Biogas Potential of Tobacco (*Nicotiana Tabacum*) Stem Waste

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Abstract

Powdered tobacco (*Nicotiana tabacum*) stem was digested alone and with buffalo dung to find out its biogas production potential. A laboratory experiment was done in 5 litre capacity glass digester bottles. A total of 9 digester bottles were used: three for control (having buffalo dung alone); three for co-digestion of powdered tobacco stem and buffalo dung (test- 1); and three for powdered tobacco stem alone (test 2). The experiment was run on daily feeding basis for a total of 191 days. In all the three treatments feeding material was added at 6% total solids. Since the Hydraulic Retention Time for Gujarat Region is 40 days, so all the digesters were fed initially with 120mL mixture of buffalo dung and water at 6% total solids upto 40 days. The digested biogas slurry of running biogas plant was also added in all the digesters @10% v/v. Biogas production was measured after 40 days and allowed to stabilize it. During this stabilization period of 65 days above feeding remains continue in all the digesters. From 104th day onward powdered tobacco stem waste was added in respective digesters either alone or in combination with buffalo dung at 6% total solids and gas production was measured daily. Biogas production was measured by water displacement method. Qualitative analysis of biogas along with nutrients content in effluent slurry was also analysed frequently. Data were analysed statistically following't' test. Results revealed that addition of tobacco stem waste alone (test 2) significantly increases the daily average biogas production between 106.33 (compared to test 1) and 266.85% (compared to control). Methane content was also found highest in this treatment. Organic carbon, available nitrogen and available potassium were also found significantly highest in its digested slurry.

Key words- Biogas production, tobacco stem waste, co-digestion, methane, fertilizer value

Introduction

Biogas production is a proven technology for management of wastes especially dung, kitchen waste, agricultural residues and industrial wastes. It has multi-facet uses. Biogas can be used for lightening purposes, as kitchen fuel, as vehicle fuel, to generate electricity etc. Broad applications of biogas enhances its demand which can be met either by enhancing the number of installed biogas plants or by increasing its production in a given plant. Production of biogas from feeding material is an anaerobic microbial process and depends upon activities of these microorganisms. Microbial activity is affected by a number of environmental factors like pH, temperature, composition of feeding material, presence of any toxic substances etc. Three groups of microorganisms are involved in conversion of feeding material into biogas i.e. hydrolytic, acetogenic and methanogenic bacteria. Among which methanogens are most sensitive towards changes in above environmental factors. In India the huge amount of dung produced daily is maintained by this technology and thatswhy the biogas is popularly known as gobar gas. Quality of dung depends on health and hygiene of the animal and varies daily but it failed to affect biogas production at greater extent because dung has tremendous buffering capacity which resists changes in pH affecting the activities of methanogens. But on the other hand dung is a digested product hence supplies lower nutrients to microorganisms which cause lower production of biogas. So to enhance biogas production in a plant it is essential to replace a portion of dung with any undigested degradable material. Grass-silage[1], composite vegetable wastes and ground nut[2], bananas, potato wastes, meat processing wastes, pasture grass, pressed lucerne, oats, poultry manure, maize, synthetic garbage, ground barley straw, newspaper and chopped rye grass straw[3], rotten vegetables, fruit skins, onion and other waste matter[4] is being used successfully for biogas production. Tobacco (*Nicotiana tabacum*) is an annual

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woody shrub containing big leaves. Almost all continents are capable to grow tobacco but the United State, China, India and Brazil are the leading countries to grow tobacco. Natural occurrence of *Nicotiana* is restricted to the American continent, Australia and the South Pacific. *Nicotiana tabacum* has a uniquely high proportion of alkaloids occurring as nicotine. The leaves supply the most important economic value of plant. It can be rolled into cigarettes or cigars to be smoked or kept almost whole or ground up to be chewed or snorted. The use of tobacco was performed by men and women as a way to relax after a meal or as a medicinal agent for headaches. Its stem has no use. Farmer generally burns it. Therefore present study was undertaken to utilize this stem for biogas production so that the economics of tobacco can also be increase. Study was aimed to find out the effect of tobacco stem waste addition on biogas production as well as to find out its effect on nutritive value of effluent slurry.

