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Research Paper

Evolution of leaf decomposition of ten plant species (Leguminous and non-Leguminous) under the ecological conditions of Kisangani Democratic Republic of Congo

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Abstract
The aim was to evaluate the leaf decomposition of ten plant species (leguminous and non-leguminous) under the ecological conditions of Kisangani/RD Congo. A collection was made in and around the agroecological plots of the IFA-Yangambi concession in Kisangani.
The method adopted for this study was the leaf-stalk bundle technique. The results obtained show that the number of days of fanning, fermentation, partial decomposition and total decomposition of the ten plant species evolve in the same way (p> 005) under the ecological conditions of Kisangani RD Congo; however, an average value of around 3.50 to 27.75 days of leguminous and 7.75 to 37.50 days of non-leguminous for fanning ; 7.75 to 15.00 days of legumes and 7.50 to 17.75 days of non-legumes for fermentation; 11.50 to 27.25 days of legumes and 8.50 to 27.50 days of non-legumes for partial decomposition; 11.50 to 27.25 days of legumes and 8.5 to 8.5 days of non-legumes for total decomposition.
Key words: ***Evolution, decomposition, legumes, Kisangani***

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I. Introduction

Ferrallitic soils, such as those in DR Congo in general and Kisangani in particular, are of fleeting fertility, exacerbated by human intervention and erosion (Van Wambeke, 1995).High temperatures and high relative humidity promote rock weathering. As a result, the upper horizons of soil covers contain more minerals that are highly resistant to weathering: quartz, type 1/1 clay (Kaolinite) and iron and aluminium oxides and hydroxides.

Vegetation is one of the major parameters behind the differentiation of litter and humus, and is the main source of soil organic matter (Duchaufour et al., 2001).It is at the interface of fundamental processes in ecosystem functioning (Berthelin et al., 2000).

Leaf decomposition in soil and water is the result of distinct phases, including the physical dissolution of water-soluble leaf substances, and microbial decomposition, in which bacteria and fungi transform plant organic matter into microbial proteins to increase their own biomass.

The application of green manure is an effective practice for increasing soil fertility, contributing to soil health and conservation while maintaining environmental quality (Duchaufour, 1983).This technique will only be effective if we know the rate of decomposition and the composition of the green manure.

This technique will only be effective if we know the rate of decomposition and the composition of these green manures. The use of synthetic chemical fertilizers poses enormous difficulties in the region, notably lack of means, low availability of these fertilizers on the market and the fact that most farmers have no control over the use of synthetic chemical fertilizers.

For many of the region's poor farmers, the alternative would be to use organic fertilizers, including green manures, legumes for biological fixation, which is a sustainable and profitable solution (Kiye, 2012), and non-legumes.

In the region under study, there are several leguminous and non-leguminous plant species producing large quantities of biomass, varying according to the species, which can be used for organic fertilization.Information on their decomposition rates and their chemical composition in essential elements is not yet available, however, to enable us to envisage the manufacture of organic fertilizers, the importance of which no longer needs to be demonstrated.

The present study investigates the leaf decomposition evolution of ten plant species usable as green manure:*Alchornia cordifolia* (Mull) Arg, *Panicum maximum* (Jacq), *Paspalum notatum* (Fluegge), *Mucuna pruriens* (L)D, *Calopogonium monoïdes* (Descv), *Eichornia crassipes* (Mart) Solms, *Pueraria Javanica* (Bentham) Baker, *Acacia mangium* (Wild) L, *Chromolaena odorata* (L)RM King and *Milletia laurentii* (De Wild) under the ecological conditions of Kisangani/RD Congo. It seeks to test the hypothesis that leguminous green manures are better than non-legumes in terms of decomposition evolution and mineral element richness under the ecological conditions of Kisangani, given that legumes have the capacity to fix atmospheric nitrogen.

