Utilization of rice crop residuals for biogas production through anaerobic digestion

A. Kalaitzidis [1,2], N.E Korres [2], G.-C. Mitraka [3], D. Katsantonis[1] and P.G Kougias[3]

[1]Institute of Plant Breeding and Genetic Resources, Hellenic Agricultural Organization – Dimitra, Thermi, 57001, Greece
[2]University of Ioannina, Department of Agriculture, University Campus of Arta, 47100 Kostakii Arta, Greece
[3]Soil and Water Resources Institute, Hellenic Agricultural Organization – Dimitra, Thermi, 57001, Greece

(E-mail: c.mitraka@swri.gr; kalaitzidis@cerealinstitute.gr; nkorres@uoi.gr; dikatsa@cerealinstitute.gr; kougiaspanos@gmail.com)

Introduction

Figure 1. Digesters used to assess the optimum ratio of pre-treated rice straw and swine slurry.

The growing global population and increasing energy demands require environmentally friendly energy sources. Anaerobic digestion (AD) of organic wastes, such as rice straw and swine slurry, can be a solution. Co-digestion of rice straw and swine slurry is more effective than mono-digestion of each substrate separately.

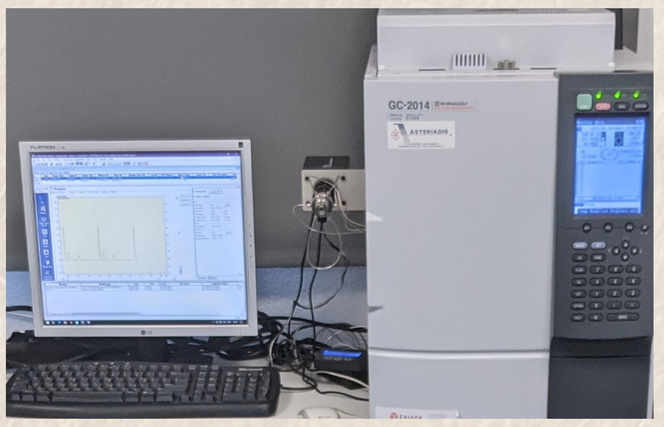

Figure 2. Gas chromatography utilised to estimate the methane production of the digesters

The aim of this research was to evaluate two methods for rice biomass pre-treatment and use the most promising to determine the optimal ratio of pre-treated rice straw and swine slurry in co-digestion batch experiments.

Results & Discussion

Table 1. Conditions applied for rice straw pre-treatment.

	Rice Straw
1	Manual (rice straw was chopped 2-3 cm in length with paper scissors) (Control)
2	Mechanical (rice straw was grinded by a laboratory mill in pieces of 0.5 mm)
	Thermal
3	Manual + LD, 130 ^{0}C for 30 min (30DIG130RAW)
4	Manual + LD, 130 ^{0}C for 60 min (60DIG130RAW)
5	Manual + LD, 190 ^{0}C for 30 min (30DIG190RAW)
6	Manual + LD, 190 0C for 60 min (60DIG190RAW)
7	Mechanical + LD, 130 ^{0}C for 30 min (30DIG130MEC)
8	Mechanical + LD, 130 ^{0}C for 60 min (60DIG130MEC)
9	Mechanical + LD, 190 ^{0}C for 30 min (30DIG190MEC)
10	Mechanical + LD, 190 ^{0}C for 60 min (60DIG190MEC)
	Thermo-chemical
11	Manual + NaOH 4% w/w TS at 121 ^{0}C for 20 min (4TS121RAW)
12	Manual + NaOH 6% w/w TS at 55 ^{0}C for 24 h (6TS55RAW)
13	Mechanical + NaOH 4% w/w TS at 121 ^{0}C for 20 min (4TS121MEC)
14	Mechanical + NaOH 6% w/w TS at 55 ^{0}C for 24 h (6TS55MEC)

* LD = liquid fraction from a commercial biogas reactor.

