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**DOCTORAL SCHOOL INTERDISCIPLINARY AGRONOMICS AND
NATURAL SCIENCES**

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**HEATING TECHNOLOGY UTILISATION OF AGRICULTURAL WASTE
AND BY-PRODUCTS CHARACTERISTIC FOR THE REGION**

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INTRODUCTION

1.1. Reasons for selecting the theme, objectives of the research

The world is warming up continuously from Alaska to the Andes. Although the earth's average temperature is only 0.6 degrees Centigrade higher than at the beginning of the last century (*APPENZELLER, 2004/b*), but the coldest, most remote regions have become warmer. Today almost all levels of science agree that the weather warmed up in the 20 century mainly due to human activity (*IPCC, 2001*). As the carbon dioxide-level increases, so does the mercury in the thermometer move upwards, by a further 1.5-5.5 degrees Centigrade by the end of the century according to the IPCC prognosis.

Satellite surveys prove that in September 2005 the polar ice caps were thinner than experienced at any time previously. The extent of ice covering the seas reduced by 1.3 km² as compared to 1979 (*KISS, 2006*). The majority of researchers agree that the main reason for increase in carbon dioxide, causing the warming up is the utilisation of fossilised fuels and the burning of forests (*MORELL, 2004*).

Estimates of the world's energy resources often appear in the technical literature, but the geologically unexploited area is still extremely large, therefore these data are uncertain (*VAJDA, 2004; BAUQUIS, 2002*). We do not know precisely how long these resources will last, but one thing is certain: the stocks are limited. 87 % of supplies today are based on the fossilised fuels (*FARKAS, 2004*) and this will probably remain the same for some decades (*MOLNÁR, 2005*). Renaissance of to abundantly available coal would however accelerate the global warming up, and in this way the environment necessary for existence could be terminated.

Hungary's hydrocarbon reserves are constantly diminishing. The yearly exploitation only covers a small part of the utilised quantity and production is reducing year by year. The import is becoming constantly more expensive and contains risks therefore counterbalancing of the unfavourable processes appearing in the area of energy supplies is a question of vital importance.

According to *BARÓTFI, 2006* the only workable route for energy supply is conscious thriftiness with the existing stocks and the provision of necessary amounts from regenerating energy sources to the highest possible degree. The most workable route for Hungary's policy on regenerating energy appears to be the increase in use of biomass, for which its utilisation for heating purposes seems to be the most favourable from among the energy production processes.

Hungary has favourable characteristics in regard to biomass stocks, which is not reflected by the present 4.2 % utilisation proportion (*BAI, 2005*). According to specialists 9-10 % of the domestic energy consumption could be covered by burning of biomass (*BAI - ZSUFFA, 2001*), and in the long-term 17-18 % is not impossible (*MAROSVÖLGYI, 2004, 2005*). Research has been going on in the country for more than twenty years in the field of biomass utilisation, thus our characteristics are not only favourable in regard to biomass resources, but the expertise is available also.

The primary condition for utilisation of biomass for heating technology is precise knowledge of the quantity of biomass. Although national surveys have been prepared on the subject, detailed data, also reflecting local conditions – which would assist in the community, small district or regional utilisation – are lacking.

In the interest of determining the quantity of biomass formed yearly in the conurbation region of Debrecen I set the following objectives:

1. Measurement of the quantity of combustible biomass of vegetable origin formed yearly in the administrative area of communities within the conurbation of Debrecen. I selected the examined plants on the basis of identical utilisation technology, by this means the object of the measurement was formed by forestry production and wooden bio-heating materials of agricultural origin.
2. Numerous data is lacking for correct determination of the weight and energy content of vine and fruit tree cuttings, therefore the large part of my research was formed by establishing the physical characteristics necessary for energy utilisation of grape and fruit species and types, characteristic of the region.

From among the physical characteristics from the point of view of heating technology utilisation I examined the wet-weight of cuttings relating to one tree for each species, the moisture content of cuttings after pruning, the ash content, the combustion heat and heating value, together with the greatest diameter characteristic for the cutting's species.

3. Establishment of basic data, which on one hand can serve as the basis for future, planned research, on the other hand can assist in preparation of the strategic plans aimed at the utilisation of regenerating energy resources in the small regions.