II.Materials and methods

Study site

The Kisangani region is located in the north-east of the central Congolese Cuvette and has geographical coordinates of 00° 30' 46"longitude North to 025° 09'54" latitude East at an altitude of 391 m.d.altitude (Bernard, 1945; De Heinzelin,1952; Kombele,2004).The location of the study environment is given in figure 1 below.

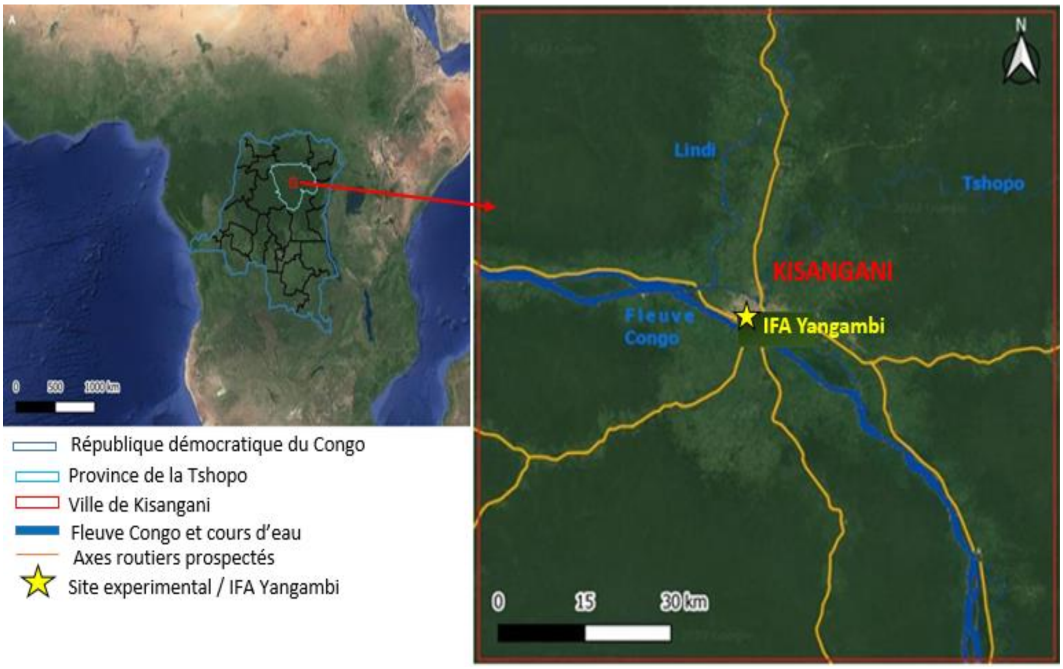

Figure 1: Location of the experimental site (yellow star) in the city of Kisangani/RD Congo.

Material

For this study, the biological material consisted of the leaves of ten plant species including *Alchornia cordifolia* (Mull) Arg, *Panicum maximum* (Jacq), *Paspalum notatum* (Fluegge), *Mucuna pruriens* (L) D, *Calopogonium mucunoïdes* (Descv) *Eichornia crassipes* (Mart) Solms, *Pueraria Javanica (*Bentham) Baker, *Acacia mangium* (Wild) L., *Chromolaena odorata* (L) RM King, *Milletia laurentii* (De Wild).

Methods

Choice of trial site and experimental design

The site was cleared and divided into ten 1m x 1m plots separated in all directions by 1m-wide alleys. The 9m x 22m (198m^2) experimental set-up (figure 2) consisted of four complete randomized blocks, each with 10 treatments plots (the ten identified leguminous and non-leguminous plant species).

Within each plot, a 50cm x 50cm (2,500 cm^2) space was created to accommodate a 3kg leaf package for each plant species. The bundle of leaves was simply placed in the space provided in each plot, and the whole area was protected by canvas.

Identification of plant species, geographical coordinates and technique used

Following a field survey of each plant species studied, we identified two different groups of plant species for study (observation): leguminous and non-leguminous plant species.

The identification of leguminous and non-leguminous plant species was carried out with the support of the Faculty of Sciences of the University of Kisangani, which provided us with a plant species identification key.

