KIU Journal of Humanities Copyright©2019
Kampala International University ISSN: *2415-0843*; 4(3): 199–208

Agronomic Performance of Maize (*Zea mays L.*) as influenced by Leaf Pruning Quality in a Cut and Carry Agroforestry System in Akure, Ondo State, Nigeria

CORNELIUS I. AKINTAN
Forestry Research Institute of Nigeria

Abstract. Mixed leaf pruning can be used to ameliorate nutrient losses for increased crop yield. This study was undertaken to investigate leaf pruning quality on maize agronomic performance in a cut and carry agroforestry system to optimize N-use efficiency. The experiment consisted treatment of 100g Gliricidia; 50g Gliricidia + 50g Acacia; 100g Acacia; 60g Gliricidia + 40g Acacia; 40g Gliricidia+ 60g Acacia and control laid out in Completely Randomized Design with three replicates. Two Oba Super 2 maize seeds per hole were sown during raining season. One week after sowing, the seedlings were thinned to one per stand and treatment was applied 3WAS. Treatment effects measurement on maize growth started two weeks after mulch application and was repeated at 4, 6 and 8 weeks. Matured and dried maize cobs were harvested; the grain yield was evaluated. Significantly higher grain yield was observed between control and plots with applied mulches; no significant difference in yield from the varied quality mulched plots. At 8WAS and 10WAS, plots treated with 40g Gliricidia + 60g Acacia, 100g Acacia, 60g Gliricidia + 40g Acacia, 50g Gliricidia + 50g Acacia, 100g Gliricidia and control were significantly $(P \leq 0.05)$ different in height. Maize plants mulched with 40g Gliricidia + 60g Acacia, control and 100g Acacia had significantly $(P \leq 0.05)$ bigger stem diameters while others were not significant at 6WAS. Plant height, stem diameter, number of leaves and below ground biomass showed that 40g Gliricidia + 60g Acacia had significantly best effects.

Keywords: Acacia leaf mulch; Gliricidia leaf mulch; litter quality and maize yield

1. Introduction

In agroforestry systems, plant residues enter soil system as crop residues, tree leaf litter and prunings. These plant residues are sources of nutrients and organic matter when they decompose and could contribute to the maintenance of soil fertility (Zeng *et al.*, 2010). Improper combination of agroforestry trees could bring about failure in an agroforestry practice (Nair, 1993). The pattern of litter decomposition and nutrient release by trees therefore needs to be known prior to the introduction of trees for agroforestry practices (Nair, 1993; Daldoum *et al*., 2010). In spite of this, information is also needed on suitable tree combinations for the improvement of nutrient cycling which in turn can improve soil quality in agroforestry systems. Residue decomposition rates and nutrient release patterns are controlled by biotic and abiotic factors, the most important of which is residue quality (Vanlauwe *et al*., 1997; Aerts and De Caluwe, 1997; Silver and Miya, 2001; Mungai and Motavalli, 2006; Teklay *et al*., 2007).

Increased nutrient availability, sustained organic carbon (C) content, enhanced biological activities and improved soil physical properties can be achieved through plant residues input into agricultural soils. (Smith *et al.*, 1993; Hadas *et al*., 2004; Cayuela *et al*., 2009). Rates of litter decomposition is determined by litter quality variables namely ratios of polyphenol/N, C/N and lignin/N; and initial concentrations of polyphenol, phosphorus (P), lignin and nitrogen (N) (Melillo *et al*., 1982; Aerts and De Caluwe, 1997; Mafongoya *et al*., 2000; Silver and Miya, 2001; Raiesi, 2006; Liu *et al*., 2007 and Teklay *et al*., 2007).
The influence of litter quality on its subsequent rate of decomposition and soil fertility has been recognized since the early stages of agriculture (Oyun *et al.*, 2006). The decomposability of litters is in part a function of their chemical composition. Short-term benefits of legume tree prunings to crop N uptake is determined by nutrient release and rates of decomposition (Handayanto *et al*., 1997).