Experimental

Five liter capacity glass digester bottles were used for experimentation connected with gas holder and water replacement bottle. A total of six digesters were used- two for control (buffalo dung only); two for test-I (mixture of buffalo dung and tobacco stem waste) and another two for test-II (tobacco stem waste only). The experiment was run on daily feeding basis. All the six digesters were fed initially with 120mL mixture of buffalo dung and water (containing 6% total solids) daily upto 40 days (Hydraulic retention time for Gujarat region). Digested slurry from running biogas plant was also added in all the digesters @ 10% (v/v) as inoculum. All the digesters were filled upto 4.8L with this mixture in 40 days. Thereafter the digesters were run as such till 103 days until the biogas production becomes stabilized. Now from 104th days onwards the above feeding remains continued in control digesters whereas in test-I digesters a portion of buffalo dung was replaced with powdered tobacco stem and in test-II digesters only powdered tobacco stem wastes were fed but care was taken to maintain 6% total solids in feeding material. The experiment was run for a total of 191 days. To maintain 4.8L level inside the digesters 120mL digested slurry is taken out daily from them.

Table 1 Contents of nutrients in raw materials

Parameters	Contents	
	Buffalo dung	Tobacco stem
pH	8.50	5.96
Electrical conductivity (mS cm-1)	0.56	5.23
Total solids (%)	20.00	95.00
Total volatile solids (%)	13.94	70.00
Organic carbon (%)	22.60	1.67
Available nitrogen (%)	0.30	1.90
Available phosphorus (%)	0.29	0.36
Available potassium (%)	0.49	1.41

From 104th days onwards daily biogas production was measured by water displacement method. To judge the quality of biogas its methane content was measured by orsat apparatus. The effluent slurry was analysed for organic carbon[5]; available nitrogen[6], phosphorus[7] and potassium[8] contents. Effluent slurry was also analysed for its pH[8]; electrical conductivity[8]; total solids[9] and; total volatile solids[9]. Contents of these parameters were also find out in initial raw materials i.e. in dung and tobacco stem and are presented in Table 1. Experimental results were compared statistically following't' test[10].

Results and Discussion

Biogas production: Quantity and quality

Daily biogas production in control and test digesters is shown in Table 2. It is clear from the data that daily biogas production fluctuates due to daily fluctuation in its composition which depends on a number of factors including age of animal, health of animal, feeding of animal, season etc. In control digesters biogas production fluctuates between 212.50 (185 day) and 942.50mL (111 day) whereas in test-I digesters it fluctuates between 392.54 (187 day) and 1312.57 mL (120 day) and between 801.00 (105 day) and 2583.00 ml (120 day) in test-II digesters. During 88 days of experimental period a total of 48406.75, 86068.14 and 177583.30mL with an average of 550.07, 978.04 and 2017.99mL of biogas is produced in control, test-I and test-II digesters, respectively (Table 2). Data suggests that supplementation of undigested tobacco stem waste resulted in significantly increased biogas production than compared to buffalo dung alone (Table 3). Among test digesters higher biogas production is recorded in tobacco stem alone (test-II digesters) treatments which clearly reflect the effect of nutrients supply on microbial activities which ultimately resulted in higher biogas production. On an average test-II digesters showed 266.85 and 106.33% higher daily biogas production over control and test-I, respectively. Average biogas production in control digesters was 550.07mL. Higher biogas production in agricultural wastes than dung and during co-digestion of agricultural wastes with dung over dung alone were also reported previously[11,12]. Powdered form of tobacco waste may also take part in higher biogas production in test digesters because microbial activity increases with increasing surface area. Besides quantity the quality of biogas in terms of its methane content was also superior in test-II digesters followed by test-I and control (Table 3).

Fertilizer value

Fertilizer value of effluent slurry is judged on the basis of contents of organic carbon, and available nitrogen, phosphorus and potassium contents. Data presented in Table 4 show that except available phosphorus values of all other nutrients were significantly higher in effluent slurry obtained from test-II digester followed by test-I digester and control. Higher nutrients content in slurry of test digesters further confirms higher nutrients supply to microorganisms in these digesters compared to control as stated above.

