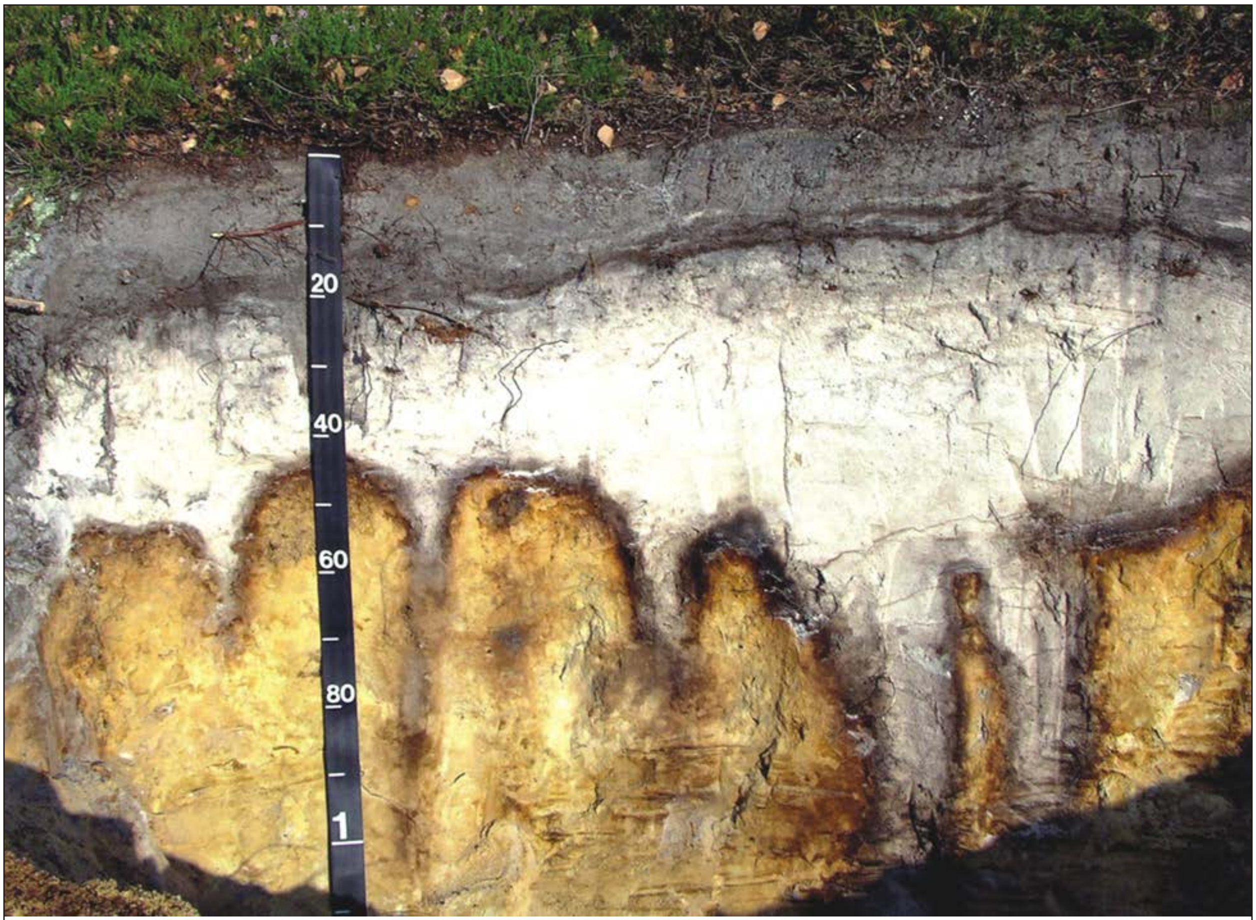

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Decomposition Patterns of Selected Organic Materials in the Nigerian Guinea Savanna

[1]C.K. Daudu, [2]E. Uyovbisere, [2]E. Iwuafor and [3]O.E. Asiribo
[1]Crop and Forestry Program, National Agricultural Extension Research and
Liaison Services, Ahmadu Bello University, Zaria, Nigeria
[2]Department of Soil Science, Institute For Agricultural Research,
Ahmadu Bello University, Zaria, Nigeria
[3]Department of Statistics, Faculty of Science,
University of Abeokuta, Abeokuta, Nigeria

