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Studies on the aerogenesis effect of different proportioned straw and pig manure blend fermentation

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Abstract. Sugarcane leaves, banana stems and pineapple stem leaves were used as raw material to research the aerogenesis effect and influence of different proportioned straw and pig manure blend fermentation. Research result showed that multi-straw different proportioned blend fermentation could shorten fermentation period. Under the condition of same fermentation temperature and time, the max total gas output 17040.58mL can be obtained by mainly using pineapple stem leaves with sugarcane leaves for blend fermentation with weight ratio of 1:4:1, with no addition of pig manure, inoculum 30% and dry material concentration 20%. Under the same condition, the total gas output of experiment group with straws containing pineapple stems leaves is higher than the group without pineapple leave residue. Research result provided theoretical basis for the actual application of various crop straws' blend fermentation methane-producing.

1. Introduction

According to statistics, the output of Chinese primary main crop straw has reached 900 million tons [1]. A large amount of crop straw discarding has caused massive farmland occupation and serious resource waste. Environmental pollution and safety accidents caused by straw burning happen a lot. Straw problem has become the key work task of summer harvesting and autumn harvesting for base-level government [2-3]. Livestock and poultry industry is the competitive industry of Chinese rural economy. Large-scale pig farm has become the main subject of pig raising in Chinese live pig producing areas. However, large-scale pig raising has brought serous environmental pollution [4] while achieving its advantage of intensive economy. At present, anaerobic digestion for transferring crop straw and poultry manure into methane has become an effective way to improve rural waste resource utilization as it can solve rural fuel shortage issue and can realize agricultural wastes' harmless treatment and multilevel resource utilization. Some scholars point out blend anaerobic fermentation and optimized blend material combination will be the important development direction of anaerobic digestion technology [5]. Dry anaerobic digestion refers to the methane anaerobe fermentation process with solid-state fermentation material rich in water barely free flow. Compared with wet fermentation, its main advantages are water-saving, less pollutant emission, and low fermentation residuum handling expense. So it is a technological approach more suitable for straw and poultry manure blend fermentation [6]. Currently, there are a lot of researches on pig manure, chicken manure and crop straw blend fermentation. But researches on different proportioned straw and pig manure blend for dry anaerobic fermentation are rarely reported. In this research, sugarcane leaves, banana stems and pineapple stem leaves were used as raw material to study the aerogenesis potential of different proportioned three straws with pig manure blend fermentation, and explore the optimal ratio of crop straw and pig manure as fermentation raw materials for the purpose of providing

theoretical basis for practical application of blend dry fermentation technology in agricultural waste treatment.

2. Materials and Methods

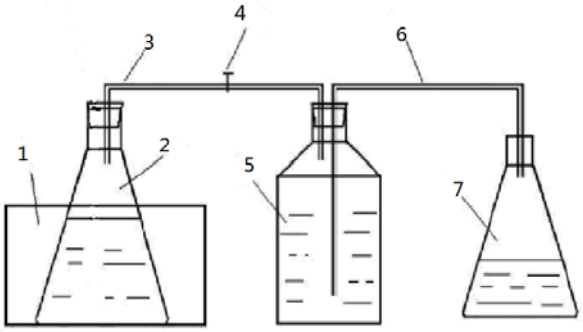
2.1. Materials

Dry yellow sugarcane leaves after harvesting in Mazhang District of Zhanjiang City were selected for bundling and storage. Grind into 1-5 cm short pieces with grinder when using; pineapple leave residues after fiber extraction were selected from Xuwen County, Zhanjiang City; Banana stem residues after fiber extraction were selected from production units around; pig manure was selected from individual pig farm in Gaoyang of Zhanjiang City.

Inoculum: selected from the normally fermented substrates (fermentation substrates with pig manure, domestic sewage sludge, and sugarcane leaves as raw materials) in the methane base of CATAS Agricultural Machinery Research Institute.

2.2. Testing Apparatus

1L conical flask was used as digestion reactor. Gases produced in the anaerobic digestion process were collected by 1L wild-mouth bottle. 1L conical flask was used as water collector. The device was connected by corrosion resistant latex tubes to compose a set of enclosed anaerobic digestion device, shown in figure 1. The electric-heated thermostatic water bath is used for testing apparatus heating and thermal insulation.



