An alternate use of *Calotropis gigantea*: Biomethanation

Calotropis gigantea, commonly known as milkweed or swallow-wort, is a common wasteland weed and belongs to family Asclepiadaceae or Milkweed or Ak. Being native to India, it grows wild up to 900 m throughout the country[1] on a variety of soils and in different climates, sometimes where nothing else grows. Traditionally it is used to treat common diseases such as fever, rheumatism, indigestion, cough, cold, eczema, asthma, elephantiasis, nausea, vomiting and diarrhoea, either alone or with other medicines[2,3]. The whole plant, root bark, roots, leaves and flowers are to treat many diseases and abnormalities in humans. Further, Oudhia and Tripathi[4] and Oudhia *et al.*[5–7] reported that extracts of different plant parts, viz. root, stem, leaf and stem + leaf of *Calotropis* affect germination and seedling vigour of many agricultural crops. Its latex content and wild availability draw attention to its use in biomethanation. The continuous increase in LPG prices and its conventional nature compel scientists to search for renewable energy sources. In a country like India where a huge population of livestock is present, biogas may be the prominent household energy source.

Biogas technology is well known, especially in India and China[8]. Its success for energy generation is possible in community-size plants only, which run on batch-feeding process. Family-size biogas plants can fulfil the kitchen fuel requirements, but it is difficult to collect the required amount of dung or other raw materials at the very first day of feeding. So we decided to start biomethanation on daily feeding basis.

Experiments were conducted at laboratory scale in four, 5 l capacity glass digester bottles during 10 June to 10 September 2005. Working volume of digester was 4.8 l and total solids (TS) content of feeding slurry was 6% (for easy in handling). For acclimatization, inoculum from running biogas plant at Biogas Research and Extension Centre, Gujarat Vidyapith, was added in the digesters @ 10% (v/v). Biogas production from *C. gigantea* was compared with control (buffalo dung only) in duplication. All the four digesters were run on buffalo dung (TS 24%) feeding only for initial 40 days (hydraulic retention time Gujarat region)[9]. To obtain 6% TS 30 g buffalo dung was mixed with 90 ml water and fed. From the 41st day onwards 6 g buffalo dung was replaced with *C. gigantea* powdered leaves in test digesters. Care was taken to maintain the TS in feeding slurry as well as the working volume in the digester. For this, 120 ml digested slurry was withdrawn daily from the exit tube of the digester. The experiment was run for a total of 92 days. Biogas production was measured at 12 h interval by water displacement method with corresponding environmental temperature, and quality of biogas (methane) was checked using Orsat Apparatus.

Results show (Figure 1) favourable effect of co-digestion over control. Significantly higher biogas production (109.82% increase) was recorded in test digesters than control digesters. This suggests that higher total N, available P and K, organic carbon, calcium and magnesium content in *C. gigantea* leaves provide sufficient nutrients to microbial community of test digesters (Table 1). Increased microbial activity may result into increased biogas production in test digesters than controls. Presence of easily degradable compounds and various enzymes in the latex of *C. gigantea* may also increase the digestion rate of feeding material in test digesters. Positive effects of co-digestion of cattle dung and agricultural wastes were also reported[10–12]. Besides nutrient content of feeding slurry, microbial activity also depends on environmental temperature. Hence daily biogas production during daytime (9:00 am to 21:00 pm) was higher compared to night time (21:00 pm to 9:00 am; Figure 2). It was 130.62% higher during daytime and 83.20% higher during night-time in test digester over control digesters. This per cent increase in test digesters was also significant at 1% level of significance.

The economic value of biogas depends on its methane content and not on the

Table 1. Average composition of raw materials used

Parameter	Buffalo dung	Ak leaves
Total nitrogen (%)	0.56	1.67
Available phosphorus (ppm)	392.00	630.00
Available potassium (ppm)	217.33	30000
Organic carbon (%)	16.25	39.00
Total solids (%)	20.5	96.00
Total volatile solids (%)	17.45	83.52
Calcium (mg l^{-1})	192.38	5500
Magnesium (mg l^{-1})	82.83	5000

Table 2. Quality of biogas (methane) produced

	Average proportion			*t*-tabulated	
Constituents of gases	Control	Test	*t*-value	5%	1%
CH_4	73.60	68.86	7.48898*	2.306	3.355
CO_2	24.36	29.15	12.86631*		
O_2	2.04	1.99	0.61085		

*Significant at 1% level of significance.

Table 3. Fertilizer value of effluent slurry

	Contents (ppm)			*t*-tabulated	
Nutrients	Control	Test	*t*-value	5%	1%
Available N	529.45	1010.0	93.00348*	2.306	3.355
Available P	1242.73	1360.0	80.50966*		
Available K	253.18	858.5	1076.663*		

*Significant at 1% level of significance.