Abstract: Organic materials are important resources that could be used more efficiently in crop production. Improving the utilization efficiency of organic materials requires improved decomposition estimates, which could stem from a better understanding of decomposition patterns of different organic manures. Four organic amendments were studied for their decomposition patterns under field conditions of the Nigerian Guinea Savanna between 1998 and 2000. Mass loss from the organic materials, was found to increase in the following order, *L. leucocephala* prunnings> *M. pruriens* vines > maize stover > cow dung. The plant residues decomposed more rapidly, losing more than 50% of their dry weight within 28 days. Decomposition of cow dung occurred more slowly reaching 50% after about six weeks. A two pool, first order, three parameter negative exponential model ($X = X_L e^{-k_L t} + X_R$) was adequate to describe dry matter loss for the organic materials. The relative rate of decomposition for the labile pool (k_L) were 0.33, 0.30, 0.55 and 0.52 g day^{-1} for cow dung, maize stover, *M. pruriens vines* and *L. leucocephala*, respectively. At zero inorganic fertilizer application, average dry matter loss for three years was 51, 49, 35 and 30% for *L. leucocephala*, *M. pruriens*, cow dung and maize stover, respectively. The results indicated that organic materials biomass could be separated into two pools, each of which responds differently to varying levels of inorganic fertilizer.

Key words: Organic material, decomposition, savanna, inorganic fertilizer, exponential model

Introduction

The importance of organic materials to soil physical, chemical and biological properties with implications on nutrient cycling, erodibility, water storage, plant vigour and resultant soil fertility and productivity has been well established (Stevenson, 1982; Swift and Sanchez, 1984; MacRea and Mehuys, 1985; Marcheisini *et al*., 1988). The nutrient supply is generally considered the most important in the short term (Lombin *et al*., 1991). The application of organic amendments not only supplies N and P but other elements like K, Mg and Ca as well. Knowledge of the relative magnitudes of decomposition and mineralization of organic materials is essential to the understanding of the organic matter and nutrient economy of savanna soils. Organic manures with different chemical compositions are expected to have differential effects on crops due to differential rates of decomposition and nutrient

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Corresponding Author: Dr. C.K. Daudu, Crop and Forestry Program,
National Agricultural Extension Research and Liaison Services,
Ahmadu Bello University, Zaria, Nigeria

release patterns. Organic matter decomposition has been found to vary widely in the short term, with type of organic material (Szott and Kass, 1993; Palm and Sanchez, 1991; Delve *et al.*, 2004), which is usually completed within one year (Jenkinson, 1981).

Proper management of organic materials necessitates quantitative knowledge of the decomposition behavior of these residues under the prevailing set of factors influencing the decomposition process. Traditional organic resources in the Nigerian savanna are crop residues and animal wastes (Daudu *et al.*, 2006). Maize residues form a major proportion of large amounts of crop residues generated annually. Cattle dung is the most widely available source of animal dung. Green manuring and legume cover cropping are however practices that have not yet been widely adopted in the region.

The research objective of this study was therefore to assess the rate of decomposition of maize crop residue, cowdung, *Leuceana luecocephala* prunnings and *Mucuna pruriens* vines in the Nigerian savanna.

Materials and Methods

The decomposition study was conducted on the field in each of the years (1998-2000) at the experiment farm of the Institute for Agricultural Research, Zaria, Nigeria (lat 11°11' N, long 7°38' E and alt 686 m above sea level) and was part of a larger field experiment with the overall objective of evaluating the effects of the organic materials on soil fertility. The various organic materials of cow dung, maize crop residue, *L. leucocepala* prunnings and *M. pruriens* crop residue were collected air-dried and chopped into small bits (about 2-5 cm). The nutrient compositions are described in Daudu *et al.* (2006). Mean values are presented in Table 1. When the organic materials were evaluated based on the contents of nutrients and deduced ratios, cow dung, *M. pruriens* vines and *L. leucocephala* were characterized as high quality materials, while maize stover was considered to be a low quality material (Daudu *et al.*, 2006).

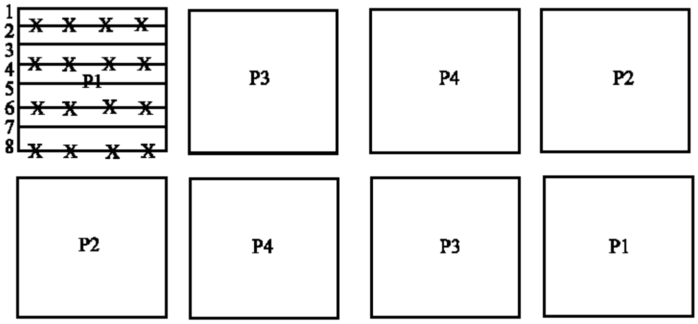
Litterbags were introduced into plots with inorganic fertilizer alone as well as control (zero organic and inorganic fertilizer) amended plots. Treatments were the four organic matter sources × four rates of chemical fertilizers with four harvest periods. The treatment was replicated twice. Twenty grams of representative sample of each of the organic matter sources (with exception of the cow dung)