I took account of the possibilities for economic transportation in the interest of an optimisation of transportation route for construction of a possible biomass power plant as a view point for selection of the region and the communities. According to this viewpoint 23 communities came within the scope of the examination.

My fundamental objective is that this knowledge should not only become known in professional circles, but extended comprehensively they also enlarge the circle of actual users.

2. MATERIAL AND METHOD

2.1. Object of the examination

1. I carried out examination for determining the physical characteristics of grape and fruit tree cuttings important for the point of view of heating technology. I took the samples necessary for the examinations in the area of the Debrecen conurbation.
The examined physical characteristics were the wet-weight of cuttings relating to one tree for each species, the moisture content of cuttings when pruned, the ash content, combustion heat and heating value of the cuttings, together with the greatest diameter of the cuttings.
2. I collected data for determining the quantity of wooden biomass, within this, of the forestry production, together with the vine and fruit tree cuttings, within the administrative boundary of the examined region.
3. I made calculations for determining the energy content of wooden biomass formed in the administrative area of the examined communities.

2.2. Site of the examination

Several small regional associations were organised in the conurbation of Debrecen after 1990. I started the research in 2002, in the communities belonging to these small regions. On the 1st January 2004 the arrangement of the small region was altered; Derecske and Konyár were also included into the small region. Data of these latter communities were not processed since the majority of area and measurement data were already completed by the time of the alteration.

When planning the energy-utilisation of wooden biomass produced in the conurbation of Debrecen knowledge of the local characteristics is absolutely necessary, since a significant difference is shown in the endowments of communities in the conurbation of Debrecen. The small regions and communities included in the examination are shown in table 1.

Table 1. Small regions and communities belonging to the conurbation of Debrecen:

Small regions	Settlement	Centre of small region
Debreceni	Debrecen	Debrecen
Derecske–Létavértesi	Álmosd, Bagamér, Derecske, Hajdúbagos, Hosszúpályi, Kokad, Konyár, Létavértes, Mikepércs, Monostorpályi, Sáránd	Létavértes
Hajdúhadházi	Bocskai kert, Fülöp, Hajdúhadház, Hajdúsámson, Nyírábrány, Nyíracsad, Nyíradony, Nyírmártonfalva, Téglás, Újléta, Vámospércs	Hajdúhadház

Source: *KSH 2004*

2.3. Methods for examining the physical characteristics of vine and fruit tree cuttings

2.3.1. Stages and methods for determining the weight of cuttings.

- Before taking samples I selected the species characteristic for the given area and the typical types grown in the area. The samples originate from plantations planted and cultivated by specialists. I took samples from productive-age plants of each species for the examination. Quality of the soil was not a subject of the examination.
- I designated the trees to be examined based on random selection of samples in the plantations and measured the weight of cuttings related to one tree. On the basis of the measured data I calculated the statistical characteristics of the weight data, the minimum, maximum and average value related to one tree, together with the confidence-interval at a 95% confidence-level.

2.3.2. Locations and circumstances of the measurements

I measured the weight data of vine and fruit tree cuttings in plantations and private gardens. I repeated the measurements twice on the same species. I carried out the first

measurement series in March 2003, and the control measurement in the spring of 2006. The locations and circumstances of the measurements are contained in table 2.

Table 2 Locations and circumstances of sample taking for determining weight data

Species	Type	S.	Date	Temp. [°C]	Rh. [%]
Apple tree	Jonathan, Mutsu	Pallag	2003.03.20-21 2006.03.16.	+3...4 +1	73...75 72
Pear tree	Bosc Kobak, Hardenpont, Hardy vajkörte	Józsa	2003.03.15. 2006.03.17.	+5 +1	75 70
Cherry tree	Érdi bőtermő	Apafa	2003.03.19. 2006.03.21.	+6	76
Peach tree	Babygold. Champion, Redhaven, Sunhaven, Sunbeam	Pallag	2003.03.22-23. 2006.04.07-08.	+3...4 +8..10	73 75...76
Plum tree	Stanley	Apafa	2003.03.18. 2006.03.22.	+5	76
Vine cuttings	Afuz Ali, Attila, Boglárka, Cardinal, Chasselas, Csaba gyöngye, Favorit, Irsai Olivér, Pannónia kincse, Pölöskei muskotály, Sarolta, Teréz	Józsa	2003.03.12-14. 2006.04.09.	+4 +9	75 76

Key to signs: S. – sample taking site, T. – temperature, Rh. – relative humidity

I measured the vine and pear species in private gardens, the characteristic cultivation data of which are contained in table 3.

