

Decomposition Rates and Nutrient Release Patterns of *Tephrosia vogelii* and *Tephrosia candida* Residues in Malawi

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Abstract

The main input of nutrients in agroforestry systems is achieved through biomass decomposition. A study was carried out to determine the rates of decomposition and N and P release pattern from *T. vogelii* and *T. candida* plant residues using litterbag experiments in Malawi. The plant residue treatments included *Tephrosia* biomass alone or in combination with maize stover. For each treatment, sixteen replicates of litter bags were buried in the soil at the depth of 20cm and Samples were drawn from each litter bag at 1, 2, 3, 4, 5, 6, 7 and 8 week intervals and were analyzed to determine remaining dry matter weight (DMW), N and P. The fastest decomposition rates (k) recorded when *T. vogelii* or *T. candida* leaves + twigs + stover were combined, while the slowest was when twigs alone or maize stover alone were used. The *Tephrosia* residues were high in N (>3.5%) and P (critical value of >2.0%). The N release rates were fastest from twigs of *T. vogelii* or *T. candida* followed by maize stover alone, while the slowest release was when *T. vogelii* leaves were combined with twigs. P release pattern from residues was the same as N release. No N and P immobilization was observed throughout the study period. The results have clearly demonstrated that the *Tephrosia* fallow biomass alone decompose considerably faster attaining their half-life within 2–3 weeks and over 95% within 8–25 weeks but when mixed with maize stover (alow quality farm residues) decomposition was slowed down. Therefore, *Tephrosia* fallow biomass can be used for short-term correction of soil fertility.

Keywords

Tephrosia, Decomposition, Release Pattern, Litterbag, Soil Fertility

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1. Introduction

Over the last century vast regions of arable and pasture lands have been degraded and abandoned in many parts of Africa. On the remaining arable land, loss of soil organic matter (SOM), nutrient limitation and imbalances are also severe. This results mainly from continuous cropping of cereals without rotation with legumes, inappropriate soil conservation practices, and inadequate amounts of fertilizer use (Bationo et al. 2006). Serious nitrogen (N) and potassium (K) deficits also develop because of heavy export in crop harvest. The loss of organic N decreases soil productivity and

the agronomic efficiency of fertilizer N, resulting in yield stagnation or decline over time (Mulvaney et al. 2009). While inorganic fertilizers are effective in driving productivity, they have limitations and negative impact on the environment. First, continuous application of large quantities of N fertilizers leads to net loss of soil organic C as mineral N promotes microbial C utilization (Mulvaney et al. 2009). Secondly, the production of fertilizer N is energy-consuming, and N is an environmental pollutant. Some authors have argued that improving the efficiency with which fertilizer N is used is vital to the long-term sustainability of the planet. An equally important goal could be the more effective

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utilization of biological N-fixation as it account for over 60% of the global production of N (Roy et al. 2003; Zahran, 1999). Given the limitations of inorganic fertilizers and the challenges to make them available at affordable costs in Africa, there is an urgent need for increased use of alternative and complementary inputs in smallholder farming systems in many parts of the developing world. Planting of N-fixing leguminous plant species either as improved fallows or green manures cover crops is receiving considerable attention in the cropping systems of sub-Saharan Africa. The legumes have been reported to increase N fertilizer use efficiency in Malawi (Kamanga et al. 2001).

In Agroforestry systems, the main input of nutrients is achieved through biomass decomposition, by which elements that are essential for plant development and are associated to plant tissues not readily available to crops of commercial interest are released. How fast these residues return to the soil is basically a function of the quality of the organic source, the weather conditions and the presence of decomposing organisms in the system (Myers et al. 1994). In order to develop more efficient systems to improve soil nutrient dynamics, a well-synchronized balance must be established between specific crop demands and supply of nutrients from decomposition of plant residues. Decomposition is a very complex process affected by a wide range of factors which are nutrient availability (soil nutrient content), residue quality (crop residue characteristics), chemical composition, specific soil factors such as texture, mineralogy and acidity, biological activity and the presence of other nutrients (Myers et al. 1994; Sing et al. 2004) and environmental factors such as soil moisture and temperature.

Tephrosia vogelii and *T. candida* are some of the shrubs that are being used as fertilizer trees in Malawi (Akinnifesi, 2009). The trees are suitable for rehabilitating degraded land, fixing atmospheric N and raise soil P and K levels in proportion to increased levels of organic matter (Huancheng and Jueiming, 1993). No much work has been done to evaluate the potential of *T. vogelii* and *T. candida* biomass for soil fertility improvement as well as their decomposition rates in Malawi. Furthermore, knowledge about the proper ways of controlling decomposition rate of *Tephrosia* biomass applied and thus synchronizing nutrients release with the critical period of high nutrient demand by agricultural crops especially is scanty and has not been well studied in Malawi. Thus, limited studies have been conducted to understand the pattern of *Tephrosia* decomposition and its release of nutrients in Malawi. Therefore, the objective of this study was to characterize the decomposition rate and N and P release pattern of *T. vogelii* and *T. vogelii* residues and optimize their use as sources of organic manure for maize production in Malawi.

