Leaflet No. 11/ 85-86

Government of the Union of Myanmar
Ministry of Forestry
Forest Department

Studies on the Biogas Production of Bawzagaing [*Leucaena leucocephala*] and Thinbaw Kokko [*Samanea saman*] leaves.

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1986

Acknowledgements

The authors are very much grateful to U Hla Tin, Researcher, Agriculture Research Institute, Yezin, (formerly Instructor of the Biogas Production and Utilization Course, Ywathagyi) for the valuable discussion, advice and cooperation given by him this study.

ဘောစကိုင်းနှင့် သဘော်ာကုက္ကို သစ်ရွက်များမှ ဇီဝဓါတ်ငွေ့အထွက်နှုန်းကို လေ့လာခြင်း။

ဦးခင်မောင်လှ B.Sc, [For.] [Rgn.] သုတေသနမှူး
ဦးစိုးတင့် B.Sc , [For.], [Rgn.], M.Sc. [ANU], ဌာနမှူး
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်းချုပ်

မြန်မာနိုင်ငံတွင် လူဦးရေတိုးပွါးလာသည်နှင့်အမျှ လောင်စာအဖြစ် ထင်းခုတ်ယူသုံးစွဲမှု မြင့်မားလာကာ၊ သစ်တောများ ပြုန်းတီးနေမည် ဖြစ်ပါသည်။ နေ့စဉ် ချက်ပြုတ်ရန် လိုအပ်သော လောင်စာ အား၊ သစ်ထင်းမှလွဲ၍၊ သစ်ရွက်များမှ ဇီဝဓါတ်ငွေ့ထုတ်လုပ်သုံးစွဲနိုင်ပါသည်။ ထိုသို့သစ်ရွက်များမှ ဇီဝဓါတ်ငွေ့ သုံးစွဲရာတွင် သစ်မျိုးအလိုက် ဇီဝဓါတ်ငွေ့ထွက်ရှိမှုကို သိရှိရန် လိုအပ်ပါသည်။ သို့ပါ၍ ပထမအဆင့် အနေဖြင့် ပေါက်ရောက်မြန်၍ ဖြစ်ထွန်းလွယ်သော ဘောစကိုင်းပင်နှင့် -နိုင်ငံအနှံ့အပြား တောရော မြို့ပါ အလွယ်တကူရရှိနိုင်သော သဘော်ာကုက္ကိုသစ်ပင်များမှ အရွက်များ၏ ဇီဝဓါတ်ငွေ့အထွက်နှုန်းကို လေ့လာ နှိုင်းယှဉ် တင်ပြထားပါသည်။

Studies on the Biogas Production of Bawzagaing *(Leucaena Leucocephala)* And Thinnbaw-Kokko *(Samanea Saman)* Leaves.

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Abstract

With the increase in population, the demand of fuelwood for domestic and other use will also increase; this inturn will speed up the rate of forest denudation. It has been known that biogas produced from tree leaves could be substituted for burning. To use effectively the biogas for heat production, it is necessary to know the biogas out turn from leaves of different tree species. To this end, leaves of Bawzagaing *(Leucaena leucocephala),* which is easily adaptable to most sites and is fast grown, and Thinbaw-kokko *(Samanea saman)* which is also easily available in both urban and rural areas, are studied for their biogas production as a first attempt.

Contents

1. Introduction

The population of Burma is increasing at the rate of 2 % annually. The demand for fuelwood for domestic consumption and industrial use has also increased.

The Forest Research Institute has been assigned the task of seeking better utilization of the forest resources including fuel for domestic use. Other agencies seek increased production of fossil energy such as gas and pertroleums. One alternative source of energy is "biogas" produced from agricultural wastes.

The Ministry of Agriculture & Forests is conducting a series of training programs for Departmental personnel to assist the general public in developing understanding of the usefulness and role of biogas in meeting domestic energy needs.

Biogas can be produced from many type of waste and leaves. Apart from wood, all organic matter is suitable for a biogas plant. The use of tree leaves rather than burning the wood itself to produce energy will reduce the rate of demand on the forest resources.

The Institute has started investigations of the use of tree leaves for biogas. The objectives are to determine the suitability of different species of tree leaves or groups of species in production of biogas and feasibility for domestic use in cost studies at a later date. This study reports the initial investigations into the use of tree leaves for biogas production from two tree species.

2. Literature Review

2.1 Biogas

Biogas is a flammable gas produced by an anaerobic fermentation of organic matter mixed with water and decomposed by Bacteria in the absence of air (Anon, 1982).

