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RESEARCHES REGARDING THE EVALUATION OF THE BIOMASS POTENTIAL RESULTED FROM THE DORMANT PRUNING OF SOME VINE VARIETIES

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Abstract: Biomass is a primary carbon resource, together with other sources of renewable energy. Biomass may be used as raw material in order to produce energy, solid bio-fuels with high energetic value or biochemical fuels, all of them used for sustaining the economic activities. Nowadays, biomass is accounted for 12% of the primary energy production and in the developing countries this share may rise to 40-50% from the overall energy needs. The debris resulted from the dormant pruning of vine may be also included among these types of raw materials. In this paper we present the results of the researches aiming to evaluate the biomass potential of the vine tendrils, resulted from the dormant pruning of vine in a plantation which is in its 5th year of production. The research was performed at the "Vasile Adamache" farm station of the University of Agricultural Sciences and Veterinary Medicine in Iaşi; the following parameters were evaluated: average quantity of tendrils (for each vine plant and for one surface unit); humidity of tendrils immediately after pruning; calorific value of the tendrils for each vine variety taken into account. The experimental results show that pruning produces large amounts of biomass, which may be turned into pellets. The energetic potential of the tendrils depends on the variety of vine.
Keywords: biomass, vine plantations, solid fuels

1. INTRODUCTION

The energy supplies of modern civilization come mostly from three types of sources: conventional fossil fuels, respectively coal, petroleum and natural gases; nuclear fossil fuels (especially uranium); renewable sources. The name renewable energy sources is referring to the energy sources which are not based on reserves, containing energy form natural renewable processes. This category includes numerous types of energy available from the environment: radiant solar energy, accumulated solar energy, the energy of running waters, wind energy, geothermal energy, and potential chemical energy stored in biomass etc. (Vlăduț et al., 2012; Picchi et al., 2013).

An important part of renewable sources is represented by the energy contained in biomass, which contributes with 14% to the worldwide consumption of primary energy (Hall, 1997; Tudor, 2009). The term biomass is referring to the non-fossil organic matters as wooden debris, agricultural waste, forest, agricultural and industrial vegetable waste, seeds and fruits of different agricultural crops. In a broader understanding biomass includes all forms of vegetal and animal material, grown and developed on earth surface, in the water or on the water, as well as the substances resulted from biological development (Tudor, 2009), and the definition given by the EU Directive 2009/28/EC on the promotion of the use of energy from renewable source, "biomass means the biodegradable fraction of products, waste and residues from biological origin from agriculture (including vegetal and animal substances), forestry and related industries including fisheries and aquaculture, as well as the biodegradable fraction of industrial and municipal waste".

Vegetable biomass is the most valuable renewable energy resource, as it is the result of the photosynthesis process: based on the CO_2 input from the atmosphere and water input from soil, under the effect of solar radiation, a product with high hydrocarbon content is produced. Vegetable biomass may be used as firewood (traditional use), liquid biofuel for engines, biogas, briquettes, pellets etc. When biomass is used as burning solid fuel the oxygen in the atmosphere is combined with the carbon contained by the plants, resulting in CO_2 and water. This is a cyclic process, as the carbon dioxide is again absorbed by the plants in what is known as the carbon cycle (Figure1) (Ion, 2006).

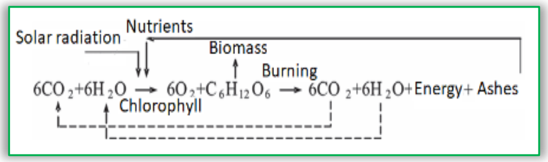

Figure1 – Carbon cycle in nature (Ion, 2006)

Worldwide researches have proven that the waste resulted from the dormant pruning of vines is an important biomass resource. The quantity of biomass resulting from the pruning of vine depends on the growth system, the age of the exploitation, variety (Merlot, Cabernet, Chardonnay etc.), geographical location of vineyard etc (Silvestri, 2011; Velazquez-Marti B et al., 2009). In the present paper the research was focused on the evaluation of the amount of biomass resulted from the dormant pruning of different varieties of vines and on the calculation of the energy potential assuming the superior use of the vine tendrils (Spinelli et al., 2011). The use of the tendrils resulted from the dormant pruning of vine is important both from an economic point of view and for the environment protection. Considering that vineyards in EU are accounted for more than 3.2 mil. hectares and that approximately 1 ton of biomass may be collected from each hectare, it results that more than 3.2 mil. tons of biofuel would available from the above mentioned surface. In the meantime, the superior use of this waste is environmentally friendly, avoiding the pollution with smoke, dust and unpleasant smell (Silvestri, 2011; Velazquez-Marti B et al., 2011).

