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EFFECT OF A BATERICIDE-FUNGICIDE ADDITIVE ON THE RATES OF DECOMPOSITION OF MATURE FRESH LEAVES OF FOUR WOODY TREES SPECIES

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ABSTRACT

A 3 X 4 factorial experimental design in a randomized complete block (RCB) with 3 replications was used to investigate the influence of a potent fungicide-bactericide, Mercuric chloride (Hgcl), on the rates of decomposition of matured fresh leaves of 2 evergreen trees species, *Dacryodes edulis* and *Irvingia gabonensis*, and 2 deciduous species, *Gmelina arboea and Ficus exasperata*. The experiment, which lasted for 90 days, was performed under the canopy of the trees in the Arboretum of the University of Calabar, Nigeria. The Hgcl significantly suppressed the rates of decomposition of the leaves. Thus the higher mean per cent decomposition of 44.66 of the leaves. Thus the higher mean per cent decomposition of 44.66 of the leaves of all the four trees at 0.0g Hgcl differed significantly ($P < 0.05$) from the other individual leaves in their mean percentage decomposition rates. Thus *Dacryodes edulis* with 0.004 mean per cent decomposition differed significantly from *Irvingia gabonensis* with the mean of 6.002, *Gmelina arborea* with a mean decomposition per cent of 99.50 differed from *Ficus exasperate* leaves whose mean rate of decomposition was 98.10%. On the whole, the leaves of the evergreen trees species – *Dacryodes edulis* and *Irvingia gabonensis* having a common mean per cent of 3.003 decomposed significantly slower than species which had a significantly higher mean per cent decomposition of 98.8. It is recommended that for greater humus accumulation, evergreen trees species should be used to establish a forest stand. However, for soil fertility enrichment and maintenance within a short period of time in a stand, deciduous trees species are better since their leaves decompose faster even in the presence of a potent fungicide/bactericide in the soil. This ensures a quick turn over of soil nutrients.

KEY WORDS : Decomposition, Fresh Leaves, woody Trees

INTRODUCTION

The decomposition of organic litter (leaves, steams, twigs, and other debris) and subsequent release of nutrients in plant-available forms is an essential process in the functioning of forest ecosystems (Prescott and Blevins, 2000). Temperature, moisture, litter chemistry, soil biota, pesticicides, herbicides, insecticides, fungicides, bactericides etc. control litter decomposition rates (Dickinson and Pugh, 1974). Within the soil ecosystem, the relative efficiency of microflora and fauna in terms of litter decomposition is determined by all the foregoing factors (Dickinson and Pugh, 1974).

However, it is apparent that organic litter decomposition rates are very habitat-specific (Janzen, 1975).

According to Janzen (1975), the inter-habitat variation of litter decomposition in the tropics is almost totally undocumented. Also, according to him, species-specific decomposition rates within and between habitats are not recorded in the tropics. Moreover, according to the same author, simple questions, such as 'do the leaves from evergreen trees last longer than those from deciduous tree?' are unanswered for the tropics. Of great interest would be to find out the effect of a potent fungicide on litter decomposition (Janzen 1975).

Concerning the speed of plant litter decomposition, Spurr and Barnes (1973) have stated the complete decomposition may take from a few weeks to many years These authors have also disclosed that the nature of the decomposition process and the time it takes depend largely on the forest tree species and the climate in which they grow.

Water-soluble Organic Matter Content of the Leaves

According to Dickinson and Pugh (1974), the water-soluble Organic Matter content of litter provides a readily available energy source for decomposers and has, therefore much influence in the initial stages of decomposition. Usually there is a rapid loss of soluble organic matter from plant litter due to microbial utilization and leaching. A 50 per cent decrease in organic matter in the first 3 months was recorded for *Casuanna* litter (Burges, 1958). Sowden and Ivarson (1962) found that sugars were removed more rapidly from deciduous than from coniferous (evergreen) litter during the first 165 days. Broadfoot and Pierre (1939) noted a correlation between litter decomposition and the content of soluble organic matter. This was most marked during the first two months. Melin (1930) suggested, that water-soluble materials only influenced decomposition rates for the first few weeks. Melillo et al; (1989) has reported that the early stages of decomposition of plant litter are influenced by the easily decomposable carbohydrates: lignin exerts the major control on decomposition rates later

