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Full length Research paper

Nutrient mineralization pattern of selected agroforestry shrub specie's foliage litter in Dello-Menna District of Bale zone, Southeast Ethiopia

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Abstract

Mineralization is a decomposition process accounting for recycling nutrients from decomposing organic materials. This study was conducted to understand the general mineralization pattern of three agroforestry species' foliage litter grown in the Dello-Menna district of Bale, Southeast Ethiopia. The experiment was laid out using factorial RCBD design where species types (Cajanus Cajan, Sesbania sesban, and Flemingia macrophylla) were assigned as the main plot and incubation period (15, 30, 45, 60, 75, and 90 days) as sub-plot factors. To understand the temporal trend of mineralization, the amount of nutrients that remained at different times were plotted against time. Furthermore, nutrient mineralization rate constants (k day^{-1}) were computed using a single exponential model as the relation between mineralization rate constants and litter chemical quality indices examined by Pearson's correlation coefficient. The result revealed that the amount of nutrients and mineralization rates varied among the species considerably ($P < 0.05$). Upon completion ofthe study period, more than 87%of the initial nutrient contents of litter residues were mineralized and added to the soil except for carbon. Among the species, a higher amount of K (97.87%), N (95.89%), Ca (95.78%), Mg (94.72%), and C (57.94%) were obtainedfor S. sesban litter residue than others. In terms of p, foliage litter material of C. cajan (94.43%) perceived the better potential, followed by F. macrophylla (90.69%) and S. sesban (87.72%), respectively. Moreover, the mineralization rate of nutrients among the species reported in the order of K > N > Ca > Mg > P > C for S. sesban, K > Mg > Ca = P > N > C for F. macrophylla, and P≥K> Mg > N = Ca > C for C. cajan. This shows that except for C. cajan, the mineralization rate constant of potassium happened to be the fastest for the remaining species. The study provided further information on the relationship between constant mineralization rates and litter chemical quality indices. Accordingly, a negative association was observed between lignin, cellulose, LCI, total phenol, and C/N ratio, while N and P showed a positive association. The tested species, S. sesban, was the best for returning a higher amount of nutrients within a short period, followed by C. cajan and F. macrophylla, respectively. Generally, our study generated baseline information and new insight that can be further extended for future research on the practical implementation of mineral patterns in various agroforestry species.

Keywords: Cajanus cajan, Flemingia macrophylla, Litter chemical quality, Sesbania sesban

INTRODUCTION

Background and Justification

Mineralization is a decomposition process accounting for recycling nutrients from decomposing organic materials (Jianru, 2013). It is a complex process that reduces dead

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Organic matter or litter into mineral nutrients, water, and carbon dioxide (Dawoe *et al.,* 2010; Kaba, 2017). A wide range of factors could influence the processes, including litter quality, soil, and climatic conditions are the main ones (Munthali *et al.,* 2015; Cisse *et al.,* 2021). The importance of the factors depends on the spatial and temporal scale at which they operate. Accordingly, when sites were compared over broad regional scales, edaphic and climatic conditions had more influence than litter quality. However, in the case of the same location (within the site), litter quality predominantly controls the mineralization of litter residues (Jianru, 2013).

Litter, in general, and leaf litter, in particular, is an essential nutrient resource,and litterfall is a critical link between plants and soils for the return and recycling of nutrients (Van Vliet *et al.,* 2015; Naik *et al.,* 2018). Naik *et al.*(2018) and Kaba (2017) described that the processis critical to the functionality of any agroforestry system. The study pointed out thata significant amount of nutrients can be returned to the soil, reducing or possibly eliminating the need for chemical fertilizers. Currently, *Cajanus Cajan (L) Millsp, Sesbania sesban (L) Merr,*and *Flemingia macrophylla (Wild) Kuntze ex Merr,* agroforestry shrub species are recommended for mid and low-altitude areas of Bale(Wondmagegn *et al.,* 2021). Introducing the species in the area is critical due to the nutritional value and can be easily integratedwith annual and perennial crops. This could be implemented through their foliage litter mineralization process.

Several studies dealt with nutrient mineralization patterns of agroforestry tree/shrub species biomass, mainly natural litterfall (senescent material) (Paudel *et al.,* 2015; Seta *et al.,* 2016). However, in addition to natural litterfall, fresh foliage biomass is deliberately collected in many agroforestry systems.