2. MATERIAL AND METHOD

In order to evaluate the biomass potential from dormant pruning, vine tendrils were collected from the vineyard of Research Station of the University of Agricultural Sciences "Ion Ionescu de la Brad" from Iași, farm no. 3 „Vasile Adamachi". The vineyard is placed on a terrain with the following features:

- # the relief consists of positive and negative shapes. large plateaus with 2...3% slope, sides with 10...25% slopes and narrow valleys with altitudes between 80 and 180 m, with south-eastern exposition of the sides;
- # the soil is a loamy chernozem, formed on loess loam;
- # soil texture is differentiated in depth: loam and clay-loam down to 30 cm; loam at the depth of 30-50 cm; sand bellow 50 cm;
- # soil structure is adequate due to the high humus content, well developed average acinose down to 30 cm and moderately developed under 30 cm, no specific aggregates being present;
- # temperate-continental climate due to the geographic position, to the relief characteristics and to the influence of the Atlantic and Siberian anthropic, being integrated into the moderate-continental climate of Central Moldavian Plateau and the excessively-continental climate of Moldavian Plain.

The vineyard covers 12 hectares and is divided into 11 plots, including 8 vine varieties; it is in second production year. The distance between the rows is 2.3 m and 1.2 m between the vines in a row. The semi-high train system is used, with the productive elements being placed on 60-80 cm high stems; there is a mixed pruning system, with the productive elements being placed on unilateral or bi-lateral cordons. Taking into account that the vines are young, formation pruning was applied.

In order to evaluate then biomass potential tendrils from 20 different vines, placed on different rows, were collected; the vineyard varieties were Busuioacă de Bohotin, Fetească neagră, Fetească albă, Fetească regală, Sauvignon blanc, Muscat ottonel, Pinot noir and Cabernet sauvignon. The tendrils collected from each vine and variety were weighted; the the humidity was calculated and, in order to measure the calorific value, the tendrils were chopped and dried. The humidity (dry basis) was evaluated using the drying closet method, at 105 ^{0}C, the sample being maintained until no humidity variation was recorded. The humidity (dry base) was calculated with the formula:

$$U = \frac{m - m_0}{m_0} x100(\%) \quad (1)$$

where: m – sample mass before drying (natural state) [g]; m_0 – mass of the same sample after drying [g].

The tendrils were chopped in two stages: rough chopping and fine chopping (5-25 mm particle length – Figure 2). The garden chopper Hecht 6173 (Figure3) was used for rough chopping; fine chopping was achieved with a laboratory hammer mill grinder.

The grinded samples were dried to a humidity of 8% (table 1), using a specialized laboratory rig. Figure 4 presents the operating diagram of the laboratory drying rig; it is equipped with touch-screen and microprocessor for the control and surveillance of the drying process.

Figure 2. - Tendril samples, grinded and dried: 1 - Busuioacă de Bohotin; 2- Fetească neagră; 3 - Fetească albă; 4 - Fetească regală; 5 - Sauvignon blanc; 6 - Muscat ottonel; 7 -Pinot noir; 8 – Cabernet sauvignon.

Figure 3 - Garden chopper Type: Hecht 6173; engine: 4 strokes S.I., 6 BHP, 173 cm^3

The gross and net calorific values were measured within the specialized laboratory at ICIA Cluj-Napoca. The gross calorific value takes into account both the heat generated by fuel combustion and the latent heat of condensation contained by the water vapour, while the net calorific value measures only the heat generated by fuel combustion. The calorific values were evaluated using standardized methods.

