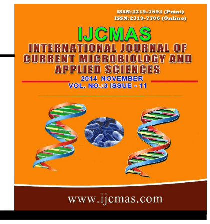


International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 3 Number 11 (2014) pp. 181-188**
http://www.ijcmas.com

Original Research Article

Comparative study of new energy crops for the production of biogas

Veselin Kirov[1*], Zaprianka Shindarska[1], Gergana Kostadinova[3], Adelina Gencheva[2], Stojan Hadgiev[3], Toncho Penev[4] and Bayko Baykov[1]

[1]University of Forestry, 10, St.Kl.Ochridsky Blvd., 1756 Sofia, Bulgaria
[2] New Bulgarian University, h.c. " Ovcha Kupel", St. Montevideo 21, 1618 Sofia, Bulgaria
[3]Trakia University, Faculty of Agriculture, Student Campus, 6000 Stara Zagora, Bulgaria
[4]Department of Applied Ecology and Animal Hygiene, Faculty of Agriculture, Trakia University, 6000 Stara Zagora, Bulgaria
**Corresponding author email:*

A B S T R A C T

Keywords

Biogas, Energy plants (crops), Biogas, Methane.

A comparative study of new energy crops has been conducted. Its aim was to give a comparative assessment of the main technological parameters for biogas production. Samples of the following energy crops were examined: four species of Paulownia – hybrid, Shan Tong, Kawakamii and Elungata, Willow, Miscanthus and Arundo. The examined energy crops have optimum values of the main technological parameters in the production of biogas/dry matter, organic matter, carbon, nitrogen and the C:N ratio.

Introduction

In recent years it has become clear that alternative energy crops are required for the production of biogas (Mueller *et al.*, 2001; Shindarska *et al.*, 2012; Baykov *et al.*, 2005; Arsova, 2010, Dimitrova *et al.*, 2009, Zaharinov *et al.*, 2012). The aim is to preserve the soil through crop rotation. With proper combination of crops and providing sowing cycle, the use of mineral fertilizers is reduced, which increases the cost efficiency of the biogas production. The use of new (and little known in Bulgaria and in the rest of Europe) energy crops is one solution due to the provision of raw materials for biofuel and achieving ecological balance. In previous studies we examined the most common species of the energy crop Paulownia Elungata (Shindarska *et al.*, 2013).

Our aim with the current study is to analyze 4 different species of Paulownia, along with willow, arundo and miscanthus in terms of their composition and technological parameters for the production of biogas.

Materials and Methods

Samples were taken from the following species of Paulownia: Paulownia (hybrid), Shan Tong, Kawakamii and Elungata. All these belong to the genus Paulownia and are widespread in Asia, especially in China. The leaves are rich in sugars, fats and protein; in terms of nutritional value they are similar to alfalfa. The reason for them not to be used as animal feed, is the high lignin content and in some species the high content of alkaloids. After the leaves fall from the trees, they fertilize the soil, enrich it with nitrogen and improve its structure.

Description of energy crops in Table 1.

Table.1 Energy crops

S.No.	Types of plant substrates
1.	Paulownia /hybrid/ leaves
2.	Paulownia Shantong /leaves
3.	Paulownia Kawakamii /leaves
4.	Paulownia Elungata /leaves
5.	Willow /leaves + branches
6.	Arundo
7.	Miscanthus

The following models of analysis were used: Dry matter (DM) by BSS (Bulgarian State Standard) EN 14346, Organic matter (OM) and Organic carbon (OC) by BSS EN 13137, Nitrogen by Kjeldahl (N) by BSS 13342, N-ammonium by BSS 3587, N-nitrate by BSS EN ISO 10304-2, (SO_4) by BSS EN ISO 10304-2, (CaO) by EPA 6010C, (MgO) by EPA 6010C, (K) by EPA 6010C, (P) by EPA 6010C, pH (H_2O) by BSS EN 12176.

