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EFFECTS OF *Tithoniadiversifolia* and *Albizialebbeck* LEAVES ON THE PRODUCTIVITY OF *Amaranthushydridus* L. IN MARGINAL SOILS LABELLED WITH STABLE ISOTOPE 15-NITROGEN

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Abstract: This study was conducted in the plastic bags *in situ* to assess the effects of *Tithoniadiversifolia* and *Albizialebbeck* leaves (TdL and AlL) on nitrogen dynamics in CREN-K and CECOMAF soils and their effects on the productivity of *Amaranthushybridus* L. using the labelling technique with stable isotope 15- nitrogen. Both marginal soils were labelled with 15-nitrogen in the form of $^{15}(NH_4)_2SO_4$ (5.42 atom%) by the indirect method at 10 Kg ha^{-1}. The field trial was arranged in a randomized complete bloc design consisting of five treatments in three replications: TdL and AlL were applied separately or combined in different proportions to give equal rate of 40 kg N ha^{-1}, NPK at the rate of 40 kg N ha^{-1} and the control. The test culture used was *Amaranthushybridus* L. Physico-chemical laboratory analyses were carried out on soil and organic matter samples. The rate of N-mineralization was 93 mg total N / kg of soil on the 14thday through an incubation study. The dominant form of inorganic N was nitrate.N recovery from TdL in CREN-K soil on the *Amaranthushybridus* roots was the highest (40%). The dry matter yields in all treatments were significantly higher than in the control. The study has shown that the TdL and AlL pure or mixed have the potential for improving plant nutrient availability in these sandy soils. The use of these residues as a nutrient source is more profitable with high-value crop, especially for resource poor farmers. In addition, they are suitable for short vegetative cycle of market gardenings.

Keywords: 15-Nitrogen, residues, *Amaranthushybridus* L.

Introduction

High population pressure and land degradation in the Kinshasa city, Democratic Republic of the Congo need to develop methods for sustainable management of sandy soils fertility, to ensure food security and contribute to human health. The use of commercial mineral fertilizer is an effective practice to improve soil fertility and crop yield. However, chemical fertilizers are expensive and the majority of the smallholder farmers have lacked the financial resources to purchase sufficient fertilizers. Organic resources are often proposed as valuable alternatives to these chemical fertilizers (Dupriez et al., 1987; Nair, 1989; Mbaya et al., 2005). Urban and peri-urban agriculture are being well developed in the Kinshasa city and professional market-gardeners are more likely to adopt the relatively cheaper and readily

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available though less profitable soil fertility replenishment technologies such as farm yard manure, waste products and *Tithoniadiversifolia*based biomass transfer. They supply almost 70% of the garden products consumed. The efficiency of green manure depends on the method and timing of application in relation to their rate of decomposition and mineralization (Lhada et al., 1992).

Tithoniadiversifiola, commonly known as Mexican sunflower, is a shrub belonging to the family Asteraceae. It is now widely distributed through the humid and sub humid tropics in Central and South America, Asia and Africa (Sonke, 1997). Green biomass of tithonia was previously recognized to be rich in plant nutrients (Nyasimi et al, 1995; Jiri and Waddington, 1998; Gachengo et al., 1999; Jama et al, 2000; Kaho et al., 2011). *Albizialebbeck* L. (Fabaceae-Mimosoideae) is a large, erect, unarmed, spreading tree native to deciduous and semi-deciduous forest in Asia from eastern Pakistan through India and Sri Lanka to Burma (Kumar et al., 2007). Previous works have reported that this nitrogen-fixing tree is a good source of fodder and green manure (Diagne, 1988; Ziblim et al., 2012).
To predict the amount of N plants will take up from residues is difficult. However, the use of isotope techniques (^{15}N-labelled) to label each type of organic residues will assess the dynamics of nitrogen in the field and its assimilation by the plant (Hood et al., 1999. Van Cleemput et al., 2008). This study was conducted in order to assess the effects of *Tithoniadiversifiola* and *Albizialebbeck*leaves (TdL and AlL) on the dynamics of nitrogen in CREN-K and CECOMAF soils and their effects on productivity of *Amaranthushydridus* L. using the labelling technique with stable isotope 15- nitrogen (^{15}N).