Conclusions

It can be concluded that the stem of *Nicotiana tabacum* can be successfully used for biogas production either in co-digestion with buffalo dung or alone and it gives 77.80 to 266.85% higher biogas production over buffalo dung alone, respectively. Anaerobic digestion of *Nicotiana tabacum* stem alone gives 106.33% daily higher biogas production over its co-digestion with buffalo dung. Methane content was also found highest in *Nicotiana tabacum* stem waste alone digesters followed by digesters having co-digestion of *Nicotiana tabacum* stem and buffalo dung and lowest methane was recorded in buffalo dung alone. Similarly nutrients content in effluent slurries also follow this trend.

Table 2 Daily biogas production (mL) and percentage changes

Age of digester (days)	Biogas production			Per cent increase in biogas production in		
	Control	Test-I	Test-II	Test-I over control	Test-II over control	Test-II over test-I
104	850.00	1030.43	919.80	21.23	8.21	-10.73
105	805.00	1220.57	801.00	51.62	-0.49	-34.37
106	762.50	1220.57	2192.40	60.07	187.53	79.62
107	671.25	1189.90	2205.00	77.26	228.49	85.31
108	783.75	1306.43	2255.40	66.68	187.77	72.64
109	800.00	1146.96	2179.80	43.37	172.47	90.05
110	800.00	1330.97	2482.20	66.37	210.27	86.49
111	942.50	1177.63	2356.20	24.95	149.99	100.08
112	645.00	1073.36	2331.00	66.41	261.39	117.17
113	850.00	1134.70	2381.40	33.49	180.16	109.87
114	767.50	1122.43	2343.60	46.24	205.35	108.79
115	745.00	1134.70	2394.00	52.31	221.34	110.98
116	750.00	1128.56	2386.80	50.47	218.24	111.49
117	716.25	1097.90	2394.00	53.28	234.24	118.05
118	720.25	1153.10	2167.20	60.09	200.89	87.95
119	690.75	1245.10	2419.20	80.25	250.23	94.29
120	729.00	1312.57	2583.00	80.05	254.32	96.78
121	755.00	1232.83	2293.20	63.29	203.73	86.01
122	717.50	1238.97	2318.40	72.68	223.12	87.12
123	725.00	1196.03	2356.20	64.97	224.99	97.00
124	841.25	1165.37	2280.60	38.53	171.09	95.69
125	712.50	1165.37	2419.20	63.56	239.54	107.59
126	650.00	1091.76	2142.00	67.96	229.54	96.19
127	628.75	1104.03	1990.80	75.59	216.63	80.32
128	480.00	1013.43	1927.80	111.13	301.62	90.22
129	558.75	1013.43	2368.80	81.37	323.95	133.74
130	542.50	1018.94	1890.00	87.82	248.39	85.48
131	587.50	1073.36	2104.20	82.69	258.16	96.04
132	625.00	1128.56	2242.80	80.57	258.85	98.73
133	628.75	1091.76	2003.40	73.64	218.63	83.50
134	703.75	1104.03	1915.20	56.88	172.14	73.47
135	628.75	1116.30	2028.60	77.54	222.64	81.72
136	562.50	1042.69	1993.40	85.36	254.38	91.18
137	559.00	828.02	1940.40	48.12	247.12	134.34
138	508.75	926.15	1902.60	82.04	273.97	105.43
139	430.00	778.95	1764.00	81.15	310.23	126.46
140	400.00	797.35	1663.20	99.34	315.80	108.59
141	480.00	867.74	1839.60	80.78	283.25	111.99
142	467.50	1134.70	1953.00	142.72	317.75	72.12
143	480.00	1061.09	1675.80	121.06	249.13	57.93
144	608.75	1048.83	1978.20	72.29	224.96	88.61
145	428.75	913.89	2406.60	113.15	461.31	163.34