Fresh tree biomasses, specifically foliage, contain higher concentrations of nutrients and perceive a better potential to improve soil fertility than any other senescent plant material (Getachew *et al.,* 2015; Wang *et al.,* 2016). To our knowledge, limited information is available on nutrient mineralization patterns. No doubt that knowledge of nutrient mineralization patterns of agroforestry specie's foliage litter is essential to optimize their use for soil amendment. Therefore, in this study, we investigated the mineralization pattern of deliberately collected foliar litter material of three agroforestry species in the Dello-Menna district of Bale, Southeast Ethiopia.

MATERIALS AND METHODS

Description of the study area

Dello-Menna district is 544 km south of Addis Ababa, in the Bale zone of Oromia National Regional State, Southeast Ethiopia. It is between 6^0 40\` to $7^0$ 10\` N latitude and 39^0 30\` to 40^0 E longitude. It is bordered in the west by Harenna-Buluk, in the east by Berbere and Guradamole, in the north by Goba, and in the south by the Meda-welabu districts of Bale Zone. The experiment was conducted at the research sub-station of the Sinana Agricultural Research Center, located in Burkiti kebele of the Dello-Menna district. The research site is located about 2.5 km the North of the administrative town of the Dello-Menna district, lying 6º 24' 42.45'' N and 39º 49' 55'' E.

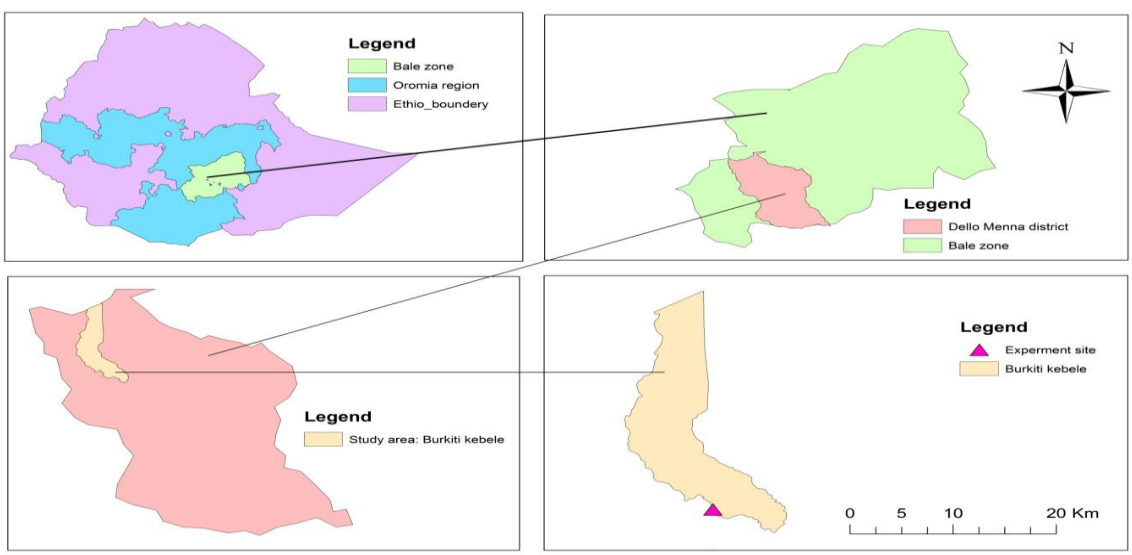

Figure 1: Location of the study area

The area is characterized by bimodal rainfall, with a rainy season from the middle of March through June and early September through November. The mean annual precipitation is 986.2mm, with mean annual temperatures of 22.5^{0}C. In the area, Niti-sol is the dominant soil characterized by its color of reddish-brown clay towards the higher altitudes and tends to red-orange sandy soil towards the lower altitudes (Fayera and Manfred, 2006; Wondmagegn, 2017).