2. MATERIALS AND METHODS

The trial was conducted at experimental garden of the Regional Centre for Nuclear Studies Kinshasa (CREN-K) on an average altitude of 430 m. The study area lies between 4°30 'South latitude and 15°18' east longitude. Experiments were carried out in the Laboratory of Applied Physical Chemistry, Faculty of Bioscience-Engineering, Ghent University (Belgium).

2. 1. Soil and organic matter

a. Soils: The soil samples were selected in the area (CECOMAF) where gardening is practiced intensively. Soils were also collected from the experimental garden (CREN-K). These soils were sieved (2 mm diameter mesh) and homogenized.

b. Organic matters: The organic materials used were *Albizialebbeck* and *Tithoniadiversifolia* leaves. They were dried at 55°C to constant weight and then ground with a mill (Thomas Scientific, USA).

2.2. Incubation Experiment

The incubation experiment was conducted in the Laboratory in view to convert organic N into mineral N during decomposition of TdL and AlL in sandy soil. Nitrogen mineralization was carried out in 200 ml glass flask containing 20 g of sandy soil, 3 ml of distilled water (75% of field capacity) and 0.4 g of residue which was added 4 days after pre incubation. The un-amended soil was used as a control and each treatment consisted of 3 replications.

The glass flasks were incubated for 42 days at constant temperature (28°C) and were covered with a single layer of gas permeable parafilm to minimize water loss.

The evapotranspiration loss was replenished by addition of distilled water. Samples were taken at day 1, 3, 7, 14, 21 and 42 days after the start of the incubation. At the end of each incubation period mineral nitrogen was extracted by adding 40 ml of 1N KCl in the glass flask which was stirred at 120 cycles per minute for one hour. The filtrate was kept in polyethylene glass at 4°C in the refrigerator up to measurement.

2.3. Chemical Analysis

The extracts were analysed for ammonium and nitrate colorimetrically with a continuous auto-analyser (AAS + BRAN and LUEBBE, Germany).

An elemental analyser connected to an Isotope Ratio Mass Spectrometer (IRMS) was used to determine the total nitrogen and carbon content in CREN-K soil, CECOMAF soil, TdL and AlL. Total concentrations of calcium, magnesium, potassium, sodium and phosphorus were determined by Plasma Spectrometry method. Lignin, hemi-cellulose and cellulose were determined by Van Soestet al. (1991) method.

Folin-Denis method as adapted by King and Heath (1991) was used for polyphenol analysis.

2.4. Data Analysis

The net N mineralization of TdL+AlL was calculated as the difference between the amounts of inorganic N released in the amended soil and those released in the control. At each sampling time, means and standard deviations were calculated.

2. 5. Experimental procedures

a. Labelling technique and amendments:

Soil samples CECOMAF and CREN-K were labelled with 15-nitrogen in the form of $^{15}(NH_4)_2SO_4$ (5.42 atom %) by the indirect method at 10 Kg ha^{-1} (Chaves, 2004).

Soils were amended and packaged in black polyethylene bags at a rate of 3 kg of soil / bags and digged in the field ¾. The field trial was arranged in a randomized complete bloc design consisting of five treatments in three replications: TdL and AlL were applied separately or combined in different proportions to give equal rate of 40 kg N ha^{-1}, NPK at the rate of 40 kg N ha^{-1} and the control. TdL and AlL were incorporated into the soil two weeks before sowing.

b. Test culture.

The seeds of *Amaranthushybridus* L. (Amaranrhaceae) were sown in the nursery. After germination, the seedlings were transplanted 14 days later.

c. Harvest and analysis

After 21 days of growth in plastic bags, harvesting has been made and the fresh weight of plant measured. These samples were then dried at 55 ° C to constant weight to obtain the dry weight. After grinding, the isotopic analysis was performed by Isotope Ratio Mass Spectrometry (IRMS).

d. Calculations:

The percentage of nitrogen derived from residues (Ndfr %) was calculated using the following equation:

• $\text{Ndfr \%} = \left(1 - \frac{\text{atoms \% 15N exces treatment}}{\text{atoms \% 15N exces control}}\right) \times 100$ (McAuliffe et al., 1958).