Table 1: Selected chemical characteristics of organic materials used in the study (averaged over three years)

	Cowdung		Maize stover		*M. pruriens*		*L. leucocephala*	
	Mean	Stand. Dev.	Mean	Stand. Dev.	Mean	Stand. Dev.	Mean	Stand. Dev.
N%	2.36	0.19	1.26	0.20	2.71	0.40	2.71	0.20
P%	0.54	0.05	0.20	0.03	0.37	0.03	0.27	0.02
K%	1.47	0.44	0.86	0.12	1.37	0.02	1.45	0.28
Ca%	1.30	0.06	0.63	0.06	1.45	0.02	1.57	0.06
Mg%	0.39	0.03	0.37	0.05	0.41	0.01	0.39	0.04
C%	52.32	1.21	57.08	1.41	42.94	1.21	32.00	0.63
Lignin g kg^{-1} DM	150.77	29.07	125.77	14.87	161.43	16.28	242.63	10.44
Cellulose g kg^{-1} DM	482.60	110.94	397.27	7.33	585.07	33.60	474.50	112.97
Fe ppm	1583.33	76.38	510.00	65.57	683.33	160.73	833.33	98.66
Cu ppm	31.67	2.89	15.00	8.66	20.00	10.00	21.67	2.89
Zn ppm	78.00	6.93	38.00	6.93	46.00	12.49	64.00	12.17
C:N	22.33	2.08	57.00	3.61	16.00	2.65	12.00	1.00
N:P	4.33	0.58	5.33	1.15	7.33	0.58	10.00	0.00
C:P	97.67	10.60	294.00	37.16	115.67	10.50	117.67	11.24
C:N:P	41.67	6.81	295.00	43.71	43.00	9.85	44.00	7.21
N:C	0.04	0.01	0.02	0.00	0.07	0.01	0.08	0.02
Lignin:N	6.33	1.15	11.67	0.58	6.33	1.53	9.00	1.00
Lignin:cellulose	0.33	0.12	0.32	0.04	0.28	0.02	0.54	0.16
Cellulose:N	20.55	4.86	39.85	2.70	22.00	4.36	17.33	3.06

were put into 20×20 cm litterbags of mesh size 2 mm. A much finer mesh size was used for the finer grain sized cow dung. The bags were sealed and the organic materials spread evenly within the bags. Eight plots of 8 ridges (4×6 cm) each were marked out. The four fertilizer rates 0, 1/4, 1/2 and optimum of the recommended rate of inorganic fertilizer for the open pollinated maize, were allocated to the relevant plots.

Maize was planted on all plots at 20 cm within row spacing. After thinning, litterbags were randomly placed in a ridge at 4-litterbags/alternate ridge/plot between alternate stands of maize at 10 cm depth (Fig. 1). Although the materials are not uniformly mixed with the soil, this should be adequate for the study, because the traditional hoe ridging simply places the plant material applied on the soil surface. Two duplicate litterbags from each treatment were randomly recovered at two-week intervals. The contents of the bags were carefully washed free of soil and then oven dried at 68°C for 48 h before being weighed.



P1- Plot with zerofertilizer applied, P2-Plot with 25% recommended rate of fertilizer applied, P3- Plot with 50% recommended rate of fertilizer applied, P4- plot with recommended rate of fertilizer applied, 1-8 = Rows of maize, X = Litterbag positions (1998 example for plot 1)

Fig. 1: Experimental layout of decomposition trial

The dry weights were expressed as percentage of sample weight remaining undecomposed at each of the sampling dates. Dry matter losses are presented in absolute amounts and proportions of initial amounts. Biomass decomposition data from the decomposition studies were also fitted to several models (Weider and Lang, 1982) to identify the model that best fits the decomposition data. Decomposition rates were calculated for all the organic materials using the formula given below

$$X = (X_t/X_0) \times 100$$

The following models were used to fit biomass loss data. The analysis was carried out on the proportion (X_t) of the initial mass (X_0) remaining at time t. The model parameters were: t = time (week); X_0 = Quantity (capacity factor) of the total biomass at time zero that is available for decomposition; k, k_1, k_2-decomposition rate constants (week^{-1}); X_L, X_l and X_R = are defined compartments based on their proportions in % of the initial biomass and X = proportion (X_t) of the initial mass (X_0) remaining at time t = X_t / X_0 defined on the interval $0 \leq X \leq 1$

