Volume 4 • Issue 4 • 2022

Research Article

Journal of Agriculture and Aquaculture

Evaluation of leaf litter nutrient composition, decomposition and releasing potential of *Cordia Africana, Terminalia Brownie* and, *Vitex Doniana* tree species

Belayneh Lemage*, Abebe Hegano, Asmelash Tesfaye and Mitiku Ayele

Southern Agricultural Research Institute, Jinka Agricultural Research Center, P.O. Box 96 Jinka, Ethiopia

***Corresponding Author:** Belayneh Lemage, Southern Agricultural Research Institute, Jinka Agricultural Research Center, P.O. Box 96 Jinka, Ethiopia.

Received: December 06, 2022; **Published:** December 19, 2022

Abstract

The decline of soil fertility is the main threat for decreasing of agricultural production and productivity. To reduce this problem, managing and utilizing essential resources obtained from multipurpose farmland trees are important to improve soil fertility and enhancing yield in sustainable way. This study was designed to evaluate the decomposition, composition and release of important soil nutrients of leaf litter of dominant farmland tree species in the study area. Decomposition of leafy litter was performed using litterbags at JARC in the main station to determine the decomposition rate of three-tree species leaf litter to understand the contribution of retained species for soil fertility improvement. The leaf litter of Cordia africana, Vitex doniana and Terminalia brownie, composed of 46.5%, 49.6%, and 49.7% organic carbon in amount, respectively. Cordia africana decomposed faster than Terminalia brownie and Vitex doniana. This study aimed to evaluate the issues concerning weight loss, decomposition rates, chemical composition, and important nutrients released from the leaf litter of the studied tree species. This study recommended that it is important to assess annually produced leaf litter resources and study species composition effect on decomposition and mineralization of organic biomass, and the association organisms with these processes in farming systems.

Keywords: *Agroforestr; Decomposition; Leaf litter; Nutrient release; Soil fertility*

Background and Justifications

Agricultural production and productivity predominantly decreased due to soil fertility loss. The causes for soil fertility problem are loss of organic matter, nutrient depletion, removal of top soil by erosion, and decline of physical soil properties (Zelleke et al., 2004). This mainly due to intensive agriculture with limited fertilization rate, affordability problem to purchase high priced inputs and lack of awareness towards integrated soil fertility management on smallholder farms. However, farmland trees have the potential of providing organic outputs used as an input in soil fertility improvement and enhancing agricultural production.

Leaf litter is an organic matter and nutrient return obtained from plants that improve soil fertility through decomposition by releasing of nutrients into the soil. Decomposition is a means in which dead organic biomass is converted into its constituents like carbon dioxide, mineral nutrients, and influenced by physical, chemical, and biological barriers. The breakdown of litter fall contributes the recycles of nutrients for plant use (Aerts et al., 1997). Knowledge concerned with the decomposition of organic biomass has great importance in the management of agro-ecosystem (Cardona and Sandeghian, 2005). Decomposition primarily influenced by the

Citation: Belayneh Lemage, Abebe Hegano, Asmelash Tesfaye and Mitiku Ayele. (2022). Evaluation of leaf litter nutrient composition, decomposition and releasing potential of Cordia Africana, Terminalia Brownie and, Vitex Doniana tree species. *Journal of Agriculture and Aquaculture* 4(4).

