

Bioavailability of Nitrogen Derived from *Jatropha Curcas* L. Seed Cake through an Incubation Study

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Abstract – Organic matters and waste products are used as nitrogen fertilizer in the urban and peri-urban agricultural plant production in Kinshasa city, Democratic Republic of Congo.

Jatropha curcas L. (JCL) seed cake was mixed thoroughly with CREN-K soil (96% sand) and incubated for 1, 3, 7, 14, 21 and 42 days in glass flask under controlled conditions (28°C and 20% of moisture content). At the end of each incubation period, mineral nitrogen was extracted by adding 1N KCl (ratio KCl: soil 1:2).

NH₄⁺-N content was higher than NO₃⁻-N content at all incubation periods and reached a maximum value of 173.95 mg N/Kg of soil. Net inorganic N (NH₄⁺-N+NO₃⁻-N) released was relatively rapid during the first 14 days of incubation. Rich in nitrogen (5.67%), JCL seed cake has a potential to be utilized for soil fertility improvement and can be used as bio-fertilizer for short vegetative cycle of market gardening's.

Keywords – *Jatropha Curcas* L. Seed Cake, CREN-K Soil, Mineral Nitrogen, Incubation in Vitro, Bio-Fertilizer.

I. INTRODUCTION

The effective use of organic matters and waste products as nitrogen fertilizer is steadily increasing in the urban and peri-urban agricultural plant production in Kinshasa city, Democratic Republic of Congo (DRC). The synthetic fertilizers are becoming increasingly scarce and expensive. A growing number of gardeners are therefore turning to leaves and vegetal residues, breweries wastes and guano to improve the fertility of soils.

Predicting the production of mineral N compounds in soil during decomposition of organic waste is important in order to advise gardeners for proper plant nutrition.

The simple laboratory incubation experiments give relatively precise predictions of mineral N released from recently incorporated organic matter during decomposition in soil [1]-[2]. Previous studies have reported that different types of organic waste can improve physical, chemical and biological properties of soils [3]-[4]-[5].

Jatropha curcas L. (JCL) or physic nut (Euphorbiaceae) is a multipurpose tree with significant economic importance because of its several industrial and medicinal uses. This plant grows through most of tropics. The oil from these seeds can serve as fuel diesel engines indicating its potential as a renewable energy source [6]-[7]. Rich in Nitrogen, the seed cake is a by-product of oil extraction and can be a valuable source of available plant nutrients or biogas production [8]-[9].

The aim of this study was to evaluate under laboratory conditions potential net N mineralization rate availability from JCL seed cake in a sandy soil.

II. MATERIALS AND METHODS

Experiments were carried out in the Laboratory of Applied Physical Chemistry, Faculty of Bioscience-Engineering, Ghent University (Ugent), Belgium from February to April 2012.

II.1. Soil and organic matter

Soil samples and seeds of JCL were collected from the experimental garden of Regional Centre for Nuclear Studies of Kinshasa (CREN-K soil), DRC. Soil samples were passed through a 2mm stainless steel sieve and air-dried at room temperature.

The JCL seed cake was obtained after oil extraction and dried at 45°C until constant weight. The oil extraction yield was 49,7% [10].

II.2. Incubation Experiment

The incubation experiment was conducted in the Laboratory in view to convert organic N into mineral N during decomposition of JCL seed cake 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 JCL seed cake which was added 4 days after pre incubation. The unamended 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.

II.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 and JCL seed cake. Total concentrations of calcium, magnesium, potassium, sodium and phosphorus were determined by

Plasma Spectrometry method. Lignin, hemi-cellulose and cellulose were determined by the method [11]. Folin-Denis method as adapted by the method [12] was used for polyphenol analysis.

II. 4. Data analysis

The net N mineralization of JCL seed cake 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.

III. RESULTS AND DISCUSSION

III.1. Soil characterization

Table 1: Chemical characteristics of CREN-K soil used for incubation study.

Parameters	CREN-K soil
pH KCl	6.4
Total Nitrogen %	0.04
Total Carbon %	0.31
P assimilable %	2.004
K %	0.047
Mg %	11
Ca %	0.1
C/N	7.75
Sand %	96
Limon %	0.26
Clay %	0.0
CaCO ₃ %	0.26

Table 1 shows that sand 96% are the essential element of CREN-K soil texture. The C/N ratio 7.75 are inferior to 20. Therefore, the CREN-K soil is able for mineralization activity [13]. The low calcium carbonate content in this soil explains the acidic pH value. Mineral element contents and a pH value near neutrality are among important conditions for adequate activity of microorganism's nitrifiers. Soil characteristics influence largely the mineralization process of organic matter [14].

