1987; Kelly et al., 1996), because over 50% of total soil profile C is stored at 20 cm depth (Weaver et al., 1935; Yonker et al., 1988; Gill et al., 1999). For plant materials, decay occurs through initial fragmentation by soil macro-fauna (earthworm, millipedes, termites, …etc), with further transformations being accomplished by microbial activity via enzyme production (Anderson et al., 1983; Stevenson, 1986; Tian et al., 1995). Recently, Loranger et al. (2002) found that litter quality was the main determinant of decomposition in the studied forests. They found that several litter quality parameters were correlated with leaf disappearance, varying according to stages of decomposition.

Factors affecting decomposition:
Decomposition is a complex microbe-fauna mediated process that is accelerated by environmental conditions that enhance faunal and microbial activity (Swift et al., 1979). The main factors affecting organic matter (O.M.) decomposition are:

1. Chemical composition (C/N ratio, N content, Polyphenols, and Lignin):

   **General:**

   The constituents of organic residues have been found to decompose at different rates. For instance, simple sugars, amino acids, most proteins and cellulose decompose rapidly (mainly by bacterial action), whilst lignin and some microbial melanin decay slowly, mostly through the action of actinomycetes and fungi (Swift et al., 1979; Berg et al., 1982; Janssen, 1984; Stevenson, 1986; Mary et al., 1996).

   Early studies by Waksman and Tenney (1927), later confirmed by many others Knapp et al. (1983); Summerell and Burgess (1989), have considered substrate quality as a critical factor in determining the rate of decay. Chemical indices of substrate quality include element concentrations and concentration of various classes of organic compounds. These include species and cultivars type (Smith and Peckenpaugh 1986); N concentration (Janzen and Kucey, 1988); C/N ratio (Tian et al. 1995) and lignin, tannin, and polyphenolics (Milillo et al. 1982; Spain and Le Feuvre 1987; Palm and Sanchez 1991; Tian et al. 1995). A number of recent studies supported that leaf chemistry factors have been reported to affect decomposition and nutrient release patterns. With regard to N
release, these factors include N content (Constantinides and Fownes, 1994), C and C-to-N ratio (Frankenberger and Abdelmagid, 1985), lignin and lignin-to-N ratio (Meliillo et al. 1982; Tian et al. 1992), soluble Polyphenols and polyphenol-to-N ratio (Palm and Sanchez 1990,1991; Oglesby and Fownes, 1992) and (lignin+polyphenol)-to-N ratio (Fox et al. 1990; Handayanto et al. 1994).

N content and C/N ratio:

A direct relationship is known to exist between N content of the decomposing leguminous plant material and rate of degradation. High initial N, low C/N, favor high rates of decomposition of fresh leguminous leaves (Vallis and Jones, 1973; Fox et al., 1990; Palm and Sanchez, 1991; Oglesby and Fownes, 1992; Constantinides and Fownes, 1994). Precott et al. (1993) stated that, the concentration of N and P in the litter influenced the rate of uptake of them during the three first years, but was not consistently related to nutrient availability in the soil. A very recent study by Reys-Reys et al. (2003) found that nitrogen release from the leaves was greater when the soil organic matter content was lower, they found that the arable soil has been disturbed each year for at least 14 years and has the smallest turnover of N, no crop residue was left on the field so the N input was limited. However, soil structure disturbance may increase mineral N release from active and physically protected N pools (Kristensen et al., 2000).
In fact, The C/N ratio was found to be an important ecological index. The lower the C/N ratio, the easier the OM decomposition would be, and vise versa (Frankenberger and Abdelmagid, 1985; Iritani and Arnold, 1960; Duchaufour, 1984). In addition the C/N ratio helps to indicate the pathway of OM decomposition process, either towards mineralization (low C/N) or humification and immobilization (high C/N). Generally, in decomposition there are three levels of C/N ratio (Duchaufour, 1984):

A) Low C/N (± 10), material that mineralizes readily and releases high N amounts e.g. as in dry blood.

B) Medium C/N (±20), e.g. as in legumes, grass and herbs, both mineralization and humification can take place at similar rates.

C) High C/N (> 35), e.g. as in the coniferous litter, peak, sawdust, in this case the mineralization process ceases almost and the humification rate is strongly lowered. Usually, there is formation of A horizon (Mor humus), which is entirely composed of organic matter.

Lignin and Polyphenols:

Lignin and Polyphenols contents of OM are known to influence the pattern and rate of its decomposition, especially during latter phases (Herman et al. 1977; Palm and Sanchez 1991; Jama and Nair, 1995; Vallis and Jones 1973). Total polyphenol content was not a useful predictor of N release, but the reactivity of the Polyphenols as measured by
their protein-binding capacity can be a useful predictor (Mafongoya et al. 1998). These authors, also found that (lignin+polyphenol): N ratio could be used to screen leguminous tree leaves for their potential to release N in short-term experiments. Material with lower quality (high C/N ratio, lignin, and polyphenol levels) decreased yield and N utilization efficiency. The lignin content exerted a much greater influence on N mineralization than did phenolic (Browaldh 1997), he's also concluded that the best predictor of N utilization efficiency was the (lignin+polyphenol): N ratio. However, this was earlier supported by studies by Fox et al.(1990), and Handayanto et al. (1994). Cumulative N mineralized was not correlated to initial N, soluble polyphenol, and insoluble tannin concentration, but was correlated to lignin and nutrient detergent fiber N (NDF-N) concentrations (Mafongoya et al. 1997). Cellulose and lignin and their ratios with other nutrients were key factors influencing litter decomposition and nutrient release (Guo and Sims 2001).