Table 3: Cultivation data of the examined vine and pear species

Type	Stock	Age in 2003 [years]	Cultivation characteristics
Bosc Kobak, Hardenpont, Hardy vajkörte	Wild pear	8	Free-standing
Afuz Ali, Attila, Boglárka, Cardinal, Chasselas, Csaba gyöngye, Favorit, Irsai Olivér, Pannónia kincse, Pölöskei muskotály, Sarolta, Teréz	American stock	7	Guyot cordon cultivation method, in 2 rows at some distance from each other, stock spacing 1.2 m

I measured several types of the apple, sour cherry, plum and peach species in the fruit orchards. I examined one of each sour cherry and plum type, two of each apple and five of each peach type. The cultivation data of the examined fruit orchards are summarised in table 4.

Table 4: Cultivation data of the examined fruit orchards

Type	Subject	Age in 2003	Area	Row and plant spacing	Number of trees per hectare	Total trees
		[years]	[ha]	[m×m]	[trees/ha]	[pcs]
Mutsu	M26	12	12,5	5×3	666	8325
Jonathan	M26	12	12,5	5×3	666	8325
Érdi bőtermő	sajmeggy	10	13	6×4	416	5408
Stanley	myrobalán	12	40	7×4	357	14280
Babygold	vadőrszi	14	2	6×4	416	832
Champion			11			4576
Redhaven			5,5			2288
Sanhaven			5,5			2288
Sunbeam			7			2912

I carried out the data analysis with the help of the Microsoft Excel table handling programme. I took the 95% probability confidence level excepted internationally for agricultural research as the basis for evaluation of the weight data. (*SVÁB, 1981*).

2.3.3. Moisture content

I carried out determination of the moisture content in the Soil Mechanics Laboratory of the Technical College Faculty of the University of Debrecen, where the conditions and implements specified in the standard were available.

I took 10 samples of cuttings from all examined types of vines and fruit trees, which were provided with code and serial numbers. I transported the test pieces in air-tight container to the laboratory and measured their wet weights. Selection of the about 10-12

cm long test pieces was done at random from the cut off branches, thus branch tips, branch-stumps and cuttings of various age were included in the material to be examined. Figure 1. shows one group of the samples.



Fig. 1. Cutting samples

I dried the measured test pieces to constant weight in a drying oven, then I measured their weight following drying to measuring-room temperature in an exsiccator. I executed both measurements with an accuracy of 0.001 g. I recorded the measured values in an examination report and summarised them in tabular form.

I carried out the data evaluation with the help of the Microsoft Excel table handling programme. I compared the samples by both type and species and depicted the results in a box diagram in the interest of demonstrative presentation.

2.3.4. Ash content

I carried out the ash content measurements in the Heat Treatment Laboratory of the Technical College Faculty of the University of Debrecen on the samples taken for determining the moisture content. I recorded the measurement data in a report. The samples were burnt in a previously weighed measuring vessel. By using the ash produced after burning and the value dried to constant weight I calculated the percentage values and statistical data of the ash content.

I carried out the data evaluation with the help of the Microsoft Excel table handling programme. I compared the samples by both type and species and depicted the results in a box diagram in the interest of demonstrative presentation.

2.3.5. Combustion heat and heating value

I carried out determination of the combustion heat and heating value at Gödöllő in the Energy Examination Laboratory of the FVM Agricultural Mechanical Institute. The laboratory operates according to the MSZ EN ISO/IEC 17025: 2001 standard and attestation by the National Accreditation Body took place in 2005, which makes our examination results acceptable within the European Union.

I carried out measurement of the moisture content, necessary for determining the heating value with the HR 73 type halogen moisture content measuring instrument, which can be seen in fig. 2. The instrument is a weigh-scale assembled together with a halogen drier, which calculates the gross moisture content after weighing the wet and dried weight of the powdered sample.



Fig. 2. HR 73 type moisture content-measuring instrument

I carried out determination of the combustion heat with the help of an IKA manufacture C 2000 type combustion heat and heating value determining measuring system, which can be seen in fig. 3.



Fig. 3. IKA, C 2000 type combustion heat and heating value measuring appliance

In the case of fruit trees I carried out the moisture content, combustion heat and heating value measurements on every type; in the case of vine types I compared the data of two randomly selected samples.