III.2. Characterization of organic matter

Table 2: Nutrient status of JCL seed cake.

Parameters	JCL seed cake
N (%)	5.67
C (%)	58.21
P (%)	2.5
Mg (%)	0.39
K (%)	0.87
Ca (%)	0.54
Lignin (%)	0.60
Cellulose (%)	3.7
Hemi-cellulose (%)	35.3
Polyphenol (%)	1.5
C/N	11.04
NDF	39.6
ADF	4.3

The analysis method, the state of organic matter and sampling method might influence the values presented in

table 2. The properties of JCL seed cake were compared with those of other organic fertilizer with regard to the basic nutrients for plant growth Nitrogen 5.67%, phosphorous 2.5% and potassium 0.87% levels. The nitrogen content was similar to that of neem oil cake, castor bean and cow/chicken manure. The results obtained corroborated those reports [15]-[16]-[17]-[18]. JCL seed cake can be substituted to chemical fertilizer: 10 kg replacing 0.15Kg of N: P: K 40: 20: 10. [19]. The application of 10 tonnes of fresh physic nut biomass resulted in increase yield of rice in Nepal [20]. Yields of *Jatropha curcas* have been shown to increase up to 120% due to JCL seed cake application [21]. It has a potential for improving soil fertility because it has low C/N ratio 11.04 suggesting that rapid N mineralization would be expected. 50 to 75% of JCL seed is left as cake during the oil extraction process [8]-[22]. Therefore, seed cake is available in large quantities.

III.3. Nitrogen Mineralization

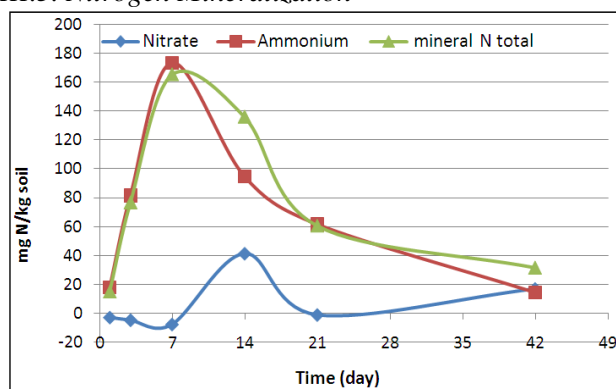


Fig.1. Extractable NH₄⁺-N and NO₃⁻-N from JCL seed cake applied to CREN-K soil.

Each point is an average of three replicates.

Fig.1 reveals changes in NH₄⁺-N and NO₃⁻-N concentrations with time in the JCL seed cake treated CREN-K soil. Nitrogen evolution in soil is highly influenced by organic matter mineralization rate. NH₄⁺-N was the dominant product of N-mineralization 7 days after incubation with 173.95 mg/Kg of soil. Net inorganic N (NH₄⁺-N and NO₃⁻-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 and thereafter decreases in total amount of inorganic nitrogen released. JCL seed cake can be suitable for short vegetative cycle of market gardening such as *Amaranthus hybridus* L.

NO₃⁻-N content was lower than NH₄⁺-N at all incubation periods. However, at the end of incubation NH₄⁺-N content was reduced significantly. The strong reduction of NH₄⁺-N was possibly due to the utilization of nitrogen from inorganic source by micro-organisms [23].

The total Nitrogen mineralized from organic waste materials varied considerably depending on the soil type and organic material [24]-[25]. C/N ratio and other parameters such as lignin, polyphenol and Nitrogen content may play an important role in the N-mineralization process [26].

IV. CONCLUSION

The investigations carried out *in vitro* incubation indicate that N-mineralization in sandy soil amended with JCL seed cake exhibited a rapid rate during the first 14 days after incubation. NH_4^+ -N content was higher than NO_3^- -N content at all incubation periods and reached a maximum value of 173.95 mg N/Kg of soil.

As the production of biodiesel from JCL increases, its residue material in terms of seed cake is anticipated to increase. To convert these residues into value added fertilizer is urgently needed.

The results presented support the conclusion that JCL seed cake is a potential fertilizer source for agricultural crops and can be used as bio-fertilizer for short vegetative cycle of market gardening's in the Kinshasa city, RDC.

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