Mulches are used for a variety of purposes: weed management, crop yield improvements, soil temperature regulation, and water retention. It is one of the useful strategies for plant pruning manipulation.

Increased knowledge of the interactions that occur when residues of differing quality are applied to crops can lead to various strategies for the management of tree residues and other nutrient inputs. These include the method and time of application and the application of mixtures of quality. The quality of prunings or litter has a crucial influence in determining their impact on soil fertility, especially with regard to nutrient supply and soil organic matter (SOM) formation. High-quality organic inputs will release nutrient rapidly (Akintan *et al.*, 2011). In contrast, low-quality organic inputs will release nutrients slowly or even immobilize them. This has practical implications for attaining synchrony between nutrient release and crop nutrient demand and hence for efficiency of nutrient use. The present study therefore attempts to investigate the effect of varying litter quality as improved tree-fallow system (improved alternative to the fallow phase of shifting cultivation) on the growth and yield of maize.

2. Methodology

2.1 Experimental Site

The research was conducted on the Teaching and Research Farm of the Federal University of Technology, Akure which lies between latitude $7^0$18'32.64^{0}N and $7^0$16'34.93^{0}N and longitude $5^0$10'35.79^{0}E and $5^0$7'38.97^{0}E. The experiment was carried out during a raining season. The mean annual temperature of about 25^{0}C (minimum 19^{0}C and maximum 34^{0}C); relative humidity 84% and mean rainfall of 76mm were obtainable in the study area (Oyun *et al.*, 2006). The elevation is about 350m above sea level with gently undulating land form. The soil is classified as ferruginous tropical soil (alfisols) on crystalline rock of basement complex and belongs to the Egbeda series (Smyth and Montgomery, 1962).

A land area of 18m x 22.5m which was previously used for *Corchorus olitorius* (Ewedu) cultivation was cleared off existing weeds and demarcated into eighteen plots of 3m x 4.5m each with a buffer of 1m x 0.5 m between plots. Oba Super 2 maize seeds (two seeds per hole) were sown on the field at a spacing of 30cm x 90cm (within and between rows) during the raining season with a total of 66 maize plants per plot. One week after sowing, the seedlings where thinned to one per stand. Leaves from three years old *Gliricidia sepium* (Jacq.) Kunth ex Walp. and *Acacia auriculiformis* A.Cunn. ex Benth. trees were applied as treatment mulch (100g Gliricidia, 50g Gliricidia + 50g Acacia, 100g Acacia, 60g Gliricidia + 40g Acacia and 40g Gliricidia + 60g Acacia) at two weeks of sowing while there was a control plot without mulch treatment.

2.2 Design of Experiment

The design of the experiment was completely randomized design (CRD). It comprises of six treatments; each with three replicates. The treatments include: control, leaf pruning of 100g Gliricidia, 50g Gliricidia + 50g Acacia, 100g Acacia, 60g Gliricidia + 40g Acacia and 40g Gliricidia + 60g Acacia.

2.3 Statistical analysis

Data obtained in this study was analyzed by analysis of variance (ANOVA) to determine significant differences between growth indices of maize, physiology of growing maize and maize yield. Least Significance Difference (LSD) was used to test significant differences among the parameters using the method described by Williams and Abdi (2010).

3. Results and Discussion

3.1 Soil status of the experimental site

Soil status of the experimental location before the experiment is presented in Table 1. Data obtained show that the soil is sandy loam in texture. The pH was found to be 6.8 indicating that the soil was near neutral and had moderate levels of residual nutrients with total nitrogen at 1.2g/kg, available P at 11.61mg/kg, organic carbon at 23.65g/kg and soil exchangeable acidity 0.15cmol/kg. The exchangeable bases were equally moderate and gave the following values, Ca (4.21 cmol/kg), Mg (1.65 cmol/kg), K (0.37 cmol/kg) and Na (0.3 cmol/kg). These values are considered adequate for crop germination (Ojeniyi and Adejobi, 2005) but cannot support high crop yields. There is therefore need for external nutrients supply to support good crop production.

