Consequence of C:N and C:P adjustments of rice straw on biomethanation in an anaerobic digester

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Abstract

Experiments were conducted at the Faculty of Agriculture, University of Ruhuna, to assess the influence of C:N and C:P ratios on anaerobic digestion of rice straw batch biomethanation.
The original rice straw C:N ratio of 80:1 was amended with urea (46% nitrogen) to maintain the C:N ratio between 10:1 to 40:1 After mixing with urea the highest total biogas production of 54.12 l and maximum methane percentage of 55% were recorded at 30:1 C:N ratio with 8 days of lag phase. The lowest gas production (23.59 l) and minimum methane percentage (18.2%) were given at 10:1 C:N ratio.
Concentrated super phosphate was added to adjust the C:P ratio on biogas production between 100:1 to 250:1 while a constant ratio of 30:1. The original C:P ratio of rice straw was 331:1. Adjusting C:P ratio to 200:1 produced the maximum gas yield of 54.99 l with five days of lag phase. Maximum percentage of methane was also produced at 200:1, while 100:1 C:P ratio gave the lower methane production.

Key words: Biomethanation, anaerobic digestion, rice straw, biogas, C: P, C: N ratios

Introduction

Anaerobic digestion may contribute a fair share to compensate for the production of methane as an alternative energy source. In Sri Lanka utilization of rice straw as a raw material for biomethanation is gain wider popularity. It is an estimated that about 2.6 million metric tons of straws are produced per annum in Sri Lanka, (De Alwis 2001) out of which over 2/3 is being wasted. Nearly 1000 biogas generators are already in operation in the country.
Methane fermentation depends upon the maintenance of optimum biological growth, which ensures satisfactory digestion. The microbial population, that is responsible for waste conversion and stabilization during anaerobic digestion, requires nitrogen, phosphorus and other elements.
Nitrogen is a major nutrient for the growth and optimum functioning of the microbial system. Phosphorus on the other hand is essential for both microbial growth and maintaining of an optimal pH as well as an important constituent of the energy yielding system the bacterial populations (Britz 1983).
Carbon to nitrogen(C: N) ratio and carbon to phosphorus (C: P) ratio of the feedstock have been found to be useful parameters in evaluating digester performance. Excess nitrogen results in inhibition of bacterial growth due to ammonia toxicity, which can be overcome by adjusting the carbon to nitrogen ratio.
The main objective of this study is to optimize C: N and C: P ratios for maximum biogas yield and methane percentage under batch condition, using urea and concentrated super phosphate as amendments to adjust C: N and C: P ratios in rice straw.

Materials and Methods

Rice straw was oven dried at 80^0 C for 8 hrs and chopped to 1.0-1.5 cm size and stored in sealed polythene bags in a cool dry place. Fertilizer grade urea (46% nitrogen) and concentrated super phosphate (20%P_2O_5) were used to adjust the C: N ratio and C: P ratio, respectively.

<u>Anaerobic digestion</u>
Plastic containers of 20-litre capacity were used as digesters for each treatment. In each digester one kg of dry straw was used. 50 grams of Cow dung was inoculated as an active inoculum of methanogenic bacteria. Digester was connected to a jar immersed in water to measure the gas production. Methane meter was used to measure methane percentage.

<u>C: N ratio</u>
The original C: N ratio of 80:1in rice straw was narrowed down using requisite quantity of urea as a source of nitrogen and adjusted to range between 10:1 and 40:1, as indicated in the Table 1.

C: P ratio

The original C: P ratio of 331:1in rice straw was narrowed down using required quantity of concentrated super phosphate as source of phosphorus and adjusted between 100: 1 to 250:1 (Table 2). In the experiment C: N ratio was maintained at 30:1 with requisite quantity

Biogas produced in the digesters was measured by the downward displacement of water. Periodically slurry samples were withdrawn to examine the p^H value. Methane percentage was measured using methane analyzer on weekly basis. Fermentation was carried out at ambient temperate, ranging from 30-35 ^{0}C for 45 days in identical experimental duplications. Time taken to liberate the burning gas i.e. Lag phase was also measured.

Results and Discussion

The highest rate of gas production (54.12 l) was recordered when the C: N ratio was maintained at 30:1 (Table 1). When C: N ratio was 10:1, gas liberation was low. When the C: N ratio was between 15:1 and 25:1, poor production of gas was detected which may be due to ammonia toxicity. The highest methane percentage (55%) was detected at 30:1 combination with 8 days of lag phase. Thus, it was evident that the C: N ratio of 30:1 was optimum for straw biomethanation.

Table 1: Biogas liberation from straw biomethanation at different C: N ratios

Parameter	10:1 C: N	15:1 C: N	25:1 C: N	30:1 C: N	40:1 C: N
pH range	6.9-7.1	7-7.2	7-7.2	7-7.2	7-7.3
Total gas production (l)	23.59	33.92	35.5	54.12	27.72
Maximum methane (%)	18.5	24.2	52	55	20.2
Lag phase (Days)	21	16	14	08	18

It was evident that gas liberation (54.99 l) and maximum methane production was achieved when C: P ratio was kept at 200:1 level (Table 2) with a lag phase period of 5 days. Gas production was low when C: P ratio was 100:1. It was apparent that C: P ratio of 200:1 was the optimum for rice straw biomethanation.

Table 2. Biogas liberation from straw biomethanation at varying C: P ratios

Parameter	100:1 C: P	150:1 C: P	200:1 C: P	250:1 C: P
'PH range	6.2-7.3	6.8-7.4	6.9-7.6	6.1-7.6
Total gas production (l)	27.31	30.5	54.99	35.50
Maximum methane (%)	53.5	54.6	58.5	55.5
Lag phase (days)	13	10	05	08

Conclusions

1. The respective C: N and C: P ratios of paddy straw lies at 80: 1 and 331:1 which is not a favorable environment for the growth and development of methanogenic bacteria.
2. Maintenance of C: N and C: P ratios 30:1 and 200:1 in straw digester appear to be the best combination to maximize the biogas production with highest percentage of methane.
3. Mixing of Nitrogen source (urea) with phosphorus source (concentrated super phosphate) helps to increase the C: N and C: P ratios.
4. Materials with low nitrogen and low phosphorus content mixed with high nitrogen and high phosphorus material could be a better option when for maximizing the biogas production.

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