environmental conditions in which decay takes place, the quality of leaf litter in chemical composition and its ability to release nutrients, and the nature and abundance of decomposing agents that exist in the system (Polyakova and Billor, 2007). The decomposition of leaf litter is depending on the leaves' Physico-chemical properties such as lignin content, tannin, lignin to nitrogen ratio, physical leaf roughness, and physical barriers. The decomposition rates are determined from the mass loss placed on the litterbag. The rate of decomposition is different between dry and wet seasons (Nigatia et al., 2014). The decomposition process breaks down the leaf litter into inorganic nutrients as well as stable humus (Bragazza et al., 2008). The imbalance between NPK and the rate of litter decomposition contributes to significant organic matter accumulations in the soil systems (Clymo et al., 1998). The main fraction of NPK is delivered to the soil as dead organic matter through above and belowground biomass (Bragazza et al., 2008). The nutrients transfer and energy from living biological components to the soil is closely related to litter fall and is the beginning point for nutrient cycling. Litter fall act as a major interface of nutrient cycling between plants and soils (Berg, 2000; Gindaba et al., 2004). The decomposition of organic biomass produces organic matter as an important means for soil formation as well as the cycling of nutrients (Onyekwelu et al., 2006; Pandey et al., 2007). Considerable variations in leaf litter decomposition rates were observed among species (Koukoura et al., 2003). The regulation of ecosystem carbon storage and nutrient cycling maintained through the process of decomposition (Wardle, 2004; Santiago, 2007). Some studies also suggested that in the initial stage of litter decomposition, nitrogen is a good predictor of decomposition rate, whereas, in later stages, chemical compounds such as lignin can play a more important role (Liu et al., 2007). Therefore, this study was initiated to know the role of farmland trees' leaf litter nutrient composition, decomposition and nutrient releasing potential to improve soil fertility. The objectives of this study focused on leaf litter of Cordia africana, Terminalia brownie, and Vitex doniana tree species in nutrient composition, rate of decomposition and important nutrient releasing potential in to the soil system.

Material and Methods

Description of study area

The study was conducted at the main station of Jinka Agricultural Research Centre located in Debub Ari District, South Omo zone. The altitude ranged from 1383 meters above sea level (m.a.s.l.). The soil type is characterized as Cambisols with fine to very fine particles, pH ranges of 4.87 to 6.18, and strongly acidic to slightly acidic (Mesfin et al., 2017) under good range for crop production with appropriate management practices. The study site has a bimodal rainfall pattern with a shorter rainy season from March to May and the longest rainy season from August to November. The total annual rainfall is 1,272.4 ± 250.7 mm. The annual mean minimum and maximum temperatures are 16.3 ± 0.9 and 27.7 ± 1.4°C.

Experimental design and Treatments

Leaf litter

The research work was conducted in Jinka agricultural research center on the main station so it was easy to monitor and attend the experiment. For this study, three dominant farmland tree species were selected and used as treatments. The treatments were labeled and sampled for leaf litter of Cordia african, Vitex doniana, and Terminalia brownie, and an equal amount was distributed in each block for each species. Randomized Complete block design (RCBD) was employed with four replications. Fresh and senesced leave samples were collected from mature trees after shaking gently or picked up from the ground after falling. To estimate the decomposition rate it is important to measure litter mass loss, an estimate obtained using litterbags (Bragazza et al., 2008). The litterbag technique consists in confining dried litter in mesh bags that are placed on the ground and collected to measure the remaining litter mass and associated litter nutrients in a fixed time interval (Bragazza et al., 2008). The litterbag size of 20cm X 15cm was made from 2mm diameter polyester mesh to allow the entering of micro-faunas. The number of litterbags was 12 (three species X four replications) and placed on each block. The C: N content needs to be examined before experimentation (from the collected soil sample and consequent analysis before burring of the leaf samples).

Data collection

The buried litterbags were collected at specified time intervals to determine the decomposability and nutrient release the potential of each species. The initial and after incorporation leaf litter samples were measured. It was grounded and packed with equal weight to analyze OC, total nitrogen, available phosphorus, available potassium Sulfur, Zink, and C: N ratio, this helped to estimate the released nutrients from leaf litter at a given time. This activity was conducted during the wet season the rate of decomposition is different during different seasons (Nigatia et al., 2014).

Data analysis

One-way Analysis of variance (ANOVA) was computed among the tree species and patterns of litter decomposition. Mean separation will be tested for determining the treatment differences. LSD was tested to determine between time and patterns of nutrient release. SAS software (version 9.1) and Microsoft excel speared sheet was employed for data analysis and organization.