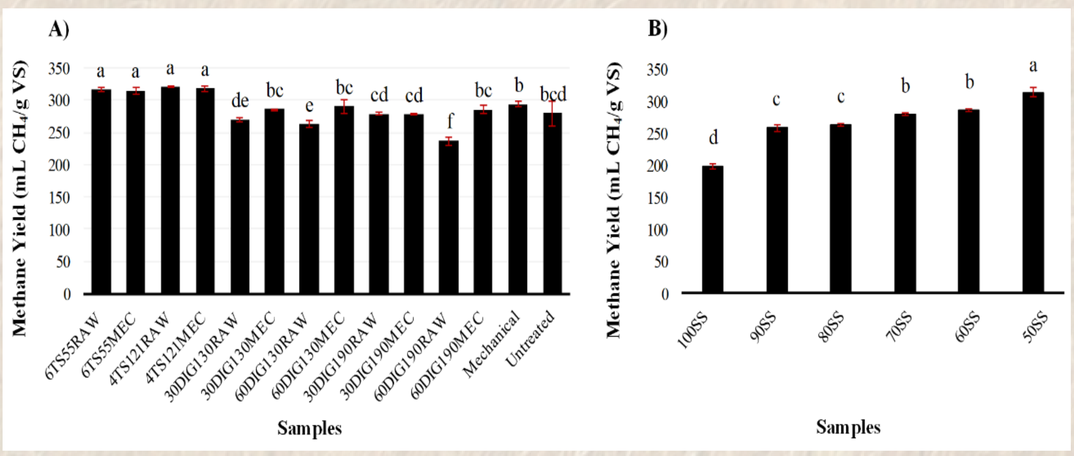

Figure 3. (A) Bar chart of statistically significant differences between the pre-treated samples, regarding methane yield; (B) Bar chart of statistically significant differences between the co-digestion samples, regarding methane yield. Different letters indicate differences between samples at a=0.05.

Rice biomass pre-treatment

Two methods were adopted to pre-treat the recalcitrant rice biomass. The first method was thermochemical and the second was thermal. The first method involved the use of either mechanically or manually chopped rice with the addition of heat and NaOH. The second was performed with mechanically or manually chopped rice, the liquid fraction (LD) from a commercial biogas plant and heat. According to the analyses, the treatments which presented the highest methane yield were those treated with NaOH. These results correspond to an increase in methane yield from 13 to 15%, compared to the untreated (control). Our results appear to be in line with those presented by Tsapekos et al. (2016).

Pre-treated rice straw (p-RS) and swine slurry (SS) co-digestion experiments

Regarding the co-digestion experiments, five ratios of p-RS:SS (% w/v) were investigated. Specifically, 50% SS and 50% p-RS (50SS), 60% SS and 40% p-RS (60SS), 70% SS and 30% p-RS (70SS), 80% SS and 20% p-RS (80SS) 90% SS and 10% p-RS (90SS), while the sample 100SS was exclusively comprised from SS and served as the control. According to the results of the analyses, the treatment which presented the highest methane yield was 50SS, followed by 60SS and 70SS. These results correspond to an increase in methane yield of 59, 44 and 41%, respectively, compared to the SS (Control). Similar conclusions were drawn from Darwin et al. (2014).

Conclusions

- The pre-treatment of the recalcitrant rice biomass with NaOH and heat enhances its biodegradability.
- While, the co-digestion of pre-treated rice straw with SS increases methane production, compared to the mono-digestion of the SS, without impairing the methanogenesis procedure.

Acknowledgments

This research was funded under the 'Innovation Investment Schemes' in the framework of the Operational Program of Central Macedonia 2014-2020 and it is co-funded by the European Social Fund through the National Strategic Reference Framework. Project code KMP6-0234326, MIS: 5136522. This research is part of Mr. Kalaitzidis PhD thesis.

European Union
European Regional Development Fund

REGION OF CENTRAL MACEDONIA
MANAGING AUTHORITY
O.P. Region of Central Macedonia

ΕΣΠΑ 2014-2020

Co-financed by Greece and the European Union