2. Environmental factors:

Despite the rare researches in tree leaves residue decomposition, especially in Sudan, much research has already been conducted to develop proper management strategies for agricultural residues. These require knowledge of their decomposition pattern and the effects of edaphic and environmental factors influencing their breakdown rate. Decomposition is essentially a biological process (Lavelle et al. 1993) but it is affected by abiotic factor through their effects on soil organisms (Mesquita et al. 1998). The environmental factors suitable for their metabolism (Parr and Papendick 1978;
Tanaka 1986), This will be discussed as climatological factor that influence the composition of the decomposer community (Stott et al. 1986). This will be discussed as the soil condition factor, and the factors which determine the activity of the decomposer community i.e. viable microbial population (Magan and Lynch 1986; Rao 1995).

2.1 Climatological factors:

These include mainly temperature, humidity, rainfall (dry or humid climates).

2.1.1 Temperature:

It is generally accepted that, high temperature leads to reduction of soil organic matter content, but it is maintained under cold conditions (5°C) since it was observed that physiological activity and substrate demand decline. High temperature enhances decomposition because it increases microbial activity responsible for the decomposition of the soil OM Very high temperature leads to oxidation of OM. It was found that high rates of microbial activity at warm soil temperature (25°C) are limited by the diffusion of substrate to metabolically active cells (Mubarak, 2001).

2.1.2 Humidity:

Humidity is caused mainly by rainfall, and it increases the soil moisture content. It leads to the existence of a good plant cover and that in turn leads to increase of OM in the soil. Losses of OM, N, and P were generally greater and more rabid during the wet, than the dry and cool seasons (Somda and Powell 1998).
Kwabiah et al. (1999) found that leaching in sub humid tropical conditions accelerated the release of (P) to meet the needs of decomposer organisms.

2.2 Soil conditions:

Plant residues entering the soil, play an important role in maintaining soil productivity by providing a source of nutrients and inputs of OM (Allison 1973). They are known to affect soil physical properties (Hulugalle et al. 1986; Blair et al. 1997), availability of soil nutrient (Wade and Sanchez, 1983) and soil faunal populations (Tian et al., 1992; Rao, 1995)

2.2.1 Soil texture:

The role of soil texture (clay and sand) on decomposition of OM incorporated into the soil seemed to be inconsistent. Generally the OM in soil is thought to be reduced in the presence of clay. Fine soil particles and organic material interact very strongly to form complexes and micro-aggregates that render organic substances less susceptible to biodegradation (Skjemstad et al., 1993). Decomposition in light texture soil is faster compared to heavy texture soil. This is thought to be due to physical protection of OM in the latter case (Hassink 1994).

2.2.2 Soil structure:

This is important in affecting OM decomposition by controlling aeration. Structure may also be considered as it determines the type and structure of
decomposers’ communities. On the other hand, organic matter increases soil aeration particularly in clay soil. Micro-morphological and processed –based studies have demonstrated the mechanistic role of organic matter in the formation and stabilization of soil aggregates (Elliott, 1986). This stability, in turn, is related to soil erodibility (Lal and Elliott, 1994), infiltration characteristics (Eldridge, 1993) and soil compactability (Soane, 1990).

2.2.3 Soil Moisture content:

Moisture content is an important factor in controlling decomposition (Linn and Doran, 1984). In most soils, net N mineralization was linearly related to moisture content in the available range (-0.03 to –4.0 MPa). Linn and Doran (1984) stated that decomposition of organic residues was carried out at 60% water filled porosity (0.24 g kg⁻¹ soil), which is considered to be optimum for microbial growth. Similarly, Myers et al. (1982) reported that optimum moisture content for net N mineralization corresponded to a soil pore water potential between –0.01 and –0.3 Mpa, while that at which no net N mineralization occurred was close to –4.0 MPa. Although moisture content is an important factor in controlling decomposition, nutrient dynamics were not directly related to OM mass. To support this, Schomberg and Steiner (1999) showed that effect of water regime on
crop residue decomposition under irrigated and non-irrigated field conditions were similar. However, K was the only nutrient affected by water regime and appeared to increase with wetting due to leaching, as it is not associated with the structural components of the plant cell (Marschner, 1995).

3.3. Soil reactions:

   Effects of addition of organic matter as plant materials on soil pH were contradictory. However most studies showed an increase in soil pH after application of organic materials. The variability in the results of the effect of plant organic matter on soil pH probably resulted from the differences in characteristics of organic materials and soils, and the experimental conditions between studies. There were a number of incubation experiments using widely different types of organic materials and soils under various experimental conditions that showed that the addition of plant materials increased, decreased or did not affect soil pH (Pocknee and Sumner, 1997; Tang and Yu, 1999). The direction and the extent of soil pH change depended on the concentration of excess cations/organic anions and nitrogen in plant materials and the initial pH of the soil. Soil pH affects decomposition by limiting the enzyme activities of microbial decomposers. Low pH decreases microbial activities and decomposition of OM (Motavalli et al. 1995). While plant residue will accumulate in the soil organic anions with negative charge
in high pH, this would improve the soil cations adsorption capacity due to increase in net negative charge. It is worth noting that at high pH values there are greater CEC values (Hue, 1992). Recently, a study found that critical levels of C and plant nutrients, which limit the enzyme activities of microbial decomposers, are important for determining nutrient release (Seneviratne 2000). Wood and Kellogg (1988) pointed out that activity of cellulose degrading enzyme lies between soil pH 4 and 7 (averaged, 5.5), whereas those of their hemi cellulose-degrading enzyme ranged from pH 3.5 to 5 (averaged, 4.3). Different leguminous leaves showed net N mineralization at soil pH of 6.2, whereas the same species showed net immobilization at pH 4.5 (Seneviratne et al. 1999). It is important to mention that, initially after application of organic matter pH decrease was attributed to nitrification as a result of microbial activities (Zaman et al., 1998). Later, pH tends to rise which reflects the pH-buffering capacity of the soil and the effect of increase of CO₂ evolution as a result of microbial activities, which release HCO₃⁻ into the soil.