Table 1: Pre-planting soil properties

Soil properties	Value
pH (1: $1H_20$)	6.8
Soil exchangeable Acidity(E.A.)	0.15 cmol/kg
Organic carbon	23.65g/kg
Organic matter content	41.26g/kg
Total Nitrogen	1.2g/kg
Available phosphorus	11.61mg/kg
Exchangeable bases	
Ca^{2+}	4.21 cmol/kg
Mg^{2+}	1.65 cmol/kg
K^{+}	0.37 cmol/kg
Na^{+}	0.30 cmol/kg
ECEC	6.68cmol/kg
Textural class	Sandy loam

3.2 Effect of mulch on maize height

The results of the analysis of variance (ANOVA) on the effect of varying quality mulches on maize height are presented in Table 2. At 8WAS, maize height (87cm) in control plot and treated plots with 40g Gliricidia and 60g Acacia (135cm), 50g Gliricidia and 50g Acacia (133cm), 60g Gliricidia and 40g Acacia (119cm), 100g Gliricidia (108cm) and 100g Acacia (101cm) mulches were significantly ($P \leq 0.05$) different. At 10WAS, maize height in plots treated with 40g Gliricidia and 60g Acacia (219cm), 50g Gliricidia and 50g Acacia (204cm), 60g Gliricidia and 40g Acacia (200cm), 100g Gliricidia (187cm), 100g Acacia (177cm) and control (169cm) were significantly ($P \leq 0.05$) different. The trend of significance in maize height shows that 40g Gliricidia and 60g Acacia had best height effect followed 50g Gliricidia and 50g Acacia, 60g Gliricidia and 40g Acacia, 100g Gliricidia, 100g Acacia and control respectively.

Table 2: Effect of mulch on maize height

	Height(cm)			
Treatment	4WAS	6WAS	8WAS	10WAS
Control (No mulch applied)	40a	45a	87f	169f
40g/60g (Gliricidia/Acacia)	48a	53a	135a	219a
50g/50g (Gliricidia/Acacia)	47a	52a	133b	204b
60g/40g (Gliricidia/Acacia)	42a	48a	119c	200c
100g (Gliricidia)	41a	47a	108d	187d
100g (Acacia)	40a	47a	101e	179e

WAS = Weeks After Sowing

Means with the same letter in a column are not significantly different($P \leq 0.05$)

3.3 Effect of mulch on maize stem diameter

Table 3 shows the stem diameter of maize plants as affected by varied quality mulches. The maize plant responded significantly ($P \leq 0.05$) at 6WAS. Maize within plots treated with 40g Gliricidia and 60g Acacia (14.02mm), 100g Acacia (9.46mm) and control (9.20mm) had significantly different stem diameters while 60g Gliricidia and 40g Acacia

(11.40mm), 50g Gliricidia and 50g Acacia(11.61mm), and100g Gliricidia (11.31mm) were not significant. The trend of significance in stem diameter shows that 40g Gliricidia had the best effect on maize stem diameter. There was no significant difference in maize stem diameter at 4, 8, and 10 weeks after sowing.

Table 3: Effect of mulch on maize stem diameter

Treatment	Stem diameter(mm) 4WAS	6WAS	8WAS	10WAS
Control (No mulch applied)	8.40a	9.20c	14.34a	16.49a
40g/60g (Gliricidia/Acacia)	11.55a	14.02a	18.52a	21.23a
50g/50g (Gliricidia/Acacia)	10.22a	11.61d	18.23a	20.75a
60g/40g (Gliricidia/Acacia)	9.76a	11.40d	17.46a	20.59a
100g (Gliricidia)	9.18a	11.31d	16.32a	18.21a
100g (Acacia)	8.83a	9.46b	14.42a	18.04a

WAS = Weeks After Sowing
Means with the same letter in a column are not significantly different($P \leq 0.05$)