Experimental Procedure

Species selection

The selected species in the study were *Cajanus Cajan (L.) Millsp, Sesbania sesban (L.) Merr* and *Flemingia macrophylla (Wild) Kuntze ex Merr*. The main reason for these species' selection is threefold. Firstly, the adaptability potential of the species was evaluated and recommended for other agroforestry research purposes. Secondly, priority is given tothose species fixingNitrogen (legumes). Thirdly, they can also be used as an alternative feed source for livestock during feed shortages and drought seasons (Wondmagegn, 2017).

Foliage collection and sample preparation

The collection and preparation of foliage biomass were undertaken to employ a standard woody perennial plant tissue sampling procedure (Benton, 1998; Wondmagegn *et al.,* 2020). Indeed, a representative of the most recent and fully developed live foliage intact to the mother plant was collected. This was foliage exposed to full sunlight just below the growing tip on main branches or stems before or when the species begins the reproductive stage. Samples of the same species from different mother plants were pooled together and air-dried for three subsequent days. About 60 grams of air-dried foliage litter material were packed into Nylon bags with dimensions of 60 cm x 40 cm size and 2 mm mesh openings. The mesh size is chosen to prevent the inflow of foreign litter materials into the weighted sample and enable the movement of soil microfauna into the litterbags. In total, about 54 litterbags (18
bags/species) was prepared and used for this study (Wondmagegn*et al.,* 2020).

Experimental layout and data management procedures

The experiment was installed by using a factorial RCBD design with three replications. The three types of species (C. cajan, S. sesban, and F. macropylla) are considered the main factor, while the biweekly sampling period intervals (15, 30, 45, 60, 75 &90 days) are used as sub-factor. After that, the litterbags were buried beneath a 15 cm depth of topsoil in the field of the experimental unit (Nair *et al.,* 1999; Wondmagegn *et al.,* 2020). At every biweekly sampling event, three litter bags per species were retrieved, oven-dried (70^{0}C), cleaned from attached soil particles, and then kept in a paper envelope for further chemical analyses (Wondmagegn, 2017).

Chemical analyses

Chemical analyses of samples were conducted employing standard analytical procedures for each parameter. Accordingly, Cellulose, hemicellulose, and lignin contents were determined using three sequential heating fiber extraction methods (Andersonand Ingram, 1993). The extraction was done in the order of neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid-determined lignin (ADL).
The neutral detergent fiber separates the soluble and insoluble fiber, which measures total cellulose, hemicellulose, and ADL. The acid detergent fiber (ADF) method was used to estimate cellulose and ADL.
The difference between NDF and ADF gave an estimate of hemicelluloses. Lignin was extracted from ADL after being heated in strong acid (72% H_2SO_4) for 16 consecutive hours. This was to fractionate ADL into ash and lignin content. After that, the Lignocellulosic index (LCI) was estimated using Herman *et al.* (2008) equation, as shown below. In contrast, total phenol was determined by a modified Folin-Denis method (Claudia *et al.,* 2008, Wondmagegn *et al.,* 2020).

$$\mathrm{LCI} = \frac{(\mathrm{Lignin})}{\mathrm{Lignin} + \mathrm{Cellulose} + \mathrm{Hemicellulose}} \qquad \text{equation (1)}$$

For determining cations (Ca, Mg, K), dry ashing of plant tissue techniques are used (Partey *et al.*, 2011; Wondmagegn *et al.,* 2020).Accordingly, as K by flame photometry, Ca and Mg were used to quantify by atomic absorption spectrophotometer. Moreover, P estimated by using Uv-spectrophotometer, and both N and CP by the Kjeldahl distillation methods (CP = N * 6.25). Further, organic carbon was determined by the calcinations method in which the ash-free dry weight of the foliage litter was obtained by combustion in a furnace at 550^{0}C for 3 hours. Fifty percent of the ash-freedry matter was considered total organic carbon (Wassie and Abebe, 2013; Wondmagegn *et al.,* 2020).

Statistical analyses

The collected data from the experiment were analyzed byGenStat (15th ed.) and Microsoft Excel computerized.

Programs. The nutrients mineralization rate is constant (day $^{-1}$)is

$$Nt = N0e^{-kt}$$

Where Nt is the amount of nutrient remaining at time t, No is the initial nutrient (considered as 100%), 'e' is the base of the natural logarithm (e = 2.718), k is the rate of constant, and t is the time in days. The amount of nutrients remained at different times plotted against the subsequent monitoring period, as this may enable us to understand the general temporal trend of the mineralization pattern. The

$$t0.5 = \frac{\ln(0.5)}{k} = \frac{0.693}{k}$$

$$t0.95 = \frac{3}{k}$$

Finally, the dependency of nutrient mineralization rates on some litter chemical quality indices is examined by Person's correlation coefficient as used by Wondmagegn *et al.* (2020).

