# Proceeding

**3rd INTERNATIONAL CONFERENCE FOR DEVELOPMENT OF IPM IN ASIA AND AFRICA**
Marcopolo Hotel
**7th – 9th December 2009**

# Development of Integrated Pest Management in Asia and Africa

## Volume 3

### Edited by:

Jamalam Lumbanraja
F.X. Susilo
Purnomo
Rosma Hasibuan
Ainin Niswati
Sri Yusnaini
Hidetaka Hori
Keiichi Okazaki

The articles published herein are proceedings of **3<sup>rd</sup> International Meeting for Development of Integrated Pest Management in Asia and Africa** held in **Bandar** Lampung, Indonesia, 7-9 December, 2009.

_____

Published by The University of Lampung Press

Printed and distributed by The University of Lampung Press
Jl. **Sumantri** Brojonegoro No. I **Bandar** Lampung 35145, Indonesia
Tel: +62 (0721) 702673,. Fax: +62 (0721) 702767

# Contents

## Gene Modified Organisms

## Soil Organic and Plant Nutrition

# Effect of Fallow Vegetation Materials Representing Different Organic Matter Quality on Soil P Availability, P-Microbial Biomass, and Soil Microbe Activities in Incubation Study

## L. Abdullah

Grassland Science Division, Faculty of Animal Science
Bogor Agricultural University

## Abstract

An incubation study on amended forest soil was conducted to investigate the effect of quality of fellow vegetation residue amended into forest soil on related soil phosphorus parameters. Plant residue from five species of secondary forest vegetation, namely: *Albizia lebeck, Trichospermum Sp., Macaranga hispida, Chromolaena odorata* and *Ficus subulata* were incorporated in a very low-P Gxisol (0,8 ppm Bray-1;pH 5.68 CaCl$_2$) and incubated for 125 days. Soil pH, Net soil P mineralization, Soil P microbial biomass, soil respiiation and phosphatase activities were evaluated. The results revealed dynamics of soil pH during incubation with range from ca. 0.2 to 0.9 units, particularly at the first week. Soil P availability, soil microbial biomass, soil respiration and soil phosphatase activities were affected by plant residue quality. *Chromolaena* resulted in the highest available P in the soil.

Keywords: plant residue, P microbial biomass, P mineralization, immobilization, phosphatase

## Introduction

The slash-and-burn method forms the basis of traditional grassland system. Opening secondary forest area for cultivating grasses or other agricultural crops with such method in the long run may lead to vegetation degradation, soil degradation, declining soil fertility and reduced crop productivity. Maintaining the slash-and-bum method will thus become a boomerang for the local farmers and food security in the future. Offering an alternative to change this common practice has to be supported by logical information that is technically and economically sound and acceptable to the users.

The scientific information collected from this study could not, of course, contribute to all aspects concerning the slash-and-mulch system. However, it deals with the improvement of P availability in soils, in which this element is always a major plant nutrient constraint (Adeptu and Corey, 1977; Harrison, 1987; Tiessen, 1995 and Sharpley, 2000) in the humid tropics. The influence of chemical composition of the plant litter/material on the rate of decomposition and its influence on soil fertility have been recognized since the early stages of agriculture. Many decomposition studies involving different litter sources have been conducted to find ways of predicting the rate of litter decomposition and, even more important, the rate of nutrient release that is dependent on the chemical composition of the source.

In natural ecosystems, plant residue quality originated from fellow vegetation determines the decomposer community by presenting a diverse range

of sources of varying decomposability. The resistance of Litter to decay may be related to intrinsic factors such as: chemical composition, hardness, mass and particle size. Many studies have demonstrated that the chemical composition of litter such as water soluble compounds, cellulose and hemicelluloses, N complex and lignin, lignin content, ratio of polyphenol content to N, cellulose and hemicelluloses are involved in determining the rate of decomposition (BRELAND, 1997). However, there is still insufficient specific information about the influence of plant material quality on the mechanisms of phosphorus mineralization and immobilization in the slash-and-mulch system. The mechanisms of P release from amended plant material of different species originating from secondary forest vegetation are important to understand. This understanding would help to set up a strategy of organic matter utilization and management in the humid tropics in order to sustain the P availability in the soil. The study aimed to assess the effect of plant material quality on soil P availability, P microbial biomass, soil microbes respiration and soil phosphatase activity.

## Materials and Methods

### Soil preparation

The incubation study was conducted in Institute of Agriculture in the Tropics, University of Goettingen, Germany, in 1999. The soil used in the incubation experiment was a typical rain forest soil red-Oxisol that contained very low available P. Before incubation, the chemical and physical properties of soil were determined (Table 1).

The soil was pre-incubated according to a modified method of Fokin and Radzhabova (1995). The air-dried soil was screened by using a 3-mm sieve, moistened and placed in plastic bags. The soil moisture content was set equal to 60% of the total water holding capacity ($380.5 \pm 26.4$g water per kg of dry soil). The moist soil was incubated in growth chamber at a temperature and relative humidity of 25-27ºC and 80%, respectively, for 14 days to stabilize the microbial activities.

### Chemical and physical characteristics of the original soil

The soil was characterized with very low organic carbon, total nitrogen, and available P contents, and a low cation exchange capacity (Table 1).

### Plant material preparation

Five tropical fallow species namely: *Albizia lebeck* (Wilalo), *Trichospermum* sp. (Wunu), *Macamnga hispida* (Umera), *Chromolaena odorata,* and *Ficus subulata* are the dominant species growing in the secondary forest in Kendari, southeast Sulawesi Province, Indonesia. They were slashed from a three-and seven-year shifting cultivation area. These fallow species were used in this experiment as a mulch source.

Before incubation, the chemical composition of the plant material was determined. The air-dry plant material, comprising wood and leaves, were chopped separately and dried at 60 ºC for 24 hours. The plant material was then ground (<2 mm) for chemical analysis.

Table 1. Chemical and physical properties of red-Oxisol used in the incubation study

| Chemical properties | |
| --- | --- |
| pH | |
| H2O | 6.18 |
| CaCl$_2$ | 5.58 |
| C organic (%) | 0.9 |
| N total (%) | 0.1 |
| Available P Bray-1 ($\mu$g P g$^{-1}$) | 0.8 |
| CEC (me/100g) | |
| Ca (me/100g) | 1.35 |
| Mg (me/100g) | 0.7 |
| K (me/100g) | 0.2 |
| Na (me/100g) | 0.17 |
| H (me/100g) | 0.18 |
| Al (me/100g) | 0.10 |
| Base saturation (%) | 32.7 |
| Physical properties | |
| Sand (%) | |
| Silt (%) | 8.4 |
| Clay (%) | 44.1 |
| | 37.5 |

## Chemical composition of phnt material

The plant material was ground with a ball mill (one-mm mesh) and weighed in aluminum capsules. Total C and N were measured using an element analyzer type NA1500 series 2.

Standard and samples were weighed (0.5±0.05) and digested in HClO$_4$+HNO and 6N HCl at 160-220°C. The diluted supernatant was then used to measure total P colorimetrically with an auto analyzer and minerals with Atomic Absorption Spectrophotometer.