Single exponential decay model

$$X = X_l e^{-k_l t} + X_R e^{-k_R t}$$ Ibewiro *et al.* (2000)

Double exponential decay model

$$X = X_L e^{-k_1 t} + X_R e^{-k_R t}$$ Somda *et al.*(1993)

Asymptotic negative exponential model

$$X = X_1 e^{-k_1 t} + X_R$$ Couteax *et al.*(1998)

Triple negative exponential decay model

$$X = X_L e^{-k_L t} + X_I e^{k_I t} + X_R e^{-k_R t}$$ Couteax *et al.*(1998)

Using decay coefficient (k) values and assuming constant decay rates for specific treatments, the half-life values (t_{50}), the time it takes for loss of 50% of the amount of the organic material to occur, were estimated from the best-fit models. The effect of different levels of inorganic fertilizer was evaluated from the equation:

Inorganic fertilizer effect = M_{IF}/M adapted from Seastedt (1984)

Where, M_{IF} = Percent biomass of organic materials remaining at time t in plots treated with chemical fertilizer.
M = Percent biomass of organic materials remaining at time t in plots that were not treated with chemical fertilizer.

Statistical analysis of all the parameters was undertaken using SAS (1989) and Sigmaplot (2001) programmes. A combined ANOVA using a variation of a factorial design (Brinson, 1977; Weider and Lang, 1982) was used to assess the effects of organic material types, rates, dates and the possible interaction between organic material sources and rates. The analysis was carried out on the initial amount of x remaining at time t, where X was the dry mass (Weider and Lang, 1982; Gordillo and Canberra, 1997). The decay models were compared using coefficients of multiple determinations (R^2) and residual mean squared errors (RMSE's).

Results and Discussion

Dry Matter Loss

Table 2 shows the effect of time and inorganic fertilizer levels on the dry matter loss of different organic materials for three years (1998-2000). The rate of decomposition of the four sources were significantly) different over the whole decomposition period and at individual sampling periods for all the study years. Mass loss from the various organic materials increased in the order *L. leucocephala* > *M. puriens* > maize stover > cow dung. The dry matter content of the organic materials in litterbags decreased rapidly during the first two weeks of decomposition. The fast decay observed immediately after incorporation of the organic materials may have been due to leaching of the water-soluble constituents of the materials (Hunt, 1977; Reinerstsen *et al.,* 1999; Janssen, 1993). At zero inorganic fertilization, average dry matter loss for three years was 51.5, 48.92, 35.21 and 29.86% for *L. leucocephala*, *M. puriens*, cowdung and maize stover, respectively.

In this study, more than 60% of the applied plant residues were already decomposed by one month after incorporation. The faster rate of decomposition of the *L. leucocephala* and *M. pruriens* could be attributed to their relatively lower C:N ratio, higher initial N content and the more tender and succulent nature of the materials. The relatively low N content of maize stover despite its low lignin content may have retarded initial decomposition compared with the other plant residues. According

Table 2: Effect of different inorganic fertilizer levels on decomposition of organic materials in 1998-2000 (amount left)