It is almost odourless with minimum smell consisting of 60-70 % of combustable methane (CH_4), 28-30 % of carbondioxide (CO_2) , 1 % of hydrogen sulphide (H_2S), traces of hydrogen (H_2), small amounts are nitrogen (N_2) and oxygen (O_2). The gas is useful for cooking, lighting, heating and engine driving.

Biogas is also known as " Marsh gas ", "Gober gas", " Thick gas", Swamp gas" and "Sledge gas".

It burns with a blue flame free from soot said to have a calorific value of 4700-5500 K Cal/m^3 (525-614 BTU/c.ft) and a density of 20 % less than that of air.

The gas burns when mixed with air. A special burner jet is required to adjust the flow of gas and air intake. The flow rate should be higher than the speed of combustion of the gas or otherwise the flame will go out. A special mantle lamp for lighting can be made by a local blacksmith. As the gas is burnt the hot mantle glows in the heat and gives off light. The gas pressure required for the lamp is said to be at least 10 cm (3.9") in the manometer. (Anon, 1982).

2.2 Organic Matter

Types of organic matter that can produce biogas are (i) animal wastes, (ii) plant (agricultural) wastes and (iii) human waste. Fibrous substance such as straw grass, leaves etc. can from a floating scum and may cause blockage of biogas plant and therefore must be chopped into small pieces as necessary. Chopping also helps to accelerate the decomposition of the raw materials.

Animal waste contains more nitrogen and can be easily digested by microbes. Thus the gas production form animal waste starts and is exhausted rapidly. Daily feeding of animal waste is necessary.

Leaves and grain straw are rich in carbon normally, and take more time to digest. Thus gas production takes time start and is said to yield gas longer from one batch. Thus daily feeding is no necessary. (Non, 1982)

2.3 History of Biogas

Production of biogas from the animal wastes was started in the 19^{th} century. India has done research on Biogas production since 1939 and beginning from 1951, the biogas was used as a substitute for fuelwood in cooking. It has been reported, that there are over 100,000 biogas plants in India.

In China, research was started in 1950, primarily for agricultural fertilizer. In 1970, it was reported that China had over 7,000,000 biogas plants for household use and over 36,000 larger biogas plants for industrial use. (Anon, 1982).

In 1960, a Frenchman experimented with leaves for biogas production. He reported that, a drum of 141 cu.ft. $2/3^{rd}$ filled with chopped leaves and water can yield gas enough for two ovens, one lighting burner, one hundred watt generator, and to drive a car for 12 miles for one year. In addition water pipes were coiled around the drum; and covered with leaves for insulation. The heat from the system heated water for the kitchen and the shower.

In Burma biogas production from leaves was carried out successfully in Ywathagyi Village, Hlegu Township. (Anon, 1982).

2.4. Processing Stages

Three main stages occur in the gas production; (i) Hydrolysis or liquefaction period, (ii) Acid producing period, and (iii) Methane producing period.

(1) Hydrolysis Period - Non-methane yielding microbes mainly consisting of Protozoa, fungi, and bacteria, start breaking down the carbohydrates, protein and fats of the solid organic matters into sugar, fatty acids and amino acids.

(2) Acid-Producing Period- The reaction of acid-producing bacteria on the hydrolysed organic matter, produce some organic acids, alcohol, carbon dioxide and hydrogen. In this condition, acetic acid is produced (70 %) which encourages the multiplication of methane-producing bacteria. Some carbon dioxide and hydrogen are also produced.

(3) Methane-Producing Period- The methane-producing bacteria (Mathanogen) act on the volatile acids and thus produces the methane gas and a small amount of carbon dioxide and hydrogen.

2.5. Types of Biogas Plants

There are five types of biogas plants, depending on the organic matter used.

(i). Fixed Dome Type
(ii). Integrated, floating drum type with continuous feed
(iii). Trench type
(iv). Flexible bag type
(v). Separate floating drum type, water sealed with continuous feed.

According to the literature, it is estimated that a brick digester may last for 20 years and a metal gas holder will last for 8 years. (Anon, (1982).

A fixed digester with separate gas-holder was the type the Frenchman used to produce gas from leaves. Empty drums, concrete containers, and glazed earthen jars can be used as digesters and old car type tubes, plastic bags and rubber bags can be used as gas holders.

The pilot plant constructed for this study is a combination of a fixed tank digester and a separate floating gas holder type. It is a batch system. A detailed description is described in the Material and Method Section.