The general pattern of early decomposition of plant litter have been recognized (Olson, 1963; and Howard and Howard, 1974). Fogel and Cromack (1977) reported on the positive correlation between litter quality and decomposition rates. Bunnel t al 19977[a]) Bunnel and Tait (1977[b]) Meentemeyer (1978) and Jansson and Berg (1985) wrote elaborately on the relationship existing between rates of litter decomposition and other environmental variables. Patterns of nitrogen accumulation and release, and factors controlling them, have also been identified for the early stage of litter decomposition (Aber and Melillo, 1982; Berg and Staaf, 1981). Aber et al (1990). have hypothesized the fraction of plant litter decomposing in the stable phase, would be 15 – 20 per cent, based on long term decomposition studies conducted in the eastern USA

However, for short term experiment, it has been indicated that the fraction of litter remaining after the early phase of decomposition is variable (3 to 40 per cent) and dependent on species and environment (Ghoiz et al, 2000)

Strasse (2000) has reported a 0.1 per cent per day decomposition rate of carbon of fresh plant litter, this may decrease to 0.00001 per cent per day or lower in move completely decomposed material

Strasse (2000) has also estimated the limit values of decomposition rates of organic matter in northern forest soils, British Columbia Canada to range from about 45 to 100 per cent indicating that between 0 0 and 55 per cent of the litter mass should either stabilize or decompose extremely slowly.

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Strasse (2000) has found out that N concentration had an overall effect on this value in no less than that 13o cases investigated, meaning that the higher the N concentration in the fresh litter (the lower the C/N ratio), the more organic matter was left. The 'limit – value' concept may mean that at higher initial N concentration, the state with either stabilized soil organic matter (SOM) or a very low decomposition rate was reached earlier, i.e at a lower mass loss. Such as effect would mean that in stands with N-rich litter, there may be a faster humus accumulation. Bocock (1964) has also indicated that plant litter with more nitrogen generally decompose faster.

Based on the foregoing facts and disclosures, the present study was designed primarily to find out the differences, if any, in the length of time required for the leaves of evergreen and deciduous trees to decompose in the University of Calabar Arboretum under the control of a potent fungicide-bactericide.

This study is significant in the sense that the results so generated will throw some light on the trees species that contribute most to the recycling of nitrogen and other nutrients from the soil to the trees and back again to the soil thus maintaining the fertility of the soil in the Arboretum ecosystem. Furthermor, the results would be of great interest and useful to practicing foresters, silviculturists, and agroforesters who are engaged in the establishment of forest stands and plantations.

MATERIALS AND METHODS

This study was carried out in the Arboretum of the University of Calabar, Nigeria and lasted fro 90 days beginning from 23rd February 23rd May, 2007,

The Arboretum of the University of Calabar which is on latitude 4.57°N and longitude 8.19°E, is in the wet lowland rain forest zone and has an annual peak dry season of less than 25mm of rainfall ?(Hopkins, 1979). Mean daily temperature range of the experimental site is 21 o – 32°C., mean monthly relative humidity is not less than 95 per cent at 06.00 hours, which usually falls to 60 per cent at noon during the driest months of December and March. Calabar experiences over 2500mm of rain fall annually (Hopkins, 1979).

MATERIALS

The materials used in this study were as follows:-

(i) 36 mesh plastic trays, each measuring (15 x 10 x 10) cm
(ii) Top soil samples obtained from the Arboretum
(iii) Mature fresh leaf samples of *Dacryodes edulis Irvingia gabonesis, Gmelina arborea* and *Ficus exasperate* also obtained from the Arboretum
(iv) Mecuric chloride which served as fungicide-bacteride

EXPERIMENTAL DESIGN

Trees species, 2 evergreen and 2 deciduous, were selected based on Raunkiaer's basic classification of plants life forms into evergreen, deciduous, perennials and annuals. Thus, four woody species were chosen, (*Dacryodes edulis* G. Don) (Burseraceae), *Irvingia gabonensis* (O'Rorke) Baill (Irvingiaceae), *Gmelina arborea* Roxb. (verbenaceae), and *Ficus exasperate* VahL (moraceae) from the Arboretum.