2. Materials and Methods

2.1. Study Area

The decomposition study was carried out at Chitedze Agricultural Research Station (located at 13° 85' S and 33°38' E) in Malawi. It lies at an altitude of 1146 m above the sea level. The site has one long growing season in a year (October to April). The station receives a mean annual rainfall of 892 mm, 85% falls between November and March. The station is characterized by a mean temperature of 28°C. Climatic data collected during the research period (between January and March 2012) is shown in Figure 1.

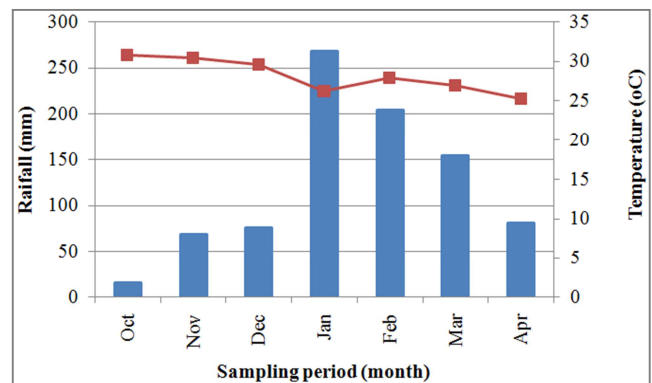


Fig. 1. Mean monthly rainfall and temperature data during the experimental period

2.2. Experimental Design and Treatments

The litterbag experiment was carried out for 8 weeks period between January 2012 and March 2012. The leaves and twigs were collected from the two fallow biomass sites under *T. vogelii* and *T. candida*. Maize stovers that were mixed with *Tephrosia* biomass were collected from the farmers' field around Chitedze station. Maize stovers were chosen because they are readily available in the fields and are low in polyphenol which is a determinant of the rate of N release. This experiment had 6 treatments. Five for each of the two *T. candida* and *T. vogelii* and one treatment of maize stover only with each sample weighing 15g as shown in Table 1.

Table 1. Treatments for the decomposition experiment on *T. candida* and *T. vogelii* residues and maize stover

Treatment	
1	15 g <i>Tephrosia</i> leaves
2	15 g <i>Tephrosia</i> twigs
3	10 g <i>Tephrosia</i> leaves + 5g twigs
4	15 g Maize stovers
5	10 g <i>Tephrosia</i> leaves+ 5g stovers
6	7.5g <i>Tephrosia</i> leaves + 3 g twigs + 4.5g stovers

Tephrosia leaves, twigs and maize stover were chopped to about 2 cm and placed in 20 cm x 20 cm nylon bag with a 2 mm mesh size to prevent losses of litter to breakage but

sufficiently small to allow colonization by microorganisms and invertebrates. For each treatment 16 replicate litter bags were buried in the soil at the depth of 20 cm. The litterbags were laid out depending on the treatments and each treatment was buried in one plot and the location of the litterbags in each plot of the blocks were marked using labeling tags. At each sampling period, two litterbags from each treatment were systematically sampled and soil particles and roots growing in the litterbags were manually removed. The litterbags were sampled after 1, 2, 3, 4, 5, 6, 7 and 8 weeks. On each sampling occasion 22 litterbags were examined.

2.3. Laboratory Analysis

The samples were analyzed for initial N, P, K, Ca, Mg, and C. On the other hand, the remaining organic materials were washed with distilled water and oven dried at 75°C for 48 hours to a constant weight for dry weight determination, N and P analysis. The N content of the plant tissues were determined by Kjeldahl procedure whereas P content were determined calorimetrically according to Murphy and Rilley (1962) and the K content of the plant tissue were determined by the Flame photometer while Ca and Mg were determined by Atomic Absorption Spectrophotometer (AAS). Organic C was determined using Dichromate-Oxidation Method.

2.4. Statistical Analysis

In all cases, the mass remaining was expressed as percentage of the initial oven dry weight of the residues. Remaining dry matter and nutrients of the residues were fitted to the exponential model of Olson (1963) and the decomposition rate and nutrient loss constants (k) were determined as follows:

$$W_t = W_0 e^{-kt}$$

Where:

W_0 and W_t are the initial and remaining (at time t) weights of oven-dry organic materials or nutrients pool, respectively

k = decomposition rate constant which was estimated as a slope of the model

t = time (week)