2.6. Consumption of biogas

The gas required for a Burmese family of 6 members is estimated at 70 cu.ft. daily. Another study estimated that the gas requirement for cooking is $0.24m^3$/person/day, this equals to 50 cu.ft of gas for family of six per day, a little less than the first estimate. The gas requirement for lighting estimated at 0.12 - 0.50 m^3/ hour/lamp or 4.23-17.65 cu.ft /hour/ lamp. Gas requirement for engine operation is 0.45 m^3/H.P/ hour. This is equal to 15.88 cu.ft / H.P /hour. Thus the gas holder should have a capacity to hold at least 70 cu.ft. of gas to enable to collect enough gas for a household use for a day. (Anon, 1982).

2.7. Temperature effect on biogas production

Temperature plays an important role in biogas yield. The bacteria, like other living organisms are active when conditions are favourable. It is therefore important that the temperature should be in the range of 25^o C and 30^o C. If the temperature is below 25^o C or tends to fluctuate, gas production drops abruptly, and below 15^o C gas production stops. Thus biogas plants have limited value in mountainous areas with cold winters. In warm tropical zones there is no problem in maintaining the required temperature.

The fermentation period depends greatly on the temperature. The higher the temperature, the shorter the time to start gas production. A smaller digester with less mass heats up faster.

2.8. Site selection for the biogas plant.

There are certain criteria that should be taken into consideration in selecting the site for a plant. They are: -

(i). The plant should stand in the sun but not exposed to the wind.
(ii). It should not be more than 100^o from the house to keep the piper-fitting cost low.
(iii). It should be down wind from residences to keep any smell away.
(iv). It should be near to the raw material.
(v). It also should be near to the place where the residue fertilizer will be used.
(vi). It should not be close to bamboo clumps and large trees as the roots may damage the biogas plant (concrete digester only).

2.9. C/N Ratio

The carbon / nitrogen ratio (C/N) is one of the important factors in gas production and a ratio of 30 optimum. The microbes utilize nitrogen to produce protein. If there is not enough nitrogen, the microbes are not able to use up all the carbon dioxide required to produce energy. Too high a C/N will decrease the rate of reaction and too low will produce excess ammonia compound which is toxic to the microbes. Various C/N ratios which have been developed are shown in Table 1,2 and 3.

Table 1. C/N ration of some organic matters.*

Sr. No.	Material	Carbon & by wt	Nitrogen & by wt	C/ N ratio
1.	Wheat straw	46	0.53	87:1
2.	Rice straw	42	0.63	67:1
3.	Corn stalks	40	0.75	53:1
4.	Fallen leaves	41	1.00	41:1
5.	Soybean stalks	41	1.30	32:1
6.	Weeds	14	0.54	27:1
7.	Peanut stalks & leaves	11	0.59	19:1
8.	Dung			
	Sheep	16	0.55	29:1
	Cattle	7.3	0.29	25:1
	horse	10.0	0.42	24:1
	pig	7.8	0.65	13:1
	Human feces	2.5	0.85	2.9:1

* Source : -Guide Book on Biogas Development.

Table 2. C/N ratio of some organic matter*

Sr. No.	Material	C/N ratio	Remarks
1.	Straw	43:1	
2.	Cow dung	25:1	
3.	Ipil - Ipil (Bawsagaing)	8:1	
4.	In*(Dipterocarpus tuberculatus)*	28:1	
5.	Husk (Rice)	146:1	
6.	Sha *(Acacia catochu)*	15:1	
7.	Dahat *(Tectona hamaltoniana)*	22:1	
8.	Bagass (Sugar)	155:1	
9.	Tan *(Terminalia oliveri)*	31:1	
10	Saw dust	840:1	

* Source: (Anon, 1982)

`Table 3. C/N ratio of some organic matter*

Sr. No.	Material	Carbon (% by wt)	Nitrogen (% by wt.)	C/N ratio
1.	Ipil - Ipil (Bawsagaing)	43.1	3.33	13.03:1
2.	Mezali *(Cassia siamea)*	45.24	2.23	20.28:1
3.	Thinbaw kokko *(Somanea saman)*	54.38	3.05	17.84:1
4.	Bizat *(Eupatorium odoratum)*	50.84	2.16	23.53:1
5.	Saw dust	45.63	0.23	194.53:1

* Source : -Forest Research Institute , Yezin, Natural Resources Division. Special study for this paper (1984).