Laboratory analysis for soil samples before (composite) and after experimentation was done in Jinka agricultural research center soil lab. The analysis of leaf samples for each tree species was done in Deber Birhan Agricultural Research Center (DBARC) soil and water laboratory. The loss in dry mass of litter samples was calculated as the difference between the initial dry mass and remaining mass at each sampling time. The rate of decomposition was calculated using the percentage of mass loss divided by respective days of sample collection (Hasanuzzaman and Hossain, 2014). The decay constant for leaf litter was calculated using the negative exponential decay model (Olson, 1963) as follows:

$K = \ln(X / Xo)/t$

Where Xo is the initial weight and X is the remaining weight at time exponential function. Half-life calculated using equation 2 (Daldoum et al., 2010).

$$t1/2 = \frac{\ln (2)}{k}$$

t½ = half-life time

Decomposition rates between the compositions and soil moisture between the treatments was compared by analysis of variance

Results

Decomposition rate and nutrients in leaf biomass (litter) of studied tree species

The current research study was conducted in Jinka agricultural research center on the main station so it was easy to monitor and attend the experimental site. The result revealed that decomposition and amount of nutrients constituted in the leaf litter vary from species to species (Table 1 and 2). This could be due to the quality of leaf litter, the amount & type of nutrients constituted in it, and the environmental condition that affects the process of decomposition. For instance, cordia africana decomposes faster than that of Terminalia brownie and Vitex doniana, which was expressed by decomposition rates of 0.00871, 0.00839, and 0.00598, respectively (Table 3).

Analysed parameters	Tree species (leaf litter collected) form		
	Cordia african	Vitex doniana	Terminalia brownie
%OC	46.46	49.55	49.74
%OM	80.11	85.42	85.75
%TN	1.96	1.71	1.87
C:N ratio	23.70	28.98	26.6
P(ppm)	1.33	0.64	1.91
S(ppm)	124.38	39.68	146.52
K(ppm)	193.100	47.63	55.67
Zn(ppm)	37.14	48.94	10.24

Where OC (organic carbon), OM (organic matter), TN (total nitrogen), C:N (carbon to nitrogen ratio)

Table 1: *Nutrients composition of leaf litter analyzed prior to incorporation into experimental plot.*

Analysed parameters	Tree species (leaf litter collected) form		
	Cordia african (gkg^{-1})	Vitex doniana (gkg^{-1})	Terminalia brownie (gkg^{-1})
OC (g)	464.6	495.5	497.4
OM(g)	801.1	854.2	857.5
TN(g)	19.6	17.1	18.7
C:N ratio	23.70	28.98	26.6

Where OC (organic carbon), OM (organic matter), TN (total nitrogen), C:N (carbon to nitrogen ratio)

Table 2: *Amount of nutrients (g) obtained from analyzed leaf litter biomass (kg) contributed to soil improvement.*

Tree species from which leaf litter collected	Decomposition Equation Parameters		
	Weight loss in %	k ($days^{-1}$)	t½ (days)
Cordia africana	16	0.00871	79
Terminalia brownie	15.45	0.00839	83
Vitex doniana	11.27	0.00598	116

Note. t½ = half-life time.

Table 3: *Parameters the equation X = X0e -kt adjusted the values of dry matter and dry of half-life time.*

Change in soil fertility status after incorporated and

The leaf litter of studied tree species result revealed that required a specified time to decompose and resulted in a change of soil

physicochemical properties. The soil nutrients level of pH, OC, C: N ratio, av. P and K showed variation after incorporating leaf litter than the soil result sampled before. The leaf litter incorporated in the soil showed certain nutrients change in their level this due to the easily decomposing and releasing tendency of nutrients into the soil profile (Table 4).

Analyzed Soil parameters after incorporated leaf litter	change observed in Soil parameters under each species leaf litter incorporation					
	pH	%OC	%TN	C:N ratio	Av. Pppm	Av. Kppm
Cordia africana	5.62^{ab}	2.91^{a}	0.17^{ab}	18.72^{ab}	13.81^{a}	19.730^{a}
Terminalia brownie	5.63^{ab}	3.15^{a}	0.15^{b}	26.24^{a}	15.56^{a}	22.013^{a}
Vitex doniana	5.67^{a}	3.11^{a}	0.14^{b}	22.75^{a}	16.36^{a}	21.724^{a}
Soil sample Before litter incorporation	5.38^{b}	2.150^{b}	0.19^{a}	11.35^{b}	7.20^{b}	13.870^{b}
LSD	0.26	0.44	0.039	9.301	3.34	3.1332
CV(%)	4.92	16.23	25.50	35.5	26.190	16.83