Leaf sections each measuring (2 x 4)cm were cut from each of the four selected trees species.

Thirty six plastic mesh trays were filled with Arboretum soil. Mecuric chloride was added to the soil in the plastic trays at 3 levels of concentration: 5.0g, 10 0g and 0.0g (control). The soil was watered to field capacity. The pieces of leaves from the four trees species were then placed on the surface of the soil in the trays. The trays containing the soil and leaf sections were kept under the trees' canopy.

Observations on the rates of decomposition of the leaves were made bi-weekly and recorded.

ANALYSIS OF DATA

The data obtained from the experimental trial were then tabulated as shown in table 1, and analyzed following standard 2 – factor factorial procedure (Wahua, 1999). The means were tested using: Fisher's least significant difference at 0.05 (F – LSD (0.05). Level of significance.

RESULTS AND DISCUSSION

Results of the effect of a potent bactericide –fungifide additive-Mecuric chloride (Hgcl) – on the rates of decomposition of the leaves of *Dacryodes edulis, Irvingia gabonensis, Gmelina arborea,* and *Fuicus exasperate* are presented in Table 1 and 2.

In table 1, the significant interaction of Mecuric chloride and the rates of the decomposition of the leaves of the four trees species depended very much on the levels of the fungicide – bacteride (Hgcl) applied. From the table, it is apparent that the best level of mercuric chloride which significantly suppressed or slowed down the decomposition process of the leaves was the 10.0g followed by 5.0g Hgcl. Conversely at 0.0g Hgcl, per cent, decomposition rates of the leaves was highest, with an overall mean of 44.66 per cent of the leaves decomposing in 90 days. This means that at 0.0g Hgcl, the soil micro-fauna carried out their function of breaking down the leaves without any kind of hindrance. At 5.0g of Mercuric chloride 28.15 per cent of the leaves decomposed in 90 days, at 10.0g of Hgcl, only 27.83 per cent of the leaves decomposed within the period of the experiment.

Accordingly, there was a significant difference ($P < 0.05$) between 0.0g level of Hgcl and the levels, (5.0g and 0.0g) respectively, in terms of overall mean per cent decomposition of the leaves in 90 days. (Table 2). There were also significant differences ($P < 0.05$) in per cent decomposition rates amongst individual leaves. Thus *Gmelina arborea* with 99.50 per cent had a higher rate of decomposition within the 90 days' trial, *Ficus exasperata* having 98.10 per cent decomposition rate came second, and *Irvingia gabonensis* with 6.00 per cent decomposition rate was third while *Dacryodes edulis* decomposed least with only 0.004 per cent within the 90 days trial (Table 2).

The results of this study on the rates of decomposition of the leaves of the four selected trees do not seem to contradict the findings of Sowden and *Ivarson* (1962) concerning the rapid loss of sugars from the litter of deciduous species in the first 165 days. Thus in the study, the leaves of the two deciduous trees species- *Gmelina arborea* and *Ficus exasperate* were the first to decompose completely, meaning that the leaves of the two evergreen trees species, *Diacryodes edulis* and *Irvigia gabonensis*. The rapid loss of sugars from the leaves of the two deciduous trees species became very obvious 4 weeks after the start of the experiment on leaf litter decomposition rates. Thus, by the 4th week of the experiment, 96.6 per cent and 99.9 mean of the leaves of the two deciduous trees species had decomposed under the control of 5.0g Hgcl. At 10.0g level of Hgcl application, 99.9 per cent and 89.9 per cent of *Gmelina arborea* and *Ficus exasperate* respectively had decomposed. At the 0.0g level of fungicide-bactericide, the per cent decomposition rates of *Gmelina arborea* and *Ficu exasperate* leaves were 99 9 and 99.9 respectively. These represent a 100 per cent decomposition rates of the leaves of the two deciduous trees species 30 days after the start of the experiment (Table 1c).