The half-life (time required for 50%, $t_{0.50}$ to be released) and 95% ($t_{0.95}$) loss in DMW or element were equal to $0.693/k$ and $3/k$, respectively (Harmon *et al.*, 1999). Non-linear regression procedure of SAS was used to estimate decomposition and N and P release rates. Bias in the estimated values of k (and its 95% confidence limits) were tested using Hougaard's measure of skewness. The values of k were considered reasonably close to linearity if the absolute value of Hougaard's measure is <0.25 but biased if >0.25 . Values of k were declared significantly different if their 95% confidence intervals overlap. Correlations between decomposition rates and initial chemical properties of *Tephrosia* residues were examined using the Pearson correlation coefficient (r)

3. Results and Discussion

3.1. Chemical Composition of Organic Materials Used in the Study

The chemical composition of the plant materials used in the decomposition study is presented in Table 2. The N content of the residues ranged from 1.56 to 5.18% with *T. candida* leaves and maize stovers alone recording the highest and lowest N content respectively. The quality of plant residues with respect to decomposition can be defined as its relative ease of mineralization by decomposer organisms (Paustian *et al.*, 1997). Quality is largely determined by the organic constituents and nutrient contents. Large differences in the quality of the residues were observed. The N concentrations of all residues apart from maize stover had values > 2.0 to 2.5% below which net N immobilization from the soil would be expected when these residues are applied as soil amendment as indicated by Palm and Sanchez (1991).

Table 2. Chemical characteristics of plant residues used in decomposition study

Species	Treatment	N (%)	P (%)	K (%)	Mg (ppm)	Ca (ppm)	OC (%)	C/N	C:P
<i>T. candida</i>	Leaves	5.18	0.35	0.39	3.88	2.64	36.4	7.0	104.9
	Twigs	2.95	0.31	0.35	3.01	2.58	35.6	12.1	116.7
	Leaves +twigs	3.38	0.27	0.39	2.87	2.52	28.9	8.6	107.0
	Leaves + stover	2.60	0.13	0.26	2.88	2.43	41.6	16.0	114.1
	Leaves + twigs + stover	2.62	0.14	0.43	3.03	2.56	41.2	15.7	302.9
<i>T. vogelii</i>	Leaves	5.02	0.21	0.43	3.96	2.78	32.1	6.4	150.0
	Twigs	2.75	0.21	0.60	2.92	2.54	31.7	11.5	152.4
	Leaves + twigs	3.35	0.18	0.52	3.44	2.58	37.6	11.2	212.4
	Leaves + stover	2.32	0.13	0.26	2.85	2.63	40.0	17.2	317.5
	Leaves + twigs + stover	2.11	0.13	0.39	3.27	2.22	37.2	17.6	297.6
	Maize stover alone	1.56	0.07	0.43	2.93	2.45	41.6	26.7	602.9

3.2. Decomposition Pattern for Different Plant Materials of *T. vogelii* and *T. candida*

The decompositions patterns for the different residues are shown in Fig. 2. The decomposition rate constants (k) and the days taken for 50% (t_{50}) and 95% (t_{95}) decomposition for the different residues are presented in Table 3. The decomposition rate constants (k) for all the plant residues were unbiased, and these ranged from 0.15 wk⁻¹ for maize stover alone to 0.34 wk⁻¹ with mixture of *T. candida* leaves + twigs + stover. (Table 3). The rate for maize stover alone was significantly slower than most treatments except twigs alone (Fig. 2; see also 95% CI in Table 3). The mass loss in all the plant residues for both species was faster between the first and fourth week. Between the second and fourth week of decomposition, the residues had lost almost 50% of their initial mass (Fig. 2). The model used explained 90-99% of the variation ($r^2 = 0.90-0.99$)

The decomposition of residues of the two species followed the same pattern and order; the highest being in the mixture of leaves + twigs + stover and lowest in maize stover alone. The decomposition pattern was biphasic with an initial rapid phase followed by a slower phase. A similar pattern was

observed by Tetteh (2004), Constantinides and Fownes (1994), McDonagh et al. (1995) and Nhamo et al. (2007). The rapid mass loss during the early stages of the organic materials was due to release of water soluble components such as sugars, amino acids and soluble phenolics (Wang et al. 2004; Bross et al. 1995). Young plant materials are more rapidly decomposed than the old materials that contain generally a large amount of stable polysaccharides such as cellulose, hemicelluloses and lignin (Zech et al. 1997). The slow loss of biomass recorded during the late stages of decomposition reflected the decline in quality of the biomass and could be due to the presence or decomposition of recalcitrant materials such as lignin, hemicelluloses and soil microbial products (Saviozzi et al. 1997). Nyamai (1994) also observed that the decomposition of the foliage of five agroforestry tree species started rapidly and continued for some weeks and then gradually became slow. The rapid decomposition of the plant residues in this study could be due to high levels of nutrients, notably N, which are reported to accelerate the decomposition process (Alhamd et al. 2004). The rapid rate of decomposition of these plant residues has implications for nutrient availability to associated crops. Rapid rate of decomposition meant less organic matter addition to the soil.