Results and Discussion

The technological indicators characterizing the production of biofuel are shown in Table 2. Of the studied energy crops, willow and miscanthus have the highest (almost equal) values of dry matter (DM) (Fig. 1) – 43.39 and 43.10% respectively, while Paulownia Elungata has the lowest value (25.52%). Of the four species of Paulownia the hybrid has the highest DM value. The differences between the remaining three species are from 1–1.5%. The DM data correspond to those for the Organic matter (OM) where willow and miscanthus have the highest values, while Paulownia Shan Tong has the lowest OM content (Fig. 2). With respect to carbon, Paulownia Elungata has the highest content (Fig. 3) – 43.68%, while Paulownia hybrid has the lowest – 32.70%. In terms of carbon content, willow and miscanthus have almost identical values. In terms of nitrogen content Paulownia hybrid contains 2.85%, followed by willow. Nitrogen content is the lowest in miscanthus (Fig. 4). The examined energy crops are in the most optimal range of the C:N ratio, where it is widest in miscanthus and most optimal in arundo (Fig. 5). The pH values are close for all the studied energy crops and are in the range between 5.10 and 5.63 (Fig. 6).

With regards to the three nitrogen forms relevant to soil fertility, ammonium nitrogen has the highest values (Fig. 7) (Table 3). The nitrite and nitrate nitrogen forms are below the admissible limits in all examined crops. The amount of ammonium nitrogen from the total nitrogen content is highest in arundo. Of the four species of Paulownia, the ammonium nitrogen content is highest in Paulownia Elungata. It is worth noting the low values of ammonium nitrogen from the total nitrogen in Paulownia hybrid. With respect to potassium content (Fig. 8) arundo has the highest content, while Paulownia Shan Tong has the lowest content (1.16%). The phosphorus content (Fig. 9) in the examined energy crops is between 0.33–0.16%.

Table.2 Content of the energy crops

№	DM %	OM %	C %	N %	C:N	pH
1	30,92±1,23	20,52±0,19	32,70±1,15	2,85±0,09	11,47	5,31±0,17
2	26,30±1,34	14,69±0,15	35,89±1,23	2,10±0,11	17,09	5,63±0,24
3	27,00±1,09	16,20±0,98	40,10±2,04	1,88±0,07	21,33	5,52±0,07
4	25,52±2,01	16,24±0,56	43,68±2,15	2,74±0,13	15,83	5,46±0,15
5	43,39±2,09	38,33±1,01	39,07±1,18	1,37±0,04	28,52	5,21±0,07
6	34,89±1,88	19,84±0,97	33,27±2,04	1,57±0,05	21,19	5,10±0,09
7	43,10±2,12	36,68±1,12	39,81±1,19	0,98±0,03	40,69	5,44±0,12

Table.3 Biogenic macroelements content in energy crops

Indicators	Nitrogen fractions, mg/kg			K, %	P, %
	ammonium	nitrite	nitrate		
1.	73,40	<5	<5	2,25	0,29
2.	60,11	<5	<5	1,16	0,21
3.	60,50	<5	<5	1,27	0,33
4.	1744	<5	<5	1,26	0,21
5.	1325	<5	<5	1,13	0,16
6.	5247	<5	<5	2,29	0,20
7.	657	<5	<5	1,53	0,17

Fig.1 Content of dry matter (DM)