However, the toxic elements from OM affect microbial action. This allelophatic effect was attributed to phenolic molecules, principally the cinnamic acid, derivate ferulic acid, p-coumaric acid, chlorogenic acid and isochlorogenic acid as cited by Purvis and Jones (1990). The phenomenon of allelopathy may be pronounced in hot conditions compared to cooler conditions (Martin et al., 1990).
2.2.4 Soil Nutrients:

Plant nutrients are released from litter either by physical leaching or by chemical breakdown of structural organic components by soil organisms. Often, the latter process is quantitatively more important, and the rate, at which elements are released, could be expected to be governed largely by decomposition rate. Kwabiah and Voroney (1999) found that leaching accelerated releasing of P to meet the needs of decomposer organisms. Different elements, however, have different patterns of release over time and it is obvious that elements are retained with different strength in the litter structures. One mechanism behind this is microbial immobilization, and attempts have been made to explain the dynamics of a single element in litter from its status as a limiting or non-limiting nutrient for microbial growth (Gosz et al. 1973; Parnas 1975; Swift et al. 1979). Thus, elements limiting for microbial growth could be expected to be retained or accumulated in litter to a certain minimum concentration and thereafter be released at the same rate as weight loss of the organic matter. N is the most limiting nutrient in many farming systems of the semi-arid tropics (Fox 1978). In most forest ecosystems the dynamics of N, P and sometimes S in decomposing litter exhibits similar pattern: an increase of the element’s amount at the initial stages, followed by release (Staaf and Berg 1982; Maheswaran and Attiwill 1987; Santa Regina et al. 1989) Sometimes some initial loss was also observed before
accumulation stated (Berg and Staaf 1987). Recently, a study carried out by Guo
and Sims (2002) on eucalyptus litter decomposition and nutrient release found
that P, N, and Mg accumulated more than their initial amount in some litter type.

While elements in nonlimiting concentrations are released during the whole
decomposition period (Berg and Staaf 1981), nutrient dynamics is further
influenced by the nature of chemical bonds. It was generally accepted that K, Na,
Ca and Mg usually decrease in absolute amounts while their concentrations may
remain constant or decrease (Dziadowiec and Kwiatkowska 1980; Staaf and Berg
1982; Maheswaran and Attiwill 1987; Blair 1988; O’Connell 1988; Mubarak and
Rosenani 2001). Elements such as K, Na, Ca and Mg, and Mass loss through the
first phase have been attributed largely to leaching (Jung et al., 1968; Bunnell and
Tiat, 1974; Berg, 1984; Saini, 1989; Reddy and Venkataiah, 1989). The cycles of N,
P, K, and other nutrients are in fact strongly linked through the common
elements of the plants, litter, and humus (Frissel 1977; Brunig and Sander 1983;
Stevenson 1986).

4. Microbial and Fauna population:

Decomposer organisms consist of a complex of community of soil biota including
micro flora and soil fauna (Tian et al., 1997). Accordingly, bacteria and fungi are
ultimately responsible for the bio chemical processes in the decomposition of organic
residues. Soil fauna enhances the biodegradation and humification of organic residues
in several ways (a) fragmentation and increasing the surface area for microbial activities (b) by producing enzymes which break down complex biomolecules into simple compounds, and polymerize compounds to form humus (c) by improving the environment for microbial growth and interactions. In this context, earthworms incorporate organic materials into the soil and termites are known to be efficient in digesting cellulose and lignified substances (Tian et al., 1995). Increase in organic matter increases C/N ratio of the microbial biomass probably due to increase in water – soluble C and nutrients that stimulate the soil biomass growth (Whalen et al., 2000).

In fact, these organisms are function of the other conditions, they do not proliferate in dry conditions (Sahara) for example, while they are numerous and abundant in warm humid conditions. A recent study found that differences in soil characteristics and fauna did not seem to be enough to affect decomposition (Loranger et al. 2002).

Effect of litter on crop-soil system:

Application of plant residues to the soil surface has widely been used in the semi-arid tropical agriculture and agro forestry. The benefits include the reduction of erosion hazards, better infiltration of rain water and less evaporation, lower soil temperatures, increase of exchange capacity and nutrient supply, higher biological activity, better root growth and suppression of weeds (Webster and Wilson, 1980).
The limited availability and high cost of mineral fertilizers mean that many tropical small holders farming system have to rely on plant residues as a plant nutrient source; trees in agroforestry systems are also an important source of such plant residues.

Proper management of residues is necessary to maximize their benefit in different crop-soil systems; this depends on knowledge of residue decomposition and nutrient release rates. Soil biological processes to sustain and build up fertility require agronomic practices that control the quantity, quality, and application timing of plant residues (Young, 1986). Management options include, in addition, the selection of plant material with different chemical composition (quality) (Anderson and Ingram 1993; Palm 1995; Palm et al. 2001).

Generally, most studies aimed at the best, synchronizing between nutrient release pattern and period of maximum supply, and demand of the crop, and thus synchronizing between N mineralization and N uptake as well (Webster and Wilson 1980; Schroth et al. 1992; Myers et al. 1994; Luna-Orea et al. 1995; Ranells and Wagger 1995; Mubarak and Rosenani 2001; Guo and Sims 2002; O’Connell et al. 2003).

1. effect of plant residue on crop:

Schroth et al. (1992) have studied application of organic matter (Cajanus cajan) as mulch, and concluded that to minimize nutrient losses from nutrient-rich
mulch materials, they should be applied repeatedly in small quantities according to the nutrient demand of the crop. Also mulching from different tree species studied by Browaldh (1997) resulted that mixing of low and high quality residues could thus be a way of increasing yield and at the same time enhance organic matter build up. Leucaena mulch and cattle manure agro forestry, may be a considerable source of N and K for crop growth in ally cropping system (Lupwayi and Haque 1999). A recent study carried out in tropical hillside agro ecosystems in which soils suffer from erosion and low availability of nutrients, by Gobo et al. (2002) showed the potential of some plant materials as sources of nutrients; they evaluated 12 plant material and found significant correlations (P<0.05) between the initial quality parameters and nutrient release. Another study carried out in central highlands of Mexico by Reys-Reys et al. (2003) concluded that in an alley cropping system the soil under canopy of mesquite and huisache effectively accumulated organic material, microorganism, and valuable nutrients. Although the mineralization of their leaves may only add a small amount of inorganic N, it’s contribution to nutrient cycling in deteriorated soils and crop yields would be substantial.