In knowledge of the moisture content the material's combustion heat and approximate value of heating value relating to the measured moisture content can be calculated with a bomb-calorimetric examination. The IKA manufacture C 2000 type bomb-calorimetric appliance automatically determines the combustion heat of the inserted material, then with entry of the moisture content automatically calculates the heating value also. I carried out the data evaluation with the help of the Microsoft Excel table handling programme.

2.3.6. Largest diameter characteristic for the types of cuttings

The largest diameter was placed in the sphere of examined characteristics from the point of view of chopping the cuttings.

This measurement took place in parallel with the measurement of weight data; the dates, sites and circumstances of the measurement agree with the entries recorded for the weight data. Determination of the largest diameter took place for each species from the cuttings collected for measurement of weight data. The data are of an informatory character and did not require statistical processing.

2.4. Determining quantity and energy content of vine and fruit tree cuttings

The determination of the quantity of vine and fruit tree cuttings in the examined region took place by estimation with data originating from statistic and literary data, from our own surveys and measurements the steps and methods of which are as follows:

- I determined the characteristic land utilisation in the examined region on the basis of *Central Statistics Office (CSO), 2002, 2004* and *Min. of Agriculture and Rural Development Hajdú-Bihar-County Land Register (MARD HBC LR), 2002* data bases then I surveyed the proportion of agricultural areas falling within the administrative boundaries of the settlements with assistance of specialists from the rural agronomist network.
- With the help of the *CSO, 2002; 2004; MARD HBC LR, 2002* data and my own surveys I determined the vine and fruit tree species and types grown in the examined region, their cultivation areas and cultivation characteristics.
- In the knowledge of the physical characteristics determined as described in section 2.3 and the cultivation data for the area, I determined the average quantity of the average wet and air-dry weight of cuttings produced in the examined region and the confidence-interval, by estimation.
- In knowledge of the average weight, moisture content and combustion heat characteristic for the species I determined by calculation the energy content relating to the estimated air-dry weight of vine and fruit tree cuttings falling within the administrative area of the communities.

2.5. Determination of the quantity and energy content of forestry produce

The determination of the forestry produce in the examined region took place by estimation utilising data originating from statistic, literary and our own surveys.

Steps and methods for determining the forestry produce:

- I determined the size of the afforested area in the examined region on the basis of *CSO, 2002; State Forestry Association (SFA), 2002, and HBC. Agriculture and Rural Office, 2002* data bases then I surveyed the proportion of afforested areas falling within the administrative boundaries of the settlements with assistance of specialists from the rural agronomist network.
- I determined the quantity of economically felled timber falling within a unit area on the basis of national and local felling indexes and literary data. The gross quantity of felleable timber was determined at a value of 3.12 m³/ha/year (*BARÁTOSSY,1999; SFA 2005*).
- In knowledge of the quantity of felleable timber calculated for unit area, with the help of literary data I determined the gross and net quantity of timber; the firewood and the proportion of waste remaining in the forest. I determined the wood remaining in the forest from the difference in gross-net timber on the basis of literary data. I took the net timber as 80 % of the gross, while I calculated the firewood as 45% of the net timber.
- In knowledge of the afforested area, the combination of tree species and the specific felling indexes for the examined area, I determined by calculation the estimated quantity and energy content of the air-dry weight of fire wood and waste remaining in the forest falling within the administrative boundaries of the communities. I determined the density and heating value relating to the air-dry condition of the wood, with a weighted average of species characteristic for the area, calculating with the values, $\rho=670 \text{ kg/m}^3$ and $HV=13,4 \text{ MJ/kg}$.

3. RESULTS AND CONCLUSIONS

3.1 Physical characteristics of vine and fruit tree cuttings

3.1.1. Weight data of vine and fruit tree cuttings

I carried out measurement of the weight of vine and fruit species cuttings in 2003, and the control measurement in 2006. I evaluated the data with the help of a table handling programme and depicted them in a box diagram. The data measured in 2003 are shown in fig. 4., the data for 2006 in fig. 5. while the summarised data are shown in fig 6.