3.4 Effect of mulch on maize number of leaves

Result of the study in table 4 shows that the treatment applications significantly ($P \leq 0.05$) affected maize number of leaves at 4WAS, 6WAS, 8WAS and 10WAS. Maize treated with 40g Gliricidia and 60g Acacia leaf mulch had higher number of leaves followed by 50g Gliricidia and 50g Acacia. This was followed by 60g Gliricidia and 40g Acacia, next to this is 100g Gliricidia. Control plots had significantly ($P \leq 0.05$) least number of leaves. The trend of maize number of leaves shows that plants treated with 40g Gliricidia and 60g Acacia had significantly highest number of leaves.

Table 4: Effect of mulch on maize number of leaves

Treatment	Number of leaves 4WAS	6WAS	8WAS	10WAS
Control (No mulch applied)	5f	6f	8f	10f
40g/60g (Gliricidia/Acacia)	8a	8a	11a	13a
50g/50g (Gliricidia/Acacia)	8b	8b	10b	12b
60g/40g (Gliricidia/Acacia)	7c	8c	10c	12c
100g (Gliricidia)	7d	7d	10d	12d
100g (Acacia)	6e	7e	9e	12e

WAS = Weeks After Sowing
Means with the same letter in a column are not significantly different($P \leq 0.05$)

3.5 Effect of mulch on maize physiological parameters

The results of the analysis of variance (ANOVA) as presented in Table 5 shows that the crop growth rates (CGR), relative growth rate (RGR) and net assimilation rate (NAR) were not significantly different ($P \leq 0.05$) between plots with applied mulches and control. The applied mulch significantly ($P \leq 0.05$) affected the below ground biomass. Maize within control plots (0.21g) was least while, 40g Gliricidia and 60g Acacia (0.56g) was of higher dry matter. This was followed by 50g Gliricidia and 50g Acacia (0.34g), then 60g Gliricidia and 40g Acacia (0.32g) and 100g Gliricidia (0.31g); and 100g Acacia

(0.30g) respectively. The above ground biomass at 2 months was significant ($P \leq 0.05$) for maize within control plots (42.21g) and plots mulched with 40g Gliricidia and 60g Acacia (68.35g) while other treated crops were not significant: 50g Gliricidia and 50g Acacia (62.76g), 60g Gliricidia and 40g Acacia (62.76g), 100g Gliricidia (45.96g) and 100g Acacia (45.39g). The trend of significance in biomass shows that 40g Gliricidia and 60g Acacia mulch had best effects on maize crop matter accumulation.

Table 5: Maize physiological parameters

Treatment	Above ground Biomass (g)	Below ground Biomass (g)	Crop growth rate (CGR $g/m^2/day$)	Relative growth rate (RGR g/g/day)	Net assimilation rate (NAR $g/m^2/day$)
Control (No mulch applied)	42.21c	0.21a	0.02a	0.18a	0.02a
40g/60g (Gliricidia/Acacia)	68.85b	0.56c	0. 11a	0.22a	0. 14a
50g/50g (Gliricidia/Acacia)	62.79a	0.34b	0.08a	0.21a	0. 09a
60g/40g (Gliricidia/Acacia)	62.79a	0.32d	0.07a	0.19a	0.08a
100g (Gliricidia)	45.96a	0.31e	0.04a	0.18a	0.05a
100g (Acacia)	45.39a	0.30f	0.02a	0.18a	0. 03a

Means with the same letter in a column are not significantly different($P \leq 0.05$)

3.6 Effect of mulch on maize grain yield

The results of the analysis of variance (ANOVA) for mulch effect on maize grain yield at physiological maturity are presented in Table 6. The highest maize yield was obtained from plots mulched with 40g Gliricidia and 60g Acacia (3436.29kg/ha), closely followed by 50g Gliricidia and 50g Acacia (3134.99kg/ha), then by 60g Gliricidia and 40g Acacia (3047.11kg/ha), next to it is 100g Acacia (2683.05kg/ha) and 100g Gliricidia (2582.62kg/ha). Maize plant without mulch (control) had the least yield (875.27kg/ha).