2. Effect of plant residue on soil

Use of plant residues can reduce soil exposure to erosive processes, promote a greater nutrient cycling and improve the synchrony of nutrient release with crop
demand (Myers et al. 1994). Cover crop residue can also conserve soil water (Blevins et al. 1971; Sullivan et al. 1991). In the Sahel zone, crop residues left in the field improved the physical and chemical properties of the sandy soils (Bationo and Okwunye, 1991). While in the humid, the contribution of the pruning to fertility of the soil will largely depend on the amount and decomposition rate of the biomass applied (Yamoah et al. 1986; Budelman 1988; Palm and Sanchez 1991). In humid lowland, Gliricidia fallow was preferred to Imperata fallow although it’s leaf litter contains little N but keeps the soil moist (Hartemink and O’Sullivan 2001). A recent study carried out by O’Connell et al. (2003) suggested that legumes used as a mulch in eucalyptus plantations are a readily available source of N for trees, and hence retention of harvested residues coupled with better management practices will maintain soil N fertility for the long-term.
CHAPTER III
MATERIALS AND METHODS

Site description:

This experiment was carried out in the demonstration farm of the Faculty of Agriculture, University of Khartoum Shambat (lat. 15° 39’ N, long. 32° 30’ E), for three month during the period between (19 April-19 July). The climate of the area is semiarid with relatively cool winter and hot summer, and the average rainfall is about 176 mm falling between June and September. The potential evapotranspiration normally exceeds precipitation throughout the year. The soil is a typic haplorthod grumustert (Vertisol). Its physicochemical analysis reported by Abdullah (1989), showed that the soil is characterized by relatively high clay content (52%), predominantly of the montmorillonite type and by low organic matter (Table 1).
### Table 1: Site descriptions and properties of Shambat soil series (Abdullah, 1989).

<table>
<thead>
<tr>
<th>Shambat Soil</th>
<th>Properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>PH</td>
<td>8.1</td>
</tr>
<tr>
<td>Total N (%)</td>
<td>0.056</td>
</tr>
<tr>
<td>O.M (%)</td>
<td>1.4</td>
</tr>
<tr>
<td>ECe ds/m.</td>
<td>0.52</td>
</tr>
<tr>
<td>K⁺ (meq/L)</td>
<td>0.1</td>
</tr>
<tr>
<td>Ca⁺² (meq/L)</td>
<td>1.8</td>
</tr>
<tr>
<td>Mg⁺² (meq/L)</td>
<td>0.5</td>
</tr>
<tr>
<td>Na⁻ (meq/L)</td>
<td>3.3</td>
</tr>
<tr>
<td>CO₃⁻² (meq/L)</td>
<td>0.36</td>
</tr>
<tr>
<td>HCO₃⁻ (meq/L)</td>
<td>2.3</td>
</tr>
<tr>
<td>Cl⁻ (meq/L)</td>
<td>3</td>
</tr>
<tr>
<td>CaCO₃ (meq/L)</td>
<td>3.5</td>
</tr>
<tr>
<td>Clay (%)</td>
<td>54.1</td>
</tr>
<tr>
<td>Silt (%)</td>
<td>26.2</td>
</tr>
<tr>
<td>Sand (%)</td>
<td>19.7</td>
</tr>
<tr>
<td>P (ppm)</td>
<td>3.3</td>
</tr>
</tbody>
</table>

Texture: Clay
Plant material:

Plant materials from different potential agroforestry tree species were screened for their C/N ratios. Accordingly, fresh plant leaves from 3 tree species were collected depending on their C/N ratios, i.e. low (17) represented by *Leucaena leucocephala*, Medium (27) represented by *Eucalyptus camaldulensis* and high C/N (51) represented by *Ficus bengalensis*. Results of the chemical analysis of the experimental plant material are given in Table 2.

**Table 2:** Chemical composition of the plant material of the three tree species.

<table>
<thead>
<tr>
<th>Plant Type</th>
<th>Dry matter Weight</th>
<th>C</th>
<th>N</th>
<th>P</th>
<th>K</th>
<th>C/N</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>mgkg(^{-1})</td>
<td>%</td>
<td>mgkg(^{-1})</td>
</tr>
<tr>
<td><strong>Leucaena</strong></td>
<td>61.7</td>
<td>15.3</td>
<td>58.5</td>
<td>8.9</td>
<td>3.5</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Eucalyptus</strong></td>
<td>54</td>
<td>17</td>
<td>62</td>
<td>10.9</td>
<td>2.3</td>
<td>0.6</td>
</tr>
<tr>
<td><strong>Ficus</strong></td>
<td>62.6</td>
<td>17.4</td>
<td>54.6</td>
<td>9.5</td>
<td>0.9</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Field decomposition:

Decomposition (mass loss) of the residues and nutrient release were monitored in the field using the litterbags method (Anderson and Ingram, 1989). Nylon bags of 15cm*20cm dimensions with a mesh size of 2mm were used. One side of the bag was lift open for faunal activity. About 40 g fresh weight from each material were placed into the bags with plastic labels.
The bags were buried in the field at depth of 20 cm. Water was sprayed on the field and soil moisture content during decomposition was determined (3.5 % to 4.2 %). Each plant material type was replicated three times and randomly distributed in the field. At each sampling date 1, 2, 3, 4, 6, 8, 10, 12 weeks three litter bags of each type were retrieved and soil was carefully removed. Each bag was placed inside a paper envelope and transferred to the laboratory for analysis. The remained residues were oven dried at 65-75 °C until constant weight. The soil attached to the dried material was carefully brushed out and the remained residue was weighed, ground to pass 0.5 mm sieve and analyzed for C, N, P, and K contents.