RESULTS AND DISCUSSION

Nutrient mineralization patterns of the three specie's foliage litter material

The mineralization of nutrients for the test species seemed to follow two stages pattern (Figure2). A faster mineralization phase was observed between 15 to 30 days of the monitoring period, whereas a slower step followed the 45th day. During the first stage of mineralization, all nutrients (N, P, K, Ca, Mg and C) attained a steadily decreasing pattern. However, onward to the 45th day of the mineralization period, a slight amount of P, Ca, and Mg accumulation was reported. This is evidenced by figure 2, where P remaining in S.sesban and F.macrophylla residues increased by their respective mean values of 2.53% and 3.66% at the sampling period's 45th and 60thdays of the sampling period. Other authors also reported an increase in P (%) remaining in the litter material at some point in the mineralization period (Seta et al., 2016). As to them, this could happen when P is limited to microbial activities due to the low level of P initially in their litter material.

Likely, a tendency of Ca accumulation was reported on the 45th day of the monitoring period. This is more pronounced in the litter material of *F. macrophylla species,* with 13.23% immediate accumulation followed by a net decrease in the subsequent mineralization period. The accumulation of Ca in *F. macrophylla* resulted in a slower mineralization rateof the remaining two species (Table 1). The increment of Ca in the later stage of mineralization is attributed to the uptake from soil by fungal hyphae into mineralizing litter residues. This is because the nature of Ca is the dominant exchangeable caution in the soil and could be actively transported by fungal hyphae into plant litter. At the end of the sampling period, a little Mg retention was reported for

calculated using a single exponential model as used below

equation (2)

method used to compare the biweekly mean values of nutrient mineralization rate constant (k) was the least significant difference (LSD). The length of time (days) required for each nutrient's weight loss ($t_{50\%}$and $t_{95\%}$) is estimated by using the following mathematical equations (Olson, 1963).

equation (3)

equation (4)

C. cajan(2.53%) and *F. macrophylla* (3.31%) species foliage litter. The retention of Mg in these two specie's litters might be due to the effect of microorganisms acting on the residues fed, dying, and decomposing during mineralization (Bargali *et al.,* 2015).

Generally, all the nutrients could mineralize more than 87% of their initial content and be added to the soil except carbon. The highest amount of mineralization reported for potassium ranging 92.62% in *F. macrophylla* to 97.87% in *S. sesban* foliage litter. After that, Ca and P were followed by mineralizing more than 91% of their initial contents. Carbon is a minor mineralized nutrient rangingfrom 43.42 to 57% among the species.

The effect of species on the rate of nutrient mineralization (*k_n*) over the subsequent sampling period

Considerable (P < 0.05) variability in the rate of nutrient mineralization (day 1) was observed among the species over the subsequent monitoring period. Accordingly, on the first 15th day of the monitoring period, the variability is statistically significant among all species for the *k* parameters (k_C, k_N, k_K, $k_{Ca,}$ and k_{Mg}), except $k_{P.}$ The phosphorus (kP) mineralization rate between *C. cajan* and *F. macrophylla*is not statistically different on the first 15th day of the sampling period. The observation is also accurate for the mineralization rate of magnesium (k_{Mg}) atthe monitoring period's 30th, 45th, and 90th days. Additionally, during the monitoring period's 30th, 60th, and 75th days, the potassium (kK) mineralization rate was reported as non-significant within the same species. Against this, the mineralization rate of carbon (k_C) and nitrogen (k_N) significantly varied among the test species throughout the study period (Table 1). As a result, the highest kC and nitrogen kN were reported for *S. Sesban* foliage litter, followed by *C. cajan* and F. *macrophylla,* respectively.

Overall, the biweekly mineralization rate of nutrients among the species reported in the order of K > N > Ca > Mg > P > C for *S. sesban*, K > Mg > Ca = P > N > C for *F. macrophylla,* and P$\geq$K> Mg > N = Ca > C for *C. cajan*. The order shows potassium happened to be the fastest.