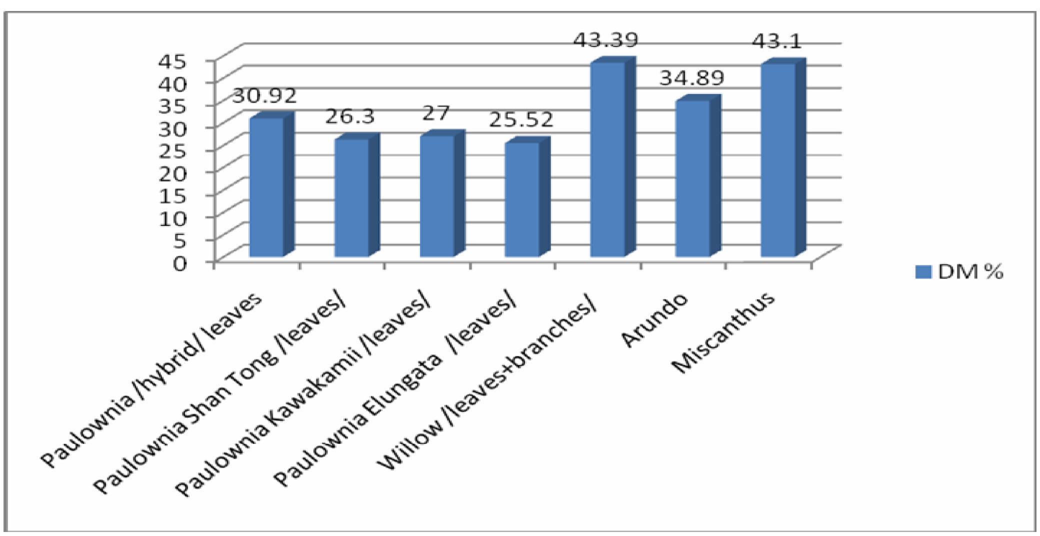


Fig.2 Content of organic matter (OM)