Acid-detergent fiber (ADF) was determined according to Van Soest (1963). One gram of sample (one-mm mesh) was boiled in an acid detergent solution (Cetyl-trimethyl-ammonium-bromide dissolved in 0.5 M H$_2$SO$_4$) for one hour. The substrate was then filtered through a crucible filter and dried at 105°C. The difference in weight between the fresh sample and the filtrate was calculated as fiber, soluble in acid. The dried sample from the ADF procedure was digested with H$_2$SO$_4$ (98%) for 3 hours to form a paste. The paste was filtered, dried at 105°C for 3 hours, and ashed at 500°C. The difference in the weight of the crucible from the ADF procedure and after ashing was calculated as lignin. cellulose was calculated from the difference in value between ADF and lignin according to Van Soest (1963).

## Soil amendment with plant material

Plant material of each species (±0.5 mm) was mixed homogeneously into the upper 5 cm of the soil. The amount of plant material was 3% of the total soil weight. The proportion of wood and leaf was 80% and 20%, respectively, based on data calculated from Denich (1989). For *Chromolaena odorata*, stem and leaf were not separated. Amendment with plant material resulted in supplementation of nutrients in the soil as depicted in Table 2.

Table **2.** Amount of nutrients supplied by plant material amendment, calculated from **3%** amended plant material (w/w of the soil weight)

| Plant species | Nutrient content ($\mu g\ g^{-1}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | C | N | P | Ca | Mg | K | Fe | Na | Mn |
| *Ficus subulata* | 1381 | 199 | 21 | 59 | 20 | 128 | 1.0 | 2.5 | 1.8 |
| *Albizia* lebeck | 1388 | 537 | 17 | 54 | 13 | 58 | 0.3 | 2.1 | 2.2 |
| Chromolaena | 142% | 319 | 36 | 47 | 13 | 173 | 1.4 | 1.4 | 0.7 |
| Macaranga | 1435 | 165 | 14 | 43 | 9 | 60 | 0.9 | 1.1 | 0.2 |
| *Trycospermum* | 1402 | 211 | 17 | 51 | 22 | 109 | 0.3 | 4.8 | 0.3 |

The soil mixtures were incubated aerobically in plastic bags. Each bag contained **160** g soil. The soil mixture was supplemented with a nutrient solution containing **60** mg N/kg and **40** mg K/kg to stimulate soil microbe activity. One ml of the nutrient solution was injected into the soil at five locations to a depth of one cm.

The bags were placed in an incubator at 27°C and **80%** relative humidity. To maintain the soil moisture content, deionized water was injected weekly into the bags. The difference in soil weight before and after incubation was considered as water losses. At 4, **8, 32, 72** and **125 days** of incubation, the soil was sampled to collect the data.

## Soil chemical, biological and biochemical properties

## Soil pH

Soil pH was determined in a **1:2.5** ratio soil and **0.01** M $CaCl_2$. The soil suspension was allowed to equilibrate for **30** minutes after which the pH values were measured with a glass electrode/ pH meter.

## Soil microbial biomass P

Soil microbial biomass P was measured with the fumigation-extraction method (Bfookes et *al.*, **1982).** The sieved moist soil was divided into nine sub-samples, each containing **10** g dry matter. Three parts of the soil were fumigated with ethanol-free-chloroform in the dark for **24** hours at 25°C. The remaining six fractions were subsequently incubated without chloroform. Mineral P was added to the soil before fumigation to recover the P sorbed by soil minerals after release from dead microbial cells during fumigation. A **200-ml** aliquot of **0.5** M $NaHCO_3$ pH **8.5** was used to extract the soil. Inorganic phosphate in the soil extract was determined photometrically at **712 nm** as a blue phosphate molybdic acid complex (Olsen and Sommers, **1982).**

## Available P (P Bray-1)

Air-dried soil (5 g) was extracted with a mixture of ammonium-fluoride and hydrochloric acid adjusted to pH **2.6±0.05.** The phosphate in the extract solution was determined colorimetrically with the autoanalyzer.

## NaHCO₃-extractable inorganic P

A 10 g of air-dried soil was extracted with **200-ml** of $NaHCO_3$ (**0.5** M pH **8.5)** for **30** minutes. To avoid coloration due to plant material or organic matter, the supernatant was filtered with a micro-cellulose filter and stored for three

hours in a refrigerator. A five milliliters aliquot was acidified with 2.5 M $H_2SO4$ and P determined by colorimetry (Murphy and Relay, 1962).

### Soil respiration rate

The soil respiration rate was measured during the experiment to detect the soil microbial activity. $CO_2$ respired from the soil during 24 hours of incubation (25°C) was collected in 0.05 M NaOH as described by Isermeyer (1952). To precipitate the absorbed $CO_2$, 1-2 ml of 0.5 M $BaCl_2$ was used. The remaining sodium hydroxide was titrated with HCl 0.5M (titrosol).

### Phosphatase activity

The measurement of the assay of the phosphatase activity was based on colorimetric estimation of the p-nitrophenol released by phosphatase activity when the soil was incubated with buffered sodium p-nitrophenol phosphatase (Tabatabai, 1982). One gram of moist soil was added with sodium p-nitrophenol, incubated at 37°C for 1 hour, and extracted with an acid-modified buffer for acid phosphatase activity measurement, and an alkaline-modified buffer for alkaline phosphatase. After incubation, 0.5 M $CaCl_2$ and 0.5 M NaOH were applied to the soil. The diluted supernatant was measured colometrically at 400 nm.

### Water-holding capacity

Five pots containing one kg oven-dried soil were saturated with a given quantity of water, and drained until the last drop of water emerged from the pots. The water flow from the pots was weighed. The difference between the water quantity added to the soil and the quantity collected from the pots is considered as the water holding capacity.

### Experimental design

A complete randomized design was used in this experiment. The main treatment was 5 different species and a control (without amendment). Each treatment was replicated 3 times. The data were analyzed with an analysis of variance. Mean values at each sampling period were compared by using Least Significant Differences (LSD) at level 5%.

## Results and Discussion

### Chemical composition of plant-material amendments

Table 3 illustrates the nutrient content of the different plant materials and their chemical composition. The rate of decomposition and nutrient mineralization is affected by both nutrient content and chemical composition of the plant material (TENNEY and WALKSMAN, 1929). *Chromolaena* has a relatively high quality as compared to other species, particularly *Macaranga*. *Chromolaena* has *a* lower C/N/P ratio and lower lignin, ADF and cellulose content than others. On the other hand, *Macaranga* has a relatively high C/P ratio and high lignin content compared to the others. *Ficus, Albizia* and *Trycospermum* are of relatively moderate quality.

Table 3. Chemical composition of plant material amendment

| Species | C-total ($Y_0$) | N-total ($Y_0$) | P-total (%) | C/P | ADF ($Y_0$) | Lignin ($Y_0$) | Cellulose (%) |
|---|---|---|---|---|---|---|---|
| *Ficussubulata* | 46.1 | 0.66 | 0.07 | 664 | 68.2 | 22.7 | 45.5 |
| *Albizia* lebeck | 47.4 | 1.06 | 0.06 | 819 | 73.1 | 19.6 | 53.3 |
| *Chromolaena* | 46.3 | 1.79 | 0.12 | 395 | 53.3 | 13.1 | 40.2 |
| *Macaranga* | 47.9 | 0.55 | 0.04 | 1073 | 72.9 | 22.9 | 49.9 |
| *Trichospermum* | 46.8 | 0.70 | 0.06 | 832 | 60.8 | 19.7 | 41.1 |

## Soil pH

Soil amendment with plant material significantly (p<0.01) increased soil pH (Figure 1). The increment ranged from ca. 0.2 to 0.9 units. Immediately following the amendment with plant material, there was a drastic increase of the pH value. This decreased with the incubation time up to 32 days, except for the soil amended with *Chromolaena* and *Albizia* (showing little increase). Soil pH did not change significantly between 32 and 125 days.