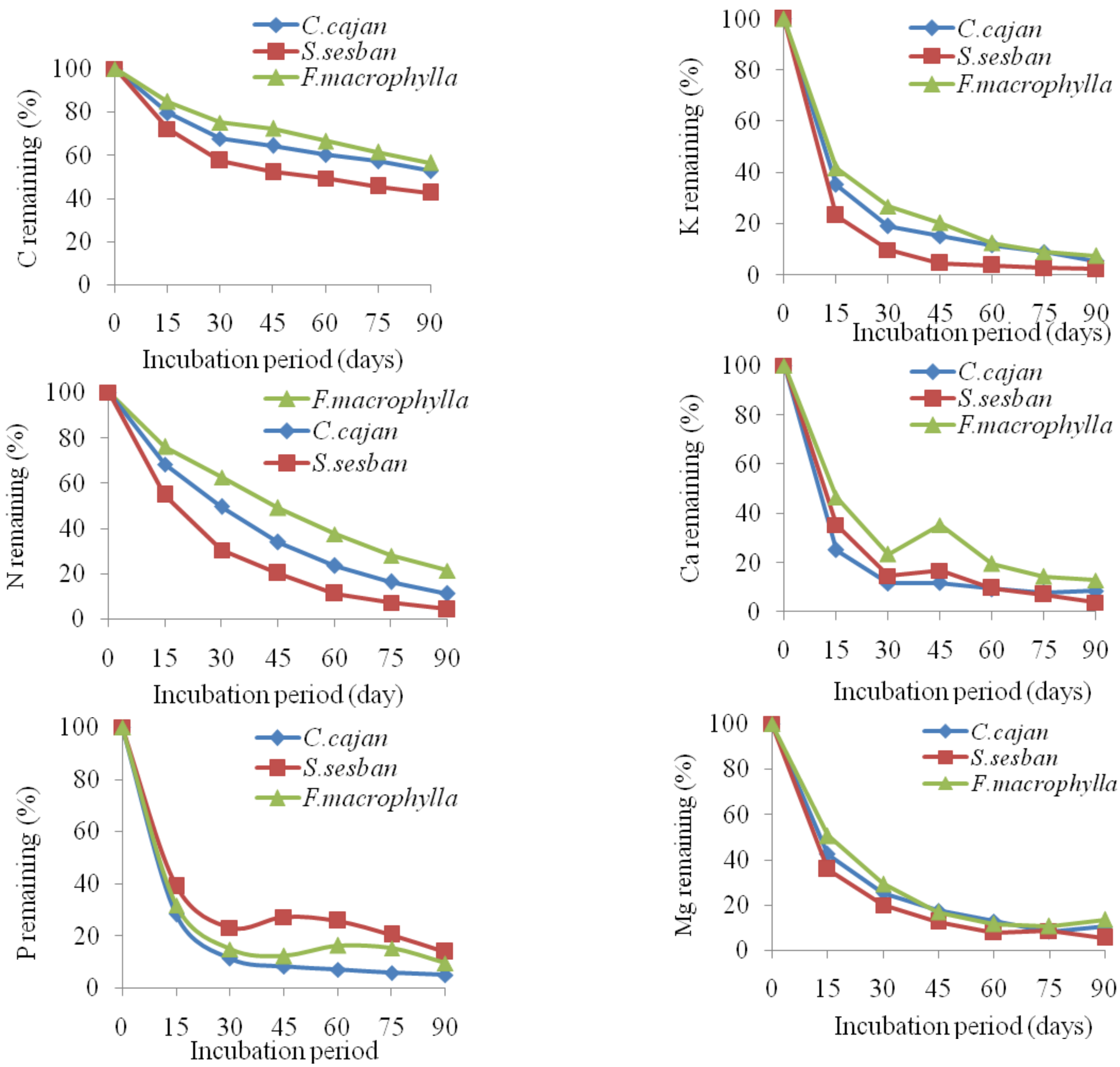

Figure 2: Nutrient mineralization pattern of the three species of foliage litter material

Table1: Nutrient mineralization rate (k_n day^{-1}) as influenced by species type over the subsequent monitoring period