**Laboratory analysis:**

1) Organic carbon was determined using the modified Walkley Black Method, (Walkley and Black, 1934); 10 ml of K$_2$Cr$_2$O$_7$ (1N) and 20 ml of concentrated H$_2$SO$_4$ were added to 0.05 g of the plant sample, completed to 100 ml with distilled water, after awhile 10 ml of concentrated H$_3$P$_2$O$_5$ (Orthophosphoric acid) and 3 drops of orthophenatrolene were added to 10ml of the pure solution. Then titrated upon ferrous sulphate (0.5N).

   1) Total N was measured by a semi- macro Kjeldahl apparatus (Bremmer and Mulranzy, 1982); after wet digestion of 0.2 g of sample by conc. H$_2$SO$_4$ and gentle heating, then distilled and titrated the abstract upon HCl (0.1N)

2) The material was ashed at 150°C for 1hr first, then at 550 °C, and dissolved in 5N HCl to determine K and P. K was analyzed by flame photometer, P was measured by spectrophotometer in a molybdate yellow indicator.
Statistical analysis:

The rates of mass loss and nutrient release of residues (expressed as percent remaining of initial contents) were calculated using the single exponential model \( W_t = W_0 e^{kt} \) \( W_t \) is the mass loss at time \( t \) in weeks, \( W_0 \) is the initial dry matter or nutrient pool and \( k \) is the rate constant (Olson, 1963). Statistical differences between the three residue types were determined by subjecting the data to the analysis of variance (ANOVA), using the SAS program (1989). Means separations were conducted using least significant differences (LSD).
Dry Matter Weight loss (DMW):

Dry matter weight loss during the incubation period is shown in Fig.1a. There was rapid DMW loss of the three species during the first three weeks period after burying the litterbags. Statistical analysis showed that there were no significant differences in remaining DMW between the three species after the first week. However, Leucaena and Ficus seemed to decompose faster than Eucalyptus ($P \leq 0.07$). The amount of DMW remained after the first week were 80.5, 81.8 and 88.5% for Leucaena, Ficus and Eucalyptus, respectively. After the second week, Leucaena (64%) and Eucalyptus (68.9%) highly significantly ($P<0.003$) decomposed, faster than Ficus (77.8%), by 13% to 21%. Similar to the second week, the third one showed that Leucaena (60.9%) and Eucalyptus (65.6%) decomposed highly significantly ($P<0.01$) faster than Ficus (73.8%) by 12% to 21%. Dry matter weight remained after the end of the third week was (60.9%, 65.6%, and 73.8% for Leucaena, Eucalyptus, and Ficus, respectively. After the fourth and sixth week, DM loss in Leucaena and Eucalyptus were faster than Ficus by 4.7 to 13.7 %. After the sixth week, remained DM were 58.2%, 66.3%, and 63.7, for Leucaena, Ficus, and Eucalyptus, respectively. Fifty percent loss in DM was attained after week 8 and 11 for Leucaena and Eucalyptus, respectively, and after week12 for Ficus (Fig.1a). At the
end of the decomposition period (12 week), DMW of the decomposed leaves were (46%) (48.5%), and (54.6%) in Leucaena, Eucalyptus, and Ficus, respectively.

The non-linear regression showed that, decomposition of the 3 species are best described using the single exponential model \( W_t = W_0 e^{-kt} \) (where \( W_0 \) is the original amount of material applied, \( W_t \) is the proportion of the initial dry matter remaining after a period of time \( t \) in weeks, and \( k \) is the rate constant (Olson, 1963). Accordingly, DMW loss rate constant \( k \) for Leucaena was 0.081% week\(^{-1}\), and 0.07% week\(^{-1}\) for Ficus and Eucalyptus (Fig.1b). From this trend-line it seems that during a period of 12 weeks, Leucaena decomposed faster than both Ficus and Eucalyptus. The exponential model also was found a best to fit the decaying period of the three species (\( R^2 \) ranged between 0.99 and 0.95)

The rapid initial mass loss could be attributed to the removal of water-soluble material by rainfall, this was supported earlier by Parsons et al. (1990). Mass loss in the early stages involved both physical leaching and microbial metabolism of water-soluble material (Berg and Staaf, 1981; Berg and Wessen, 1984).

Mass loss of the Leucaena species was faster than that of Ficus and Eucalyptus, the rate recorded in this study are similar to those observed by Blair (1988) using deciduous leaf litter of comparable quality, and Musvoto et al. (1999) using mango and miombo leaf litter. It was agreed that decomposition and nutrient release rates are determined by the resource quality of the organic material (Swift et al. 1979). Leucaena leaf litter had a higher \( N \) content (low C/N ratio), considering that resource quality include the C/N ratio, it was found that the C/N ratio is a good
predictor in mass loss in Leucaena. Where as the rapid mass loss of Eucalyptus leave than Ficus leave although their higher C/N ratio, show that the C/N ratio is not a good quality predictor factor on that later stages. This may be attributed to their lignin and polyphenol contents (Jama and Nair 1995). Several workers have pointed out the importance of lignin and polyphenol contents in plant materials for their influence on decomposition. Fogel and Cromack (1977) found that the lignin concentration was inversely related to the rate of organic matter decay, and Berg and Staaf (1981) showed that the higher the initial lignin content, the lesser the influence of initial N on decomposition rate. At the end of 5 months period of eucalypt decomposition, Parsons et al. (1990) observed a mass loss of 35% and similar result 36% observed by Huang and Schoenau (1997). While only 48.5% of eucalypt remained after only 3 months in our study. This slower rate in both studies may be attributed to the cooled boreal aspen forest condition.
Figure 1a: Actual changes of percent dry matter weight remaining of the three species during the period of 12 weeks of incubation.
Figure 1b: Non-linear decomposition rate curves of the three species during the period of 12 weeks of incubation.
Nutrient Release:

Remaining C:

Generally, the release of Carbon during decomposition of the three species seemed to follow a three stages pattern Fig.2a. These stages are the rapid stage, the medium stage, and the slow stage. The rapid stage lasted for the third week. In this stage, there was rapid loss of C after the first week, where C remained in the decomposed Leucaena (68.8%) was significantly (P<0.002) lower than that determined in the decomposed Ficus (70.4%), and Eucalyptus (90.6%) by about 2.33% and 31.7%, respectively. Then, after the second week, C remained in Leucaena (59%) was also significantly (P<0.03) lower than that remained in Ficus (67%) and Eucalyptus (71.6%) by about 13.6% and 21.4%, respectively. At the end of this stage (after three weeks of decomposition) there were significant (P<0.02) differences between the three species. At the end of this stage, about 46.6%, 35.8%, and 34.4% of the initial C content were lost from Leucaena, Ficus, and Eucalyptus, respectively. In the second stage, (the period between the fourth and the sixth week), there were no obvious Carbon loss from the three species and even no significantly differences between them. As in the fourth week, the C remained were 52%, 63.3%, and 65.4% for Leucaena, Ficus, and Eucalyptus, respectively. After the sixth week, the C losses were only 4.8%, 10.5%, and 3.5% from Leucaena, Ficus, and Eucalyptus, respectively. Similar to the first stage pattern, the third one starts with a rapid C loss. Significant differences (P<0.004) in C remained after the eighth week was
found 35.9% in Leucaena, 49.2% in Ficus, and 57.60% in Eucalyptus. Then by the tenth week, C remained in Leucaena (29.5%) was significantly (P<0.03) lower than that remained in Ficus (43.8%), and Eucalyptus 48.7%, 48.5% and 65% respectively. At the end of the last stage (after 12 weeks incubation) the C remained in Leucaena was only 28.2%, and also significantly (P<0.04) lower than that remained in Ficus (38.3%), and Eucalyptus 47.5 %, 35.8% and 68.4% respectively. It was also observed that 50% C loss was attained in the second slow stage (between the fourth and sixth week) for the three species Fig.2a.

The pattern of C release was best fitted to the same exponential model for decomposition or DMW. The model showed that, carbon release rate constant (k) of Leucaena (0.15 % week\(^{-1}\) was significantly (P<0.01) higher than that of Ficus (0.1 % week\(^{-1}\)), and Eucalyptus (0.08 % week\(^{-1}\)), Fig .2b.

Rates of total carbon loss occurred at rates similar to total mass loss in Leucaena and ficus compared to Eucalypt which rate of mass loss was higher than Ficus, although Ficus with C: N ratio lower than that in eucalypt leaves, this could be attributed partly to the soil depth (Elzein and Balesdent, 1995; Jobbagy and Jackson, 2000; Nepstad et al., 1994, Trumbore et al., 1995; Van Dam et al., 1997). They consistently found that deep soils were an important
component of both local regional C cycling and that decomposition rates
decreased with depth in the soil profile. Another reason may be the resources
quality of both, especially cellulose (Gill and Burke, 2002). They found that
cellulose loss rate occurred more quickly than total mass, also they supported
that depth was a significant factor in explaining variation in loss rates for total C
and cellulose. It has been demonstrated that in soils where mineral N supply is
limited, relatively more C is mineralized per unit of N immobilized (Nommik,
1962). This explains why Ficus accumulate more N and release more C
therefore.
Figure 2a: Actual changes of percent Carbon remaining of the three species during the period of 12 weeks of incubation.
Figure 1.b: Non-linear decomposition rate curves of the three species during the period of 12 weeks of incubation.
Remaining N:

During the incubation period (12 weeks), the three species have clearly shown significant (p<0.1) different rates pattern in releasing N (Fig. 3a).

Nitrogen was released from Leucaena at a rate of 12.15% per week. After the first week, only 66.75% of the initial content of N in Leucaena was remained. Where in Ficus and Eucalyptus there were a high accumulation of N after the first week, the initial content of N in Ficus and Eucalyptus increased to 80.7% and 136.3%, respectively. After the second week Ficus and Eucalyptus began to lose N at rates of 19.2%/week for Ficus, and 6.5%/week for Eucalyptus.

There was a highly significant (P<0.001) difference between the three species after the second week. The remaining N was 52.9%, 160.8%, and 99.8% for Leucaena, Ficus, and Eucalyptus respectively. Also N values showed high significant (P<0.0005) differences after the third week, where the remaining N was 50.7%, 118.6%, and 75.6% for Leucaena, Ficus, and Eucalyptus, respectively. After the fourth week, Leucaena (45.3%) and Eucalyptus (62.9%), N amounts were significantly (P<0.005) lower than Ficus (112.9%). Similar to the fourth week, the following weeks continued with the same pattern, where the remaining N in Leucaena (43.2%) and Eucalyptus (61.7%) were significantly (P<0.003) lower than that of Ficus (110.6%) after the sixth week. Then after the eighth week, the remaining N in Leucaena (33.7%) and Eucalyptus (51.2%) were significantly (P<0.02) lower than that of Ficus (84.9%). After the tenth week the remaining N in Leucaena (27.7%) and Eucalyptus (38.3%) were significantly (P<0.002) lower than that of Ficus (77.5%). After the end of the incubation, the remaining N in Leucaena was
only 12%, which was significantly (P<0.01) lower than that of Ficus (50.6%) and Eucalyptus (34.1%).

Trend-line was bested fitted to the exponential model (R² between 0.62 and 0.92). Nitrogen decomposition rate constant (k) for Leucaena (0.2 % week⁻¹) was highly significantly (P<0.001) faster than that of Ficus (0.1% week⁻¹) and Eucalyptus (0.15% week⁻¹), Fig.3b.

