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Research Article

Rate of Decomposition and Nutrient Release from the Foliages of *Acacia nilotica* (L) in Three Alfisols

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ABSTRACT
Leaves of leguminous tree species used as manure are potential alternatives to commercial fertilizer for agricultural crop production. *Acacia nilotica* (L), *Acacia* is a genus of about 160 species of trees and shrubs in the pea family (Fabaceae). *Acacia* are native to tropical and subtropical regions of the world, particularly Australia (where they are called wattles) and Africa, where they are well-known landmarks on the savanna. This research is aimed at investigating and estimating the rate of decomposition and nutrients released from the foliage of *Acacia nilotica* (L) incorporated in three alfisols from the school farm of Bayero University Kano in a Completely Randomized Design (CRD) where the standard methods of laboratory analysis were conducted to determine the macro and microelements and nutrients released into the soils for three months of the study period. From the treatment involving *Acacia nilotica* (L), Magnesium (Mg) in *Acacia nilotica* (L) was found to be highly released at 1.66(cmol/kg) in loamy Soil. In contrast, Calcium (Ca) content was highly released in loam at 3.65(cmol/kg) by *Acacia nilotica* (L). The most active soil for decomposition and nutrient release was found to be highest in loamy soil followed by clay with the lowest rate in Sandy soil. It is advisable for farmers willing to practice agro-forestry to critically assess the leguminous tree foliage that would release the most significant mineral nutrients into a particular soil. Similarly, the nutrient demand of the crop that will be integrated should be studied.

Keywords: *Acacia nilotica*; Alfisols; Decomposition; Foliage; Nutrients

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INTRODUCTION

Acacia, (genus *Acacia*) is a genus of about 160 species of trees and shrubs in the pea family (Fabaceae) (Brenan 1983). Acacias are native to tropical and subtropical regions of the world, particularly Australia (where they are called wattles) and Africa, where they are well-known landmarks on the savanna (Carter1994).

Acacia nilotica is a multipurpose tree, which provides timber, fuel, shade, food, fodder, honey, dye, gum and fences (Audru *et al.,* 1993). It also impacts on the environment through soil reclamation, soil enrichment, protection against fire and wind, and as a heaven for biodiversity and ornament. It is widely used in ethno-medicine (Orwa *et al.,* 2005; Fagg *et al.,* 2005). However it is considered a weed in some areas including Australia, the Galapagos Islands, and the Pacific Islands (US Forest Service, 2012). *Acacia nilotica* is a useful fodder source, and sometimes a very important one, particularly in dry regions. The foliage and the pods dropped during the dry season can be a fundamental source of nutrients in periods of feed scarcity (Orwa *et al.,* 2005; Carter, 1994; Audru *et al.,* 1993).

The aim and objective of investigating and estimating the rate of decomposition and nutrients release from the foliage of A*cacia nilotica* incorporated into three Alfisols, to evaluate, determine and also describe the characteristics, uses and economic importance of *Acacia nilotica* in the three alfisols.

Soil improvement and reclamation: *Acacia nilotica* is an N-fixing legume that can be grown with grass or cereal crops in order to enhance their N value. It is used as a pioneer species in the reclamation of mining areas and in areas where degradation and erosion have occurred, an example being the Chambal ravines in India (Fagg *et al.,* 2005; Carter, 1994).

Acacia nilotica (*L*), commonly known as the Nile acacia or babul tree, is another agroforestry species that can contribute to soil fertility and nutrient cycling through the decomposition and nutrient release from its foliage. The decomposition and nutrient release processes of *Acacia nilotica* (*L*), foliage can vary depending on various factors, including climate, soil properties, and management practices.

The foliage of *Acacia nilotica* (*L*), undergoes decomposition in Alfisols through the activities of soil microorganisms, including bacteria and fungi. The organic matter breakdown is also influenced by such factors as temperature, moisture, litter quality, and microbial activity. *Acacia nilotica* foliage generally contains nitrogen, phosphorus, potassium, calcium, and other essential elements, which become available for plant uptake during decomposition (Havlin *et al.,* 1999). Over the years, there has been a population explosion requesting more land for farming and infrastructural development. This thirst for land acquisition has led to a dwindling percentage of food production. Owing to this development the quest for food and poor economic management has impacted a lot in the cost of fertilizer which invariably calls for the scientific investigation of alternative tree crops that will boost soil fertility and reduce the effect of desertification and climate change, those variables are the brain behind the necessity of this study.

Agroforestry as a scientific model encourages tree-crop integration as a solution to the cost of fertilizers, deforestation and climate change which are bedeviling the world's ecosystem. However, this research focuses its attention on the desirable species that would assuage the present crisis of man and his environment. The study evaluated the characteristics, uses and economic importance of *Acacia nilotica* in the three alfisols.