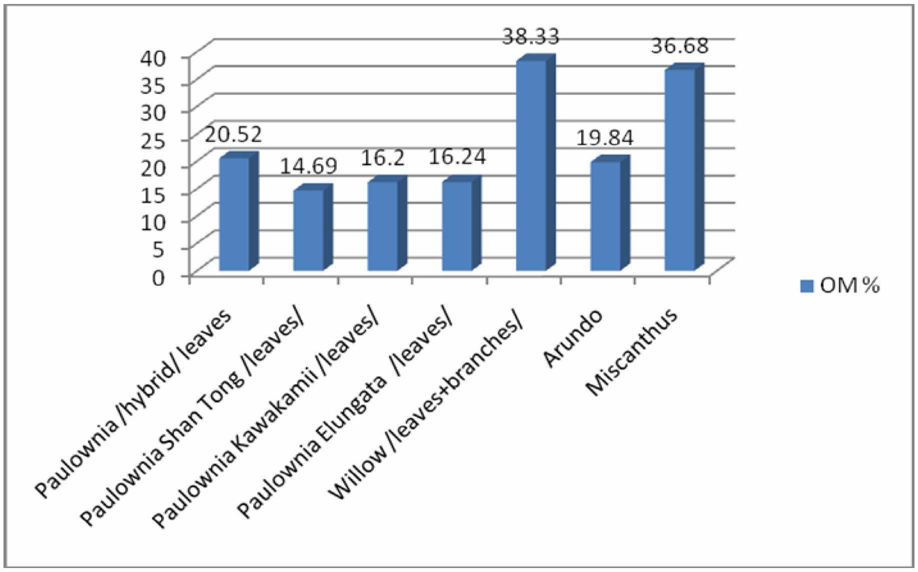


Fig.3 Content of carbon

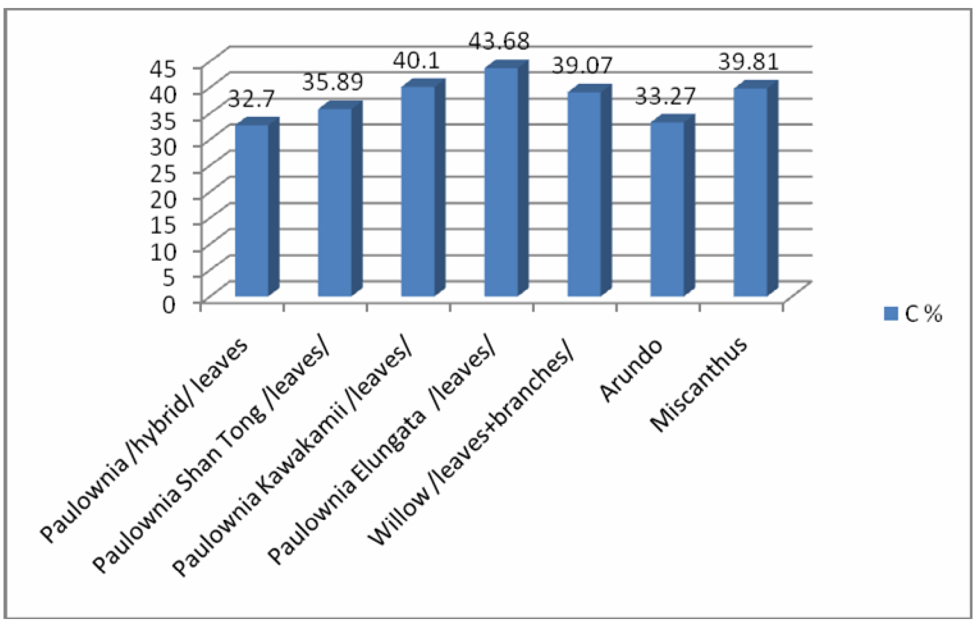


Fig.4 Content of nitrogen

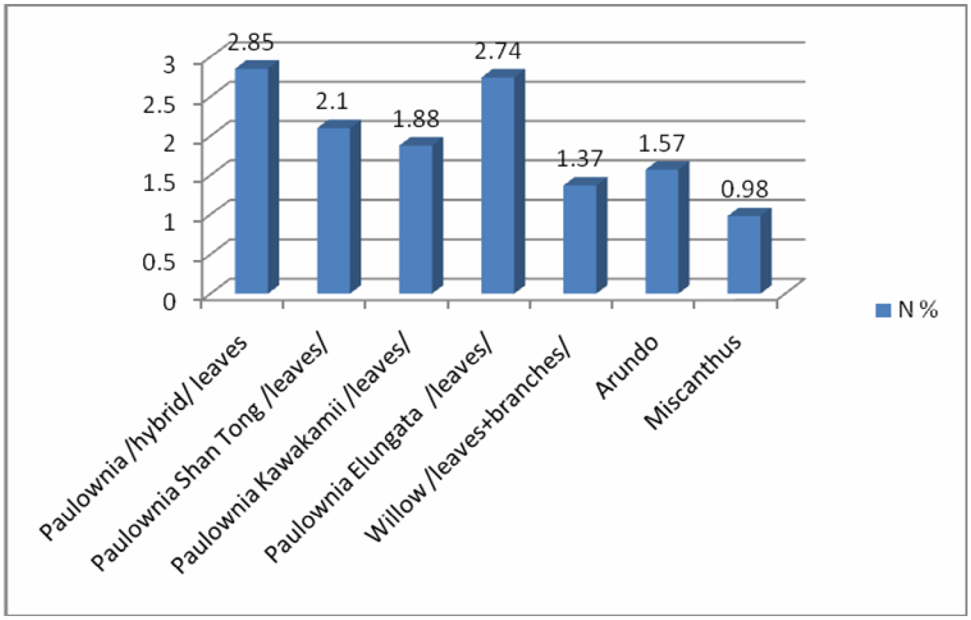


Fig.5 Range of the C:N ratio

