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Anaerobic Co-digestion of Fresh Maize Leaves with Elephant Grass

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ABSTRACT: Anaerobic co-digestion of maize leaves (ML) with Elephant grass (EG) was studied in a single phase digester at ambient temperature (29±3°C). Special attention was paid to synergistic and antagonistic effect of co-digestion of the substrates on biogas production in order to establish the best blend. Six different treatments were set up based on mixture proportions in digesters labelled A-E. Digester A contained 100% maize leaves (100% ML), which served as control. The compositions of other digesters were as follows: Digester B contained 90% ML and 10% EG, C 80% ML, 20% EG, D 70% ML, 30% EG, and E 60% ML, 40% EG. The initial pH of the digesters varied from 3.94-4.12 while the final pH ranged from 3.01-10.49. 100% ML produced 520ml of biogas at the end of 20 days of the experiment. Digesters B and E had synergistic effects on biogas production with total volume of 870ml and 610ml respectively. However, Digesters C and D had negative effects on biogas yield producing 460ml and 400ml. Percentage decreases of the two digesters were 11.5% and 23.1% respectively. Digester E showed 67.3% higher biogas production compared to digestion of maize leaves alone. @JASEM

Keywords: co-digestion, maize leaves, elephant grass, biogas, synergistic effect

Anaerobic digestion (AD) is a process by which micro-organisms break down biodegradable material in the absence of oxygen (Clemens, 2006). Anaerobic digestion process for biogas generation occurs in four steps: Hydrolysis, Acidogenesis, Acetogenesis and Metanogenesis. In the first step, hydrolysis, insoluble and complex organic compounds such as lipids, polysaccharides, proteins, fats, nucleic acids, etc. transform into soluble and simpler organic materials such as amino acids, sugars and fatty acids by strict anaerobic hydrolytic bacteria (Davidsson, 2007; Yadvika et al., 2004). In the acidogenesis step obligate and facultative anaerobic group of bacteria (acidogens) ferments and breakdown soluble products from the first step into acetic acid, hydrogen, carbon dioxide, some volatile fatty acids (VFA) and alcohols. In the third step, acetogenesis, long chain fatty acids and volatile fatty acids will be converted to acetate, hydrogen and carbon dioxide by obligate hydrogen-producing acetogens. Finally in the methanogenesis step strict anaerobic methanogens convert acetic acid, hydrogen, carbon dioxide, methanol and other compounds into a mixture of methane and carbon dioxide and other trace gases (Davidsson, 2007; Yadvika et al., 2004). Anaerobic digestion can be used to treat various organic wastes and recover bio-energy in the form of biogas, which consists mainly of CH_4 and CO_2 (Clemens, 2006). Biogas production from agricultural biomass is of growing importance as it offers considerable environmental benefits such as energy savings, recycling of nutrients within agriculture and reduced CO_2 emissions (Kacprzak, 2009).

In anaerobic digestion, co-digestion is the term used to describe the combined treatment of several wastes with complementary characteristics, being one of the main advantages of anaerobic technology (Fernandez et al., 2005). The most common situation is when a major amount of a main basic substrate is mixed and digested together with minor amount of a single, or a variety of additional substrate (Braun, 2002). The use of co-substrates usually improves the biogas yields from anaerobic digester due to positive synergisms established in the digestion medium and the supply of missing nutrients by the co-substrates (Mata-alvarez et al., 2000). On the other hand, some authors have reported negative results in co-digestion processes, which were attributed to the specific characteristics of the digested wastes (Murto et al., 2004).

The objective of this study was to investigate synergistic and antagonistic effect of co-digestion of maize leaves (ML) with Elephant grass (EG) and determine the optimal ML/EG ratio for anaerobic digestion.

MATERIALS AND METHODS

Two different substrates, fresh maize leaves and Elephant grass were anaerobically co-digested in a 2L digester with working volume of 1L. The substrates were obtained from Auchi, Edo State, Nigeria. Maize leaves were the major substrate while Elephant grass was the minor substrate.