MATERIALS AND METHODS

Study Area

Bayero University Kano (BUK) is located in Kano, the capital city of Kano State in Nigeria. The latitude and longitude coordinates for Bayero University Kano (BUK) in Nigeria are approximately 11,97ºN and 8.43ºE

Research Methodology

The foliage/leaf sample of the legumenous tree was collected from different locations of the university farm. The collected samples of both fresh foliage were pooled together in a container and oven dried at 65°C,after which the sample was milled and sieved to 2mm, and added or incorporated into 500g of sandy, loamy and clay soils each. The buckets were kept in a screen house and watered uniformly at an ambient temperature of 16°C - 33°C for 90 days. Measurement of mineral nutrients released was taken after thirty days each using the standard method of laboratory analysis to determine the macro and microelements together with three controls in sand, loamy and clay as enunciated by Adeboye *et al.,* 2009.

Laboratory Analysis

The determination (quantity) of the above elements released was carried out on a monthly basis in the University Soil Laboratory using the following methods;

Organic carbon (O. c): Walkley black wet oxidation (Walkley and Black, 1934).method

Total nitrogen (TN): Macro Kjeldahl method (Dupont *et al.,* 2013).

Available phosphorus (AVP) Bray 1 method (Bray,& Kurtz, 1945).

Cation exchange capacity (CEC): Ammonium acetate saturation method (Chapman, & Davidson (1965).).

Iron (Fe): HCL extraction method (Vomocil, 1965).

Zinc (Zn): HCL extraction method (Vomocil, 1965).

Magnesium (Mg): Atomic absorption Spectrophotometry method (Vomocil, 1965).

Sodium (Na): Ammonium acetate saturation method (Thomas, G. W. 1982).

Potassium (K): Ammonium acetate saturation method (Thomas, G. W. 1982).

Calcium (Ca): Atomic absorption Spectrophotometry method (Bisergaeva and Sirieva 2020 J).

RESULTS

In Table 1 percentage organic carbon shows increase in both soil type as compare to the control, thus addition of *Acacia nilotica* to the soil has increase the organic carbon content in the soil. AVP was slightly increase in ANL and ANC but no increase realize in ANS. TN% and Na were not significantly added to the soil during the period of decomposition for all the Alfisols, rather decreases. CEC and Zn were significantly added across all the three soil classes as compared to the control. Fe was highly added during the decomposition period in ANS, ANL and ANC. Mg content was only increase in ANL but in ANS and ANC the content decrease. Ca shows increase in ANL and ANC as compared to the control but decrease in ANS as compared to the control thus *Acacia nilotica* did not add Ca in ANS soil. K was slightly increase in ANL and ANC, but decrease in ANS.

Table 1: A Tables Showing Nutrient Release in Three Alfisols

Sample ID	%O.C	AVP (mg/kg)	% TN	CEC (+cmol/ kg)	Fe (mg/kg)	Mg (cmol/ kg)	Zn (mg/kg)	Ca (cmol/ kg)	Na (cmol/ kg)	K (cmol/ kg)
ANS	0.57efgh	10.73fgh	0.23c	4.57d	2.77defg	0.86def	3.57ef	1.54c	0.19cdef	0.24d
ANL	1.21c	9.82gh	0.16c	6.21bc	4.40b	1.66a	4.08d	3.65a	0.15	0.33cd
ANC	0.62defg	8.89gh	0.29c	6.54b	3.60c	1.22abcd	3.74e	2.44b	0.23bcdef	0.33cd
C. S	0.41h	6.94h	0.24c	4.36d	2.56fg	1.11bcde	2.01i	1.56c	0.49a	0.49bc
C. L	0.70def	9.01gh	0.25c	5.58bcd	3.10cdef	0.92cdef	2.72h	1.81c	0.37b	0.30cd
C. C	0.55fgh	14.18edf	1.26a	6.18bc	2.37g	1.52ab	3.13g	1.87c	0.33bc	0.75a

Means followed by same letter(s) within same treatment column are not different statistically at P=0.05 level of probability using DMRT. Key: ANC = *Acacia nilotica* clay, ANL = *Acacia nilotica* loam, ANS = *Acacia nilotica* sand, CS= Control experiment sand, CL=Control experiment loam, CC = control experiment clay

DISCUSSION

Organic carbon acts as a binding agent, promoting the formation of stable soil aggregates. As suggested by Brady and Weil's (2014) Organic matter in loamy soils increases their water-holding capacity. Brady and Weil's (2014).

Organic carbon enhances the aggregation of clay particles, improving soil structure.

According to a study by Tarchitzky and Chen (2002), available phosphorus in sandy soils is essential for efficient nutrient uptake by plants. Adequate phosphorus levels enhance root development and nutrient absorption.

Available phosphorus is vital for optimal nutrient uptake by plants in loamy soils. In research by Meharg, (2011), it was emphasized that phosphorus availability directly affects root growth and nutrient absorption by plants.

Available phosphorus is essential for efficient nutrient uptake by plants in clay soils. Research by Lynch and Adeboye (2009) emphasizes that phosphorus availability affects root development and nutrient absorption by plants.