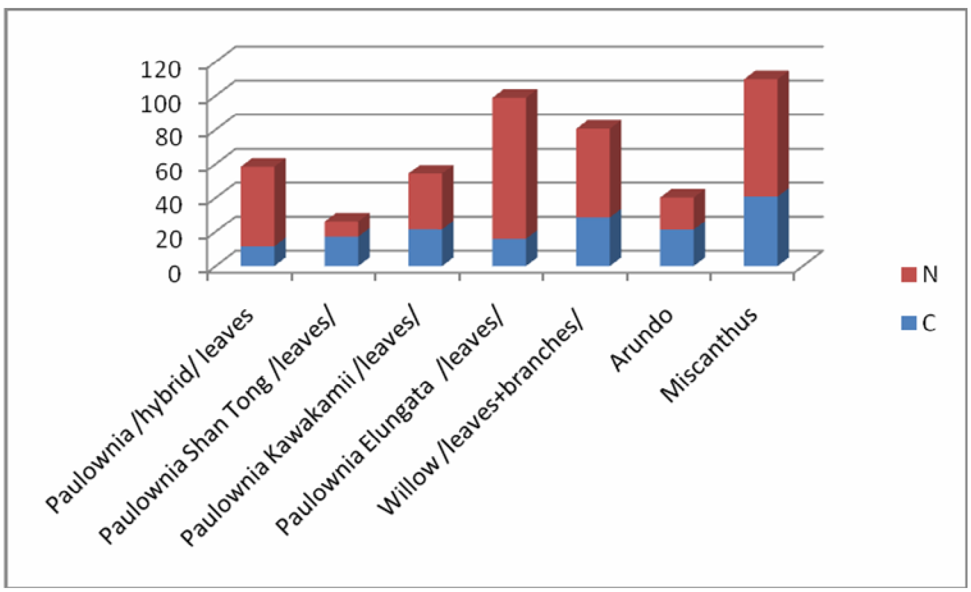


Fig.6 Values of pH in the energy crops

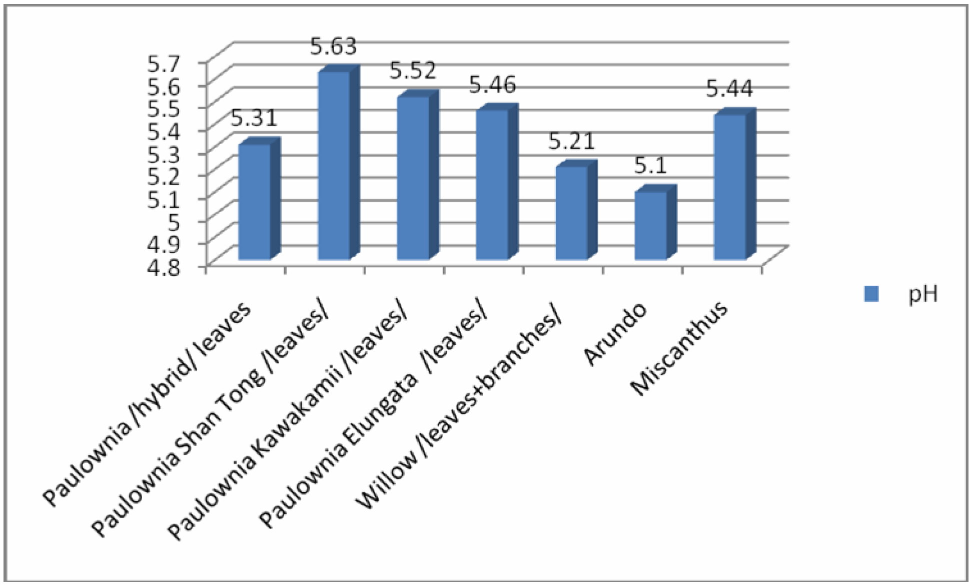


Fig.7 Nitrogen fractions ammonium mg/kg

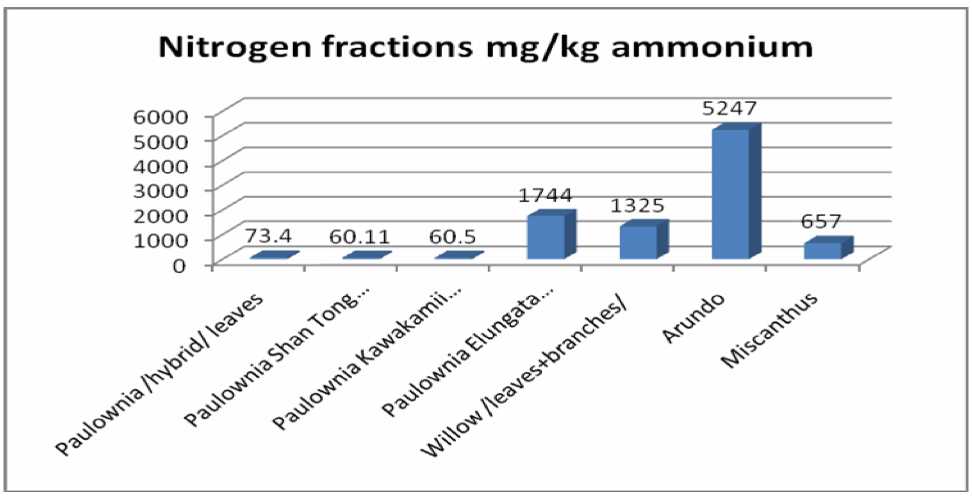