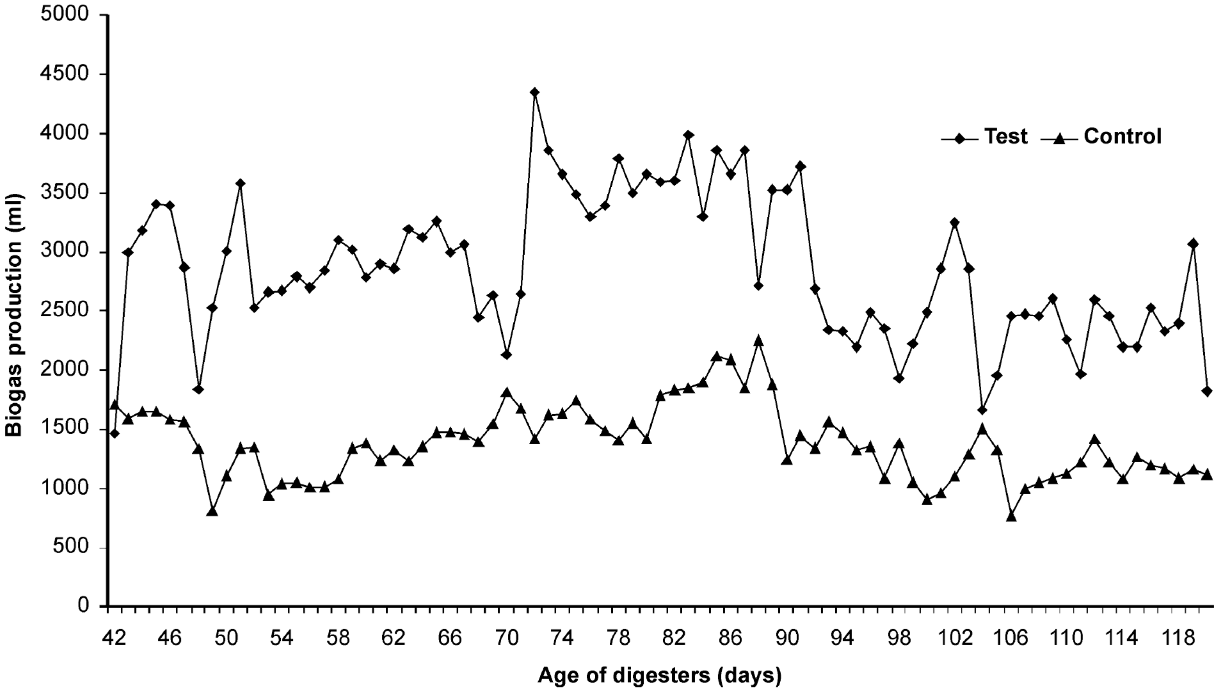

Figure 1. Effect of addition of *Calotropis gigantea* on daily biogas production (ml).