3. Materials and Methods

3.1. The Biogas Plant

The biogas plant was prepared by the Forest Department and was sent to the Forest Research Institute (FRI) for experimentation. It is a small pilot model suitable for experimentation use only. (Soe Figure 1)

The plant consists of four digesters and two gas holders made of sheet metal " thick. A set consists of two digesters and one gas holder. The biogas plant consisted of: -

(1) The digester (Rectangular in shape) See Figure 2)
Length 4 ft, breadth 4 ft, depth 3 ft = volume 48 cu.ft.

(2) The gas holder (See Figure 3)
Diameter 43", height 6 ft = volume 60.5 cm. ft.

(3) Car tyre tube
Tyre tubes of any size are used to hold gas samples taken for burning tests.

(4) Pipe fittingd
To deliver the gas from the digesters to the gas holder and then to the gas utilization point. (See sketch)

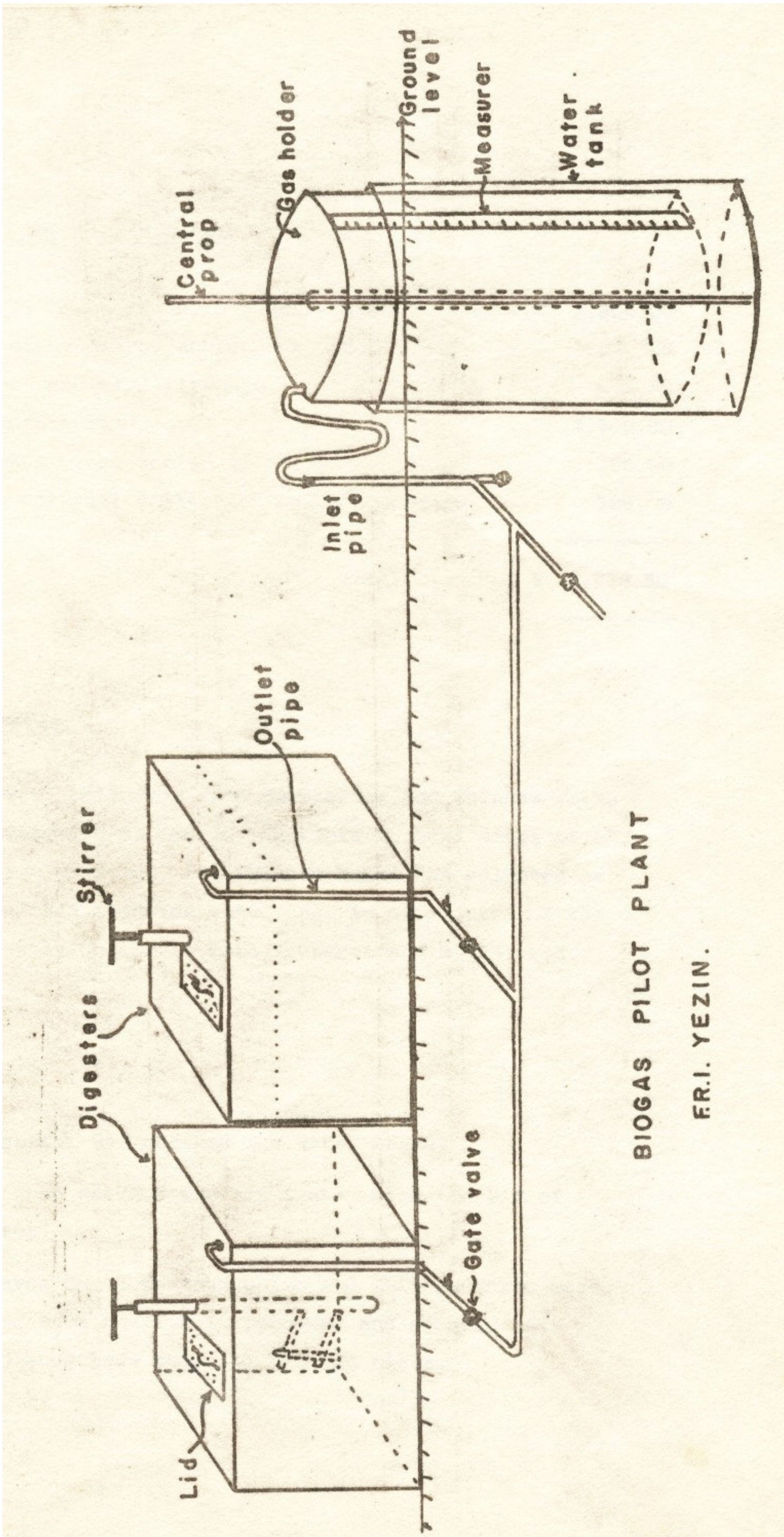
(5) A stove and a lamp.
A ready-made stove and a lamp for lighting were obtained from the "Biogas Center" in Rangoon.