1.Electric-heated thermostatic water bath 2.1L conical flask (fermentation flask) 3. Gas-guide tube 4.Gas port 5.Gas collecting bottle (1L wild-mouth bottle) 6. Water aqueduct 7. Gas collecting bottle (1L conical flask)

Figure 1. Dry anaerobic methane fermentation device

2.3. Test Method

Sugarcane leaves, banana stems and pineapple stem leaves were blended in pairs (sugarcane leaves and banana stems, sugarcane leaves and pineapple stem leaves, banana stems and pineapple stem leaves) in the test. Selected four greater influence factors, different straw proportions, manure-straw proportion, dry material concentration, and inoculum concentration, and designed the blend materials' anaerobic fermentation scheme containing 4 factors and 7 levels with uniform design method.

Material proportion blending was conducted according to uniform experiment design table for inoculation of design dosage inoculum; canning after stirring evenly with canning coefficient of 70% (1000mL×70%=700mL); fermentation temperature of 38℃; fermentation time of 18d; each treatment was repeated twice and measured the gas output on time every day.

Table 1. Blend material fermentation methane producing experiment factor level table

Level	X1 Straw blend proportion(W:W)	X2 Manure-straw proportion (dry material proportion)	X3 Dry material concentration %	X4 Inoculum concentration (%)
1	0.2	0	5	10
2	0.4	0.25	10	20
3	0.6	0.5	15	30
4	0.8	0.75	20	40
5	1.0	1.0	25	50
6	1.2	1.25	30	60
7	1.4	1.5	35	70

Table 2. Different proportioned straw and pig manure blend fermentation uniform experiment design table

Level	X1 Straw different proportions(W:W)	X2 Manure-straw proportion (dry material proportion)	X3 Dry material concentration %	X4 Inoculum concentration(%)
1	4	3	7	1
2	6	6	6	6
3	5	4	1	5
4	7	1	4	3
5	1	5	5	4
6	3	7	2	2
7	2	2	3	7

3. Result and Analysis

3.1. Influence of different proportioned straw and pig manure blend fermentation on daily gas output

In this test, discarded straws of three crops, sugarcane leaves, banana stems and pineapple stem leaves, were blended in pairs in different proportions as main elements, considering the comprehensive influence of manure-straw proportion, dry material concentration, inoculum factors, by designing totally 21 experiments with complete design method to comprehensively analyze the feasibility of different straws, straw and manure blend fermentation. It can be seen from figure 2 that the first three days before fermentation of all blend materials containing pineapple leaves is the aerogenesis peak period. Small aerogenesis peak occurred from the fifth day to the eleventh day of fermentation. Max daily gas output 2767ml was obtained on the second day of fermentation when the proportion of pineapple leave residues and sugarcane leaves was 1.4, manure-straw proportion was 0, dry material concentration was 20% and inoculum was 30%. There were large gas output in different proportioned blend fermentation within 24h but the gas output reduced sharply after 3 days of fermentation. Then, the change trend of different proportioned daily gas output was different, showing a declining tendency as a whole. After 11 days' fermentation, most gas output approached 0. Therefore, we think different proportioned blend fermentation of straws can effectively shorten fermentation cycle and improve device processing efficiency compared with sole-straw fermentation [7], sole straw and poultry manure fermentation [8], and sole poultry manure fermentation [9].

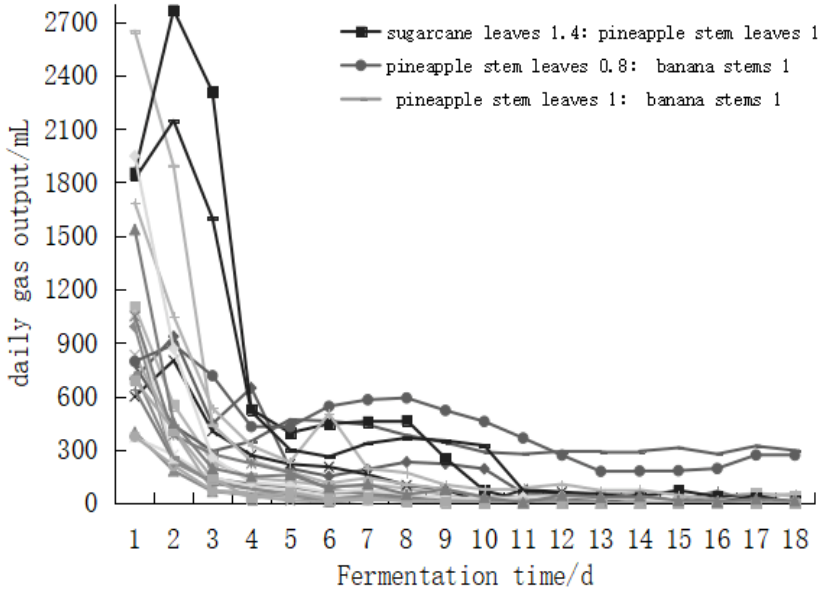


Figure 2. Influence of different proportioned straw and pig manure blend fermentation on daily gas output