The difference in maize grain yield is significant ($P \leq 0.05$) between control plots and the plots with applied mulches, though there were no significant differences when grain yield from the varied quality mulched plots were compared.

Table 6: Effect of mulch on maize grain yield

Treatment	Yield (kg/plot)	Yield (kg/ha)
Control (No mulch applied)	1.18	875.27b
40g/60g (Gliricidia/Acacia)	4.64	3436.29a
50g/50g (Gliricidia/Acacia)	4.23	3134.99a
60g/40g (Gliricidia/Acacia)	4.11	3047.11a
100g (Gliricidia)	3.49	2582.62a
100g (Acacia)	3.62	2683.05a

Means with the same letter in a column are not significantly different($P \leq 0.05$)

4. Discussion

The observed significant differences as manifested in 40g Gliricidia and 60g Acacia mulched plant could be said to be as a result of mixing high and low quality organic materials i.e *Gliricidia sepium* and *Acacia auriculiformis* respectively which in turn regulated nutrients availability to the plant. This is supported by Palm *et al.* (2001) who postulated that there is no single organic material that releases N in perfect synchrony to plant demand, giving slow initial mineralization or immobilization followed by a large, rapid mineralization. Hoorens *et al.* (2002) reported that interactive effects of residue mixtures on decomposition may occur when residues of component species with contrasting residue quality are mixed.

The significant increase in maize height could be attributed to reduced leaching, movement of nutrients and more nutrient availability to the crop. Ossom and Matsenjwa (2007) and Kumar *et al.* (2014), reported similar results in field bean (*Phaseolus vulgaris* L.) and poplar and silver oak tree leaf mulch research works respectively.

In this study, below ground biomass (root dry weight) was significantly the lowest in control plots while highest with application of 40g Gliricidia and 60g Acacia which resulted in an increase in grain yield per hectare over control. Ogbonna and Obi (2005) reported similar results where increases in organic manure application resulted in high dry matter partitioning towards increased grain yield and higher harvest index. The observed insignificance in maize physiological parameters can be corroborated by the study of Akongwubel *et al.* (2012): maize plots treated with poultry manure were significantly better in vegetative growth characteristics over control.

Also, higher number of leaves was significantly observed with application of 40g Gliricidia and 60g Acacia. This finding corroborates the report of Okoruwa (1998) who observed significant increases in LAI and dry matter accumulation in maize with successive increases in organic manure rates.

The higher significant values observed in yield of maize with applied mulch in this study is in consonance with Cayuela *et al*. (2009) who earlier published that incorporating plant residues into agricultural soils can sustain organic carbon (C) content, improve soil physical properties, enhance biological activities, and increase nutrient availability. In the opinion of Sakala *et al*. (2000), mixing residues of trees and crops in tropical agroforestry systems, with different qualities can potentially be used to manipulate residue decomposition and regulate the timing of nutrient availability.

Also, the higher maize yield obtained is possibly due partly to suppressed weed, conserved soil moisture, improved carbon, moderate soil temperatures and improved crop health throughout the season and may have accounted for the better crop performance and yield obtained. This agrees with the findings of Khurshid *et al.*, (2006) who ascribed positive yield response in maize to increased water contents in soils due to reduced evaporation in mulched plots.

Generally, the observed significant performance in growth and yield parameters with the application of leaf mulches could be attributed to the essential nutrient elements contained in the mulches that are associated with increased photo-synthetic efficiency (Dauda *et al.*, 2008). It could also be due to the ability of the organic manure to supply the nutrient elements necessary to promote more vigorous growth, improve meristematic and physiological activities in the plants, as well as improve the soil properties; thereby resulting in the synthesis of increased photo-assimilates that enhanced maize yielding ability (Akongwubel *et al.*, 2012).