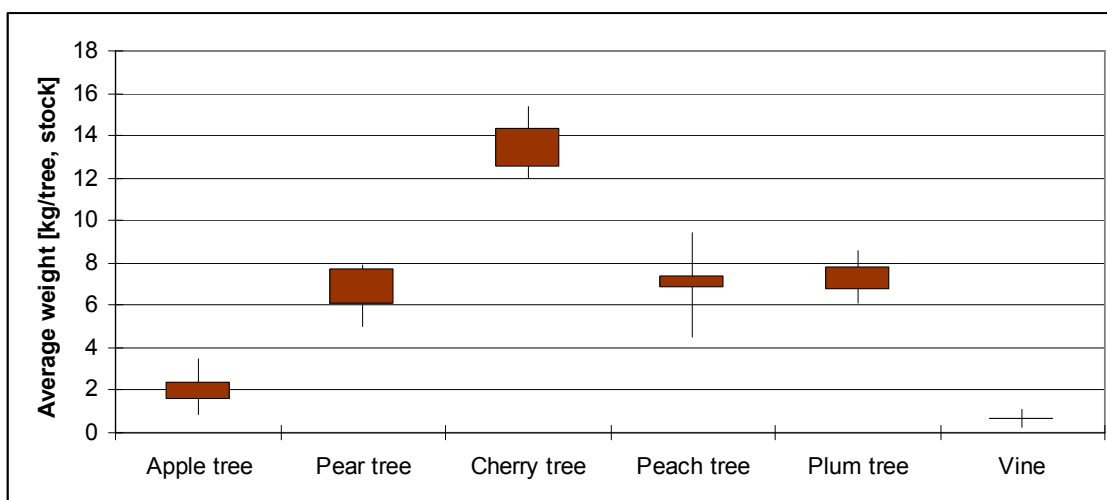


Fig. 4. Minimum and maximum values of the weight data and confidence interval for vine and fruit tree species on the basis of measurements in 2003

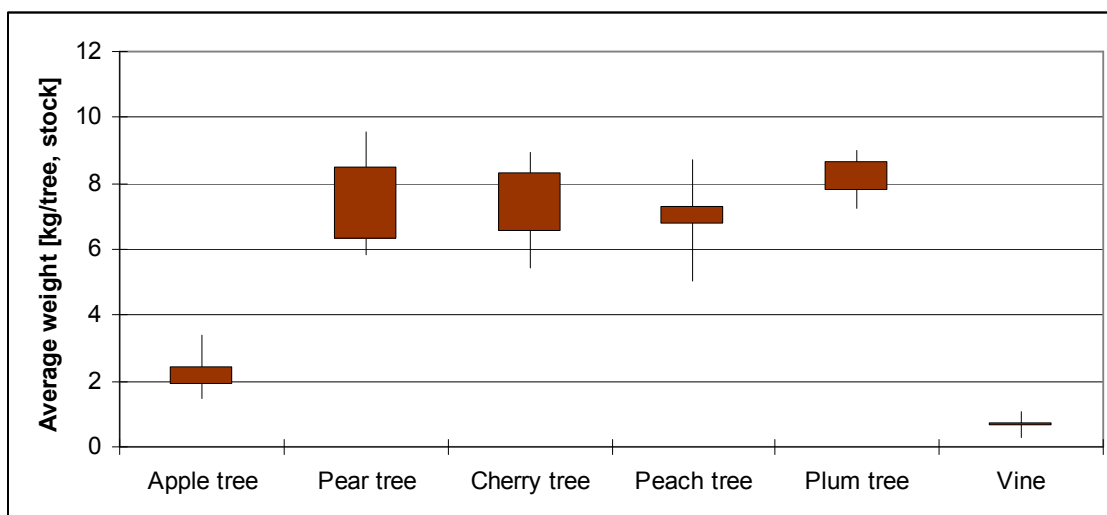


Fig. 5. Minimum and maximum values of the weight data and confidence interval for vine and fruit tree species on the basis of measurements in 2006