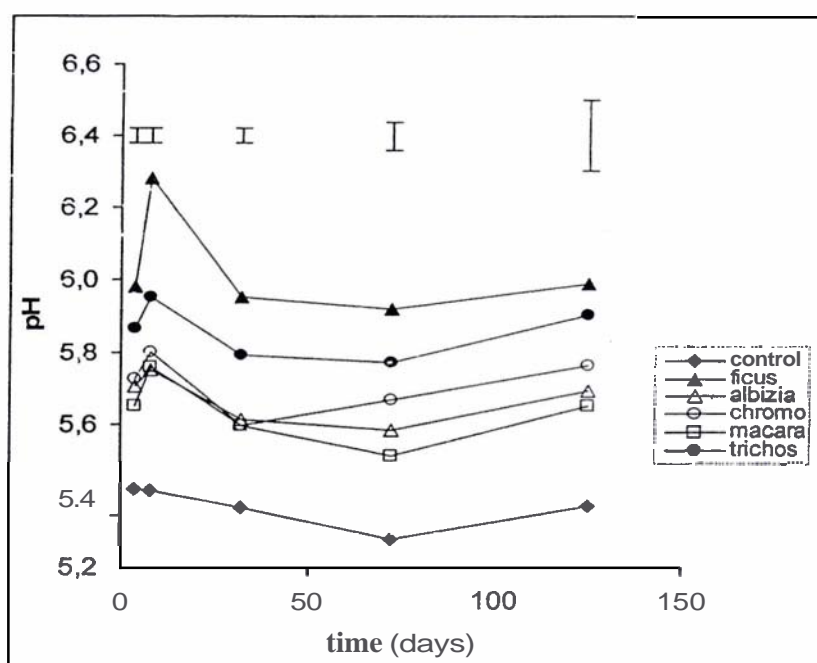Figure 1. Effect of plant material amendment from different species on the soil pH during incubation. Plant materials consist of 80% wood and 20% leaf for *Ficus, Albizia, Macaranga* and *Trycospermum*, while plant material from *Chromolaena* were not separated.

The increase in soil pH in the amended soil may be related to the supply of cations originating from the plant material. The mineral elements in the plant

material (Ca, Mg, K, Fe, Na and Mn) are positively charged, and may be released into the soil. However, there was no a significant correlation between the concentration of these elements in the plant material and the soil pH. A similar result was reported by Marschnera and Nobleb (2000), who applied plant material to soil and found up to 50% of the added alkalinity was available for acid neutralization immediately after mixing. The shift from stronger to weaker acidity is evidence of the microbial decarboxylation of soluble organic anions (Marschneraand Nobleb, 2000).

## NaHCO₃-inorganic P

NaHCO₃-inorganic P (Pi) is a pool of P, which is sorbed by soil minerals and available to plants. According to the modified concept of P flows during decomposition of plant residue (Huffman et *al.*, 1996), this pool of P can be transformed to an inorganic P in solution or. to labile P in the organic pool by microorganisms. Amendment with plant material significantly ($P<0.01$) affected the Pi concentration in the soil (Figure 2).
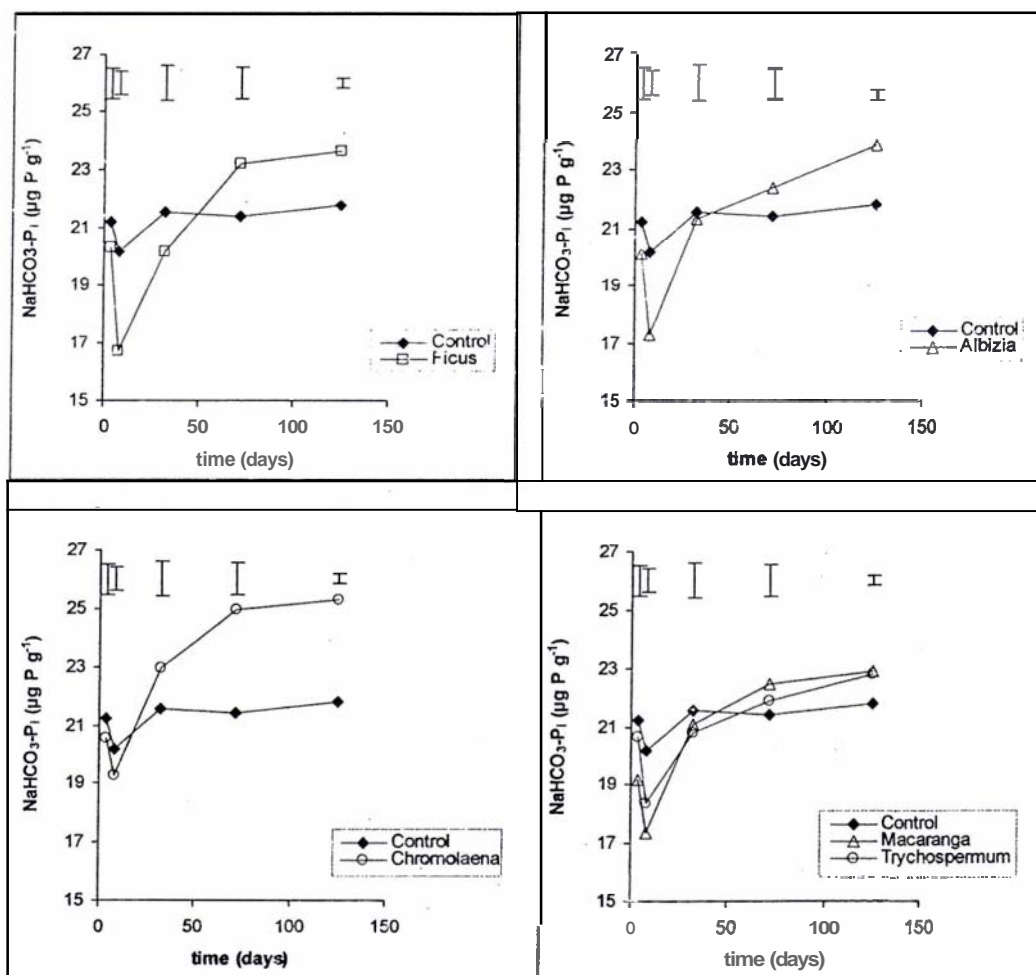


Figure 2. Effect of plant material amendment from different species on NaHCO₃-extractable-inorganic P dynamics in the soil during incubation. Plant materials consist of 80% wood and 20% leaf for *Ficus, Albizia, Macaranga* and *Trycospermum,* while plant material from *Chromolaena* were not separated

After 8 days, the decrease in Pi was highest in the soil amended with *Ficus,* followed by Macaranga, Albizia, *Trycospermum* and Chromolaena. Apparently, the high demand for P for microbial growth could not be obtained from P released by plant material. This is substantiated by the data of net mineralization as depicted in Fig. 4, with a negative value of mineralized P during this period of incubation. There was no such immobilization of labile $P_i$ from the soil without amendment (control),which had a higher level of Pi compared to amended soil over this incubation period. An appreciable net significant level of P release occurred after the 32 days period in Chromolaena amended soils up to the end of experiment. At 125 days, a considerable release of P had taken place in each species. At the end of incubation, $P_i$ according to plant material amendment, increased 4 µg P g⁻¹ (Chromolaena),2 µg P g⁻¹ *(Ficus* and Albizia), and lpg P g⁻¹ *(Trycospermum).*