Quantity of fresh leaves applied per experimental plot

The fresh leaves harvested from each plant species were collected in 3 kg bundles and deposited in the space provided in each 1 x 1 m plot, in order to assess the evolution of the qualitative and quantitative decomposition of the plant species. For each plant species, the dose was 3 $^{kg/m2}$ depending on the desired yield level and crop requirements (Comifer, 1996).

Frequency of in situ observations

Field observations in the experimental plots were made every three days

They consisted of tests on a color scale by leaf packets in each experimental plot (Pierre et al., 2006).

Frequent observations at 3-day intervals (starting with a survey questionnaire) focused on the following parameters:

- Number of days of withering: drying of leaves,
- Number of days of fermentation: preparatory phase of decomposition due to heat and soil humidity,
- Partial decomposition: observations showed the coloration or non-recognition of the different leaves used, the quantity of material in place starting to decrease; the transformation of green leaves into brown leaves,
- Total decomposition: macroscopic observations were made regularly every week from June 28 to November 28, every three days, to assess the dynamics of the complete transformation or total degradation of plant biomass or phytomass.

All these parameters were evaluated in terms of the number of days elapsed from set-up to the date of observation of the phenomenon. The evolution of all these decomposition phases was checked regularly (every 3 days) in the experimental set-up.

Statistical analysis

Hypothesis testing and comparison of means

The evolution of decomposition on all parameters was analyzed using the one-factor analysis of variance (ANOVA) test (Anderson et al, 1999 ; Bar-Hen, 2001), in order to compare variables between the different leaves of the plant species. The Tukey HSD (*Honest Significant Differences*) post-hoc test was used for multiple comparisons of means.

The Student's *t-test*, a parametric test, was applied to compare the two means, namely leguminous and non-leguminous. Statistical analyses were carried out using STATISTICA version 10 and R version 4.3.0.

III.Results and discussion

Results

Number of days for withering

The results relating to the average number of days to withering for leguminous and non-leguminousleaves are illustrated by the graph in figures 3 and 4.

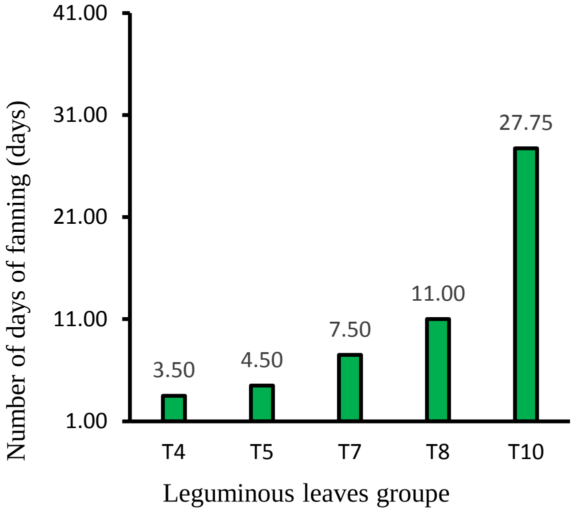

Figure 3. Observation of the number of days of leaf withering on leguminous plants

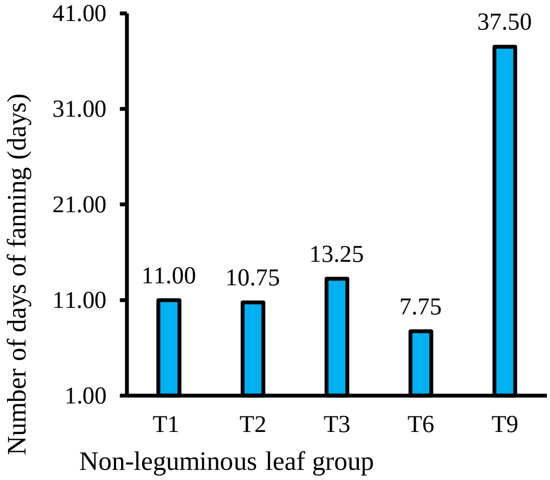

Figure 4. Observation on the number of days of leaf withering of non-leguminous plants

However, the Student *'s t* value found shows that there are no significant differences between these two groups of plant species, despite the differences observed in the means at the 5% threshold (0.239>0.05). On the other hand, between the different species, there is a significant difference for legumes as shown in Table 3 of one-factor ANOVA results.