5. Conclusion and Recommendations

5.1 Conclusion

Evidently from this study, considerable amount of nitrogen can be added to the soil from leguminous leaves thereby partly replacing mineral fertilizer. The application of litter through biomass transfer to crop plant by resource poor farmers in the humid tropical environment can serve as low input systems for crop production.

5.2 Recommendations

Practically, it is recommended that the application of mixed low and high quality litter in alley cropping practice be effected. Farmers are encouraged to use varied quality leaves mulch (40g high quality litter i.e 8 compound leaves in case of *Gliricidia sepium* is equivalent to 10g and 60g low quality litter i.e 7 single leaves in case of *Acacia auriculiformis* is equivalent to 10g) in agroforestry practice in order to benefit from the synergy of the different ecosystem functions from different tree species such as enhanced decomposition rate and nutrient release from low quality tree species. Generally, the level of agroforestry techniques adoption with the potential to increase crop productivity is still low among the practicing rural farmers. Therefore, intensive efforts should be made by government agencies that are relevant in this aspect to further disseminate the technologies to the farmers and follow up to the stage of adoption. Finally, more research on residual effect of mixed mulches on soil is recommended.

References

Aerts, R. and De Caluwe, H. (1997): Nutritional and plant mediated controls on leaf litter decomposition of Larex species. *Ecology* 78: 244 – 260.

Akongwubel, A. O., Ubi B. E., Abam, P., Ogbechi, J., Akeh, M., Odey, S. and Ogar Nicholas (2012): Evaluation of Agronomic Performance of Maize (*Zea mays L.*) under Different Rates of Poultry Manure Application in an Ultisol of Obubra, Cross River State, Nigeria, *International Journal of Agriculture and Forestry*, 2(4): 138-144.

Cayuela, M.L., Sinicco, T. and Mondini, C. (2009): Mineralization dynamics and biochemical properties during initial decomposition of plant and animal residues in soil, *Appl. soil ecol.,* 41, 118-127.

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. *Jonares*, *5*, 75–88.

Dauda, S. N., Ajayi, F. A. and Dor, E. N. (2008): Growth and yield of watermelon (*Citrullus lunatus*) as affected by poultry manure application, *J. Agric. & Social Sci* 4 (3), 121-124.

Hadas, A., Kautsky, L., Goek, M. and Kara, E.E. (2004): Rates of decomposition of plant residues and available nitrogen in soil, related to residue composition through simulation of carbon and nitrogen turnover. *Soil Biol. Biochem*. 36: 255-256.

Handayanto, E. Cadisch, G. and Giller, K.E. (1997): Regulating N-mineralization from plant residues by manipulation of quality. CAB international. Driven by nature: Litter Quality and Decomposition, Cadisch, G. and K.E. Giller (Eds.), pp: 174-184.

Hoorens, B., Aerts, R. and Stroetenga, M. (2002): Litter quality and interactive effects in litter mixtures: more negative interactions under elevated CO2? *J. Ecol*. 90: 1009–1016.

Khurshid, K., Iqbal, M., Arif, M. S. and Nawaz, A. (2006): Effect of tillage and mulch on soil physical properties and growth of maize. *Int. J. Agric.Biol.,* 8(5):593-596.

Liu, P., Huang, J.H., Han, X.G., Sun, O.J. and Zhou, Z. (2007): Differential responses of litter decomposition to increased soil nutrients and water between two contrasting grassland plant species of Inner Mongolia, China. *Applied Soil Ecology*, 34: 266 – 275.

Mafongoya, P.L., Bationo, A., Kihara, J. and Waswa, B.S. (2000): Appropriate technologies to replenish soil fertility in Southern Africa, *Nutr. Cycl. Agroecosyst*. 76:137–151.

Melillo, J.M., Aber, J.D. and Muratore, J.F. (1982): Nitrogen and lignin control of hardwood leaf litter decomposition dynamics. *Ecology 63*: 621-626.

Mungai, N.W. and Motavalli, P.P. (2006): Litter quality effects on soil carbon and nitrogen dynamics in temperate alley cropping systems; *Applied Soil Ecology* 31(1):32-42.