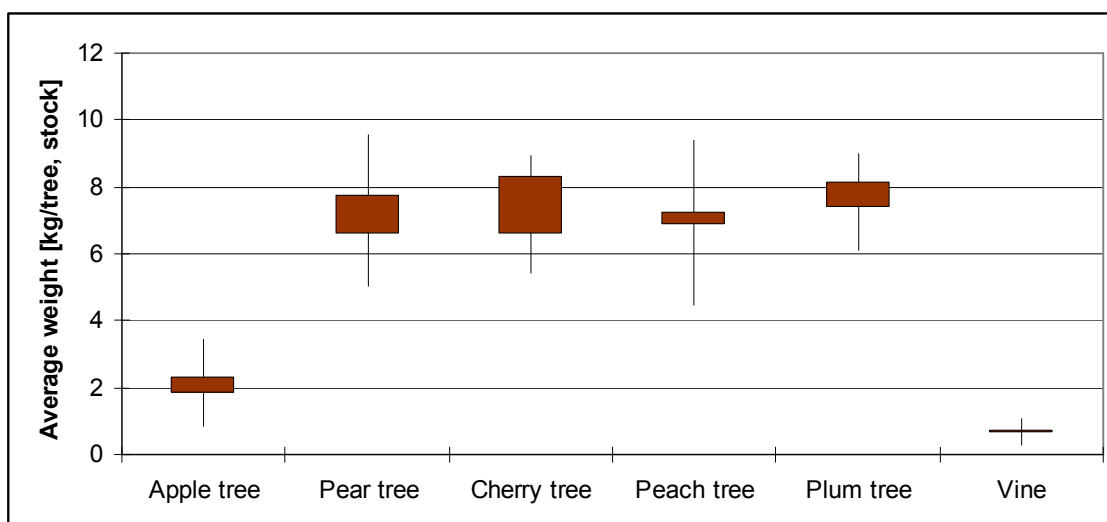


Fig. 6. Minimum and maximum values of the weight data and confidence interval for vine and fruit tree species on the basis of the summarised data

With two species of apple tree the data of measurements in the two years showed a deviating tendency. In 2003 the weight of Mutsu cuttings exceeded that of the Jonathán, while at 2006 measurement this proportion was reversed. The stock, cultivation fundamentals, the age of trees and the cultivation methods for the two species conformed completely, thus the results make it probable, that the influence of species on the weight of cuttings is not determinant, namely the values display an evening up tendency. On the basis of the summarised data, comparing the two years the weight of cuttings increased moderately.

With the pear tree the measurement data for the two years display a similar tendency. The quantity of cuttings measured in 2006 increased moderately for all three types.

With the sour cherry tree the average weight of cuttings measured in 2003 was almost twice the value measured in 2006, which can be explained by the pruning method. The sour cherry is thinned out moderately every year which is represented by the data for year 2006 and rejuvenated every 3-4 years which is shown by the data for year 2003. Therefore I took the measurement data for year 2006 as a representative value for the further calculations.

Analysing the measurement data for *the peach tree* species a great deviation characteristic for year and species could not be observed, which makes it probable, that in the case of peach orchards of identical age, growing fundamentals and cultivation

method, the examined types have no determinant significance on the weight of cuttings, therefore the quantity of cuttings produced in the orchards can be predicted well

Comparing the weight data of *the plum tree* cuttings for the two years a moderate increase is displayed, which makes it probable that the average of the two years represents well the average production age of the given type.

On the basis of comparing summary data of *the vine cuttings* for two years it can be established, that from among the examined species the confidence interval relating to weight data for vines is the smallest, which displays the most uniform cuttings production from among the examined species. On this basis it can be established that, disregarding extreme weather conditions, in the case of unaltered composition of species the vine provides a uniform and reliable quantity of cuttings each year in the given area.

In knowledge of the calculated average weight, confidence-interval and cultivation data for the species, I calculated the specific weight of cuttings related to the unit area for each species, the data of which are contained in table 5.

Table 5: The calculated values of wet-weight of cuttings for unit area

Species	Average weight of the cuttings			Specific cuttings weight		
	B.limit	Average	T. limit	B. limit	Average	T. limit
	[kg/trees, stocks]			[t/ha]		
Apple tree	1,8	2,05	2,29	1,20	1,37	1,53
Pear tree	6,59	7,18	7,77	2,35	2,56	2,77
Cherry tree	6,54	7,43	8,32	2,33	2,65	2,97
Peach tree	6,9	7,09	7,28	2,88	2,96	3,04
Plum tree	7,35	7,74	8,12	2,62	2,76	2,90
Vine cuttings	0,61	0,66	0,71	2,03	2,20	2,37

The data show that with the examined species of vines and fruit trees the average weight of cuttings related to one tree/stock depends significantly on the species, but the species has less effect from the point of view of specific weight calculated for unit area, than the method of cultivation. On the basis of the specific quantity of cuttings weight I established that the vineyards and fruit tree orchards provide a significant quantity of wooden bio-fuel each year in a calculable, reliable manner.