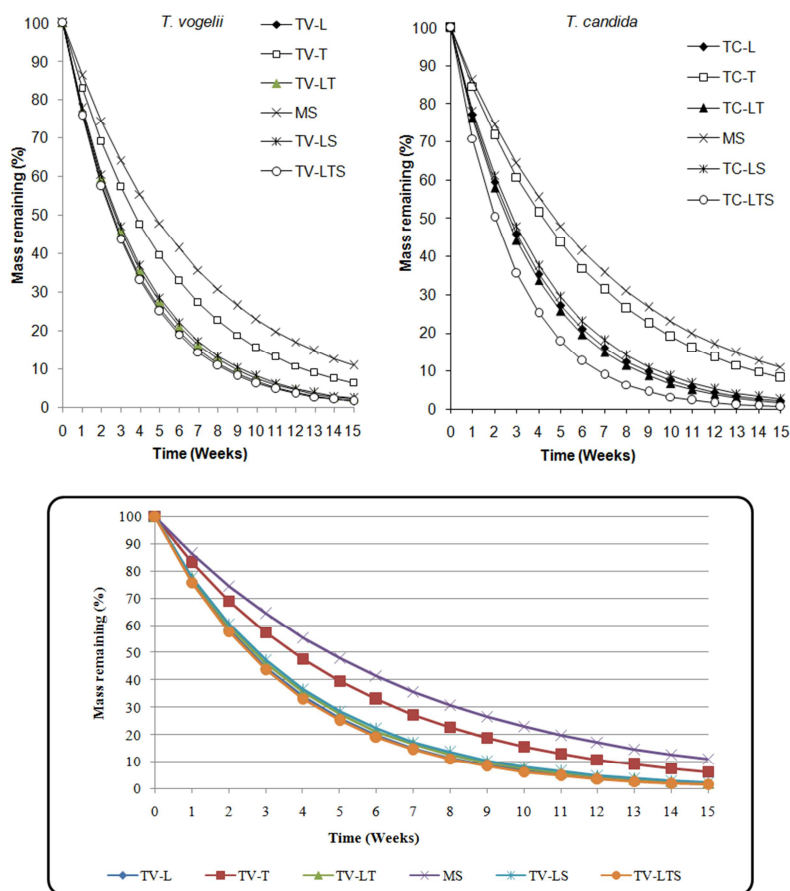


Fig. 2. Biomass loss by organic materials from *T. vogelii*

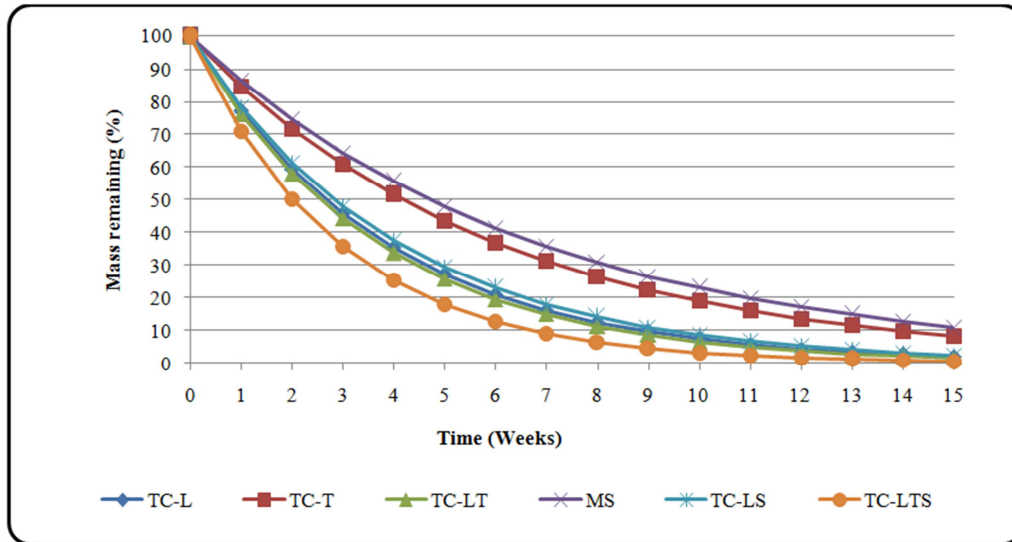


Fig. 3. Biomass loss by organic materials from *T. candida*

Key
 TV = *T. vogelii*, TC = *T. candida*, L = Leaves, T = Twigs, LT = Leaves + twigs
 MS = Maize stover, LS = Leaves + stover, LTS = Leaves+ twigs + stovers

Table 3. Decomposition rate constant (k), coefficient of determination (r²), correlation coefficient (r) and half life (t₅₀) and t_{0.95} of the residues of Tephrosia