## Bray P

Bray P in the soil was significantly (p<0.01) increased by amendment with plant material. Similar to the $NaHCO_3$-extractable inorganic P (Pi), there was a depletion of Bray P levels after 8 days of incubation with plant material amendment, but not in the control (Figure 3). Up to day 8, Bray P of the control was higher than that of the amended soil, except with Chromolaena. However, following the first 8 days of incubation, the amended soils showed a drastic increase in Pi contrary to the control. Bray P did not change between 32 and 125 days. The highest level of Bray P was obtained in the soil amended with Chromolaena, reaching almost 2.5 times the Bray F of the control.
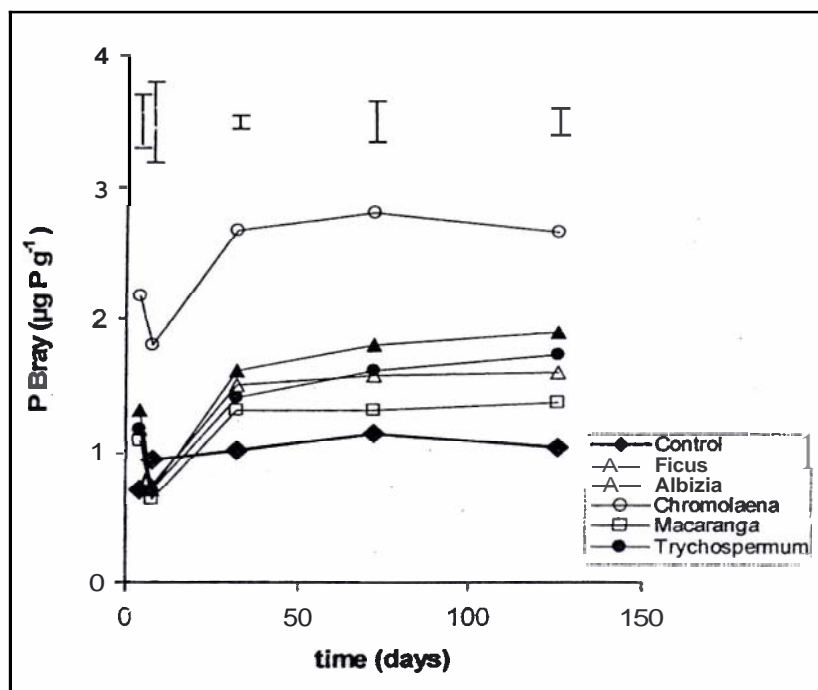


Figure 3. Effect of plant material amendment from different species on Bray P of the soil during incubation. Plant materials consist of 80% wood and 20% leaf for *Ficus,* Albizia, *Macaranga* and *Trycospermum,* while plant material from *Chromolaena* were not separated

The increased P concentration in the amended soil may be attributed to the P content, C/N/P ratio and lignin content of the plant material. A higher P content and a lower C/N/P ratio and lignin content of the plant material increased the available P concentration in the amended soil. The P content of the plant material was the most important factor in regulating the mineralization of P. Blair and Boland (1978) also suggested that there was a close relationship between the organic P mineralization rate and C/P ratio in forest mulch. Phosphorus in plant material high in total P was more readily available than P contained in plant material low in total P (FULLER *et* al., 1956). This is supported by the high correlation soil-available P and P content ($r = 0.73$; $p < 0.05$), lignin/P ratio ($r = -0.71$; $p < 0.05$) and lignin/N ratio ($r = -0.64$; $p = 0.066$) of added plant material, as found in this study.

## Net P mineralization

According to Bowman and Cole (1978), $NaHCO_3$-inorganic P (Pi) was the best indicator for predicting P mineralization in the soil. In our study, net P mineralization was calculated from the differences of the $NaHCO_3$-$P_i$ concentration in the amended soil and the control.

The P mineralization was affected ($P < 0.01$) by the species, which reflects the quality of the plant material. As shown in Figure 4, labile Pi was immobilized at the beginning of incubation. The peak in P immobilization was seen by 8 days, reflecting the high P consumption by soil microbes as shown by the maximum level of soil microbial biomass P at this point in time. The P immobilization was dependent on the P content of the amended plant material. In this study, the P content of the amended plant material ranged between 0.04% and 0.12%. Other researchers reported that immobilization of P could occur if the P content of the amended plant material was less then 0.2% (Fuller *et* al., 1956) and 0.3% (Kaila, 1954 and Singh and Jones 1976).

Remineralization of P occurred in the soil amended with *Chromolaena* within a month. The remineralized P may be from dead cells of microorganisms due to consumption by grazers (Huffman *et* al., 1996) or due to competition within their own tropic level. Phosphorus was still immobilized in the soil amended with *Trichospermum*, Macaranga, *Albizia* and *Ficus* up to 32 days. Remineralization for *Trichospermum*, Macaranga, *Albizia* and *Ficus* was evident after 72 days.

Mineralization of plant material is dependent on the C/P ratio of the amended plant material. Blair and Boland (1978) reported that mineralization of P was found if the C/P ratio of the amended organic matter ranged from as low as 55 to as high as 300. This is comparable to our study. Here net P mineralization already occurred after several days of incubation, although the C/P ratio of the amended plant material was more than 300 (395-1073).

## Microbial-biomass P

Microbial biomass P is the labile organic P in microbial cells, which is easily hydrolyzed after cell death and rupture, resulting in the release of mostly inorganic P upon chloroform fumigation of soil microbes (Brookes *et* al., 1982). The level of microbial biomass P in the soil was significantly ($p < 0.05$) influenced by amendment with plant material.
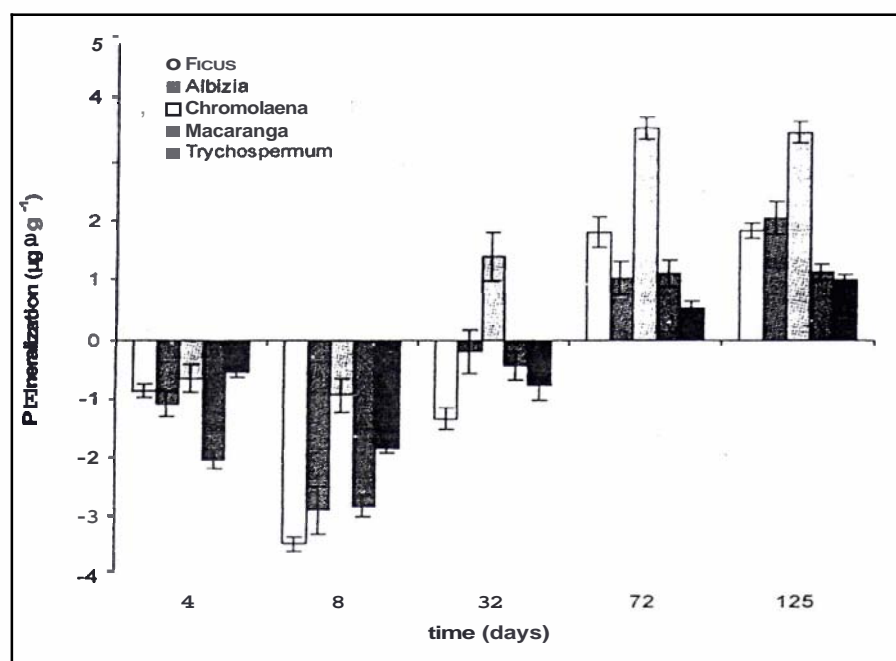
Figure 4. Phosphorus mineralization in the soil during incubation as a result of amendment with plant material of different species. The negative value showed P immobilization and the positive value showed P mineralization. Plant materials consist of 80% wood and 20% leaf for *Ficus, Albizia, Macaranga* and *Trycospermum,* while plant material from Chromolaena were not separated