Batch digestion of samples was carried out at ambient temperature for 20 days and agitated once daily. A set of five batch reactors were used as digesters. Each digester contained varying amount of maize leaves and Elephant grass but fixed amount of water. The digesters were labelled A-E. Digester labeled A had 100% maize leaves. Compositions of other batch reactors B to E are as follows:

i. Digester B consisted of 90% maize leaves and 10% Elephant grass
ii. Digester C consisted of 80% maize leaves and 20% Elephant grass

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iii. Digester D consisted of 70% maize leaves and 30% Elephant grass

iv. Digester E consisted of 60% maize leaves and 40% Elephant grass

RESULTS AND DISCUSSION

The pH of the digesters before and after anaerobic digestion is depicted in table 1. The initial pH ranged from 3.94-4.12, while the final pH varied from 3.01-10.49. The rate of biogas production for all the samples is shown in fig 1. It is worthy of note that all the digesters started producing biogas from day 2 with only one day lag phase. This may indicate fast acclimatization of the micro-organisms to the feed stocks. Digester A recorded the highest daily yield on the 14th day, B on day 11, C on day 2, D on day 3 and E on day 10. Daily gas production did not follow a regular pattern in all the digesters. This may be due to the fact that the carbons contained in the samples were not equally degraded or converted to biogas through anaerobic digestion. Since the substrates were made up of non-degradable, rapidly degradable and slowly degradable fractions (Budiyono et al., 2009; Hobson, 1983).

Table 1: pH values of different mixture proportions of maize leaves and Elephant grass

pH	100%ML	90%EG:10%ML	80%EG:20%ML	70%EG:30%ML	60%EG:40%ML
Initial	3.98	3.94	4.02	4.07	4.12
Final	10.49	3.36	3.84	3.01	3.34

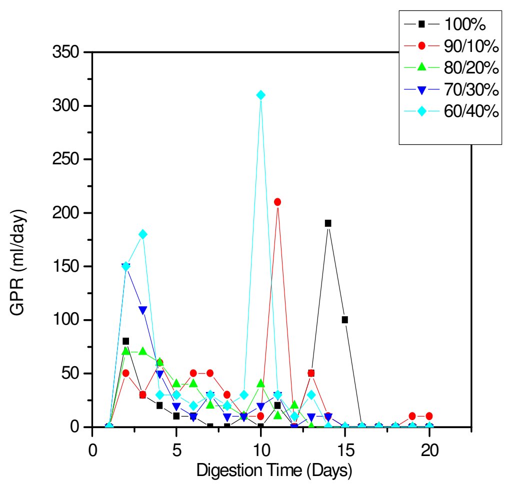

Fig. 1 Daily Gas Yield of Codigestion of Maize Leaves and Elephant Grass

Fig. 2 shows cumulative biogas yields for all the digesters. It was found that digester E with 60% ML and 40% EG produced the highest quantity of biogas (870ml); followed by digesters B with 610ml. Digesters B and E produced more biogas compared to the control (100% ML). This is in agreement with Mata-Alvarez et al., 2000, that digestion of more than one kind of substrate could establish positive synergism in the digester. The synergistic effect may be attributed to more balanced nutrients at these mixture proportions which would support microbial growth for efficient digestion. This is, however, contrary to the situation in digesters C and D in which antagonistic effect was observed on biogas yield.

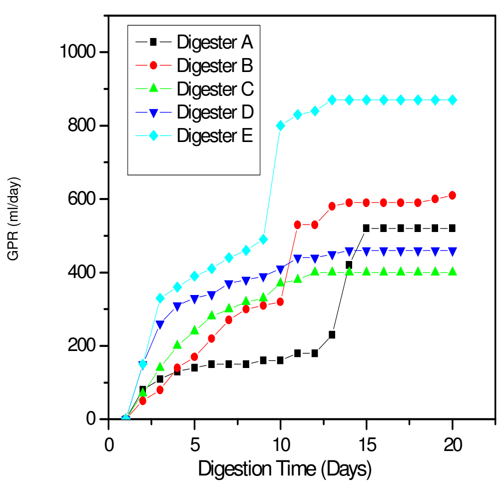

Fig. 2 Cumulative Daily Gas Yield of Co-digestion of Maize Leaves and Elephant Grass

Conclusion: The results showed that co-digestion of maize leaves (ML) with Elephant grass has both synergistic and antagonistic effects on biogas production depending on the mixture proportion. Digester E (60% ML, 40% EG) gave the optimum biogas yield which was 67.3% higher than the control. On the other hand, antagonistic effect was observed in digesters C and D with percentage decrease of 11.5% and 23.1% respectively. It is believed that the results obtained will provide useful information for further research work.

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