Organic Material Type	Inorganic fertilizer level	1998				1999				2000			
		2 wks	4 wks	6 wks	8 wks	2wks	4 wks	6 wks	8 wks	2wks	4 wks	6 wks	8 wks
Cow dung	0	14.2	12.0	10.9	9.0	12.3	10.4	8.1	6.8	12.4	11.8	10.6	8.7
Cow dung	1/4	13.7	12.7	9.6	8.2	12.7	11.1	9.2	7.2	13.2	11.9	11.1	9.5
Cow dung	1/2	15.9	14.8	11.5	8.8	13.2	12.3	11.8	7.8	13.7	12.6	11.6	9.9
Cow dung	1	16.8	12.0	9.1	6.9	13.4	12.5	11.1	8.2	14.0	13.0	12.1	10.8
Maize stover	0	13.6	7.7	7.2	4.3	14.0	8.2	7.3	5.5	14.5	8.8	7.8	5.5
Maize stover	1/4	17.7	8.2	5.9	5.3	14.9	10.1	7.8	6.0	15.1	10.8	7.6	6.3
Maize stover	1/2	12.7	7.7	6.7	5.3	15.2	10.5	9.8	5.5	15.6	11.3	9.5	6.8
Maize stover	1	11.9	6.7	5.8	5.0	15.9	11.1	8.8	5.5	16.2	11.3	9.8	5.1
M. pruriens	0	11.8	5.6	4.5	4.4	9.6	6.6	5.3	4.3	9.4	6.6	5.4	4.4
M. pruriens	1/4	11.8	8.5	6.7	4.6	9.6	7.4	5.3	4.8	9.8	7.6	5.9	4.4
M. pruriens	1/2	12.7	7.3	7.1	5.3	10.0	7.9	7.0	5.1	10.1	7.8	7.3	4.5
M. pruriens	1	10.7	6.6	5.7	4.7	10.4	8.0	7.1	5.2	10.3	8.0	7.5	4.5
L. leucocephala	0	14.3	7.9	4.6	3.3	7.9	7.0	5.7	4.3	6.9	6.5	4.6	3.8
L. leucocephala	1/4	13.0	7.7	5.0	1.3	8.0	7.1	6.1	4.2	7.0	6.5	5.2	4.1
L. leucocephala	1/2	16.9	10.0	7.0	2.2	8.1	7.4	6.4	4.3	7.2	6.7	5.7	4.1
L. leucocephala	1	13.7	9.7	6.3	3.6	8.2	7.6	6.6	4.3	7.7	6.8	6.4	4.4
LSD at p = 0.05													
organic mattere type (M)		<0.0001				<0.0001				<0.0001			
inorganic fertilizer level (F)		<0.0233				<0.0001				<0.0001			
Harvest periods (P)		<0.0001				<0.0001				<0.0001			
M × F		<0.0464				<0.0001				<0.3556			
M × F × P		<0.3516				<0.0823				<0.3507			
SE		1.51				0.388				0.646			

to Swift (1984, 1985), successful management of organic materials should aim at synchronizing the nutrient release pattern with the crop nutrient rate. The higher persistence of the maize stover compared with the other three organic materials may be an advantage in reducing erosion hazard (Young, 1989). Because of its slow rate of decomposition, maize stover may not be suitable for topdressing, but should always be incorporated prior to planting.

Cow dung had a relatively lower rate of decomposition than the plant materials as the easily decomposable compounds in feedstuffs had been digested when passing the digestive tract of the animal (Janssen, 1996). The very low decomposition associated with cow dung may not have resulted from its quality characteristics, as there was a lot of contamination of the cow dung with soil during the decomposition study, which was difficult to separate. Evidence for this was observed considering the higher decomposition rate at the first sampling date. The contact period with soil during the first sampling date was less, relative to the extended periods for other sampling dates and hence reduced contamination with soil.

Generally increasing levels of inorganic fertilizers tended to lead to a decrease in decomposition. Decomposition was highest under zero inorganic fertilization and least under optimum inorganic fertilizer rates. Table 3 shows the relative effect of inorganic fertilizer calculated from the modified equation of Seastedt (1984). When results of this equation produce a value greater than one, inorganic fertilizers have caused a net negative effect on decomposition (reduced the rate of decomposition). When values are less than one, net loss of biomass has occurred. Several values of greater than one in this study (Table 2) confirm, that in general, inorganic fertilizers retard the rate of decomposition. A possible explanation is that the high availability of nutrients in the inorganic fertilizer may have suppressed microbial activity thereby inhibiting decomposition of the organic materials (MacRae and Mehuys, 1985). Also, high nutrient concentrations that occurred with the application of fertilizers enhanced the decomposition of water-soluble compounds and non- lignified enzymes and repressed the formation of lignolytic enzymes (Couteaux *et al*., 1998). This resulted in the slow degradation of both lignin and lignified cellulose and the decomposition of the whole organic material was retarded. The results would tend to suggest that decomposition and hence the potential contribution of organic

Table 3: Relative effects of inorganic fertilizers on decomposition of organic materials