Tie microbial biomass P peaked by 8 days for all treatments (Figure 5). This corresponded with the time when $P_i$ and Bray P were the lowest and the soil pH reached the maximum level. In the soil amended with plant material, a significant positive correlation ($i = 0.47$; $p<0.01$) between soil microbial biomass P and soil pH was found, suggesting a considerable effect of soil pH on soil microbial activity (Chandini et *al.,* 1999) and soil fungi (Donnison et al., 2000). An increase of ca. 0.4 to 0.9 units in pH increased microbial biomass P about 2 to 7 yg P $g^{-1}$.

Amended soils had higher levels of microbial biomass P at every incubation time than the control. At the time of the maximum value of microbial-biomass P, the differences between the amended soils and control were 3-5 µg P $g^{-1}$ for *Ficus, Macaranga, Albizia* and *Trycospermum* and 7 yg P $g^{-1}$ for Chromolaena. The soil amended with Chromolaena had a higher microbial-biomass P by 8 days, but this declined rapidly to the lowest level after one month compared to other species. Following the first month of incubation, the microbial- biomass P was relatively constant.

## Soil respiration rate and cumulative-respired $CO_2$

Carbon dioxide was monitored throughout the experiment. The respiration rates across species were significantly different ($p<0.01$); amendment with plant material to the soil increased the respiration rate as compared to the control (Figure 6).
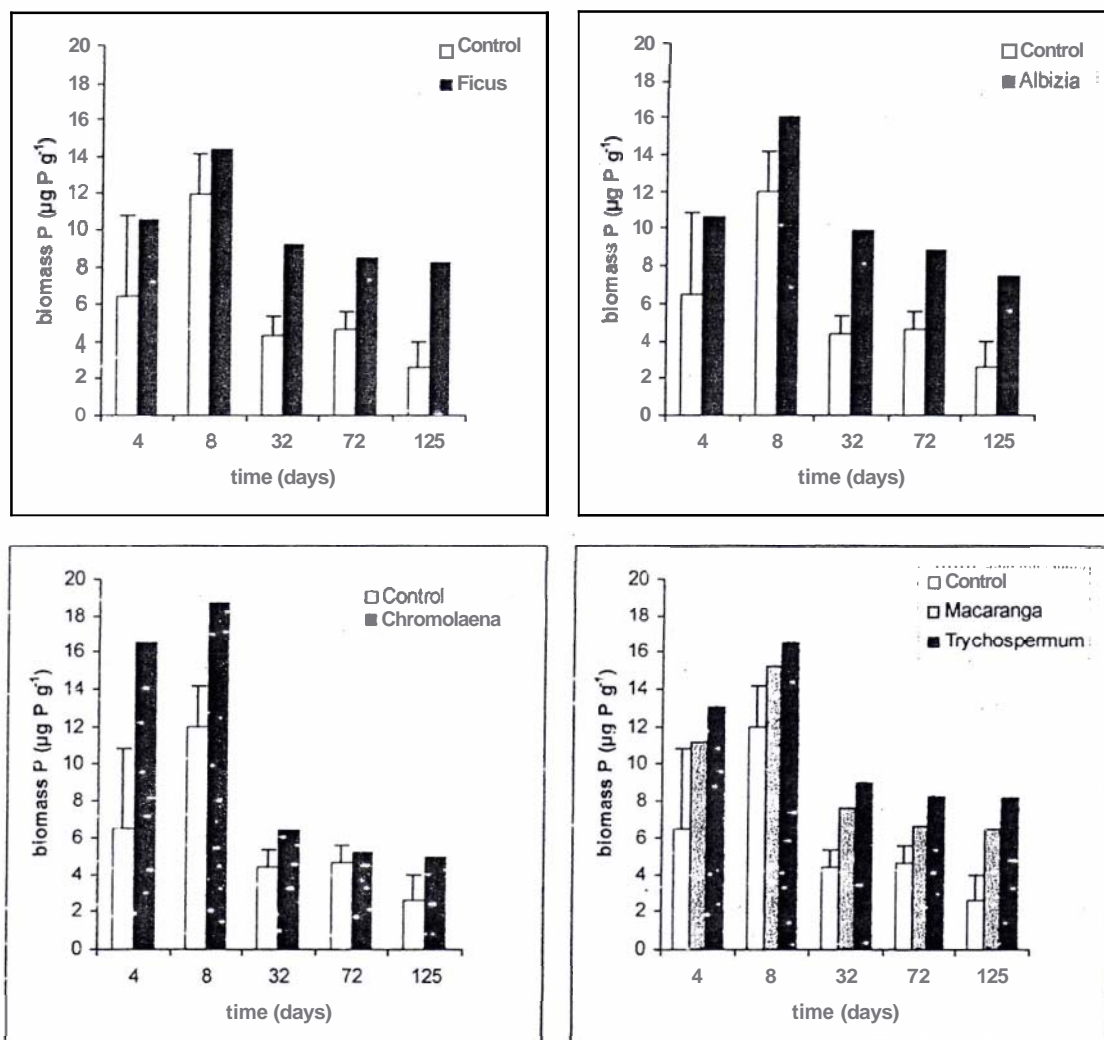
Figure 5. Effect of plant material amendment from different species on microbial-biomass P of the soil during incubation. Plant materials consist of 80% wood and 20% leaf for *Ficus, Albizia,* Macaranga and *Trycospermum,* while plant material from *Chromolaena* were not separated