Fermentation

Results for the average number of days of odor release for the different species are shown in figures 5 and 6 below.

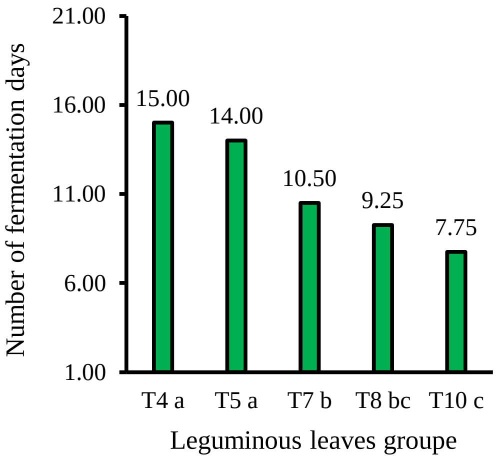

Figure 5. Observation of number of days for leaf fermentation in leguminous species

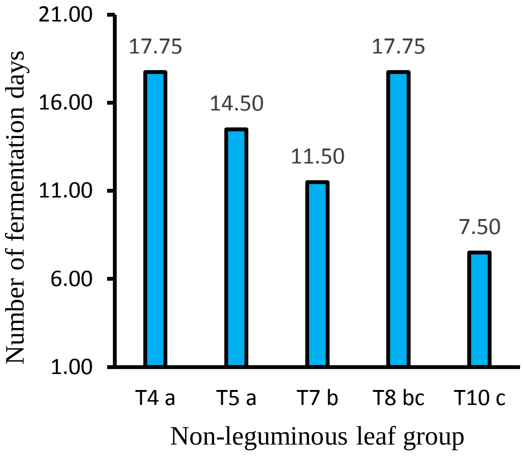

Figure 6. Observation of number of days for leaf fermentation of non-legumes

The Student's t-test applied between these two groups (leguminous and non-leguminous) affirms that there is a significant difference for this stage of decomposition. Comparing our results two by two using the Tukey HSD post hoc test, we obtain a very highly significant difference between the different leguminous plant species (p > 0.001) except betweenT4 with T5 and T7 with T8 in order to T8 with T10 where the difference is non-significant (p > 0, 05),while for non-legumes this test shows that there is a very highly significant difference between the different plant species (p < 0.001) except betweenT1 withT2 and underT3 with T6 so T6 with T17 where the difference is non-significant(p < 0.001).

Partial decomposition
Data on the average number of days of partial decomposition for the various species are shown in figures 7 and 8 below.

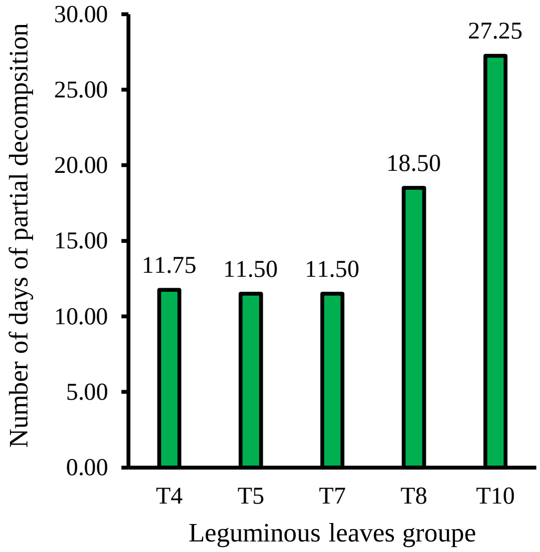

Figure 7. Observation sur le nombre de jours de la décomposition partielle des feuilles des légumineuses.