Organic material	Time (wks)	1998			1999			2000			Mean		
		0.25 FL	0.50 FL	FL	0.25 FL	0.50 FL	FL	0.25 FL	0.50 FL	FL	0.25 FL	0.50 FL	FL
Cow dung	0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2	1.0	1.1	1.2	1.0	1.1	1.1	1.1	1.1	1.1	1.0	1.1	1.1
	4	1.1	1.2	1.0	1.1	1.2	1.2	1.0	1.1	1.1	1.0	1.2	1.1
	6	0.9	1.1	0.8	1.1	1.5	1.4	1.1	1.1	1.1	1.0	1.2	1.1
	8	0.9	1.0	0.8	1.1	1.1	1.2	1.1	1.1	1.2	1.0	1.1	1.1
Maize stover	0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2	1.3	0.9	0.9	1.1	1.1	1.1	1.0	1.1	1.1	1.1	1.0	1.0
	4	1.1	1.0	0.9	1.2	1.3	1.3	1.2	1.3	1.3	1.2	1.2	1.2
	6	0.8	0.9	0.8	1.1	1.3	1.2	1.0	1.2	1.3	1.0	1.2	1.1
	8	1.2	1.2	1.2	1.1	1.0	1.0	1.1	1.2	0.9	1.2	1.2	1.0
M. pruriens vines	0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2	1.0	1.1	0.9	1.0	1.0	1.1	1.0	1.1	1.1	1.0	1.1	1.0
	4	1.5	1.3	1.2	1.1	1.2	1.2	1.2	1.2	1.2	1.3	1.2	1.2
	6	1.5	1.6	1.3	1.0	1.3	1.3	1.1	1.4	1.4	1.2	1.4	1.3
	8	1.0	1.2	1.1	1.1	1.2	1.2	1.0	1.0	1.0	1.1	1.1	1.1
L. leucocephala prunnings	0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	2	0.9	1.2	1.0	1.0	1.0	1.0	0.7	1.0	1.1	1.0	1.0	1.1
	4	1.0	1.3	1.2	1.0	1.1	1.1	1.0	1.0	1.1	1.0	1.1	1.1
	6	1.1	1.5	1.4	1.1	1.1	1.2	1.1	1.2	1.4	1.1	1.3	1.3
	8	0.4	0.7	1.1	1.0	1.0	1.0	1.1	1.1	1.2	0.8	0.9	1.1

0.25FL - 25% recommended inorganic fertilizer rate, 0.50FL - 50% recommended inorganic fertilizer rate, FL - recommended inorganic fertilizer rate

materials will be greater if inorganic fertilizers are used as top-dressing than if they are applied simultaneously. An analysis of the three-year study indicated that at the end of the decomposition period, 59-66% of the cow dung, 70-73% of the maize stover, 74-79% of the *M. pruriens* and 78-79% of *L. leucocepahala* had decomposed. The amounts of C mineralised in this study are typical of tropical soils and the values obtained compare favourably with results obtained by other workers (Mugendi *et al*., 1994; Tarfa, 2001). The relative order of decomposition at 5% level of significance was as follows: *L. leucocephala*> *M. pruriens* >Maize stover> cow dung. The differences are indicative of the variable amounts of labile organic C available in the organic materials.

Fitting Decay Functions to Mass Loss Values of Organic Materials

The double and triple exponential models were unable to fit describe data from cow dung and *L. leucocephala* decomposition. The best fit to data of remaining mass from cow dung, maize stover, M. pruriens and *L. leucocephala* across the four rates of inorganic fertilizer was obtained from a three parameter, two pool, negative exponential given by:

$$X = X_I e^{-k_L t} + X_R$$

The fits were unbiased and satisfactory for decomposition of cow dung, maize stover *M. pruriens* and *L. leuceana* (Table 4-7). This model described decomposition across all the rates used and had lower RMSE's. The higher the k value, the faster, the rate of decomposition. High decay rates (k_L) in the first pool were indicative of soluble, non-structural carbohydrates and other low C:N ratio compounds. Decay rates (k_I and k_R) in the second and third pools can be related to the more recalcitrant structural carbohydrates (cellulose and hemi-cellulose) and other lignified compounds, which are more resistant to decomposition. The results indicated that the decomposition of the organic materials expressed as the relative decomposition K_L (% proportion of biomass remaining week^{-1}) of the labile fractions, varied according to source of the organic material and level of inorganic fertilizer treatments, ranging from 0.18 g day $^{-1}$ for cow dung at 60:30:30 to 0.55 g day^{-1} for *M. pruriens* at zero

Table 4: Goodness of fit statistics and parameter estimates of the single exponential decay model ($Y = X_o e^{-k_o t}$) fitted to dry matter loss of the four organic materials