Nitrogen is a primary nutrient essential for plant growth. In sandy soils, where nutrient retention is often poor due to low cation exchange capacity (CEC), nitrogen availability is critical. According to Landon (2014), sandy soils generally have low CEC, resulting in reduced nutrient retention.

Loamy soils are known for their intermediate texture, which includes a balanced proportion of sand, silt, and clay. This texture provides good nutrient retention. According to Brady and Weil (2014), loamy soils generally have a higher cation exchange capacity (CEC), which allows them to retain nutrients like nitrogen more effectively.

Clay soils have a high cation exchange capacity (CEC), which allows them to retain nutrients like nitrogen effectively. According to Sumner and Miller (1996), clay soils can retain more nutrients due to their high CEC.

Moreover, Cation Exchange Capacity (CEC) plays a crucial role in sandy soils by influencing nutrient retention and availability for plants. Sandy soils typically have a low CEC due to their coarse texture. This has been highlighted in numerous studies (Smith *et al.,* 2009; Sumner and Miller, 1996) where it was found that sandy soils have a limited capacity to retain essential cations, such as calcium, magnesium, and potassium.

Smith *et al.* (2009) investigated the relationship between CEC and nutrient availability in loamy soils. They found that higher CEC in loamy soils allows for better retention of essential cations, leading to improved nutrient availability for crops.

Sparks, (2003) in "Advances in Agronomy" discussed the high CEC of clay soils and its significance in nutrient management. Clay soils' ability to retain cations was a central focus of this work, highlighting its role in providing a stable reservoir of essential nutrients for plants.

Furthermore, Iron is an essential micronutrient for plant growth. It is required for various biochemical processes, including photosynthesis and respiration (Marschner, 1995). In sandy soils, which often lack essential nutrients, iron availability becomes crucial for plant health (Cakmak and Kirkby, 2008).

Iron is an essential micronutrient for plants, and it plays a significant role in nutrient uptake. Loamy soils, with their good nutrient-holding capacity, require iron for optimal plant growth (Marschner and Clarkson, 2011).

Iron is a vital micronutrient for plants and is crucial for various metabolic processes. In clay soil, which generally retains nutrients well, iron availability is essential for optimal plant growth (Marschner and Clarkson, 2011).

However, Magnesium is an essential nutrient for plants, aiding in photosynthesis and overall growth. In sandy soils, where nutrient retention can be a challenge, adequate magnesium is very vital. (Marschner and Clarkson, 2011)

Magnesium is a crucial nutrient for plant growth and development. In loamy soils, it aids in the uptake of other essential nutrients by plants (Marschner and Clarkson, 2011).

Magnesium is essential for plant nutrition and growth, and in clay soils, it contributes to the uptake of other essential nutrients (Marschner and Clarkson, 2011).

Zinc is required for the uptake of other essential nutrients. Research by Adeboye (2009) highlights its role in facilitating the absorption of phosphorus and iron by plants.

Zinc is vital for nutrient uptake in plants, and this role is particularly important in loamy soils. In a study by Adeboye (2009), it is emphasized that zinc facilitates the uptake of essential nutrients, such as phosphorus and iron, by plants.

Zinc is essential for nutrient uptake by plants. In clay soils, which can retain nutrients but often suffer from reduced nutrient availability, zinc is vital. Studies like Mclaughlin *et al.* (2011) emphasize how zinc can influence nutrient availability in clay soils.

Calcium as a major element aids in flocculation, which improves the aggregation of soil particles, making sandy soils less prone to erosion and better at retaining moisture (Brady and Weil, 2014).

Calcium promotes flocculation and enhances the aggregation of soil particles in loamy soils, contributing to good soil structure (Brady and Weil, 2014).

Calcium is critical in clay soils for promoting flocculation and reducing compaction, which improves soil structure and aeration (Brady and Weil, 2014).

Sumner and Naidu, 1998, suggested that High levels of sodium can disperse soil particles, which may improve soil structure by reducing compaction and enhancing water infiltration.

Sumner and Naidu, 1998 further discuss that how Sodium can disperse soil particles in loamy soil, which may improve soil structure by reducing compaction and enhancing water infiltration.

But clay soil Adeboye *et al*, (2009), proclaimed that sodium can disperse clay particles, leading to the deflocculation of soil particles. This can improve soil structure by reducing compaction and enhancing water infiltration.

Potassium is known with the power of enhancing Nutrient Management for Sustainable Crop Production in Sandy Soils (Havlin *et al.,* 1999). And the same Potassium is known with vigor of improving Soil Productivity in Loamy Soils (Meharg, 2011)

Smith *et al.,* (2009) finally explores how potassium is essentials Potassium in Clay Soils and Its Impact on Crop Growth (Smith *et al.,* 2009): This research study explores the essential in crop growth and yield.

CONCLUSION

Conclusively, the most active soil for decomposition and release of nutrient was found to be highest in loamy soil followed by clay with the least rate in Sandy soil sequentially.

Based on the above findings, It is recommended that nutrient demand of the crop that will be integrated should be studied together with its life cycle so that the rate of decomposition and release of nutrients would go hand in hand with the crop to be raised.

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