Fig.8 Content of potassium

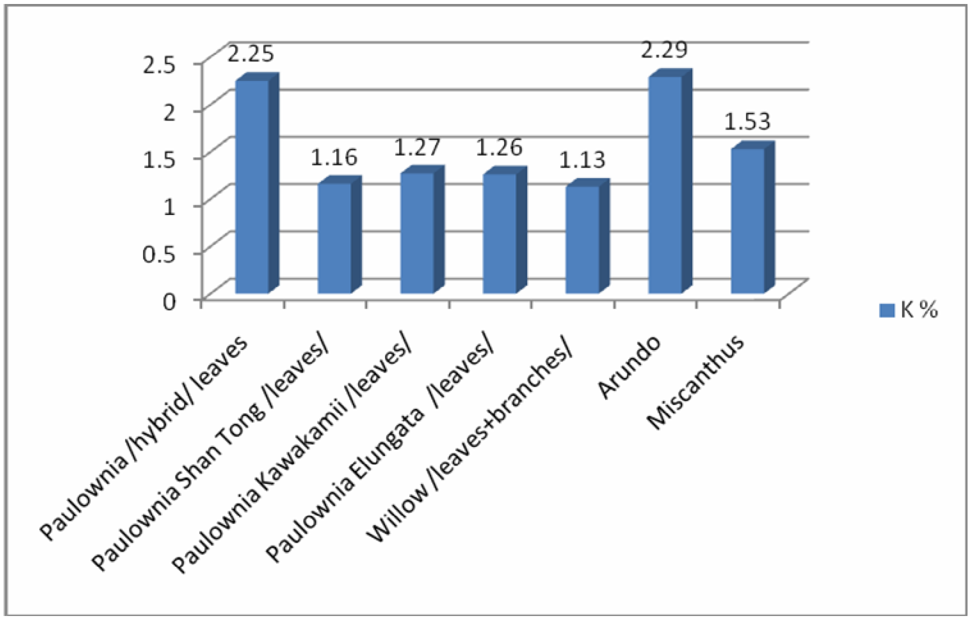
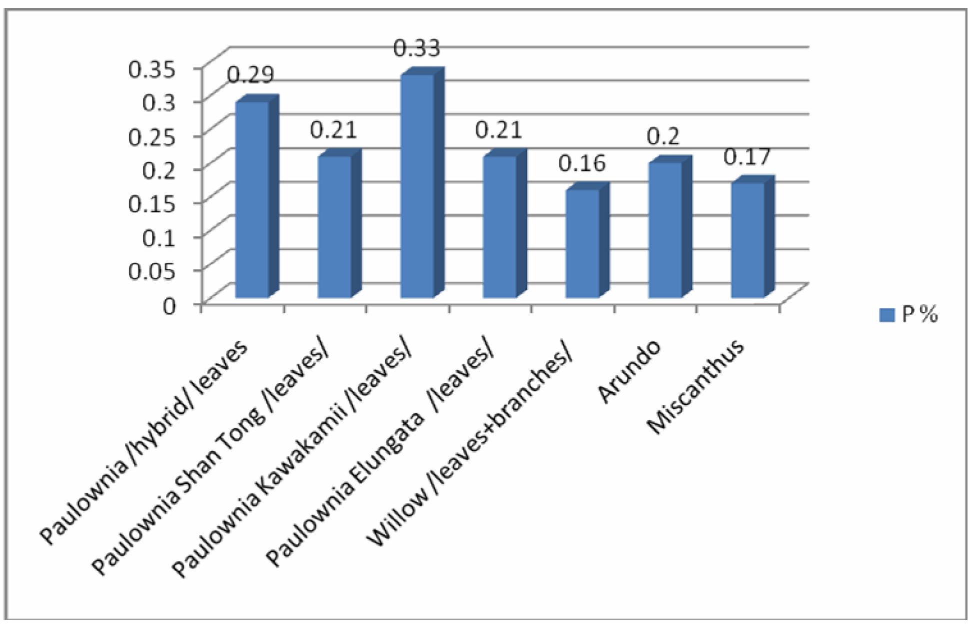


Fig.9 Content of nitrogen phosphorus



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