The highest respiration rate of amended soil was found when the microbial biomass P was maximum (8 days), due to vigorous growth of the microbial community after addition of nutrients (Vesterdal, 1998). The maximum respiration rate was: 0.56 mg $CO_2$ $g^{-1}$ $d^{-1}$ (Chromolaena), 0.47 mg $CO_2$ $g^{-1}$ $d^{-1}$ (Albizia) and 0.37 mg $CO_2$ $g^{-1}d^{-1}$ *(Macaranga, Trycospermum* and *Ficus).* By extension of the incubation time up to the end of the experiment, it dropped by 66, 74, 80, 67 and 57 % for *Chromolaena,* Albizia, Macaranga, *Trycospermum* and *Ficus,* respectively.
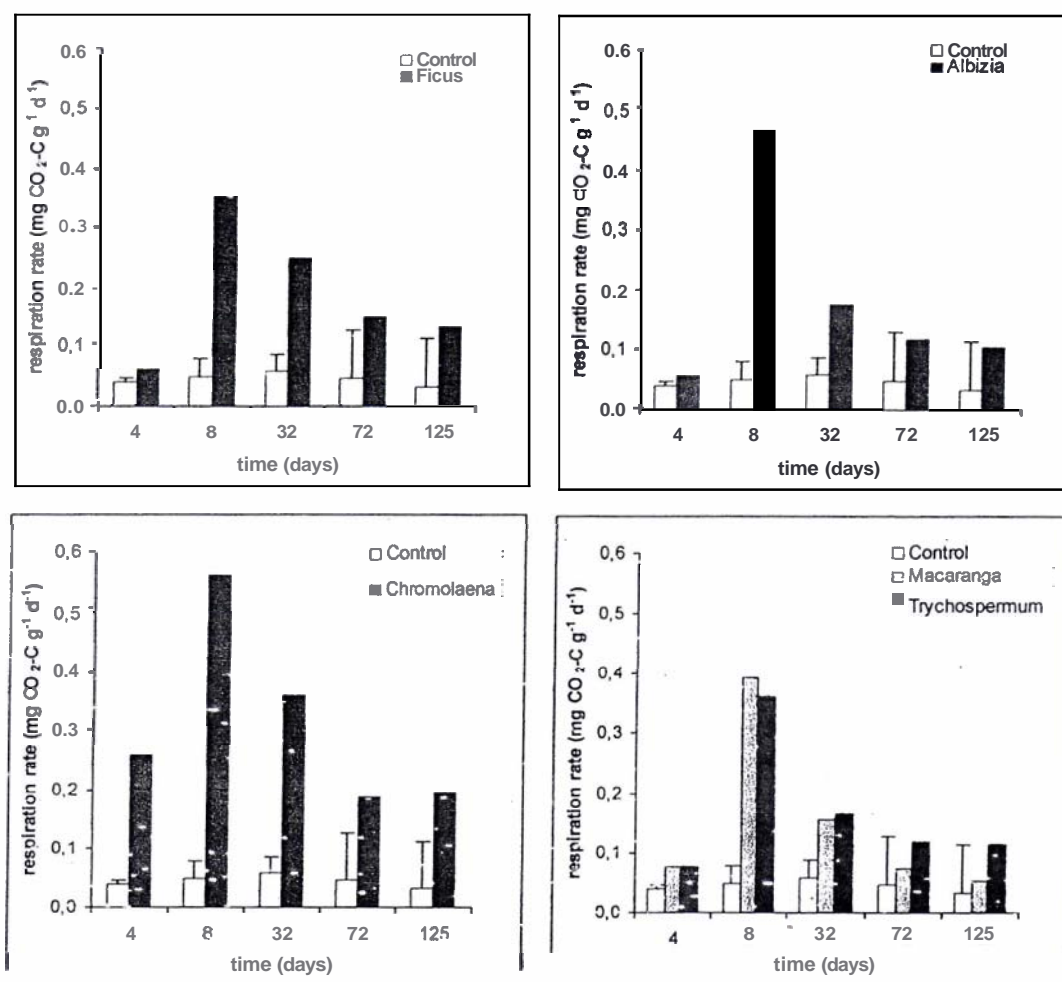
Figure 6. Effect of plant material amendment from different species on soil respiration rate (CO$_2$-C) during incubation. Plant materials consist of 80% wood and 20% leaf for *Ficus, Albizia, Macaranga* and *Trycospermum,* while plant material from *Chromolaena* were not separated

Soil amendment with plant material increased the cumulative respired CO$_2$-C 2 to 5 times that of the control. *Chromolaena* demonstrated the highest cumulative respired CO$_2$-C levels followed by *Albizia, Trycospermum, Ficus* and *Macaranga.* A drastic increase in cumulative respired CO$_2$-C was recorded during the first 32 days of incubation, demonstrating a high microbial activity within this period (indicated by a high rate of P immobilization) (Figure 7). The cumulative respired CO$_2$-C for the first 32 days was: 0.4, 2, 2.5, 3.7, 1.8, and 2 mg CO$_2$-C g$^{-1}$ d$^{-1}$ for control, Ficus, *Albizia, Chromolaena, Macaranga and Trycospermum,* respectively. A slight increase of cumulative respired CO$_2$-C was seen at 72 days, after which it remained constant, except for *Chromolaena-*amended soil (which still increased by about 1.8 mg CO$_2$ g$^{-1}$ d$^{-1}$).
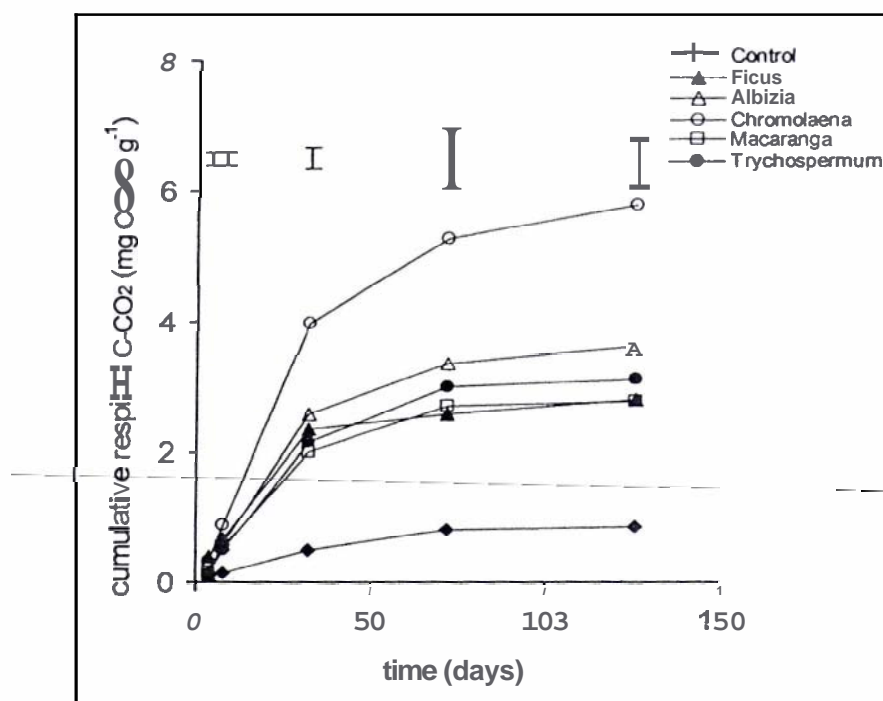
Figure 7. Effect of plant material amendment from different species on
cumulative respired $CO_2$-C during incubation. Plant materials
consist of 80% wood and 20% leaf for *Ficus, Albizia, Macaranga
and Trycospermum, while plant* material from *Chromolaena* were
not separated

interestingly, there was a positive correlation between cumulative $CO_2$-C and
inorganic P (Pi and Bray P wit?.? r = 0.47 and r = 0.49; p<0.01, respectively). This
is suspected that during the mineralization of P from organic material, a certain
$CO_2$-C was respired as a result of microbiological activity. A similar finding was
reported by Scheu and Parkinson (1995) and Vesterdal (1998).

**Alkaline phosphatase activity** .

The alkaline phosphatase activity of the soil ranged from 78 to 224 μg p-nitro-
phenol $g^{-1}$ $h^{-1}$. This value is close to the results of Wick (1997), who reported that
at 0-5 cm depth the soil alkaline phosphatase activity ranged from 55 to 293μg
p-nitrophenol $g^{-1}$ $h^{-1}$.