Nutrient*/species	**Monitoring period (days)**					
	15	30	45	60	75	90
Carbon (k_C)						
C. cajan	0.0152 ^{b}	0.0131 ^{b}	0.0098 ^{b}	0.0084 ^{b}	0.0074 ^{b}	0.0071 ^{b}
S. sesban	0.0218 ^{c}	0.0180 ^{c}	0.0140 ^{c}	0.0118 ^{c}	0.0098 ^{c}	0.0096 ^{c}
F. mycrophylla	0.0105 ^{a}	0.0095 ^{a}	0.0072 ^{a}	0.0068 ^{a}	0.0065 ^{a}	0.0063 ^{a}
LSD (P<0.05)	0.0006	0.0015	0.0005	0.0005	0.0003	0.0013
Nitrogen(k_N)						
C. cajan	0.0260 ^{b}	0.0247 ^{b}	0.0250 ^{b}	0.0240 ^{b}	0.0230 ^{b}	0.0243 ^{b}
S. sesban	0.0400 ^{c}	0.0396 ^{c}	0.0351 ^{c}	0.0365 ^{c}	0..345 ^{c}	0.0355 ^{c}
F. mycrophylla	0.0180 ^{a}	0.0162 ^{a}	0.0170 ^{a}	0.0163 ^{a}	0.0162 ^{a}	0.0162 ^{a}
LSD (P<0.05)	0.0009	0.0019	0.0018	0.0017	0.0027	0.00013
Phosphorus(k_P)						
C. cajan	0.0853 ^{b}	0.0721 ^{c}	0.0523 ^{b}	0.0429 ^{c}	0.0357 ^{b}	0.0321 ^{b}
S. sesban	0.0618 ^{a}	0.0484 ^{a}	0.0288 ^{a}	0.0237 ^{a}	0.0214 ^{a}	0.0234 ^{a}
F. mycrophylla	0.0778 ^{b}	0.0645 ^{b}	0.0472 ^{b}	0.0305 ^{b}	0.0255 ^{a}	0.0265 ^{a}
LSD (P<0.05)	0.0098	0.0070	0.0066	0.0045	0.0070	0.0048
Potassium(k_K)						
C. cajan	0.0697 ^{b}	0.0553 ^{a}	0.0421 ^{b}	0.0362 ^{a}	0.0324 ^{a}	0.0326 ^{b}
S. sesban	0.0971 ^{c}	0.0783 ^{b}	0.0694 ^{c}	0.0552 ^{b}	0.0489 ^{b}	0.0428 ^{c}
F. mycrophylla	0.0583 ^{a}	0.0442 ^{a}	0.0354 ^{a}	0.0350 ^{a}	0.0323 ^{a}	0.0290 ^{a}
LSD (P<0.05)	0.0067	0.01467	0.0041	0.0064	0.0018	0.0028
Calcium(k_{Ca})						
C. cajan	0.0918 ^{c}	0.0744 ^{c}	0.0498 ^{b}	0.0396 ^{b}	0.0339 ^{b}	0.0282 ^{a}
S. sesban	0.0690 ^{b}	0.0645 ^{b}	0.4070 ^{b}	0.0396 ^{b}	0.0354 ^{b}	0.0355 ^{b}
F. mycrophylla	0.0521 ^{a}	0.0500 ^{a}	0.0230 ^{a}	0.0272 ^{a}	0.0259 ^{a}	0.0228 ^{a}
LSD (P<0.05)	0.0146	0.0068	0.0130	0.0064	0.0072	0.0062

Magnesium(k_{Mg})						
C. cajan	0.0579 [b]	0.0467 [b]	0.0396 [a]	0.0338 [a]	0.0343 [b]	0.0256 [a]
S. sesban	0.0691 [c]	0.0533 [c]	0.0475 [b]	0.0433 [b]	0.0340[ab]	0.0327 [b]
F. mycrophylla	0.0460 [a]	0.0410 [a]	0.0400 [a]	0.0367 [a]	0.0305 [a]	0.0223 [a]
LSD (P<0.05)	0.0061	0.0051	0.0061	0.0045	0.0037	0.0041

Mean values within the same columns represented by the same letters are not statistically different. *Nutrient mineralization rate (k_n day^1)

Mineralizing nutrient despite it is not statistically varied with phosphorus for *C. cajan*. This rapid mineralization of potassium might be linked to its high mobility and leachability compared to other nutrients. Other authors reported the fastest potassium mineralization rate in Ghana for the leaf litter of *Senna spectabilis, Gliricidia sepium, Leucaena leucocephala,* and *Acacia auriculiformis* (Parteyet al.,2011).