Organic Material Type	Chemical fertilizer level	R^2	RMSE	k_0 (% wk^{-1})	X_0 (%)	Prob value
Cow dung	0	0.88	58.2	0.1164	93.5	<0.0001
“	1/4	0.91	44.25	0.1148	94.58	<0.0001
“	1/2	0.90	40.63	0.0957	95.96	<0.0001
“	1	0.90	46.99	0.1049	96.88	<0.0001
“	**C	0.88	48.91	0.1075	95.30	<0.0001
Maize stover	0	0.98	19.10	0.1816	99.27	<0.0001
“	1/4	0.96	36.61	0.1657	102.03	<0.0001
“	1/2	0.95	39.71	0.1532	99.56	<0.0001
“	1	0.92	71.15	0.1644	100.08	<0.0001
“	**C	0.94	41.21	0.1658	100.2	<0.0001
M. pruriens vines	0	0.95	48.94	0.2508	96.21	<0.0001
“	1/4	0.94	48.92	0.2153	95.21	<0.0001
“	1/2	0.93	56.43	0.1974	94.83	<0.0001
“	1	0.93	61.03	0.2060	94.38	<0.0001
“	**C	0.96	53.3	0.2163	95.12	<0.0001
L. leucocephala prunnings	0	0.90	103.90	0.2502	95.90	<0.0001
“	1/4	0.91	96.79	0.2539	95.59	<0.0001
“	1/2	0.85	158.33	0.2184	96.27	<0.0001
“	1	0.89	105.01	0.2155	94.51	<0.0001
“	**C	0.88	108.01	0.2335	93.88	<0.0001

**C - Model was fit to data over the four inorganic fertilizer levels

Table 5: Goodness of fit statistics and parameter estimates of the double exponential decay ($Y = X_L e^{-k_L t} + X_R e^{-k_R t}$) model fitted to dry matter loss of the four organic materials

Organic Material Type	Chemical fertilizer level	R^2	RMSE	k_L (% wk^{-1})	k_R	X_L (%)	X_R	Prob value
Maize stover	0	0.98	17.84	0.2453	0.00	86.85	13.82	<0.0001
“	1/4	0.96	43.27	0.1652	0.1661	50.82	51.20	<0.0001
“	1/2	0.95	45.83	0.2536	0.1006	45.65	54.70	<0.0001
“	1	0.92	84.04	0.2507	0.1361	45.87	54.36	<0.0001
“	**C	0.95	42.16	0.1894	0.00	93.7	7.05	<0.0001
M. pruriens vines	0	0.99	10.64	0.4790	0.00	79.89	20.15	<0.0001
“	1/4	0.99	11.09	1.6167	0.1318	33.97	66.03	<0.0001
“	1/2	0.98	16.05	0.9472	0.1002	41.16	58.87	<0.0001
“	1	0.99	9.89	1.0758	0.100	42.91	57.10	<0.0001
“	**C	0.98	14.8	0.8565	0.0997	46.45	53.57	<0.0001

**C - Model was fit to data over the four inorganic fertilizer levels

Table 6: Goodness of fit statistics and parameter estimates of the asymptotic negative exponential model ($Y = X_L e^{-k_L t} + X_R$) fitted to dry matter loss of the four organic materials

Organic Material type	Chemical fertilizer level	R^2	RMSE	k_L (% wk^{-1})	X_L (%)	X_R (%)	Prob value
Cow dung	0	0.94	33.04	0.3863	59.91	41.35	<0.0001
“	1/4	0.95	26.12	0.337	39.76	59.32	<0.0001
“	1/2	0.91	39.48	0.2066	62.64	35.58	<0.0001
“	1	0.91	45.01	0.2129	66.24	32.93	<0.0001
“	**C	0.90	38.3	0.2587	59.86	39.08	<0.0001
Maize stover	0	0.98	16.35	0.2435	86.85	13.82	<0.0001
“	1/4	0.96	39.63	0.1607	103.73	-1.82	<0.0001
“	1/2	0.95	42.05	0.1853	90.24	10.06	<0.0001
“	1	0.92	77.04	0.1701	98.30	1.92	<0.0001
“	**C	0.95	41.42	0.1894	93.70	7.05	<0.0001
M. pruriens vines	0	0.99	9.75	0.4790	79.89	20.15	<0.0001
“	1/4	0.98	15.85	0.4448	76.29	23.22	<0.0001
“	1/2	0.98	18.86	0.4511	73.41	26.27	<0.0001
“	1	0.98	13.93	0.4973	76.23	26.46	<0.0001
“	**C	0.97	16.86	0.4682	75.67	24.07	<0.0001
L. leucocephala prunnings	0	0.93	80.53	0.4547	80.59	18.56	<0.0001
	1/4	0.93	74.41	0.4628	80.63	18.60	<0.0001
“	1/2	0.86	157.47	0.3521	81.63	17.36	<0.0001
“	1	0.92	75.86	0.4679	75.34	23.84	<0.0001
“	**C	0.90	86.17	0.4332	79.30	19.93	<0.0001

**C - Model was fit to data over the four inorganic fertilizer levels

Table 7: Goodness of fit statistics and parameter estimates of the triple negative exponential decay model ($Y = X_1 e^{-k_L t} + X_1 e^{k_I t} + X_R e^{-k_R t}$) fitted to dry matter loss of the four organic materials