As depicted in Figure 8, the amendment with plant material significantly
(p<0.05) increased alkaline phosphatase activity as compared to the control.
Early during the incubation period, alkaline phosphatase activity in the soil
amended with *Chromolaena, Trywspennum* and *Ficus* was significantly higher
than that of the control and somewhat higher than that of soils amended with
*Albizia* and *Macaranga,* which were not different from the control.
Alkaline phosphatase activity decreased drastically during the first 8 days
(especially for soil amended with *Chromolaena, Trycospermum* and *Ficus)* and
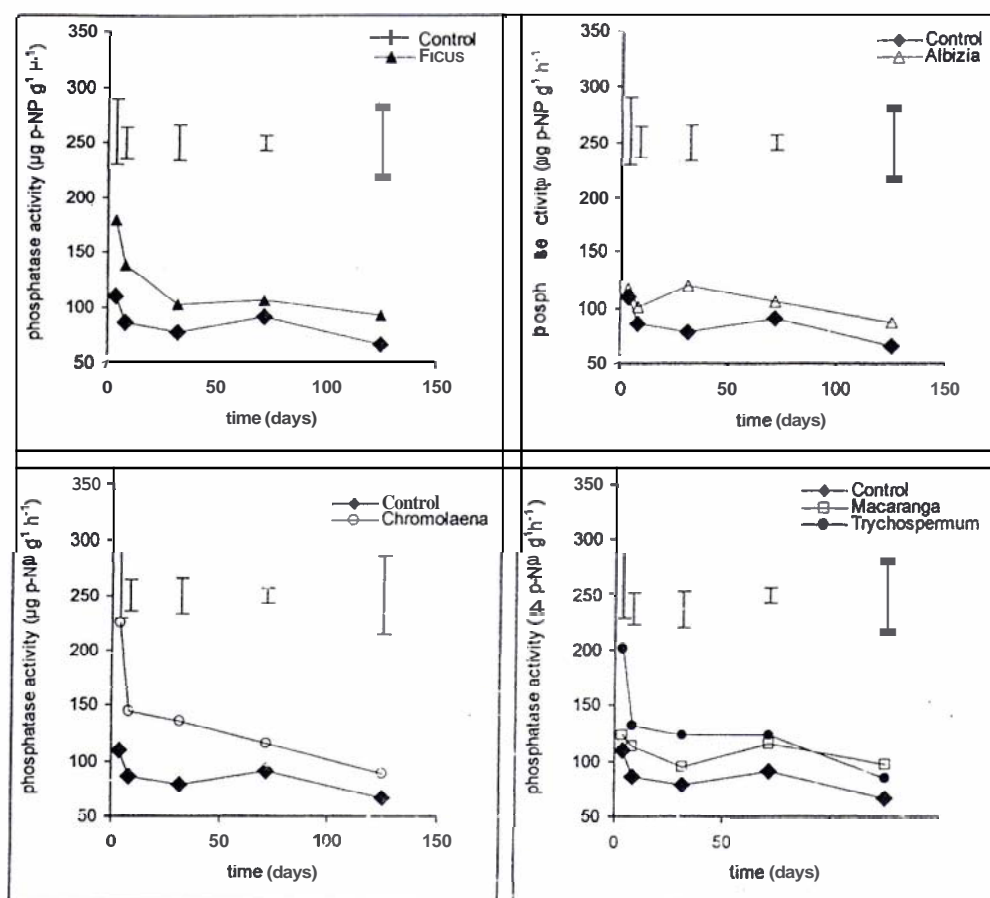showed a slight decrease up to 125 days.

Figure 8. Effect of plant material amendment from different species on alkaline phosphatase activity during incubation. Plant materials consist of 80% wood and 20% leaf for *Ficus, Albizia, Macaranga* and *Trycospermum*, while plant material from *Chromolaena* were not separated

## Acid phosphatase activity

The level of acid phosphatase activity was higher than that of alkaline phosphatase activity (Figure 9). It ranged from 167 to 621 µg p-nitrophenol $g^{-1}$ $h^{-1}$, which was higher than the values reported by Wick (1997) (139 to 412 µg p-nitrophenol $g^{-1}$ $h^{-1}$). Amendment with plant material caused an increase (p<0.01) of acid phosphatase activity over the control.

The dynamics of acid phosphatase activity were similar to those of alkaline phosphatase activity. Amendment *with Chromolaena* resulted in the highest average of acid phosphatase activity during incubation with about 295 µg p-nitrophenol $g^{-1}$ $h^{-1}$, followed by *Ficus, Albizia, Macaranga* and *Trycospermum* (216, 148, 143, and 95 µg p-nitrophenol $g^{-1}$ $h^{-1}$, respectively].

There is a tendency, that the lower the C/P ratio of the amended plant material, the higher the soil microbial-biomass P (r = 0.65 p=0.062). The nutrient supply stimulated the activity of soil microbes, particularly at the beginning of incubation. The higher the activities of soil microbes, the higher the concentration of soil microbial-biomass P, resulting in a significant correlation between soil microbial biomass P and related soil microbe activities parameters,

221

such as: respiration rate (r = 0.41, **p<0.01)** and soil phosphatase activities (r = 0.49, **p<0.01** and r = 0.43, **p<0.05;** for alkaline and acid phosphatase activity, respectively). **Ladd** et *al.* (1996) reported similar results, suggesting that plant material added to topsoils is quickly colonized by a variety of soil microorganisms, and the microbial cells growing on amended plant material themselves serve as the main agent of enzymic attack during the first stage of plant material decomposition. This may be the reason why a peak in microbial biomass P and **phosphatase** activity is seen at the beginning of incubation.
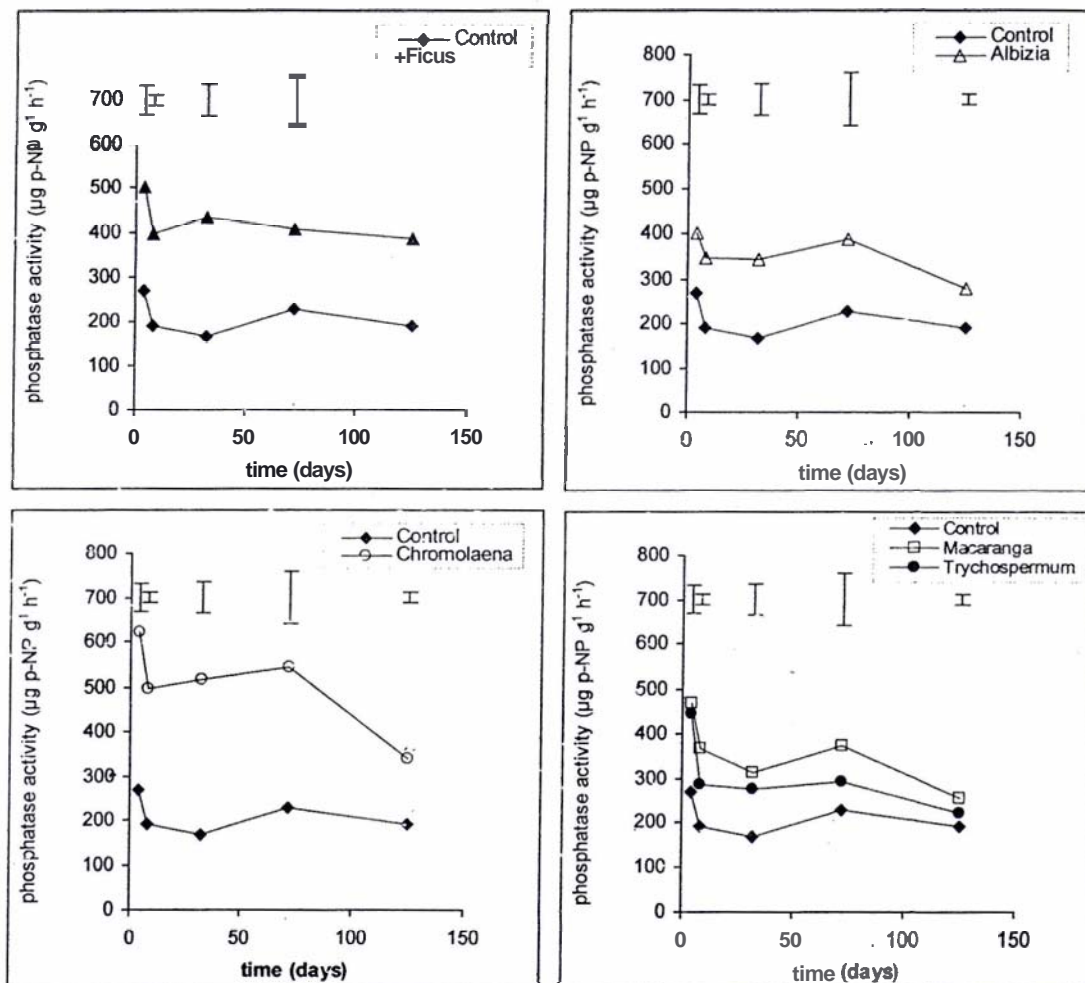