Nair, P.K.R. (1993): An introduction to Agroforestry. Kluwer Academic Publishers, Dordrecht, The Netherlands. Pp 13.

Ogbonna, P. E. and Obi, I. U. (2005): Effect of time of planting and poultry manure application on growth and yield of maize (Zea mays L) in a derived savannah Agro-ecology, *Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension* (2):133-38

Ojeniyi, S.O. and Adejobi, K.B. (2005): Comparative effect of poultry manure and NPK fertilizer on growth, yield and nutrients content of sweet potato (*Ipomea batatas)*: Proceedings of Conference of the Agricultural Society of Nigeria, held at

University of Benin, Benin City, Nigeria; October, 9-13, 2005. Pp 115-118.

Okoruwa, E. A. (1998): Effects of NPK fertilizer and Organic manure on the growth and yield of maize (*Zea mays L.*) Hybrid, *Crop Sci*. 22: 119-124.

Ossom, E.M. and Matsenjwa, V.N. (2007): Influence of mulch on agronomic characteristics, soil properties, disease and insect pest infestation of dry bean (*Phaseolus vulgaris* L.) in Swaziland. *World J. Agric. Sci.* 3: 696-703.

Oyun, M.B., Kadeba, O. and Aletor, V.A. (2006): Nitrogen Release Patterns of Mixed *Gliricidia sepium* and *Acacia auriculiformis* leaves as Influenced by Polyphenol, Lignin and Nitrogen contents. *Journal of Applied Science* 6(10): 2217-2223.

Palm, C.A., Gachengo, C.N., Delve, R.J., Cadisch, G. and Giller, K.E. (2001): Organic inputs for soil fertility management: some rules and tools, *Agric. Ecosyst. Environ*. 83: 27- 42.

Raiesi, F. (2006): Carbon and N Mineralization as Affected by Soil Cultivation and Crop Residue in a Calcareous Wetland Ecosystem in Central Iran. *Agriculture, Ecosystems & Environment,* 112: 13-20.

Sakala W.D., Cadisch, G. and Giller, K.E.(2000): Interactions between residues of maize and pigeon pea and mineral N fertilizers during decomposition and N mineralization. *Soil Biology and Biochemistry* 32: 699–706.

Silver, W. L., and Miya, R. K. (2001): Global patterns in root decomposition: comparisons of climate and litter quality effects. *Oecologia* 129:407–419.

Smith, J.L., Papendick, R.I., Bezd-icek, D.F. and Lynch, J.M. (1993): Soil organic matter dynamics and crop residue management. In: Soil Microbial Ecology Application in Agricultural and Environmental Management. Meeting Jr FB (ed). Marcel Dekker, NY, pp. 65-94.

Smyth, A.J., and Montgomery, R.F. (1962): Soils and land-use in Central Western Nigeria, Government Printer, Ibadan, Nigeria 50pp.

Teklay, T., Nordgren, A., Nyberg, G. and Malmer, A. (2007): Carbon Mineralization of Leaves from Four Ethiopian Agroforestry Species under Laboratory and Field Conditions. *Applied Soil Ecology,* 35: 193-202.

Vanlauwe B., Diels J., Sanginga, N. And Merckx, R. (1997): Residue quality and decomposition: an unsteady relationship? In: Cadisch G and Giller KE (Eds.), Driven by nature: plant litter quality and decomposition. 157-166. CAB International.

Williams, M.J. and Abdi, H. (2010): Fisher's Least Significant Difference (LSD) Test, Neil Salkind (Ed.), Encyclopaedia of Research Design. Thousand Oaks, CA: Sage.

Zeng, D., Mao, R., Chang, S.X., Li, L. and Yang, D. (2010): Carbon mineralization of tree leaf litter and crop residues from poplar-based agroforestry systems in Northeast China: A laboratory study; *Applied Soil Ecology* 44: 133-137.