Table 4: *Analyzed soil parameters after decomposition of incorporated leaf litter in Jinka agricultural station.*

Discussion

Decomposition rate and nutrients in leaf biomass (litter) of studied tree species

Retained tree species found on farmland play a significant role in terms of soil improvement through litter fall and recycling of nutrients in the soil system. Each studied species has its own contribution to soil fertility improvement through addition of decomposable leaf litter fall and the potential of releasing available nutrients into the soil solution. For instance, leaf litter of cordia africana provides a high level of nitrogen (Table 1) than the other species whereas the carbon composition in Terminalia brownie and Vitex doniana leaf litter was higher. This result is in line with the findings (Mahari, 2014) who reported there was variation in leaf litter nutrient composition and decomposition rate of cordia africana and Croton macrostachyus. Leaf litter of Cordia africana decomposes faster than the other tree species due to high Nitrogen and lower carbon-to-nitrogen ratio composition. The present study results are in agreement with the findings reported by (Sanchez, 2001; Su et al., 2004).

Change in soil fertility status after incorporated and decomposed leaf litter

The changing of soil nutrient status resulted from decomposed and released nutrients of incorporated leaf litter in the study area. Retaining of these species on farmland provide such important production enhancing functions. Management of easily decomposing and soil fertility improving organic inputs are important to restore soil for better production. According to Petit-Aldana et al. (2012), trees contribute the maintenance of soil organic matter through the production and decomposition of litter and pruning residues. The changing of soil nutrient status resulted from decomposed and released nutrients of incorporated leaf litter in the study area.

Conclusion and Recommendation

The result revealed that tree species retained on farmland should have a multifunctional value that contributes to ecological, economic, and social benefits. Multipurpose tree species play important role in terms of soil fertility improvement through leaf litter fall and nutrient turnover. Decomposition and nutrient release in the leaf litter of tree species is determined by climatic conditions and the inherent characteristics of the leaf quality. Leaf litter of tree species with high nitrogen concentration and low carbon to nitrogen ratio decomposes faster than the species with reverse character. Cordia african leaf litter decomposed and releases nutrients in a short time than that of Terminalia brownie and Vitex doniana. Based on the result it is important to recommend farmland tree species should need better management in terms of tree-crop compatibility, leaf litter resource assessment, and harmonizing crop nutrient demand to enhance nutrient use efficiency.

Author Contributions

Belayneh Lemage and Asmelash Tesfaye set up the experiments; Belayneh Lemage carried out the experimentation in the respective location. Belayneh Lemage and Abebe Hegano analyzed the data and developed the manuscript. Belayneh Lemage contributed to data analysis and manuscript review.

Acknowledgements

The authors acknowledge the Southern Agricultural Research institute for financial support to conduct this experimentation and the Jinka Agricultural Research center for its good facilitation by

providing important inputs to handle the research work accordingly. The collaboration of researchers was highly appreciated.

Competing Interests

The authors declare that there is no conflict of interest regarding the publication of this paper