N release rate in Leucaena was higher than that recorded by Lupwayi and Haque (1997) in theirs study that evaluated Leucaena and Sesbania in a 5-week laboratory incubation. The differences attributed to the field situations and organism activity. Results from laboratory experiments of short rotation *Eucalyptus globulus* plantation (O’Connell et al. 2003) indicated that the eucalyptus leaves in the cumulative maximum with ground incorporated case, had a stronger potential of N immobilization than that observed in our study. This may be linked to the degree of mixing into the soil (Per Ambus and Jensen, 1997; Jensen, 1994), they have also found that N immobilization rates were higher for ground residue compared to intact or coarse material, especially in the early stages of decomposition. Some studies, however reported no effect of particle size on N turnover (Bremer et al., 1991). Earlier field studies in eucalypt forests (e.g., O’Connell, 1994) also showed significant immobilization of N during decomposition of surface leaf litter. Eucalypt leaf litter in those studies had, however, a higher C/N ratio than the leaf residue in our study. Senescented Eucalypt leaf litter has higher C/N ratio than green leaves, because about 40-50% of N is retranslocated from green leaves during senescence (Sauer et al., 2000).
The increases of N concentration in Ficus and Eucalyptus decomposing litter may be attributed partly due to mechanisms such as microbial immobilization of N, similar results observed by Koenig and Cochran (1994), or as fungal translocation, through fall and insect frass as observed by Melillo et al. (1982), which resulted in a decrease in the C/N ratio of the residue. The N accumulated in the first weeks in Ficus more than in Eucalyptus, can be attributed partly to the insufficient N which may limit decomposer activity in early stages (Swift et al. 1979), and partly by the effluent water thronged by mistake in the experiment site in the first week. But more studies in the lignin and phenol levels are required as suggested recently by Guo and Sims (2002) in their study on Eucalyptus litter decomposition and nutrient release. They found that effluent irrigation significantly increased decomposition of Eucalypt from 46% to 62%, P, N, and Mg accumulated more than their initial concentrations.
Figure 3a: Actual changes of percent Nitrogen remaining of the three species during the period of 12 weeks of incubation.
Figure 3b: Non-linear Nitrogen decomposition rate curves of the three species during the period of 12 weeks of incubation.

- Leucaena
- Ficus
- Eucalyptus

Legend:

- Expon. (Leucaena)
- Expon. (Ficus)
- Expon. (Eucalyptus)
**Remaining P:**

Similar to the C release pattern, the P release curve may also be divided into two stages. The first rapid stage and the second slow stage, Fig. 4a. The first stage lasted until the third week and began with a rapid loss of P after the first week; Ficus (45.7%) released P significantly (P<0.01) higher than that of Leucaena (65.2%) and Eucalyptus (63.5%), by 29.9% and 28%, respectively. Then a break point was observed after two weeks where Ficus (45.3%) significantly (P<0.01) released P higher than that of Leucaena (59.5%) and Eucalyptus (60 %), by 24.3% and 25.1% respectively. After the end of the first stage (3rd week), only 1.3 and 1.2 %, of the initial content of P remained in Leucaena, Ficus, and Eucalyptus, respectively. The rate of P release in the three species was 33% week⁻¹. However, the release of P was slow during the second stage. Briefly in the second stage (from week 4 to week 12), remaining P was 0.78 % in Leucaena, 0.99 % in Ficus, and 0.95 % in Eucalyptus, and became 0.7% in Leucaena, 0.95 % in Ficus, and 0.84 % in Eucalyptus (Fig. 4a). The rate of P release in this stage was only 0.01 - 0.03% week⁻¹.

Statistical analysis indicated that there were no significant differences between the three species in the fourth and tenth week. However, after the sixth week Leucaena significantly (P<0.008) released P (0.9%) lower than that of Ficus (1.2%) and Eucalyptus (1.1%). Also, after the eighth week, Leucaena (0.78%) significantly (P<0.0007) released P highly lower than that of Ficus (0.99%) and Eucalyptus (0.95%); and in twelfth week, Leucaena (0.7%) significantly (P<0.01) released P highly lower than that of Ficus (0.95%) and Eucalyptus (0.84%). From this trend line it seems that Ficus released P faster than Leucaena and Eucalyptus in the first three
weeks, while Leucaena released P, faster than Ficus and Eucalyptus after the third week of incubation, Fig. 4a.

Results on P release rate constant (k) showed highly significant (P<0.001) differences between the three species. Values were found to be 0.71 % week⁻¹, 0.63% week⁻¹, and 0.67% week⁻¹ in Leucaena, Ficus and Eucalyptus, respectively, Fig. 4b.

The rapid P loss observed in the first weeks was probably a consequence of leaching of soluble P containing compounds. The placement of the litterbags in the field at the beginning of the rainy season probably intensified P leaching. Many workers have reported leaching of P in the early stages of decomposition (Tripathi and Singh 1992; Musvoto et al. 1999; and Tiquia et al. 2002). The variability of P leached had been explained by Babbar and Ewel (1989) to be due to the differences in solubility of P-compounds in the investigated leaf type, and could also be attributed to the differences in residue mineralization.
Figure 4a: Actual changes of percent Phosphorous remaining of the three species during the period of 12 weeks of incubation.
Figure 4b: Non-linear Phosphorous decomposition rate curves of the three species during the period of 12 weeks of incubation.
Remaining K:

Potassium release followed a two stage pattern. The first stage started with immediate loss of K from the three species that happened within a period of two weeks. In the second stage, there was a steady slow release (period from the 3rd to 12th week), Fig. 5a.