3.1.2. Moisture content of vine and fruit tree cuttings

When using the biomass for heating the moisture content influences the heating value to a large degree, therefore I measured the moisture content of cuttings from all vine and fruit tree species directly after pruning. I selected the average, minimum, maximum values and the inter-quartile extent (green area) for statistic characterisation of the measured data, which is shown in the box diagram in fig. 7.

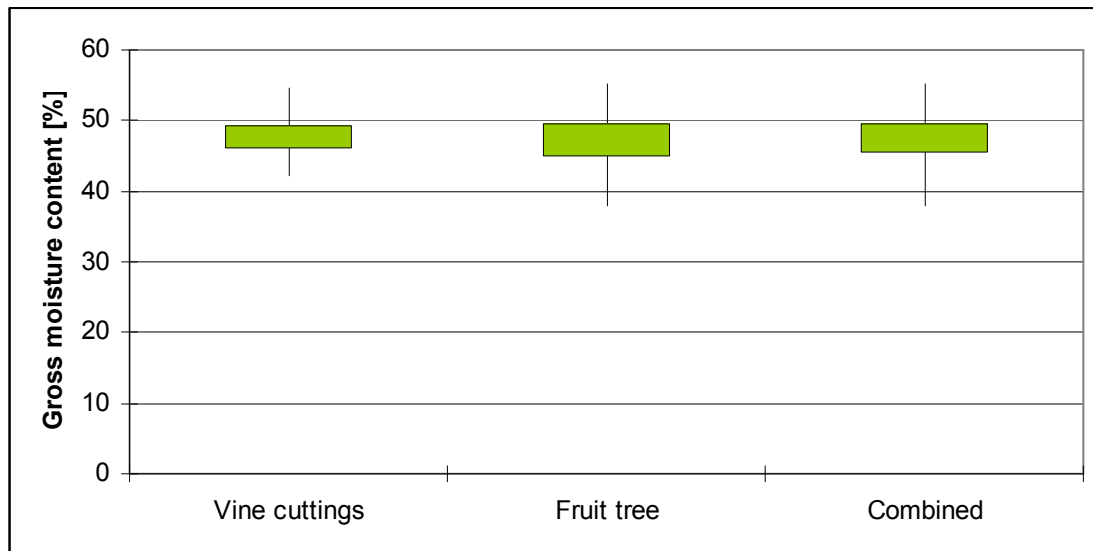


Fig. 7. Combined statistical characteristics of moisture content of vine and fruit tree cuttings

The data show that the moisture content of the cuttings when pruned is uniformly high independent of species, therefore the direct utilisation for heating is only economic after drying. In knowledge of the moisture contents and the weights I calculated the specific values for air-dry weights of the cuttings, which I used for determining the energy content related to the air-dry weight of cuttings produced yearly in the examined region. These values are contained in table 6.

Table 6: Values of air-dry weights of cuttings calculated for unit area

Species	Average weight of the cuttings			Specific cuttings weight		
	B.limit	Average	T. limit	B. limit	Average	T. limit
	[kg/trees, stocks]			[t/ha]		
Apple tree	1,15	1,32	1,47	0,77	0,88	0,98
Pear tree	4,12	4,46	4,86	1,47	1,59	1,74
Cherry tree	4,2	4,78	5,35	1,50	1,71	1,91
Peach tree	4,49	4,61	4,73	1,87	1,92	1,97
Plum tree	4,75	5	5,25	1,70	1,79	1,87
Vine cuttings	0,39	0,42	0,45	1,30	1,40	1,50

3.1.3. Ash content of vine and fruit tree cuttings

For selection of the firing equipment the ash content of the raw material must be known, therefore I measured the ash content of every vine and fruit tree species. The statistical characteristics of the data are shown by the box diagram in fig. 8.