Comparing the rates of the decomposition of the leaves of the two evergreen trees species, *Dacryodes edulis* and *Irvingia gabonensis* with that of two deciduous species, we observe significant difference ($P < 0.05$) between the deciduous and the evergreen species. Thus at the 4th week after the start of the experiment, only 0.004 per cent of the leaves of the two evergreen species, *Dacryodes edulis* and *Irvingia gabonensis* had decomposed at the 5.0g, 10g, and 0.0g Hgcl levels respectively. This agrees with the reports of Sowden and Ivarson (1962) who avered that the litter of evergreen trees do not easily lose their sugars hence, they decomposed very slowly. The study seem to confirm this finding.

At 60 days after the start of the experiment, the per cent decomposition of the leaves of the two evergreen trees species remained at 0.004 at 5g and 10g Hgcl levels; at 0.0g Hgcl level, *Dacryodes edulis* leaves also decomposed by 0.004 per cent, that of *Irvingia gabonensis* decomposed by 62.9 per cent. On the other hand, the leaves of the two deciduous trees species had attained 99.9 per cent decomposition at 5.0g, 10.0g and 0.0g Hgcl levels. The significance of this is the fact that the leaves of the two deciduous trees species had seemingly lost their sugars very easily hence they attained that high level of decomposition at the 60th day of the experiment.

At the close of the experiment at 90 days, the rates of the decomposition of the leaves of the two evergreen trees species remained at 0.004 per cent, while that of the deciduous trees species had reached almost a 100 per cent decomposition level. Judging from the mean per cent decomposition rates of the leaves of the four trees species, there were significant differences ($P<0.05$) among them.

The overall mean per cent decomposition rates for all the leaves at 30 days after the start of experiment was 49.9 at 5.0g and 0.0g Hgcl levels. At 10.0g Hgcl the mean per cent decomposition was 47.4., at the 60th day. Mean per cent decomposition rates for all the leaves stood at 49.9 at 5.0g and 10.0g Hgcl levels, while at 0.0g Hgcl it was 65.7.

At the close of 90 days experiment, mean per cent decomposition of all the leaves of the four trees species was 49.9 at 5.0g and 10.0g Hgcl, while at 0.0g Hgcl, mean per cent decomposition rates of all the leaves was to 74.9 (Table 1c)

The fact that the early stages of decomposition of plant litter are dominated by the easily decomposable carbohydrates, while at the later stages, lignin exerts the major control on decomposition rates has also been reported (Melillo et al' 1989).

The report of Melillo et al does not depart much from the results obtained in this study. Thus the results of this study which are summarized in Table 1c show that 1 – 4 per cent of *Gmelina arborea* and *Ficus exasperate* leaves remained undecomposed at 30 days after the start of the experiment; at the 60th day only 1.0 per cent of *Gmelina arborea* and *Ficus exasperate* leaves remained and at 90 days which marked the end of the experiment only 1 – 3 per cent of the leaves of the two species remained undecomposed, regardless of the effect of Hgcl concentration in the soil medium on which the leaves were placed.

On the otherhand, 99.9 per cent of the leaves of *Dacryodes edulis* and *Irvingia gabonensis* remained undecomposed at the 30th day of the experiment at all levels of Hgcl concentration. At 60 days after the start of the experiment also 99.9 per cent of the leaves of *Dacryodes edulis* and *Irvingia gabonensis* remained undecomposed at 5.0g and 10.0g of Hgcl; at 0.0g Hgcl 99.9 per cent of *Dacryodes edulis* leaf litter remainded undecomposed, and 30.10 per cent of *Irvingia gabonensis* undecomposed also at the 60th day.

At the 90th day, 99.9 per cent of *Gmelina arborea* and *Ficus exasperate* had decomposed completely.

On the whole, the mean percentages of each leaf litter which remained undecomposed after 90 days of experiment were as follows:-

- At 5.0g Hgcl 99.9 per cent undecomposed leaves of *Dacrydoes edulis* and *Irvingia gabonensis*; 2.0 and 1.0 per cent of the leaves of *Gmelina arborea* and *Ficus exasperate* respectively remained undecomposed.
- At 10.0g Hgcl, 99.9 per cent undecomposed leaves of *Dacrydoes edulis* and *Irvingia gabonensis*, 1 -4 per cent of the leaves of *Gmelina arborea* and *Ficus exasperate* did not decompose.
- At 0.0g Hgcl, 99.9 per cent *Dacryodes edulis* leaves remained undecomposed, 61.7 per cent of the leaves of *Irvingia gabonensis* was undecomposed, and 1.0 – 2.0 per cent only of the leaves of *Gmelina arborea* and *Ficus exasperate* respectively remained undecomposed.