By the end of the study period, the net mineralization rate (k day^{-1}) and the length of time needed ($t_{0.50}$ and $t_{0.95}$) for the mineralization of nutrients were computed as well (table 2). The k value of nutrients (except phosphorus, k = 0.017) was reported greater for *S. sesban* foliage litter than for *C. cajan* and *F. macropylla*.

Indeed, the net k values of*S. sesban* foliage litter were reported within range of 0.009 in carbon to 0.040 in potassium, followed by *C. cajan* (Table 2).Regression coefficients (R^2) ranged from moderate to very high (R^2 = 0.71 and R^2 = 0.99) among litter types denoting the model fitness for the study.

Table2: Net nutrient mineralization rate constant (*k*), coefficient of determination (R^2), half-life ($t_{0.50}$), $t_{0.95}$, and estimated equation for the studied species foliage litter material.

Nutrient/species	*K* (day^{-1})	R^2	$t_{0.50}$	$t_{0.95}$	equation
Carbon					
C. cajan	0.006	0.91	115.5	500.00	$y = 89.90e^{-kt}$
S. sesban	0.009	0.88	77.00	333.33	$y = 84.77e^{-kt}$
F. mycrophylla	0.006	0.96	115.5	500.00	$y = 94.67e^{-kt}$
Nitrogen					
C. cajan	0.024	0.99	28.87	125.00	$y = 100.23e^{-kt}$
S. sesban	0.035	0.99	19.80	85.710	$y = 93.35e^{-kt}$
F. mycrophylla	0.017	0.99	40.76	176.47	$y = 101.44e^{-kt}$
Phosphorus					
C. cajan	0.030	0.82	23.10	100.00	$y = 49.16e^{-kt}$
S. sesban	0.017	0.76	40.76	176.47	$y = 62.52e^{-kt}$
F. mycrophylla	0.020	0.67	34.65	150.00	$y = 49.93e^{-kt}$
Potassium					
C. cajan	0.029	0.92	23.89	103.45	$y = 64.43e^{-kt}$

S. sesban	0.040	0.88	17.32	75.00	$y = 48.83e^{-kt}$
F. mycrophylla	0.028	0.95	24.75	107.14	$y = 73.65e^{-kt}$
Calcium					
C. cajan	0.024	0.71	28.87	125.00	$y = 45.08^{-kt}$
S. sesban	0.032	0.92	21.65	93.75	$y = 65.64e^{-kt}$
F. mycrophylla	0.021	0.85	33.00	142.85	$y = 71.24e^{-kt}$
Magnesium					
C. cajan	0.025	0.89	27.72	120.00	$y = 67.56e^{-kt}$
S. sesban	0.030	0.90	23.10	100.00	$y = 63.13e^{-kt}$
F. macrophylla	0.024	0.84	28.87	125.00	$y = 69.42e^{-kt}$

Further, *S. sesban* foliage litter requires a lower time of mineralization ($t_{0.5}$ = 17.32 to 77 days, $t_{0.95}$ = 75 to 333.33 days) compared to *C. cajan* ($t_{0.5}$ = 23.10 to 115.5 days $t_{0.95}$ = 100 to 500 days) and *F. macrophylla (*$t_{0.5}$ = 24.75 to 115.5 days, $t_{0.95}$ = 107.14 to 500 days) species.

The association between nutrient mineralization rate constant and litter chemical quality indices parameter

The relationship between nutrient mineralization rates constant and some litter chemical quality indices parameters were examined by Pearson's correlation coefficient (table 3).As to results, Nitrogen and Phosphorus positively correlated with Carbon (kC), Phosphorus (KP), potassium (kK), calcium (kCa), and magnesium (k_{Mg}). Contrarily, Lignin (with Kc, Kn, kCa and kMg), LCI (with Kc, Kn, Kk, kCa and kMg), Cellulose (with Kp and kCa), and total phenol (with Kn) correlated negatively. Moreover, C/N correlated negatively withall the mineralization rate constants.