The gross and net calorific values of vineyard grapes samples were carried out using a Parr 6200 Isoperibol Calorimeter, according to standards DIN 51900 -1:2000 (Determination of gross calorific value of solid and liquid fuels using the bomb calorimeter, and calculation of net calorific value) and DIN 51900-2:2003 (Determination of gross calorific value of solid and liquid fuels).Sample pellets of 1.0 g were used for each analysis. A nickel ignition wire was placed in contact with the pellet. The bomb was filled with oxygen at 25°C with 1.0 cm^3 distilled water added to the bomb. The calorimeter was placed in an isoperibol jacket with an air gap separation of 10 mm between all surfaces.

The bomb calorimeter was submerged in a calorimeter and filled with distilled water. The calorimeter jacket was maintained at constant temperature by circulating water at 27°C. The gross calorific value of the samples was calculated from the corrected temperature rise and the effective heat capacity of the calorimeter.

The net calorific value differs from the gross calorific value in that the water in the samples before combustion and that formed during combustion of hydrogen-containing compounds in the sample in the gaseous state, at 25°C, after combustion. The net calorific value was calculated using the moisture, ash, carbon, hydrogen and sulphur contents of the samples. The Ash content was determined by calcination at 550°C according to standard ISO 1762:1974 (Pulps–Determination of ash). The moisture content was determined according to standard ISO 11465:1993 (Soil quality–Determination of dry matter and water content on a mass basis –gravimetric method).

The carbon, hydrogen and sulphur contents was determined by using a Flash EA 2000 CHNS/O analyser (Thermo Fisher Scientific, USA) according to standards ISO 10694:1995 (Soil quality--Determination of organic and total carbon after dry combustion (elementary analysis), ISO 13878:1998 (Soil quality--Determination of total nitrogen content by dry combustion ("elemental analysis") and ISO 15178:2000 (Soil quality--Determination of total sulphur by dry combustion) (table 1).

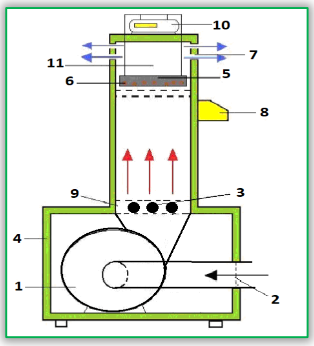

Figure 4. - Operating diagram of the laboratory drying rig: 1 –fan; 2 – air intake; 3 – grate; 4 – thermal insulation; 5 – product tray; 6 – products; 7 – drying agent discharge ports; 8 – touch – screen interface; 9 –electric heaters; 10 – electronic balance; 11 – drying chamber; 12 – electric motor.

Table 1. Chemical composition used for the calculation of calorific value

No.	Variety	N (%)	C (%)	H (%)	S (%)	Ash (%)	Moisture (%)
1	Busuioaca de Bohotin	0.837	43.6	5.89	<0.01	2.69	8.20
2	Fetesca Neagra	0.996	43.8	5.84	<0.01	6.01	7.78
3	Feteasca Alba	1.000	44.6	6.14	<0.01	5.92	8.01
4	Feteasca Regala	0.874	44.0	5.66	<0.01	6.48	8.07
5	Sauvignon Blanc	1.600	43.1	6.23	<0.01	5.92	8.19
6	Muscat Ottonel	0.896	44.1	6.05	<0.01	4.34	7.89
7	Pinot Noir	0.851	43.9	5.83	<0.01	5.83	8.02
8	Cabernet Sauvignon	0.902	43.9	5.98	<0.01	4.93	7.86

3. RESULTS

The tendrils which resulted from dormant pruning of vines were separately collected from each vine, were chopped and then wrapped in individually marked (plot number and current number) plastic bags. Table 3 presents the amount of tendrils (biomass) harvested for each vine and variety, as the average value for 20 samples. In order to calculate the biomass potential for one hectare the distances between rows (2.3 m) and between vines in a row (1.2 m) were considered, resulting in 3623.19 vines/ha. The analysis of data presented in Table 2 showed that the amount of harvested biomass depends on the vineyard variety; the lowest value of 0.327 kg/vine, respectively 1184.8 kg/ha was recorded for Cabernet sauvignon and the highest value of 0.433 kg/vine, respectively 1568.8 kg/ha for Muscat ottonel. The humidity of vines was comprised between 42.28% for Cabernet sauvignon and 53.35 for Sauvignon blanc.