According to Strasse (2000) the decomposition rate of fresh litter was 0.1 per cent per day and may decrease to 0.00001 per cent per day or lower in more completely decomposed material. The foregoing report of Strasse (2000), is not at variance with the findings in this study, thus the mean'** decomposition rate per day (after 90 days) of fresh leaf litter decreased from 1.01 to 0.00004% per day (Tables 2)**.

The little difference observed between my result and that of Strasse may be due to the fact that my experiment lasted for only 90 days in a warm and moist tropical environment, while Strasse's study took place in the northern forest soils with a temperate climate. If the duration of my experiment was extended for say a longer period, and conducted in a location having a similar climate like that of the northern forest soils, the two results might have coincided.

In my study that lasted 90 days here in Nigeria with a tropical climate, the decomposition of leaf litter of the 4 selected trees species ranged from 0.004 to 99.9 per cent, indicating that between 1.0 and 99.9 per cent of the leaf litter mass stabilized or decomposed extremely slowly in 90 days of experiment. The leaves of *Dacryodes edulis* and *Irvingia gabonensis* decomposed extremely slowly while the leaves of *Gmelina arborea* and *Ficus exasperate* decomposed very fast.

The two evergreen trees species seemed to have less N concentrations in their leaves, hence their extreme slow rate of decomposition. Thus from tables 1c and 2 it is quite clear that *Dacryodes edulis* and *Irvingia gabonensis* – the two evergreen trees species – had 99 9 per cent of the leaves undecomposed at 90 days, whereas the leaves of the two deciduous trees species – *Gmelina arborea* and *Ficu exasperate* – had 98.9 and 99.9 per cent respectively as portions of their leaves decomposed at 5.0g Hgcl, 99.9 and 96 9 percent respectively decomposed at 10g Hgcl, and 99 9 and 98 1 per cent respectively decomposed at 0.0g Hgcl at 90 days duration of the experiment.

**Weighted means (Table 2)

CONCLUSION AND RECOMMENDATION

Based on the results of this study, it makes sense to conclude that the leaves of the two deciduous trees species - *Gmelina arborea* and *Ficus exasperate* – decomposed faster than those of the evergreen trees species – *Dacryodes edulis* and *Irvingia gabonensis* whose leaves were very slow to decompose. This means that the two deciduous trees species had more nitrogen in their leaves (Bocock, 1964) and therefore a fast rate of decomposition of the leaves. On the contrary evergreen trees species whose leaves decomposed very slowly seemed to have less nitrogen but more recalcitrant elements in them.

RECOMMENDATIONS

Judging from the findings of this study, the following recommendations are made:

1. *Dacryodes edulis* and *Irvingai gabonensis* should be used to raise stands for a faster humus accumulation on the forest soil
2. For faster soil nutrient turnover, forest soil fertility maintenance and improvement, *Gmelina arborea* and *Ficus exasperate* trees species are recommended for the establishment of the forest stand since their leaves decompose very fast.
3.

Table 1a: Data Arrangement of a 2 – Factor Factorial Analysis of Data on Decomposition Rates of leaves of four selected trees species.

(Mecuric chloride Hgcl)	(Leaves of woody spp)	(Blocks)				
		I (23 March)	II (23 April)	III (23 May)	Treatment Total	Trt Means
5gm	1. *Dacryodes edulis*	0.71	0.71	0.71	2.13	0.71*
	2. *Irvingia gabonensis*	0.71	0.71	0.71	2.13	0.71*
	3. *Gmelina arborea*	9.87	10.02	10.02	29.91	9.97*
	4. *Ficus exasperata*	10.02	10.02	10.02	30.06	10.02*
10gm	1. *Dacryodes edulis*	0.71	0.71	0.71	2.13	0.71*
	2. *Irvingia gabonensis*	0.71	0.71	0.71	2.13	0.71*
	3. *Gmelina arborea*	10.02	10.02	10.02	30.06	10.02*
	4. *Ficus exasperata*	9.51	10.02	10.02	29.55	9.85*
0.0gm (Control)	1. *Dacryodes edulis*	0.71	0.71	0.71	2.13	0.71*
	2. *Irvingia gabonensis*	0.71	7.96	10.02	18.69	6.23*
	3. *Gmelina arborea*	10.02	10.02	10.02	30.06	10.02*
	4. *Ficus exasperate*	9.77	10.02	10.02	29.81	9.93*

* = Transformed data and means using the $\sqrt{(x + 0.5)}$ transformation.