Figure 9. Effect of plant material amendment from **different** species on acid phosphatase activity during incubation. Plant materials consist of 80% wood and 20% leaf for *Ficus, Albizia, Macaranga and Trycospermum, while* plant material from *Chromolaena* were not separated

## Conclusions

According to the results of this study, it **can** be concluded that the chemical composition characterized by total P, **N, C/P** ratio, **lignin, lignin/P** and **lignin/N** were important parameters for **evaluating** the plant material quality determining the P availability in the slash-and-mulch system. This is

emphasized by signi cant correlation between total P, lignin content, lignin/P ratio, C/P ratio of the amended plant material and dynamic of P (available P and microbial-biomass P)

Amendment with high quality plant material, such as *Chromolaena* and *Albizia lebeck,* derived from fallow vegetation increased the availability of P although it caused an increase in P microbial consumption of P at the beginning of the incubation. High quality material allowed a faster remineralization of P as compared to low qualfiy plant material.

# References

Adeptu, J.A. and R.B. Corey. 1977. Change in N and P availability of and P fraction in Iwo soil from Nigeria under intensive cultivation. Plant and Soil 46:309-316.

Breland, T.A. 1997. Modeling mineralization of plant residues: Effect of physical protection. Biol. Fertil. Soils 25: 233-239.

Bowman, R.A. and C.V Cole. 1978. Transformation of organic phosphorus substrates in soil evaluated by NaHCO3 extraction. Soil Sci. 125:49-54.

Brookes, P.C., D.S. Powlson, and D.S. Jenkinson. 1982. Measurement of soil microbial biomass phosphorus in soil. Soil Biology and Biochemistry 14:319-329.

Chandini, M., Thirukkumaran, and D. Parkinson. 1999. Microbial respiration, biomass, metabolic quotient and litter decomposition in lodge pole pine forest floor amended with nitrogen and phosphorous fertilizer. Soil Biology and Biochemistry 31: 59-66.

Denich, M. 1989. Untersuchungen zur Bedeutung junger Sekundärvegetation für die Nutzungsystemproductivität im östlichen Amazonasgebiet, Brazilien. Ph.D. Diss. Georg-August Universität Göttingen, 265p

Donnison, LM., G.S. Griffith, and R.D. Bardgett. 2000. Determinants of fungal growth and activity in botanically diverse hay meadow: effects of litter type and fertilizer addition. Soil Biology and Biochemistry 32: 289-294.

Fokin, A.D. and P.A. Radzhabova. 1996. Availability of phosphates in soil as a function of the state and transformation of organic matter. Eurasian Soil Sci. 29(11): 1216-1221.

Fuller, W.H., D.R Nielsen, and RW Miller. 1956. Some factors influencing the utilization of phosphorus from crop residue. Proc. Soil Sci. Soc. Am. 20: 218-224.

Harrison, A.F. 1987. A Review of World Literature: Soil Organic Phosphorus. CAB International, p. 87-113 .

Huffman, S.A., C.V. Cole, and N.A Scott. 1996. Soil texture and residue addition effects on soil phosphorus transformations. Soil Sci. Soc. Am. J. 60:1095-1101.

Isermeyer, H. 1952. Eine einfache Methode zur Bestimmung der Bodenatmung und der Karbonate im Boden. Z. Pflanzenernährung und Diing. Bodenkunde 56:26-38.

Kaila, A. 1954. Über mikrobiologische Festlegung und Mineralisierung des Phosphors bei der Zersetzung organischen Stoffe. Z. Pflanzenernährung und Düng Bodenkunde 64:27-35.

Ladd, J.N., R.C.Foster, P. Nannipieri, and J.M. Oudes. 1996. Soil structure and biological activity, p.23-78. In Soil Biochemistry. Stotzky, G. and. Bollag J.M. (Eds.),Vol. 9, Marcal Dekker, Inc.

Marschnera, B. and A.D. Nobleb. 2000. Chemical and biological processes leading to the neutralisation of acidity in soil incubated with litter materials. Soil Biology and Biochemistry 32 (6):805-813.

Murphy, J. and J.P. Riley. 1962. A modified single solution method for the determination of phosphate in natural waters. Anal. Chem. Acta. 27:31-36.

Olsen, S.R. and L.E. Sommers. 1982. Phosphorus. In Method of soil Analysis: II. Chemical and microbiological properties. Page, A.L., Miller, R.H. and Keeney, D.R. (Eds.), Am. Soc. of Agr. Publ., Madison, Wisconsin USA.

Sharpley, A.N. 2000. Phosphorus and the Chesapeake bay -opening remarks.3-5p. In: Agriculture and phosphorus management: The Chesapeake Bay, Sharpley A.N. (Ed.),Lewis Publ., London.

Singh, B.B. and J.P. Jones. 1976. Phosphorus sorption and desorption characteristics of soil affected by organic residues. Soil Sci. Soc. Am. J. 40:389-394.

Tabatai, M.A. 1982. Soil Enzymes. In : Methods of Soil Analysis, Part 2. Chemical and Microbiological Properties, Agronomy no. 9, (2nd edition), Page, A.L., R.H. Miller and D.R. Keeney (Eds.),p.903-943.

Tenney, G. and S.A. Walksman.1929. Composition of natural organic materials and their decomposition in the soil IV. The nature and rapidly of decomposition of the various organic complexes in different plant materials, under aerobic conditions. Soil Sci. 28:55-84

Tiessen, H. and J.O. Moir. 1993. Characterization of available P by sequential extraction. Soil Sampling and Methods of Analysis. Carter, M.R., (Ed.), Canadian Society of Soil Science, p. 75-86.

Van Soest, P.J. 1963. Use of detergent in the analyses of fibrous feeds. II. A rapid method for the determination of fiber and lignin. Association of Official Agricultural Chemist Journal. 46:829-835.

Vesterdal, L. 1998. Potential microbial nitrogen and phosphorus availability in forest floors. Soil Biology and Biochemistry 30(14):2031-2041.

Wick, B. 1997. Microbiological indicators for quality of soil at various stage of degradation in forest-savanna-transition zone south-western Nigeria. Ph.D. Diss. Georg-August-Universität Göttingen. 171p.