3.2. The Cost of the Biogas Plant

(i).	M.S Sheet 14 no. @ K.200/ each	K 2,800.00
(ii).	Other hardware, angle iron, etc.	2,248.00
(iii).	Pipes and pipe fittings	876.50
(iv).	Manufacturing cost	2,799.00
(v).	Biogas plant set up (F. R. I)	250.00
(vi).	Paw material collection and preparation	208.00
	Total	K 8,978.50

Fig 1. Biogas pilot plant in F. R. I., Yezin.

Fig 2. Digester of the Biogas Plant.



BIOGAS PILOT PLANT

F.R.I. YEZIN.

3.3. The Tree Leaves

The leaves were collected from Bawsagaing and Thinbaw-kokko (rain tree). Bawsagaing is easily adaptable to most sites of the country and is fast growing. The Thinbaw-kokko was selected as it has been grown as a roadside shade tree in many parts of the country and is easily available both in rural and urban areas.

3.4. Method

(i). The digester was checked for water leaks.

(ii). It was then checked for air leaks with the aid of manometer.

(iii). The leaves for both Bawsagaing and Thinbaw-kokko were obtained from the FRI. compound and chopped into small pieces less than one inch in sizes.

(iv). The amount of water and the leaves to be mixed was calculated from the formula below: -

$$N = \frac{I \times C}{I + X} \quad \text{(Anon, 1982)}$$

Where, N = Percent solids in slurry
I = daily input-pounds
C = total weight of raw material
X = weight of water - pounds

$$X = \frac{I \times C}{N} - I$$

Therefore, the amount of water (1 imp. gallon = 10 pounds) to be added to 350 lb Bawsagaing leaves is 1510 lds, or 151 gallons for an individual digester. C = 31.886 is the oven-dry weight of leaves.

Similarly, the amount of water to be added for Thinbaw-kokko is 1702.5 lbs or 70 gallongs, where C = 35.186 lbs and N = for a single digester.

(v). The chopped leaves were mixed with the water in the digester. The fueling and closing dates of the digesters are shown below: -

Operation	1st run		2nd run	
	Bawsagaing	Thinbaw-kokko	Bawsagaing	Thinbaw-kokko
Date of fueling	5/8/94	6/8/84	3/4/85	7/4/85
Days left open	21	20	27	25
Date of closing (gas collection started)	26/8/84	26/6/84	30/4/85	2/5/85

(vi). The digesters were stirred twice a day (once in the morning and once in the evening) from the start.

(vii). After 4 o 5 days gas production started but at first it did not burn readily due to the carbon dioxide and other gases, mixed with the methane. When the gas was found to burn, the biogas plant was ready for consumption.

(viii). The volume of gas produced was recorded twice a day, at 9:00 AM. and 3:00 P.M.

(ix). Water to make (9) cups of tea (1600 cc) was boiled daily, the amount of gas used , the time required to boil the water and the pressure on the manometer were recorded for both species..

(x). Occasionally, rice cooking and lamp-lighting were carried out and recorded.

(xi). Daily rainfall, highest and lowest temperatures and the relative humidity (RH) were recorded for future use.

(xii). No heating or insulation was used in this study, but the digesters were painted with a black coal-tar paint to absorb more heat.

4. Results

The monthly and daily average gas outturn for both Bawsagaing and Thinbaw-kokko in the First Run are given in Table(4). The monthly rainfall, daily average high temperature, and relative humidity & (R. H) are included.

Similarly, the monthly and daily average outturn of gas and weather data for the Second Run are shown in Table (5).

The monthly total gas outturn for both species and both runs are shown in histograms in Figure (4). The average daily gas outturn by months for both species and both runs is shown in Figure (5).

The relationship between the temperature and the gas outturn was studied grouping the data into 10 days periods for both species. The correlation coefficients, for linear exponential logarithmic and power regressions did not show any significant relation ships. Nevertheless, studying individual days of higher temperature, the gas outturn on these days were a bit higher than the days of lower temperature.

The R.H. has a positive relationship with gas outturn. The coefficients were found to be .61, .46, .64 and .55 for Bawsagaing and .52, .39, .53 and .44 respectively for Thinbaw-kokko. This indicates that the higher the R.H., the higher the gas outturn. This could be the reason of coincidence with the drop of gas outturn in the change of weather from wet to dry.

The experiment of boiling water (1600 c.c.) consumed 1.5-2.0 cu. ft. of gas and took 10-13 minutes depending on the manometer pressure.