3.2. Influence of different proportioned straw and pig manure blend fermentation on total gas output

It can be seen from figure 3 that with total gas output as the index, within design scope under the same fermentation condition, the total gas output of experiment group with straws containing pineapple stems leaves is higher than the group without pineapple leave residue. Under the condition of same fermentation temperature and time, pineapple stem leaves were used with sugarcane leaves for blend ratio of 1:4, manure-straw ration of 0; dry material concentration 20% and inoculum 30%, the max total gas output 17041mL could be obtained. . It is the optimal pineapple leaf residue and sugarcane leaf blend fermentation technology. The optimal condition for pineapple leaf residue and banana stem residue is blend ratio of 1.4; manure-straw ration of 0; dry material concentration 20% and inoculum 30%, the max total gas output 12657mL could be obtained. Under the condition of banana stem residue and sugarcane leaf blend ratio of 0.8, manure-straw ration of 0.5; dry material concentration 30% and inoculum 30%, the max total gas output 7845mL could be obtained. It is the most suitable banana stem residue and sugarcane leaf blend ratio and dry anaerobic fermentation condition. Compared with the experiment group under the optimal fermentation condition, pineapple leaf residue and sugarcane leaf blend fermentation is most effective for methane producing. Its total gas output is 2.17 times of the sugarcane leaf and banana stem blend group, not different with pineapple stem leaf and banana steam blend fermentation group. The second is pineapple stem leaf and banana steam blend fermentation, with total gas output 1.61 times of sugarcane leaf and banana steam blend group. Optimal aerogenesis effect could be obtained with no need to add pig manure into the optimal process obtained in pineapple stem leaf and sugarcane leaf, banana stem leaf blend fermentation. This is possibly because the pineapple leaf contains rich nitrogen element which can match with other straws (sugarcane leaf and banana stem) containing rich carbon element to obtain suitable carbon nitrogen ratio required by fermentation. Therefore, it can be considered that pineapple leaves can be independently used with other straws for blend fermentation in main pineapple producing areas so as to solve uneven raw material distribution, and seasonal straw production problems.

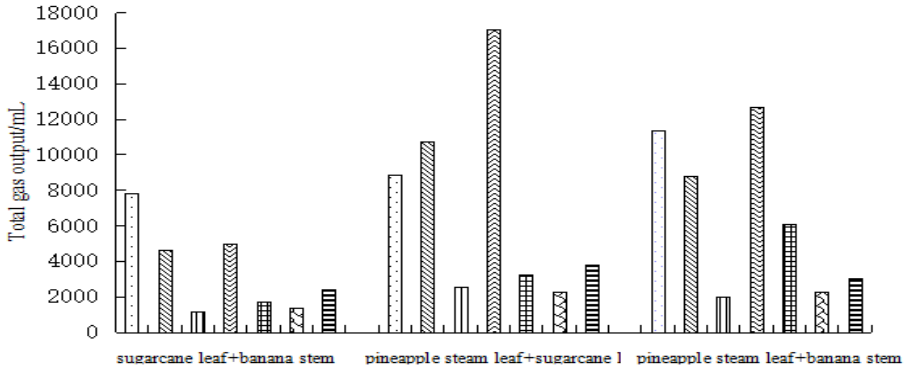


Figure 3. Influence of different proportioned straw and pig manure blend fermentation on total gas output

4. Conclusion

Different raw material blend proportion determines the gas output and aerogenesis potential, as well as the important factor influences the anaerobic fermentation aerogenesis effect. Various straws' different proportion blend fermentation can shorten the fermentation cycle. Under the same condition of same fermentation temperature and time, the max total gas output 17040.58mL can be obtained by mainly using pineapple stem leaves with sugarcane leaves for blend fermentation with weight ratio of 1:4:1, with no addition of pig manure, inoculum 30% and dry material concentration 20%. Under the same condition, the total gas output of experiment group with straw containing pineapple stem leaf is higher than the group which contains no pineapple leaf residue.

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