In the rapid stage, only 30.2%, 34.9%, and 29.1% of the initial K from Leucaena, Ficus, and Eucalyptus, respectively remained after the first week. After the second week K content decreased to about 15.9% in Leucaena, and 21.9% in Eucalyptus. Both were significantly (P<0.008) lower than that of Ficus (30.4%) by 91.2% and 38.8%, respectively. It was observed that Eucalyptus continued to loose K at the same rapid rate after the third week (remained K was only 7.5%). However, in the second stage (specially after the third week) K remained in Leucaena (14.1%) and Eucalyptus (7.5%) were significantly (P<0.04) lower than that of Ficus (28.7%). Also after the fourth week, it's content in Leucaena (12.7%) and Eucalyptus (6.8%) was significantly (P<0.03) lower than that of Ficus (45.7%). At the end of the sixth week, K remained in Leucaena (12.4%) was almost double than that remained in Eucalyptus (6.5%), and both were significantly (P<0.04) lower than that of Ficus (21.6%). However, results of the eighth week showed that Leucaena and Eucalyptus significantly (P<0.001) released K faster than Ficus. During this week, (5.1%, 3.6%, and 14.8% of the initial K was washed out from Leucaena, Eucalyptus, and Ficus, respectively. After ten weeks of decomposition, similar to the 8th week, K remained in Ficus was significantly (P<0.0025) higher and it was almost six times than that remained in both Leucaena (2.4%) and Eucalyptus (2.2%). After twelve weeks (i.e. at the end of
the period), the remaining K was only (1.8, 3.06, and 2.06 %) for Leucaena, Ficus, and Eucalyptus respectively and there were no significant differences recorded between them. These results showed that more than half of the initial content of K was lost in the earlier weeks. The trend of the K release clearly indicates that rate of K loss from Leucaena –and eucalyptus- was rapid compared to that of Ficus (Fig. 5a).

On the other hand, the exponential model revealed that the K release rate constant (k) for Leucaena (0.43%/week⁻¹) and Eucalyptus (0.46%/week⁻¹) were highly significant (P<0.003) than that for Ficus (0.32% week⁻¹), Fig. 5b.

It was clearly noticed that from the trend lines, Leucaena decomposed and released C more rapid than both Ficus and Eucalyptus. Despite the fact that, in the first stages P was released faster from Ficus compared to Leucaena and Eucalyptus, but oppositely, release of K was faster from Eucalyptus compared to Leucaena and Ficus.

The rapid release of the K reported in this study could be attributed to its high mobility. This has also been observed by most studies in decomposition of organic materials (Bunnell and Tiat 1974; Berg 1984; Saini 1989; Reddy and Venkataiah 1989; Jung et al. 1968). They reported that K release appears not to be affected by leaf anatomy or chemical composition because this cation is not incorporated into the organic compounds tissue in the plant so it is easily leached from residues. The slower release rate thereafter observed in this study may be attributed to the little change in soil exchangeable cation contents, this was also supported by the study of Lupwayi and Haque (1998). And also attributed to the environmental condition (e.g. lower humidity after the rainy season).
Figure 5a: Actual changes of percent Potassium remaining of the three species during the period of 12 weeks of incubation.
Figure 5b: Non-linear Potassium decomposition rate curves of the three species during the period of 12 weeks of incubation.
Table 3: Decomposition and nutrient release rate constants of the three species.

(W₀ = Dry matter or nutrient pool, k = rate constant).

<table>
<thead>
<tr>
<th>Leaf residue Type</th>
<th>Dry matter</th>
<th>Carbon</th>
<th>Nitrogen</th>
<th>Phosphorous</th>
<th>Potassium</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Leucaena</em></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K (%Week⁻¹)</td>
<td>0.09</td>
<td>0.14</td>
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<td>0.70</td>
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<tr>
<td>W₀</td>
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<td>101.29</td>
<td>115.54</td>
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<td>96.83</td>
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<tr>
<td>R²</td>
<td>0.89</td>
<td>0.94</td>
<td>0.88</td>
<td>0.73</td>
<td>0.92</td>
</tr>
<tr>
<td><em>Ficus</em></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>K (%Week⁻¹)</td>
<td>0.07</td>
<td>0.10</td>
<td>0.11</td>
<td>0.64</td>
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<td>W₀</td>
<td>98.17</td>
<td>97.73</td>
<td>108.54</td>
<td>102.76</td>
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<tr>
<td>R²</td>
<td>0.95</td>
<td>0.93</td>
<td>0.62</td>
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<td>0.82</td>
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<tr>
<td><em>Eucalyptus</em></td>
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</tr>
<tr>
<td>K (%Week⁻¹)</td>
<td>0.08</td>
<td>0.07</td>
<td>0.16</td>
<td>0.67</td>
<td>0.45</td>
</tr>
<tr>
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<td>102.66</td>
<td>149.37</td>
<td>119.96</td>
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<tr>
<td>R²</td>
<td>0.92</td>
<td>0.94</td>
<td>0.92</td>
<td>0.73</td>
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</tr>
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</table>
CONCLUSION

It could be concluded that:

1- the chemical characteristics of plant materials used as litter residues play a fundamental role in the decomposition and nutrient release processes.

2- it is assumed that the litter residue from leguminous plants, such as *Leucaena sp*, are considered to be of a high resource quality to microorganisms. Agreed with most authors, they decomposed and released N quickly.

3- adding materials with “lower quality” (high C/N ratio, lignin and phenol level) such as Ficus and Eucalypt leaf litters however, will decrease yield and N mineralization, but at the same time may enhance the build up of organic matter and soil fertility.

4- It is very important in alley cropping management systems that use Ficus and Eucalypt plantation with the crops, to apply N fertilizers.

5- the result of this study agreed with the study of O'Connell et al. (2003), who suggested that Leucaena legumes could be used as a mulch in Eucalypt plantations, and provide a readily available source of N for trees, and that the benefits from retention of harvest residue are more likely in maintaining soil N fertility on the long-term.
REFERENCES


Figure 2b: Non-linear Carbon decomposition rate curves of the three species during the period of 12 weeks of incubation.