Species	Treatment	Model	k wk ⁻¹	r ²	t ₅₀	t ₉₅
<i>T. vogelii</i>	Leaves	y = 14.14e ^{-0.27t}	0.27	0.97	2.57	11.11
	Twigs	y = 15.32e ^{-0.19t}	0.19	0.98	3.75	16.22
	Leaves +twigs	y = 14.19e ^{-0.26t}	0.26	0.97	2.69	11.63
	Leaves + stover	y = 13.58e ^{-0.25t}	0.25	0.91	2.77	12.00
	Leaves + twigs + stover	y = 14.56e ^{-0.28t}	0.28	0.91	2.51	10.87
<i>T. candida</i>	Leaves	y = 14.20e ^{-0.26t}	0.26	0.97	2.67	11.54
	Twigs	y = 15.43e ^{-0.17t}	0.17	0.98	4.17	18.07
	Leaves +twigs	y = 13.48e ^{-0.27t}	0.27	0.90	2.55	11.03
	Leaves + stover	y = 14.27e ^{-0.25t}	0.25	0.96	2.83	12.24
	Leaves + twigs + stover	y = 14.51e ^{-0.34t}	0.34	0.97	2.01	8.72
	Maize stover alone	y = 15.10e ^{-0.15t}	0.15	0.98	4.71	20.41

Note: The significance of fit for all the treatments was P<0.0001.

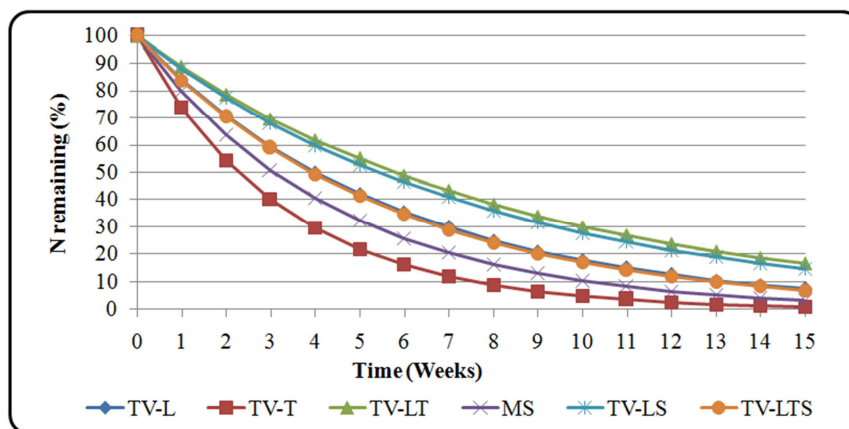


Fig. 4. N release pattern from *T. vogelii* plant residues

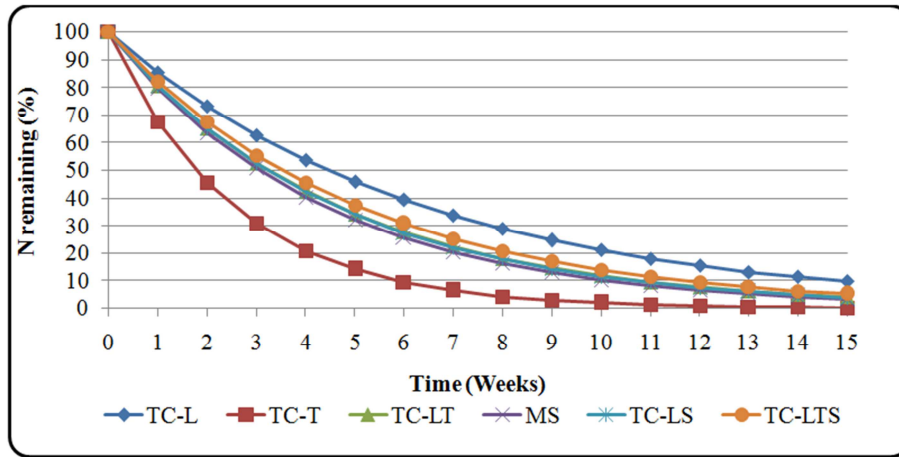


Fig. 5. N release pattern from *T. candida* plant residues

Key

TV = *T. vogelii*, TC = *T. candida*, L = Leaves, T = Twigs, LT = Leaves + twigs
 MS = Maize stover, LS = Leaves + stover, LTS = Leaves+ twigs + stovers

Table 4. N release pattern for *T. vogelii* and *T. candida* plant residues

Species	Treatment	Model	k wk ⁻¹	r ²	t ₅₀	t ₉₅
<i>T. vogelii</i>	Leaves	y = 5.17e ^{-0.17t}	0.17	0.94	4.01	17.34
	Twigs	y = 2.74e ^{-0.30t}	0.30	0.98	2.28	9.87
	Leaves +twigs	y = 3.54e ^{-0.12t}	0.12	0.94	5.78	25.00
	Leaves + stover	y = 2.34e ^{-0.13t}	0.13	0.97	5.41	23.44
	Leaves + twigs + stover	y = 2.25e ^{-0.18t}	0.18	0.95	3.92	16.95
<i>T. candida</i>	Leaves	y = 4.95e ^{-0.16t}	0.16	0.90	4.47	19.35
	Twigs	y = 2.69e ^{-0.39t}	0.39	0.92	1.78	7.69
	Leaves +twigs	y = 3.64e ^{-0.21t}	0.21	0.94	3.25	14.08
	Leaves + stover	y = 2.87e ^{-0.22t}	0.22	0.91	3.22	13.95
	Leaves + twigs + stover	y = 2.90e ^{-0.20t}	0.20	0.91	3.54	15.31
	Maize stover alone	y = 1.48e ^{-0.23t}	0.23	0.97	3.07	13.27