Table 4. Biogas Yield for Bawsagaing and Thinbaw-kokko First Run -Sept. 1984 - Feb. 1985

Month	Monthly Rainfall (mm)	Average Highest Temperature F	Average Relative Humidity %	Biogas yield (Bawsagaing)		Biogas yield (Thinbaw-kokko)	
				Monthly Total cu. ft.	Daily average cu. ft.	Monthly Total cu. ft.	Daily average cu. ft.
Sept. 84	3.89	89.86	56.53	218	7.26	251	8.36
Oct. 84	4.09	89.43	55.13	324	10.45	353	11.38
Nov. 84		88.93	44.06	257	8.56	280	9.33
Dec. 84		85.43	34.5	176	5.67	191	6.16
Jan. 85		87.5	27.82	192	6.19	204	6.58
Feb. 85		90.4	19.3	93	3.20	179	6.17
Total				1260		1458	

Table 5. Biogas Yield for Bawsagaing and Thinbaw-kokko Second Run - May. 1985 - Sept. 1985

Month	Monthly Rainfall (mm)	Average Highest Temperature F	Average Relative Humidity %	Biogas yield (Bowsagaing)		Biogas yield (Thinbaw-kokko)	
				Monthly Total cu. ft.	Daily average cu. ft.	Monthly Total cu. ft.	Daily average cu. ft.
May 85	55.93	96.16	36.5	296	9.5	236	7.6
June 85	259.93	86.96	52.7	179	5.9	443.5	14.4
July 85	162.57	86.35	51.56	102.5	3.31	280.5	9.0
Aug. 85	285.28	36.1	53.36	64	2.06	158.2	5.1
Sept. 85	250.44	88.83	49.5	49	1.63	120.7	4.0
Oct. 85	159.52	90.43	46.7	23	0.7	56	1.8
Total				713.5		1294.9	