Table 2. The amount of biomass from each vine, variety and surface unit

Nr. crt.	Variety	Average amount of tendrils per vine (kg/vine)	Average amount of tendrils per hectare (kg/ha)	Humidity of tendrils (%)
1	Busuioacă de Bohotin	0.332	1202.9	49.75
2	Fetească neagră	0.367	1329.7	49.60
3	Fetească albă	0.347	1257.3	51.38
4	Fetească regală	0.343	1242.8	49.99
5	Sauvignon blanc	0.370	1340.6	53.35
6	Muscat ottonel	0.433	1568.8	49.20
7	Pinot noir	0.420	1521.7	50.91
8	Cabernet sauvignon	0.327	1184.8	48.28

Table 3. Energy potential of biomass harvested during dormant pruning of vine

Nr. crt.	Variety	Amount of biomass (dry base) [kg/ha]	Calorific value (dry base) [MJ/kg]		Energy potential (dry base) [MJ/(kg.ha)]	
			Gross	Net	Gross	Net
1	Busuioacă de Bohotin	604.45	15.90	14.47	9610.75	8746.39
2	Fetească neagră	670.17	17.405	15.99	11664.31	10716.02
3	Fetească albă	611.30	17.48	16.01	10685.52	9786.91
4	Fetească regală	621.52	2.00*	0.632*	1243.04*	392.80*
5	Sauvignon blanc	625.39	16.98	15.66	10619.12	9793.61
6	Muscat ottonel	796.95	17.07	15.62	13603.94	12448.36
7	Pinot noir	747.00	14.49	13.08	10824.03	9770.76
8	Cabernet sauvignon	612.78	17.21	15.77	10545.94	9663.54

*Note: for the Fetească regală variety the test will be repeated in the next season

In order to emphasize the energy level which could be obtained as a result of the dormant pruning operation, the amount of dry substance harvested from one hectare was calculated. The upper and lower calorific values were evaluated according to the described method and then the energy potential was calculated (table 3).

The gross and net calorific values of the tendrils depend on variety, with values comprised between 13.08 MJ/kg for the net calorific value and 17.48 MJ/kg for the gross calorific value. The data show that the calorific value of the Fetească regală tendrils is much lower compared with the other varieties; as a result we take into account a re-evaluation of these results in the next pruning season and they were not used in the subsequent interpretation of the results.

When comparing the calorific value of vine tendrils with the one of dry firewood (which is comprised between 12.56 MJ/kg and 16.75 MJ/kg) we concluded that the values are very close to each other. The energy potential of the tendrils harvested from one hectare of vineyard is comprised between 8746.39 MJ/(kg.ha) and 13603.94 MJ/(kg.ha), which is equivalent to the energy contained by 696.37- 812.18 kg of firewood. This confirms the value and energy potential of the vine tendrils, which turn out to be an important resource of renewable energy.

4. CONCLUSIONS

The analysis of both the elements presented in the first part of the paper and the experimental results led to the following conclusions.

biomass is a primary source of carbon, together with the other sources of renewable energy;
vegetable biomass is the most valuable of the renewable energy sources due to the cyclic evolution of carbon;
the amount of biomass harvested from the dormant pruning of vine depends on the vine variety. being comprised between 1184.8 kg/ha and 1568.8 kg/ha;
the calorific value of vine tendrils is comprised between 13.08 MJ/kg (net calorific value) and 17.48 MJ/kg (gross calorific value);
a comparison between the calorific values of tendrils and firewood (12.56 MJ/kg...16.75 MJ/kg) shows that there are very small differences between them from this point of view;
the energy potential of the tendrils harvested from one hectare of vineyard is comprised between 8746.39 MJ/(kg.ha) and 13603.94 MJ/(kg.ha), which is equivalent to the energy contained by 696.37- 812.18 kg of firewood

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