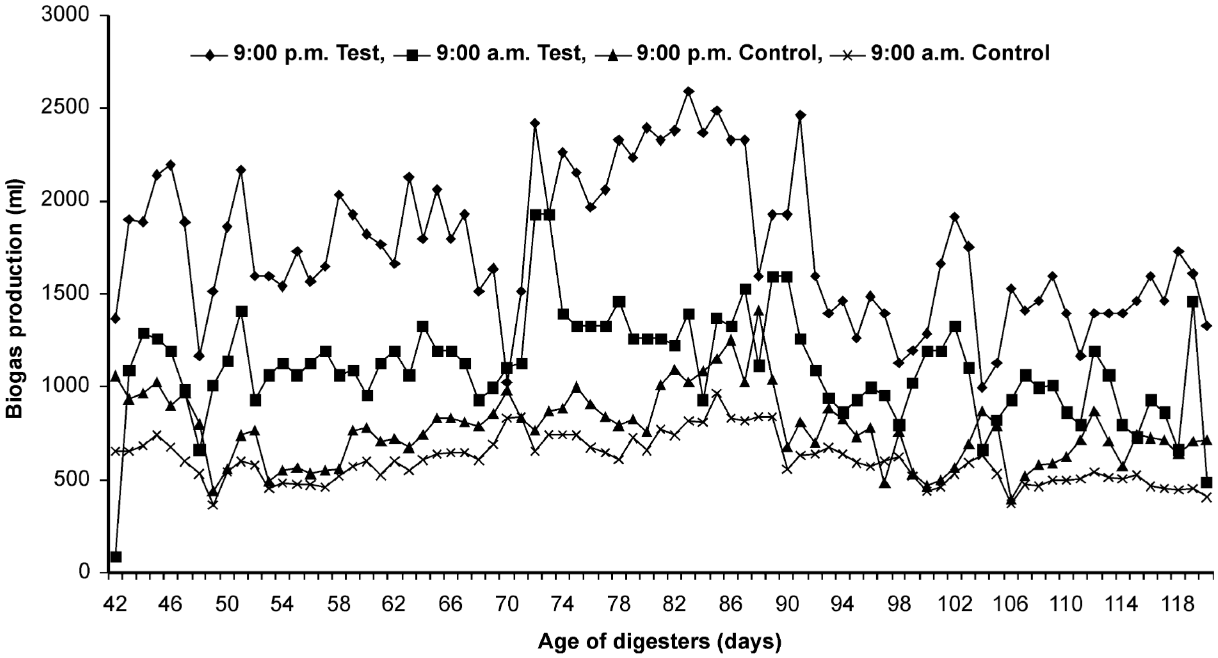

Figure 2. Effect of addition of *C. gigantea* on day (9:00 p.m.) and night (9:00 a.m.) biogas production (ml).

quantity of biogas produced. Results presented in Table 2 show significantly lower methane content and significantly higher carbon dioxide content in test digesters than those of control digesters. Although the oxygen content in biogas in test digesters was lower than the control it failed to reach significant levels. Proportion of gases in the biogas depends on lipid and sugar content of the feeding slurry. Callaghan *et al.*[13], suggest that degradation of sugars gives a mixture of equal volumes of carbon dioxide and methane, whereas degradation of lipids gives a greater percentage of methane.

Fertilizer value of produced biogas slurry in test digesters was also significantly higher than those of control digesters in terms of its available nitrogen, phosphorus and potassium content (Table 3). Results are in tune with Shyam[14].

Results suggest that besides medicinal use, bloom of Ak can be successfully used for production of biogas with higher fertilizer value.

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Studies on stem structure of *X Laburnocytisus adamii* (Poit) Scheid

X Laburnocytisus adamii (Poit.) Scheid. is a graft hybrid of *Laburnum anagyroides* Medik. and *Cytisus purpureus* Scop., both belonging to the family Fabaceae. Adam, a nurseryman from Vitry near Paris, inserted a shield from the bark of a low-spreading, purple-flowered shrub *C. purpureus* (purple broom) into a stock of yellow-flowered *L. anagyroides* (golden chain tree). The bud lay dormant for a year and then grew upright and vigorous with larger leaves than is usual for broom. This graft hybrid continued to grow, the main limb producing foliage and long drooping chains of yellow flowers along with clumps of purple flowers on twiggy branches and pinkish flowers on other longer branches.

The yellow and purple flowers produced by *X L. adamii* were similar to those of the parent plants, while the pink flowers had characteristics intermediate between the two originally grafted plants. The pink flowers were associated with somatic fusion of cells of the two graft partners, while the revertant sectors (i.e. branches that formed flowers identical to either of the originally grafted plants) were the result of segregation of the characters back to uniformity. Such a graft hybrid, also called 'chimera', is a bi-generic hybrid, which has originated artificially as a result of grafting of two different genera[1,2].

Here we compare the stem structure of shoots associated with the three different types of flowers found in *X L. adamii*, and see whether the *Laburnum*-type and *Cytisus*-type differed in stem structure from *L. vossii* and *C. purpureus* respectively.

Shoots were selected from the *X L. adamii* tree growing in the Treborth Botanic Garden, UK, having leaf and flower types characteristic of *Laburnum*, *Cytisus* and *X Laburnocytisus*. Shoots were also selected from plants of *C. purpureus* and *L. vossii* (a close relative of *L. anagyroides*). Samples from these shoots were pickled and preserved in formalin–propionic–alcohol (FPA). These samples were washed in tap water before cutting sections, and portions remaining after sectioning were preserved in 70% alcohol.

Sections were cut by hand with a single-edged razor blade, in transverse, tangential longitudinal and radial longitudinal directions. These were mounted in a dilute solution of iodine in potassium iodide (which stains starch grain black and acts as a general differential stain for cellulose and lignin). These temporary mounts were examined and photographed immediately with a transmitted light microscope. Polarized light was also used to show up any crystals present.

The three types of shoot from the *X L. adamii* tree are described here as *Laburnum*-type, *Cytisus*-type and *Laburnocytisus*-type.

Laburnum-type shoots were similar to those of *L. vossii* in having a rounded first-year stem, with slight ridges on each side of the petiole base, but these faded out a short distance below the leaf axil. The young first-year stems of both *Laburnum*-type and *L. vossii* were covered in white hairs closely adpressed to the stem, but these soon disappeared leaving a green stem. Later, in the season the epidermis turned pale brown, then broke up to show a smooth and shiny green periderm below.

In contrast, *C. purpureus* and the *Cytisus*-type stems both had persistent longitudinal ridges on either side of each petiole, continuing up to the petiole above: these ridges became less obvious in third-year stems. The bark of older *C. purpureus* and *Cytisus*-type stems was rougher than in the *L. vossii and Laburnum*-type, with