Fig (4) Monthly Total Gas Yield

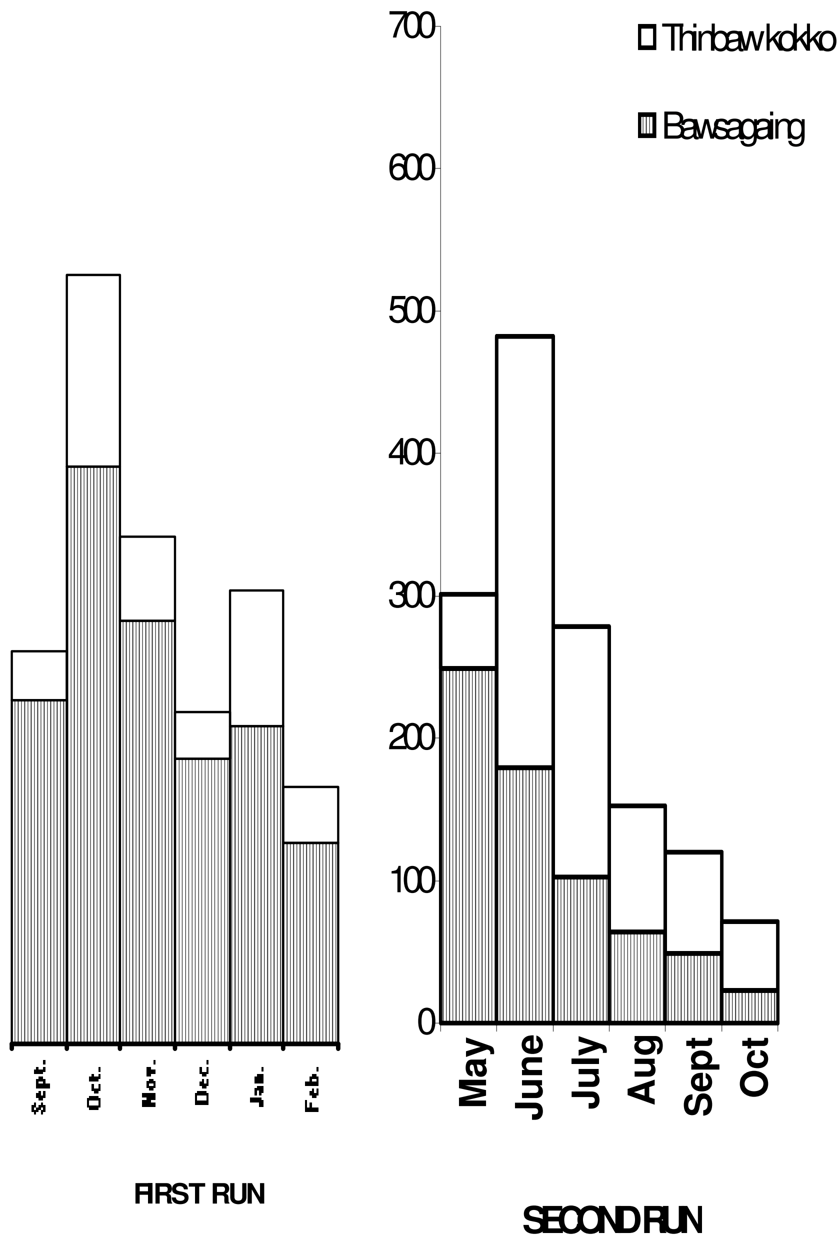
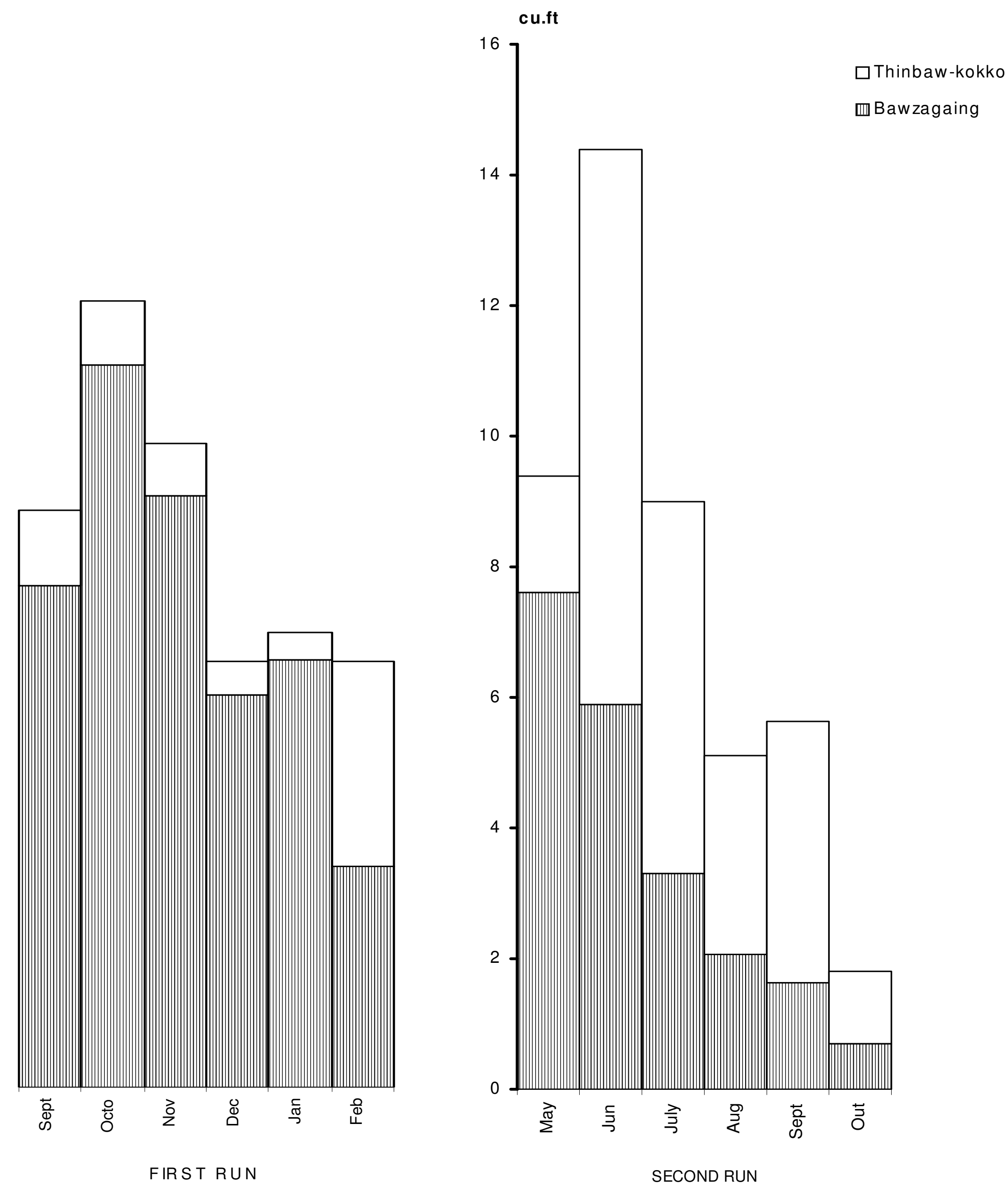


Fig (5) . Average Daily Gas Yield.