3.3. N Release Pattern for *Tephrosia*

Fig. 4 and Fig. 5 show the N release pattern of different plant residues for *T. vogelii* and *T. candida* respectively. The percent N release for plant residues for both species was highest in twigs (Fig. 4 and 5) and k_N ranged from 0.12 to 0.39 wk⁻¹. In all cases, there was an initial rapid release of N and slower release from the sixth week onwards from all the plant residues but Plant residues for *T. candida* had the highest N release rates than *T. vogelii* (Table 4). Percent N release rate for both species was in decreasing order TC twigs>TV twigs>maize stover>TC leaves and stovers>TC leaves + twigs>TC Leaves + twigs + stover>TV Leaves + twigs + stover>TV leaves>TC leaves>TV leaves + stover>TV leaves + twigs (Table 4.5). At two weeks, twigs had almost released 50% N while the rest of the residue treatments released almost 50% of N between third and fourth week. The highest N release by twigs indicates fast mineralization while lowest means slow N release. There was no period of N immobilization during the whole period of the experiment.

The % N remaining in each sampling date did not exceed 100%

for all residues from both species and N immobilization was not evident throughout the incubation period. Generally, there was rapid decrease in N content for all the treatments especially in the first week which indicates removal of water-soluble organic substances (Wang et al. 2004; Bross et al. 1995). N release from the crop residues followed a different pattern from that of the mass loss. All treatments showed rapid rate of mineralization throughout the study period. Similar pattern of N dynamics have been reported by other researchers (Schomberg et al. 1994). The twigs for both species released N rapidly than maize stover especially during the first two weeks. This could be attributed to their high N content and low C: N ratios compared to low N content and high C: N ratio in maize stover. Mixing maize stover with *Tephrosia* biomass or mixture of soft twigs and leaves slowed the rate of decomposition. The findings are in accordance with Bunyasi (1997), Handayanto et al. (1997) and Kuo and Sinju (1998) who reported that mixing high with low quality organic materials contributed to better N use through slowing the fast release of nutrients by former and reducing immobilization by the latter materials.

Organic residues with high C to N ratios tend to mineralize

much slowly than materials with lower ratios under the same conditions. High quality organic materials decompose very fast releasing N initially in excess of plant demand (Handayanto *et al.* 1994). Much of the N from organic inputs not used by the crop is usually incorporated into various SOM pools or assimilated by the associated trees and remains in the systems (Vanlauwe *et al.* 1999). On the other hand, N from inorganic pools not taken by the crop is subjected to higher levels of leaching and denitrification. The accumulation of N in SOM pools over time is more sustainable compared to inorganic N fertilizer which releases nutrients rapidly. Synchrony between N release from high organic materials with the crop's N demand can be achieved by optimizing timing of the application of organic materials, and by combining high and low quality organic materials (Rutunga *et al.* 2001; Gitari 2000a; Handayanto *et al.* 1997). The lack of net N immobilization in some species such as *T. diversifolia* was also reported (Rutunga *et al.* 2001) in the tropics which is consistent with the observation made here. Improved synchronization between N net mineralization (N

release) from organic materials and plant N demand has been advocated as a means of improving N use efficiency (Myers *et al.* 1994), especially in tropical cropping systems.

3.4. P Release Pattern for *Tephrosia*

Release of P from the *T. vogelii* and *T. candida* residues was very rapid and regular for all the residues during the first week (Fig. 6 and Fig. 7). All the plant residues released almost 50% of their initial P content by fourth week (Table 5). As observed for N, P release rates (k_p week⁻¹) were highest in *T. candida* twigs ($k_p = 0.44$ wk⁻¹) and lowest in maize stover and TV Leaves + twigs + stover ($k_p = 0.16$ wk⁻¹) throughout the incubation period (Table 5). Percent P release rate for both species was in the order TC twigs>TC leaves + twigs>TC leaves>TC leaves and stovers>TC Leaves + twigs + stover>TV twigs>TV leaves + stover>TV leaves>TV leaves + twigs=maize stover=TV Leaves + twigs + stover. No P immobilization for *T. vogelii* residues were observed throughout the experiment.