The amount of fertilizer was estimated using the following formula:

• Q = a x b / c x 100 (Rohrmoser, 1986):

a = required amount of nutrients (kg / ha)

b = area of the experimental field (m^2)

c = nutrient content of the fertilizer (%)

Statistical analyzes were performed by ANOVA to differentiate between treatments in soil type.

3. RESULTS AND DISCUSSION

3.1. Physico-chemical characterization of soil and organic matter.

3.1.1. Soil characterization

Table 1: Soil physico-chemical characteristics (CREN-K and CECOMAF).

Soils	pH Kcl	Ntotal (%)	P (%)	K(%)	Mg(%)	Ca(%)	Sand (%)	Limon (%)	Clay(%)	$CaCO_3$ (%)	C total	C/N
CREN-K	6,4	0,04	2,004	0,047	11	0,1	96	0,26	0, 0	0,26	0,31	7,75
CECOMAF	6,2	0,02	2,649	0,172	7,4	0,1	97	0,5	0,03	0,52	0,12	6

Soil samples collected were subjected to laboratory analysis to determine their physico-chemical characteristics. The results revealed that the sand is the essential element of soil texture of CREN-K and CECOMAF whose contents are respectively about 96% and 97%. Low calcium carbonate content in the both soils explains the acidic pH value. The potassium and phosphorus content in CECOMAF are higher than in CREN-K. This fact can be justified by the persistence of phosphorus and potassium effect due to the widespread use of chemical fertilizer market gardening. Low nitrogen content in CECOMAF result of subsequent leaching precipitation. These nitrogen losses can be in the form of dissolved organic compounds or inorganic nitrogen (Van Breemen, 2002). The C/N ratio 7.75 and 6 are inferior to 20 so, CREN-K and CECOMAF are able for mineralization activity (Puustjarvi, 1970). Mineral element contents and a pH value near neutrality are among important conditions for adequate activity of microorganism's nitrificaters. Soil characteristics influence largely the mineralization process of organic matter (Halstead et al., 1963).

3.1.2. Characterization of organic matter.

Table 2: Nutrient status of TdL and AlL.

RESIDUES	N(%)	P organic(%)	K (%)	C (%)	Ca (%)	Lignin (ADL)(%)	Cellulose (%)	Hemi-cellulose(%)	Polyphenol (%)	NDF	ADF
TdL	5	11,5	0,7	44,2	0,4	7,6	11	13,1	1,2	31,7	18,6
AlL	3,4	5	1,5	47	4	6,5	16	19,7	0,5	42,1	22,4

Table 2 shows that TdL nitrogen content is higher than most species used in agro-forestry to improve soil fertility such as *Leucaenaleucocephala* 3, 8%, *Sesbaniasesban* 3, 7%. (Jama et al., 2000), *Puerariaphaseoloides* 2, 7% (Kaho et al., 2009). The AlL are rich in C (47%), Ca

(4%) and cellulose (16%). The ability of an agro-forestry species to improve the productivity of a soil depends on the yield and quality of the biomass and the rate of decomposition (Palm, 1995; Cobo et al., 2002).

Table 3: Ratio of chemical compounds

RESIDUES	C/N	C/P	Lignin/N	Cellulose/N	Hemi-cellulose/N	Polyphenol/N
TdL	8,8	3,8	1,5	2,2	2,6	0,2
AlL	13,5	9,4	1,9	4,6	5,7	0,1

The values of C/N presented in table 3 are lower than 20. Therefore, these residues have the ability to decompose or more less rapidly in soil (Audesse and Giroux, 2004).