It took 19 - 23 minutes to cook 2 ½ canfulls of rice (condensed milk size) and used about 2.5 -3 cu. ft of gas at 3" manometer pressure

In the lighting experiment, it required 4.2 cu. ft. of gas for one lamp for one hour at a manometer reading of 3 pressure.

The volume of gas produced per pound of leaves were found to be 1.80 cu.ft in Bawsagaing and 2.08 cu. ft. in Thinbaw-kokko in the First Run. In the Second Run, they were 1.02 and 1.85 cu. ft. respectively.

The daily average gas outturn of Bawsagaing was 5.5 cu.ft. and that of Thinbaw-kokko was 8.2 cu. ft.

5. Discussion

Observations showed that Bawsagaing leaves produced gas at the start but which burned within three days after closing, whereas Thinbaw-kokko took 9 days to produce combustible gas. The difference may be due to the smaller Bawsagaing leaves with smaller surface area and softer texture making them faster to react in the digester. On the other hand, the daily gas outturn of Bawsagaing reduced quickly.
In both runs, gas was produced even after six months, but in negligible amounts.

The total gas outturn was 1260 cu. ft. in Bawsagaing and 1458 cu. ft. in Thinbaw-kokko in the First Run, with 713.5 and 1294.9 cu. ft. respectively in the Second Run. This indicates a grater yield of gas from Thinbaw-kokko leaves than from Bawsagaing. higher in the First Run and 44.9% higher in the Second. The First was carried out in dry season and the Second Run in the rainy season.

The total gas outturn of both Bawsagaing and Thinbaw-kokko decreased in the rainy season, but the decrease in Bawsagaing was 43 % of the dry season total and that in Thinbaw-kokko only 11 %.

Observations of the gas outturn as related to temperature did not show any appreciable difference. This appears to indicate that, although the temperature was high enough, the gas-producing capability at that time may have been already reduced.

The volume of gas required to boil water in this experiment is comparable to those of gas produced from cow dung. According to the Agriculture Corporation it tooks 60 minutes and 6 cu. ft. of gas to boil one gallon of water (Anon, 1976). The result of this experiment indicated that one gallon of water took 32 minutes and 5.8 cu. ft. of gas to boil (on a per gallon basis). Test results from the Kayah State Biogas Plant showed that a kettle of water needed 4 cu. ft of gas and took 15 minutes to boil. Although the amount of water was not well defined, the results seem to be similar (Anon, 1984).

Cooking rice (4 condensed milk cans) required 12 cu.ft of gas and took 35 minutes (Kayah State experience). The Agricultural Corporation stated that it took 12-15 cu.ft of gas per day to cook a full course meal for one person. These tow findings seem to be close reasonably to the experimental results reported herein. Cooking rice variables in the amount of water and the thickness of the pot not measured. The Kayah State and Agricultural Corporation both used gas from cow dung.

In the case of lighting experiment, the Kayah State and the Agricultural Corporation reported 10 cu. ft of gas needed to light one lamp for one hour. This trial showed that it needed 4.2 cu. ft. of gas to light a lamp for one hour but the intensity of light was lower so the results seem comparable.

The gas outturn calculated from the data given in the lecture notes (Anon, 1982) for cow dung was found to be 0.49 cu. ft. / pound whereas the gas outturn from this experiment were found to be 1.4 cu. ft./ lb for Bawsagaing and 1.97 cu. ft/ lb for Thinbaw-kokko.

6. Conclusion

Bawsagaing leaves produced gas about a week earlier than Thinbaw-kokko but latter produced more gas. In both species the drier period encouraged more gas production than the wet season. Normally the gas-produced period in both species was about six months. Gas may be produced even after six months, but the volume is negligible. The gas outturn from the two species used was greater than that production from cow dung on a weight basis. The calorific values of the gas produced were not evaluated in this study, but the volume of gas used, the time taken for water boiling and cooking and the intensity of heat produced by this gas is quite comparable to the from cow dung.

The initial cost for the plant seemed high but by substituting local materials, the cost could be lowered, depending on the availability of materials such as hardware and pipe and pipe fittings.

Between the two species studied, the authors concluded that Thinbaw-kokko is more feasible for both urban and rural areas in availability and in gas outturn.

Further investigations of biogas of production will be done using leaves of mixed species.

Reference

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