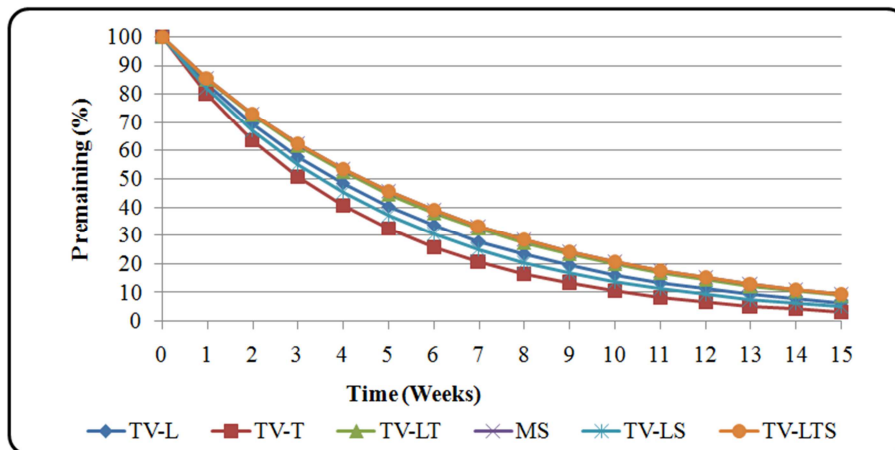


Fig. 6. P release pattern from *T. vogelii* plant residues

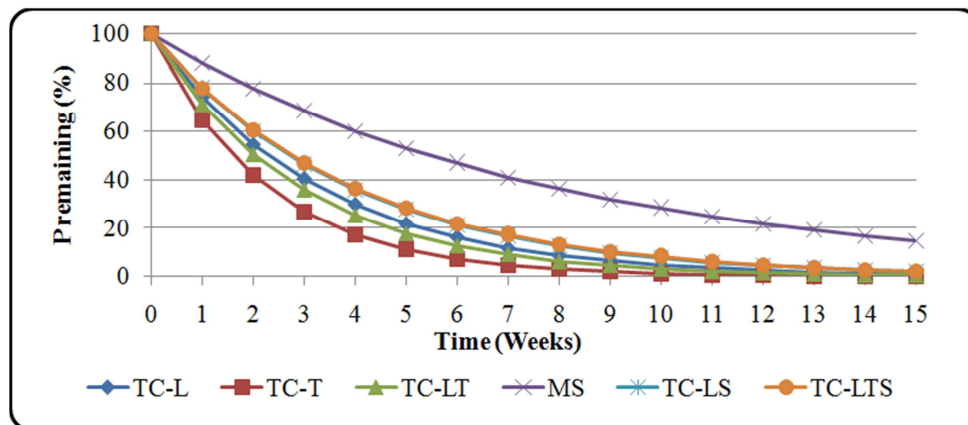


Fig. 7. P release pattern from *T. candida* plant residues

Key
 TV = *T. vogelii*, TC = *T. candida*, L = Leaves, T = Twigs, LT = Leaves + twigs
 MS = Maize stover, LS = Leaves + stover, LTS = Leaves+ twigs + stovers

Table 5. Parameters of the P release pattern for *T. vogelii* and *T. candida* plant residues

Species	Treatment	Model	k wk ⁻¹	r ²	t ₅₀	t ₉₅
<i>T. vogelii</i>	Leaves	y=0.20 ^{e-0.18t}	0.18	0.97	3.81	16.48
	Twigs	y=0.21 ^{e-0.23t}	0.23	0.96	3.08	13.33
	Leaves +twigs	y=0.19 ^{e-0.16t}	0.16	0.94	4.30	18.63
	Leaves + stover	y=0.13 ^{e-0.20t}	0.20	0.98	3.50	15.15
	Leaves + twigs + stover	y=0.13 ^{e-0.16t}	0.16	0.96	4.41	19.11
<i>T. candida</i>	Leaves	y=0.34 ^{e-0.34t}	0.34	0.95	2.04	8.82
	Twigs	y=0.28 ^{e-0.48t}	0.44	0.91	1.59	6.86
	Leaves +twigs	y=0.27 ^{e-0.34t}	0.34	0.99	2.02	8.75
	Leaves + stover	y=0.13 ^{e-0.26t}	0.26	0.99	2.70	11.67
	Leaves + twigs + stover	y=0.14 ^{e-0.25t}	0.25	0.99	2.74	11.86
	Maize stover alone	y=0.07 ^{e-0.16t}	0.16	0.94	4.41	19.11

Note: The significance of fit for all the treatments was $p < 0.0001$ except for TC-T which had $P < 0.0001$

Table 6. Pearson correlation coefficient (r) between decomposition rates (k_M), nutrient release rate (k_N and (k_P)) and initial chemical properties of the organic materials