3.2. Mineralization of organic matter

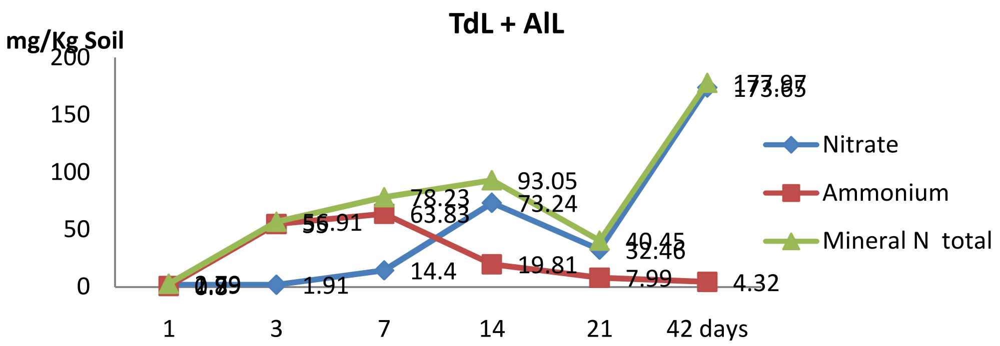

Figure 1: Extraction of NH_4^+-N+ and NO_3^--N from mixture TdL and AlL applied to CREN-K. Each point is the mean of three replicates.

Figure 1 reveals changes in NH_4^+-N and NO_3^--N concentrations with time in the TdL+AlL treated CREN-K soil. Net inorganic N (NH_4^+-N and NO_3^--N) released was relatively rapid. The amended soil showed an increase in total amount of inorganic nitrogen released during the first 14 days of incubation. NO_3^--N was the dominant product of N-mineralization. The rate of N- mineralization is 93 mg total N / kg of soil on the 14th day. Nitrogen evolution in soil is highly influenced by organic matter mineralization rate. However, at the end of incubation NH_4^+-N content was reduced significantly. The strong reduction of NH_4^+-N was possibly due to the utilization of nitrogen from inorganic source by micro-organisms (Pengnoo et al., 2002).

The total nitrogen mineralized from organic waste materials varied considerably depending on the soil type and organic material (Chescheir et al., 1986; Iwegbue et al., 2011).

3.3. Nitrogen efficiency derived from residues

Tableau 4: The percentage of nitrogen derived from residues (% Ndfr).

residues	Leaves		Roots	
	% Ndfr		% Ndfr	
	CREN-K	CECOMAF	CREN-K	CECOMAF
TdL	31	27	40	24
AlL	23	18	25	17
TdL+AlL	29	20	30	22

The results presented in table 4 show that the effect of residues on N uptake by *Amaranthushybridus* L. was significant in all treatments. N recovery from TdL in CREN-K soil on the *Amaranthushybridus* roots was the highest (40%). TdL and AlL gave a net N benefit to *Amaranthushybridus* L. The values obtained were high compared to field estimates of residue N recovery from *Leucaena*8.6% and pea shoots 5% using the direct approach (Jensen, 1994; Vanlauwe et al., 1998).

Recovery of residue N by the test culture is higher in CRENK than in CECOMAF. Indeed, several factors influence the efficiency of nutrients derived from residues, such as the chemical composition, the rate of decomposition of organic matter, time and mode of application, the amount applied, biological and physico-chemical properties of soil (Miller et al.1990; Buresh et al 1991). The soil pre-labelling technique allows reasonable measurement of N derived from residues (Hood, 2001).

3.4. Dry matter yield

Table 5: Dry weight of *Amaranthushybridus* L.

	Dry weight (t/ha)	
	CREN-K	CECOMAF
Control	0.42	2.3
NPK	0.89	5.0
TdL	0.87	4.7
AlL	0.76	3.9
TdL+AlL	0.77	4.8

Table 5 shows that the dry weights in all treatments were higher than in the control. CECOMAF is a rich soil. This may explain why the dry matter yields in CECOMAF were significantly higher than in CRENK. These finding suggest that the timing of the release of nutrients from residues during decomposition and assimilation by the plant test was good. Indeed, Palm, 1995 and Cobo et al, 2002 showed that the rate of decomposition of organic matter and increased yields were closely related to the synchronization between nutrient release and uptake by the plant.

Conclusion

The study has shown that the TdL and AlL applied separately or combined have the potential for improving plant nutrient availability in sandy soils (CRENK and CECOMAF). The dominant form of inorganic N was nitrate. Incorporation to both soils of TdL and AlL had a significant effect on the dry matter yield of *Amaranthushybridus* L. The use of these residues as a nutrient source is more profitable with high-value crops, especially for resource poor farmers. In addition, they are suitable for short vegetative cycle of market gardenings.

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