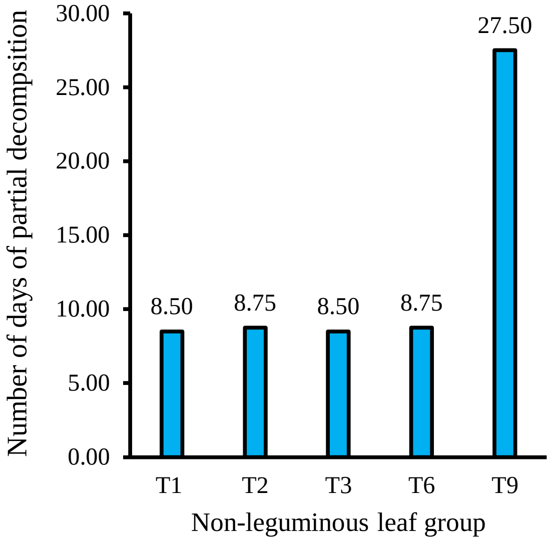

Figure 8. Observation of the number of days of partial decomposition of non-leguminous leaves

For partial decomposition, the results of the one-way ANOVA indicate a non-significant effect at the 5% threshold (p= 7.7007E - 18 < 0.05) for the different leguminous species and (p= 2.3267E -15 < 0.05) for the different non-leguminous species.
For partial decomposition, the results of the one-factor ANOVA indicate a non-significant effect at the 5% threshold (p= 2.3267E -15 < 0.05) for the different non-leguminous species.

Total decomposition
Data on the average number of days for total decomposition of the different species are shown in figures 9 and 10 below.

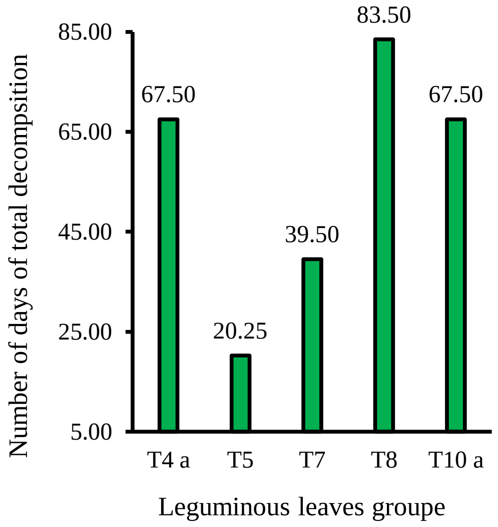

Figure 9. Observation of the number of days of total decomposition of legume leaves

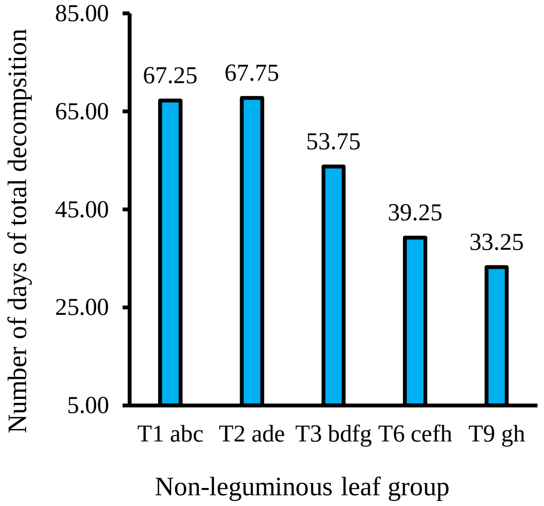

Figure 10. Observation of the number of days of total leaf decomposition for non-leguminous plants.