Decomposition rate Nutrient	<i>T. vogelii</i>			<i>T. candida</i>		
	k_M	k_N	k_P	k_M	k_N	k_P
N	0.52*	-0.21	0.16	0.35	-0.32	0.58*
P	0.39	0.13	0.55*	0.06	0.18	0.89**
C	-0.35	0.62*	0.25	0.12	-0.24	-0.28
K	0.11	-0.18	0.42	0.28	0.02	0.65*
Ca	0.61*	-0.34	-0.30	0.16	-0.40	0.25
Mg	-0.24	-0.42	-0.57*	-0.07	-0.14	-0.66*
C:N	-0.59*	0.11	-0.40	-0.45	0.06	-0.81**
C:P	-0.60*	0.03	-0.51	-0.35	-0.11	-0.80**

Note: k_M = mass loss decomposition rate k_N = N release rate k_P = P release rate

* Correlation significant at $P < 0.05$

** Correlation is significant at $P < 0.001$

The rapid loss of P observed in this study after the first week was probably due to removal of soluble P after burying the litterbags. Many studies indicated that P can be leached in the early stages of decomposition (Musvoto et al. 2000). However, the increase of P leaching reported here at the last stages of decomposition period which synchronized with the onset of the rainy season had also been observed in other studies (Blair, 1988; Tripathi and Singh, 1992).

3.5. Relationship Between Decomposition Rates (k_M , k_N , k_P) and Initial Chemical Properties of *Tephrosia* Plant Residues

Correlations between decomposition rates and initial chemical properties of *Tephrosia* residues were examined using the Pearson correlation coefficient (r) Significant and positive correlations were found between k_P day⁻¹ and P ($p < 0.001$, $r = 0.89$), N ($p < 0.05$, $r = 0.58$), K ($p < 0.05$, $r = 0.65$), C:N ratio ($p < 0.001$, $r = -0.81$) and C: P ratio ($p < 0.05$, $r = -0.58$) (Table 6).

The results from Table 6 have indicated that initial chemical characteristics (N, Ca, C: N and C: P ratios) of the plant residues did significantly affect the decomposition rate (k_M) for *T. vogelii* residues while k_M for *T. candida* was not affected by a single parameter. k_N for *T. vogelii* was affected by initial organic carbon alone while *T. candida* was affected by none. In terms of k_P , *T. vogelii* residues were affected by P,

Mg and C: N ratio while *T. candida* residues were affected by all the initial chemical characteristics except C and Ca. Thus, in this study, either N concentration or C to N ratio was useful in predicting decomposition rate (k_M) and P release (k_P) of *T. vogelii* and *T. candida*. Meaning, in this study, neither N concentration nor C/N ratio was useful in predicting decomposition rates (k_M) of *T. candida* and N and P release rates (k_N and k_P) of *T. vogelii*. The assertion that initial N concentration and C: N ratio influences the degradability of organic residues added to the soil was not confirmed by the results of this experiment. Results may be related to different decomposer communities which may have developed on plant materials based on their intrinsic qualities (Cobo et al. 2002). Among the plant chemical characteristics studied, only N, P, C: N and C: P ratio served as useful indicators of degradability of plant materials based on significant results (Table 4.7). The nutrient release patterns followed by the tree species studied demonstrate the importance of substrate quality in nutrient dynamics. The findings corroborate with findings of Kwabiah et al. (2001), who studied the relationship between quality and the per cent of leaf mass, N and P remaining. They found out that, total P and C: P ratio showed more consistent relationships with the per cent of leaf mass, N, and P remaining compared to other quality parameters such as N: P and L + PP: P ratios.

4. Conclusion and Recommendations

From the decomposition study, it can be concluded that the *Tephrosia* fallow biomass alone decompose considerably fast attaining their half-life within 2 – 3 weeks and over 95% within 8 – 25 weeks but when mixed with maize stover, a low quality farm residues, the decomposition rates slowed down. Based on these results the fresh leaves or twigs or mixture of leaves and twigs of *T. candida* and *T. vogelii* can be considered of high quality litter and may be applied as green manure to short duration crops such as vegetables as well as most annual crops. Meanwhile, the accelerated decomposition and nutrient release of *Tephrosia* fallow biomass may limit its potential for long term build-up of soil fertility. *Tephrosia* fallow biomass can be used for short-term correction of soil fertility while maize stover alone can be used for long-term build-up of soil organic matter. Alternatively, organic residues such as *Tephrosia* can be mixed with maize stover in order to slow down the decomposition and nutrient release rates so that it can be considered for long-term build up of soil fertility. Results from this study have added to knowledge on how to tailor the application of *Tephrosia* biomass in cropping systems and Agroforestry for improved nutrient synchronization. This study has also added to knowledge on the quality, decomposition and nutrient release patterns of *Tephrosia* residues in farming systems in Malawi. An understanding of how plant residues decompose and release nutrients would help to provide an insight into how to complement this with the use of aboveground litter to synchronize with crop demand in Agroforestry systems in Malawi.

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