146	721.25	993.62	2394.00	37.76	231.92	140.94
147	383.75	607.21	1710.00	58.23	345.60	181.62
148	371.25	693.08	1915.20	86.69	415.88	176.33
149	583.75	932.29	2142.00	59.71	266.94	129.75
150	742.50	1183.76	2154.60	59.43	190.18	82.01
151	803.75	1306.43	2179.80	62.54	171.20	66.85
152	796.50	1245.10	2179.80	56.32	173.67	75.07
153	833.75	1189.89	2188.80	42.72	162.52	83.95
154	575.00	1245.10	2394.00	116.54	316.35	92.27
155	700.00	1176.63	1990.80	68.09	184.40	69.19
156	562.50	1036.56	1896.00	84.27	237.07	82.91
157	528.75	1018.13	1789.20	92.55	238.38	75.73
158	400.00	1097.90	1663.20	174.47	315.80	51.48
159	442.50	920.01	1953.00	107.91	341.35	112.28
160	487.50	895.48	2154.60	83.69	341.97	140.61
161	571.25	1061.09	2003.40	85.75	250.70	88.80
162	675.00	1183.75	2167.20	75.37	221.07	83.08
163	521.25	1202.15	2091.60	130.63	301.27	73.98
164	516.25	1189.89	2090.60	130.48	304.96	75.69
165	646.25	1167.81	2103.60	80.70	225.51	80.13
166	562.50	1018.16	2016.00	81.01	258.40	98.00
167	521.25	1171.50	2268.00	124.75	335.11	93.59
168	353.75	778.96	2041.29	120.20	477.04	162.05
169	396.25	920.02	1915.20	132.18	383.33	108.17
170	371.25	895.49	1638.00	141.21	341.21	82.92
171	362.50	785.09	1713.60	116.58	372.72	118.27
172	396.25	791.22	1625.40	99.68	310.19	105.43
173	262.50	760.55	1612.80	189.73	514.40	112.06
174	258.75	729.88	1738.80	182.08	572.00	138.23
175	283.75	754.42	1902.60	165.87	570.52	152.19
176	325.00	791.23	1938.80	143.45	496.55	145.04
177	300.00	821.89	1827.00	173.96	509.00	122.29
178	362.50	840.29	1600.20	131.80	341.43	90.43
179	375.00	558.15	1877.40	48.84	400.64	236.36
180	337.50	840.29	1915.80	148.97	467.64	127.99
181	316.25	693.09	2142.00	119.16	577.31	209.05
182	328.75	515.22	2091.60	56.72	536.23	305.96
183	287.50	515.21	1864.80	79.20	548.63	261.95
184	300.00	466.15	1587.60	55.38	429.20	240.58
185	212.50	478.41	1764.00	125.13	730.12	268.72
186	325.00	552.02	1675.80	69.85	415.63	203.57
187	282.50	392.54	1663.20	38.95	488.74	323.70
188	316.25	594.95	1877.40	88.13	493.64	215.55
189	287.50	607.21	2053.80	111.20	614.36	238.24
190	346.25	613.35	1890.00	77.14	445.85	208.14
191	333.75	657.51	1990.80	97.01	496.49	202.78
Total	48406.75	86068.14	177583.30	77.80	266.85	106.33
Average	550.07	978.04	2017.992	77.80	266.85	106.33

Table 3 t value for biogas production

	Test I	Test II
Control	13.46601472**	38.83711**
Test I		25.46752**

**significant at 1%

Table 4 Average contents of methane in biogas and chemical characteristics of effluent slurries

Parameters	Contents			t- value		
	Control	Test-I	Test-II	Test-I V/S control	Test-II V/S control	Test-I V/S test-II
Methane (%) in biogas	74.56	78.03	79.70	NS	3.23*	NS
Chemical characteristics of effluent slurry						
pH	7.34	7.16	6.92	NS	4.14**	4.33**
Electrical conductivity (mS cm^{-1})	2.96	9.96	12.00	20.09**	42.22**	11.15**
Total solids (%)	4.67	4.60	4.20	NS	2.78*	2.56*
Total volatile solids (%)	3.33	3.61	3.38	NS	NS	NS
Organic carbon (%)	15.30	27.07	33.27	5.07**	4.44**	NS
Available nitrogen (%)	0.67	0.77	1.28	NS	5.19**	4.65**
Available phosphorus (%)	0.10	0.02	0.02	12.36**	12.95**	NS
Available potassium (%)	0.88	0.70	0.94	5.58**	NS	7.38**

*significant at 5%, **significant at 1%

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