Comparing our results two by two using the Tukey HSD post hoc test, we obtain a very highly significant difference between the different leguminous plant species ($p > 0.001$) except between$_{T4 \text{ with } T10}$ where the difference is non-significant ($p > 0.05$), whereas for non-legumes this test shows that there is a very highly significant difference between the different plant species ($p < 0.001$) except between$_{T1}$ with$_{T2}$,$_{T2}$ with$_{T3}$ in order$_{T3}$ with T6$_{\text{and } T6}$ with $_{T9}$ where the difference is non-significant($p < 0.001$).

IV. Discussion

The results concerning the decomposition evolution of the parameters number of days of withering, fermentation, partial decomposition and total decomposition are compared in the following paragraphs with leguminous and non-leguminous species under the ecological conditions of Kisangani/RD Congo.

The results of observations made on the number of days of leaf withering of leguminous and non-leguminous species show that the average number of days of leaves of leguminous species is significantly lower than the average number of days of non-leguminous species are different from those observed by Duchaufour (1957), Ruiz (2022), Baumont et al (2016), Voisin et al (2013) a change in soil texture and environmental conditions, the biochemical composition of plant species studied may explain this discrepancy.However, the tendency for the number of days of leaf wilting of leguminous species to decrease compared with non-leguminous species.

However, if we compare leguminous and non-leguminous plants, we find a number of differences in fermentation days, which are secondary for both.

The results of the present work do not corroborate those of (Moukaumi, 2006) on the effect of forest tree species on the biodegradation of organic matter: impact on the dynamics and cycling of carbon, nitrogen and mineral elements.

This situation may be due to the continuous action of the symbiotic association between leguminous species and bacteria, with the latter providing the plant with energy and the plant providing the bacteria with photosyntas, which is not observed in non-leguminous species and is already a problem for agricultural practice in the tropics, and perhaps also for silvicultural management, especially as most plants do not possess this symbiotic feature.

Overall analysis shows that, for all species, the number of days for partial decomposition varies around 27.00 and 28.00 days for leguminous and non-leguminous species under Kisangani ecological conditions.

Several studies have shown, and it is now accepted, that the quality (biodegradability) and quantity of fresh organic matter reaching the soil vary from one species to another. This translates into equally varied effects on soil potential and the diversity and efficiency of decomposer organisms and microorganisms (Binkley, 1995; Ponge, 2003; Albers et al., 2004 in Tshinyangu, 2017).

The results of total leaf decomposition of the plant species studied decomposed in opposite directions from one species to another, i.e. total decomposition under non-leguminous plant species decomposed faster than leguminous species, this sequential variation is observed in figure (10 and 11).

This is explained by the activity of telluric microorganisms evolving in a decreasing manner according to the nature and age of the plant species, as well as by the textural nature of the soil. This hypothesis is in agreement with Neffar S., Fraga Beddiar A., Redjel N., and Boulkheloua (2011). Effects of the age of prickly pear *(Opuntia ficus indica finermis*) plantations on soil properties and vegetation in Tébessa (semi-arid zone of eastern Algeria) *Ecologia mediterranea*. This is also one of the characteristics of tropical soils (Duchaufour, 1983).

V. Conclusion

The overall objective is to monitor the evolution of leaf decomposition in ten plant species (leguminous and non-leguminous) under the ecological conditions of Kisangani/RD Congo.

After field observations, the results obtained show that: (1) the number of days before odour release under legumes decreases as a result of intrinsic and extrinsic factors; the ANOVA at the 5% threshold indicates that there are no significant differences between these ten plant species observed under the ecological conditions of Kisangani.(2) the number of days before odour release under leguminous and non-leguminous plants remains at least different in the Kisangani ecological condition; consequently, no significant differences were observed between the different plant species studied. (3) partial decomposition indicates the beginning of decomposition by the partial transformation of green leaves into brown leaves. (4) total decomposition indicates the complete transformation or total degradation of plant biomass or phytomass.

Dense forest is more stable thanks to the presence of plant debris that falls to the soil surface and decomposes into humus, playing a major role in the formation of structures. We suggest conducting similar experiments in this field, including other varied species.

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