Organic Material Type	Chemical fertilizer level	R^2	RMSE	k_L	K_I (% wk^{-1})	k_R	X_L	X_I %	X_R	Prob value
Maize stover	1/4	0.96	52.88	0.1657	0.1657	0.1657	33.61	34.46	33.95	<0.0001
“	1/2	0.95	56.02	0.2264	0.2159	0.0771	31.01	33.10	36.22	<0.0001
“	**C	0.95	43.72	0.1888	0.1899	0.00	45.23	48.46	7.05	<0.0001
M. pruriens vines	0	0.99	13.00	0.4780	0.4803	0.00	44.74	35.15	20.15	<0.0001
“	1/4	0.98	13.55	1.7411	0.1692	0.1077	32.93	32.3	34.77	<0.0001
“	1/2	0.98	19.62	0.9476	0.1007	0.0999	41.15	27.0	31.88	<0.0001
“	1	0.99	12.08	1.075	0.100	0.0999	42.91	25.74	31.36	<0.0001
“	**C	0.98	15.35	0.8575	0.0999	0.997	46.41	23.08	30.52	<0.0001

**C - Model was fit to data over the four inorganic fertilizer levels

inorganic fertilization levels. The effect of application of increasing levels of inorganic fertilizer was not consistent, but it generally led to lower rates of decomposition of the labile pools. This trend was expected and could be explained by the fact that the inorganic fertilizer provided a readily available source of nutrients for the micro-organisms. The microbes did not therefore need to break down the organic materials for food and energy. The decrease in decomposition rates was more distinct with the leguminous materials than with cow dung and maize stover. This was rather difficult to explain, as a sharper decrease was expected for *L. leuceana* and *M. pruriens* that had relatively higher N contents.

On the other hand, inorganic fertilizer applications was found to lead to lower values of the proportions of the recalcitrant pools of maize stover and cow dung biomass while increasing values for proportions of the recalcitrant pools of biomass was observed for *L. leuceana* and *M. pruriens*. This is consistent with current understanding of organic material decomposition and may be explained by the relative amounts of nutrients contained in the organic materials. The estimated time required for 50% biomass decomposition (t_{50}) of the organic materials under zero fertilization to occur ranged from 14 days for *L. leucocephala* and *M. pruriens* to 35 days for cow dung (Fig. 2). Application of increasing levels of fertilizer was observed to extend the period in which time t_{50} occurred.

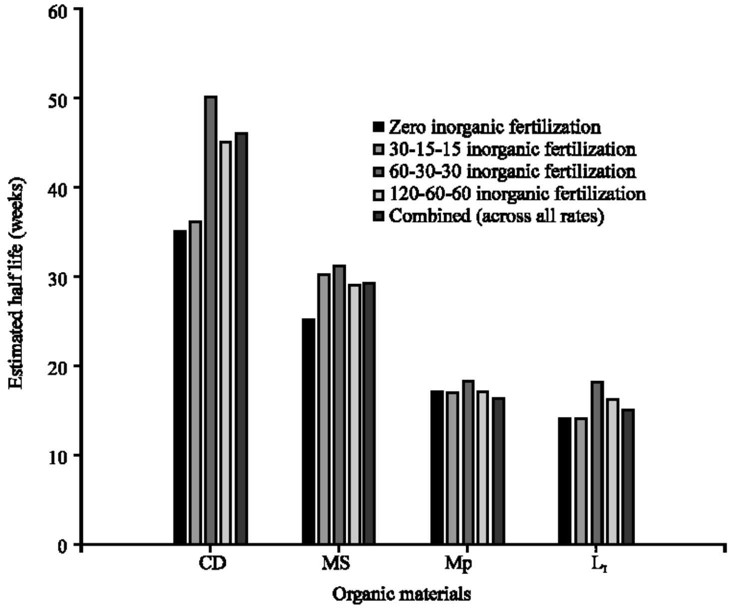


Fig. 2: Effect of inorganic fertilizers on estimated half life of four organic materials

Conclusions

This research found the relative order of decomposition of four organic materials to be in the order: *L. leucocephala* pruning> *M. pruriens* vines> maize stover> cow dung. The relative effect of varying level of inorganic fertilizer was seen to reduce rate of decomposition. A first order, two pool, three-parameter, negative exponential model was found to adequately describe the decomposition process. The model indicated a differential effect of inorganic fertilizer on decomposition of the two functional pools. This effect was also seen to vary with the source of organic material. Techniques using labelled organic materials, will improve the quantification of decomposition as a function of time.

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