Tables 1b: analysis of variance (ANOVA) mercuric chloride (Hgcl) X percent decomposition rates of the leaves of *Dacryodes edulis, Irvingia gabonensis, Amelina aborea* and *Ficus exasperate.*

Sources of Variation	df	SS	MS	F-factor (0.05) Cal. (0.05)	Tab. (0.05)
Total (36 – 1)	35	750.2	21.4		
Block (3 – 1)	2	4.9	2.1		
A (3 – 1)	2	15.4	7.7	4.0*	3.4
B (4 – 1)	3	Z641.2	213.7	112.5**	3.05
AB (2 x 3)	6	45.6	7.6	4.0*	2.55
Error	22	43.1	1.9		

Table 1c: Rates of decomposition of leaves of *Dacryodes edulis, Irvingia gabonensis, Gmelina arborea* and *Ficus exasperate* in University of Calabar Arboretum.

S/N	Level of applied Fungicide/ bactericide (Hgcl)	Leaves of woody species	Percent decomposition of leaves according to Time: 30 days after (23 March)	60 days after (23 April)	90 days after (23 May)	Mean per cent decomposition of each leaf after 90 days
1	5g	*Dacryodes edulis*	0.004	0.004	0.004	0.004**
		Irvingia gabonensis	0.004	0.004	0.004	0.004**
		Gmelina arborea	96.6	99.9	99.9	98.9**
		Ficus exasperata	99.9	99.9	99.9	99.9**
			49.1	49.9	49.9	49.7**
2	10g	*Dacryodes edulis*	0.004	0.004	0.004	0.004**
		Irvingia gabonensis	0.004	0.004	0.004	0.004**
		Gmelina arborea	99.6	99.9	99.9	99.9**
		Ficus exasperata	89.9	99.9	99.9	96.9**
			47.4	49.9	49.9	49.1**
3	0g (control)	*Dacryodes edulis*	0.004	0.004	0.004	0.004**
		Irvingia gabonensis	0.004	9.99	9.99	38.3**
		Gmelina arborea	99.9	99.9	99.9	99.9**
		Ficus exasperata	99.9	99.9	99.9	98.1**
			74.9	74.9	74.9	59.1
		Mean for all the leaves	48.8	53.3	58.3	52.6**

** = detransformed means

Table 2: Mean percent decomposition rates of Dacroydes *edulis, Irvingia gabonensis, Gmelina arborea* and *Ficus exasperate* under the influence of Mecuric chloride (Hgcl)

S/N		Mean percent decomposition under the influence of Hgcl level:			Mean % decomposition individual lead
	Leaf litter	0.0g (Hgcl)	5.0g (Hgcl)	10.0g (Hgcl)	
1	*Dacryodes edulis*	0.71*	0.71*	0.71*	
2	*Irvingia gabonensis*	6.23*	0.71*	0.71*	$0.71^{*}(0.004)_{d}$
3	*Gmelina arborea*	10.02*	9.97	10.02	$2.55^{*}(6.002)_{b}$**
4	*Ficus exasperate*	9.93*	10.02*	9.85*	10.00^{*} $(99.50)_{b}$**
	Overall means % Decomposition of Leaves as affected by Hgcl	6.72*	5.35*	5.32*	9.93^{*} $(98.10)_{a}$**
		$(44.66)_{a}$**	$(28.15)_{b}$**	$(7.83)_{b}$**	

FLD (0.05)

Effect of Fungicide/bactericide (Hgcl) - 1.2
Leaf litter decomposition - 1.3
Effect of Hgcl x leaf litter decomposition - 2.3

* Transformed mean percent decomposition of leaf litter.
** Weighted means or "detransformed means"
Mean in the vertical and horizontal columns having different subscripts are significantly different (P > 0.05)

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