Table 3: Pearson's correlation coefficient (r) between litter chemical quality indices parameter and mineralization rate constant (n = 54).

Quality indices	Nutrient mineralization rate constant					
	k_C	k_N	k_P	k_K	k_{Ca}	k_{Mg}
Lignin	-0.81***	-0.866**	-0.21^{ns}	$-0. 17^{ns}$	-0.649**	-0.637***
Cellulose	-0.053^{ns}	-0.11^{ns}	0.284*	-0.155^{ns}	0.333*	-0.098^{ns}
Hemicellulose	0.134^{ns}	0.183^{ns}	0.106^{ns}	0.182^{ns}	0.179^{ns}	0.128^{ns}
Total phenol	-0.146	-0.23*	0.215^{ns}	-0.045^{ns}	-0.1308	-0.287
LCI	-0.633**	-0.69***	-0.217^{ns}	-0. 56**	-0.59**	-0.432**
Nitrogen	0.45***	-0.235^{ns}	0.921***	0.47*	0.708***	0.698***
Phosphorus	0.55***	0.24^{ns}	0.587***	0.544***	0.806***	0.625***
C/N	-0.311*	0.318*	-0.642***	-0.323*	-0.438**	-0.507***

*=Significant at p< 0.05, **=significant at p< 0.01, ***=significant at p < 0.001, ns=not significant

Overall, litter chemical quality indices, namely, lignin, LCI, C/N. Cellulose and phenol are reported as retarding factors of the nutrient mineralization process, while nitrogen and phosphorus are pointed as facilitating factors. Hence, in favor of Fonte *et al.* (2014) and Naik *et al.* (2018) hypothesis, the faster rate of nutrient mineralization in the early stages is linked to the effect of N and P as the slower in the latter stage attributed to the accumulation of recalcitrant fractions (cellulose, lignin, LCI, and phenol).

SUMMARY AND CONCLUSION

The objective of agroforestry systems is to use tree/shrub species as sources of nutrients for crops via their biomass mineralization process. Knowledge of nutrient mineralization of agroforestry species is essential to optimize their use for soil amendment. A study was planned to understand the general mineralization process of three-agroforestry shrub species foliage litter in the Dello-Menna district of Bale, southeast Ethiopia. The experiment installed by using factorial in RCBD design with three replications considering species types as main factors (*C.cajan, S.sesban,* and *F. macropylla*) and incubation period (15, 30, 45, 60, 75, and 90 days) as sub-factors. Data collected from the experiment were analyzed by Genstat and Excel computerized programs.

As to results showed significant ($p < 0.05$) differences among and within the foliage litter mineralization patterns of the studied species. The mineralization pattern of the species reported in the order of K > P > Mg > N > Ca > C for *C.cajan*, K > N > Ca > Mg > P > C for *S.sesban,* and K > Mg > Ca = P > N > C for *F.macrophylla.* The result has suggested that potassium was rapidly mineralized (k = 0.029 to 0.097 day^{-1}) among all species against carbon which was mineralized very slowly (k = 0.006 to 0.0218 day^{-1}) during the experimental period. In this respect, a considerable amount of nutrients is added to the soil. By the end of the study, more than 87% of nutrients were mineralized and added into the soil except for carbon. Carbon was mineralized within a range of 43.2 to 57.94% among the species.

Moreover, the study also provides insight and knowledge on the relationship between nutrient mineralization rate constant and some litter chemical quality indices. As to results obtained from the Pearson correlation coefficient, N and P were associated positively with nutrient mineralization rates, whilelignin, cellulose, phenol, C/N, and LCI were contrarily associated negatively. Overall, foliage litter material of *S. sesban* was identified as high quality and can be used as the primary source of nutrients in agroforestry land use systems. This is because the foliage litter of *S.sesban* furnished considerably more elevated amounts of nutrients within a short period than *F.macrophylla* and *C.cajan*. Since the experiment was conducted in one site for one season, further long-time study over location is required to come to a conclusive recommendation. Beyond this, another part of the species (roots, stems, and flowers) needs to be considered for further investigation in the future.

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