References

1. Aerts, R., (1997). Climate, leaf litter chemistry and leaf litter decomposition in terrestrial ecosystems: a triangular relationship. Oikos, pp.439-449.
2. Berg, B., (2000). Litter decomposition and organic matter turnover in northern forest soils. Forest ecology and Management, 133(1-2): 13-22.
3. Bragazza, L., Buttler, A., Siegenthaler, A. and Mitchell, E.A., (2009). Plant litter decomposition and nutrient release in peatlands. Carbon cycling in northern peatlands, 184: 99-110.
4. Cardona, D.A. and Sadeghian, S., (2005). Ciclo de nutrimentos y actividad microbiana en cafetales a libre exposición solar y con sombrío de Inga spp.
5. Clymo, R.S., Turunen, J. and Tolonen, K., (1998). Carbon accumulation in peatland. Oikos, pp.368-388.
6. Daldoum, D.M., Mubarak, A.R. and Elbashir, A.A., (2010). Leaf litter decomposition and nutrient release pattern of tree species under semi-arid conditions.
7. Gindaba, J., Olsson, M. and Itanna, F., (2004). Nutrient composition and short-term release from Croton macrostachyus Del. and Millettia ferruginea (Hochst.) Baker leaves. Biology and fertility of soils, 40(6): pp.393-397.
8. Hasanuzzaman, M. and Hossain, M., (2014). Leaf litter decomposition and nutrient dynamics associated with common horticultural cropland agroforest tree species of Bangladesh. International Journal of Forestry Research, 2014.
9. Koukoura, Z., Mamolos, A.P. and Kalburtji, K.L., (2003). Decomposition of dominant plant species litter in a semi-arid grassland. Applied Soil Ecology, 23(1), pp.13-23.
10. Liu, P., Sun, O.J., Huang, J., Li, L. and Han, X., (2007). Nonadditive effects of litter mixtures on decomposition and correlation with initial litter N and P concentrations in grassland plant species of northern China. Biology and Fertility of Soils, 44(1): pp.211-216.
11. Mahari, A., (2014). Leaf litter decomposition and nutrient release from Cordia africana Lam. and Croton Macrostachyus Del. tree species. J Environ Earth Sci, 4(15), pp.1-7.
12. Mesfin, K., Tesfaye, S., Girma, K., Dejene, A. and Tsegaye, G., (2017). Description, characterization and classification of the major soils in Jinka Agricultural Research Center, South Western Ethiopia. Journal of Soil Science and Environmental Management, 8(3): pp.61-69.
13. Ngatia, L.W., Reddy, K.R., Nair, P.R., Pringle, R.M., Palmer, T.M. and Turner, B.L., (2014). Seasonal patterns in decomposition and nutrient release from East African savanna grasses grown under contrasting nutrient conditions. Agriculture, ecosystems & environment, 188: pp.12-19.
14. Olson, J.S., (1963). Energy storage and the balance of producers and decomposers in ecological systems. Ecology, 44(2): pp.322-331.
15. Onyekwelu, J.C., Mosandl, R. and Stimm, B., (2006). Productivity, site evaluation and state of nutrition of Gmelina arborea plantations in Oluwa and Omo forest reserves, Nigeria. Forest ecology and management, 229(1-3): pp.214-227.
16. Pandey, R.R., Sharma, G., Tripathi, S.K. and Singh, A.K., (2007). Litterfall, litter decomposition and nutrient dynamics in a subtropical natural oak forest and managed plantation in northeastern India. Forest Ecology and Management, 240(1-3): pp.96-104.
17. Petit-Aldana, J., Uribe-Valle, G., Casanova-Lugo, F., Solorio-Sánchez, J. and Ramírez-Avilés, L., (2012). Descomposition and nutrient release patterns of leaves of Leucaena leucocephala (Lam.) de Wit, Guazuma ulmifolia Lam. and Moringa oleifera Lam. in a mixed fodder bank. Revista Chapingo serie ciencias forestales y del ambiente, 18(1): pp.5-25.
18. Polyakova, O. and Billor, N., (2007). Impact of deciduous tree species on litterfall quality, decomposition rates and nutrient circulation in pine stands. Forest Ecology and Management, 253(1-3): pp.11-18.
19. Sanchez, F.G., (2001). Loblolly pine needle decomposition and nutrient dynamics as affected by irrigation, fertilization, and substrate quality. Forest Ecology and Management, 152(1-3): pp.85-96.
20. Santiago, L.S., (2007). Extending the leaf economics spectrum to decomposition: evidence from a tropical forest. Ecology, 88(5): 1126-1131.
21. Su, Y., Zhao, H., Li, Y. and Cui, J., (2004). Carbon mineralization potential in soils of different habitats in the semiarid Horqin sandy land: a laboratory experiment. Arid Land Research and Management, 18(1): 39-50.

22. Wardle, D.A., Bardgett, R.D., Klironomos, J.N., Setala, H., Van Der Putten, W.H. and Wall, D.H., (2004). Ecological linkages between aboveground and belowground biota. science, 304(5677): pp.1629-1633.
23. Zeleke, T.B., Grevers, M.C.J., Si, B.C., Mermut, A.R. and Beyene, S., (2004). Effect of residue incorporation on physical properties of the surface soil in the South-Central Rift Valley of Ethiopia. Soil and Tillage Research, 77(1): pp.35-46.