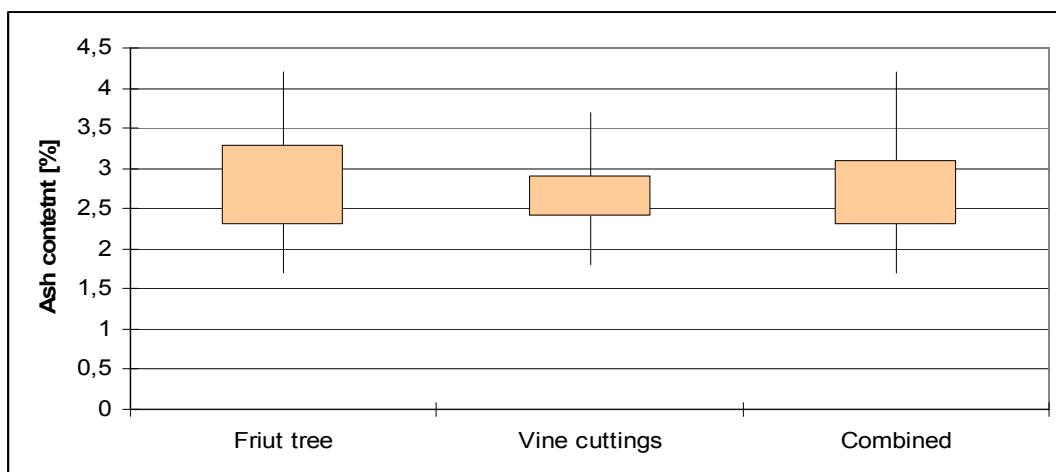


Fig. 8. Combined statistical characteristics of the ash content of vine and fruit tree cuttings

On the basis of the data I established that the cuttings can be regarded as homogenous from the technological point of view and in the case of direct heating the vine and fruit tree cuttings can be used with identical equipment and technology.

3.1.4. Combustion heat and heating value of vine and fruit tree species

I carried out combustion heat measurements on the examined vine and fruit tree cuttings in the MARD Hungarian Economics Institute (HEI) Energy Examination Laboratory. The measured values of combustion heat, the heating value of the species recalculated for air-dry state, the averages related to the species and the statistical characteristics of the data are summarised in table 7.

The average combustion heat calculated from the data is 18.7 MJ/kg and the maximum value of deviation from the average does not exceed 3 %. On this basis it can be stated that from the combustion heat point of view the examined vine and fruit tree cuttings are homogenous independent of species and type and can be regarded as equivalent to the forest bio-heating materials.

Table 7: Data and statistical characteristics of the combustion heat and heating value of the examined species and types

Species	Type	Type		Average
		H _o [MJ/kg]	H _u [MJ/kg]	
Apple tree	Jonathan	18,270	13,958	13,991
	Mutsu	18,349	14,025	
Pear tree	Bosc Kobak	18,466	14,123	14,123
	Hardenpont	18,627	14,260	
	Hardy vajkörte	18,304	13,986	
Cherry tree	Érdi bőtermő	18,799	14,406	14,406
Peach tree	Babygold	18,977	14,557	14,663
	Champion	19,469	14,974	
	Redhaven	18,921	14,509	
	Sunhaven	19,220	14,763	
	Sunbeam	18,924	14,512	
Plum tree	Stanley	18,955	14,538	14,538
Vine cuttings	Attila	18,424	14,088	13,977
	Boglárka	18,162	13,866	

Explanation of signs: H_o – combustion heat, H_u – heating value in air-dry state

3.1.5. Largest diameters of vine and fruit tree cuttings

The largest diameter of the examined types influences selection of the chopping machine. The measured largest diameters are contained in table 8.

Table 8: Largest diameter of cuttings of the examined types

Species	Type	Largest diameter [mm]
Apple tree	Jonathan, Mutsu	23-38
Pear tree	Bosc Kobak, Hardenpont, Hardy	28-31
Cherry tree	Érdi bőtermő	36
Peach tree	Babygold, Champion, Redhaven, Sunhaven, Sunbeam	43-86
Plum tree	Stanley	40
Vine cuttings	Afuz A., Attila, Cardinál, Chasselas, Boglárka, Csaba gy., Favorit, Irsai O., Pannónia k., Pölöskei m., Sarolta, Teréz	7-10

On the basis of the measured data I established that the examined vine and fruit tree cuttings can be regarded as homogenous from the point of view of preparation technology for heating independent of species and type.

3.2. Average, estimated values of weight of cuttings produced yearly in the examined region

In knowledge of area data of vine and fruit tree species and values of air-dry weight of cuttings related to unit area I determined the average, estimated values of weight of cuttings broken down by communities, which is demonstrated in fig. 9.

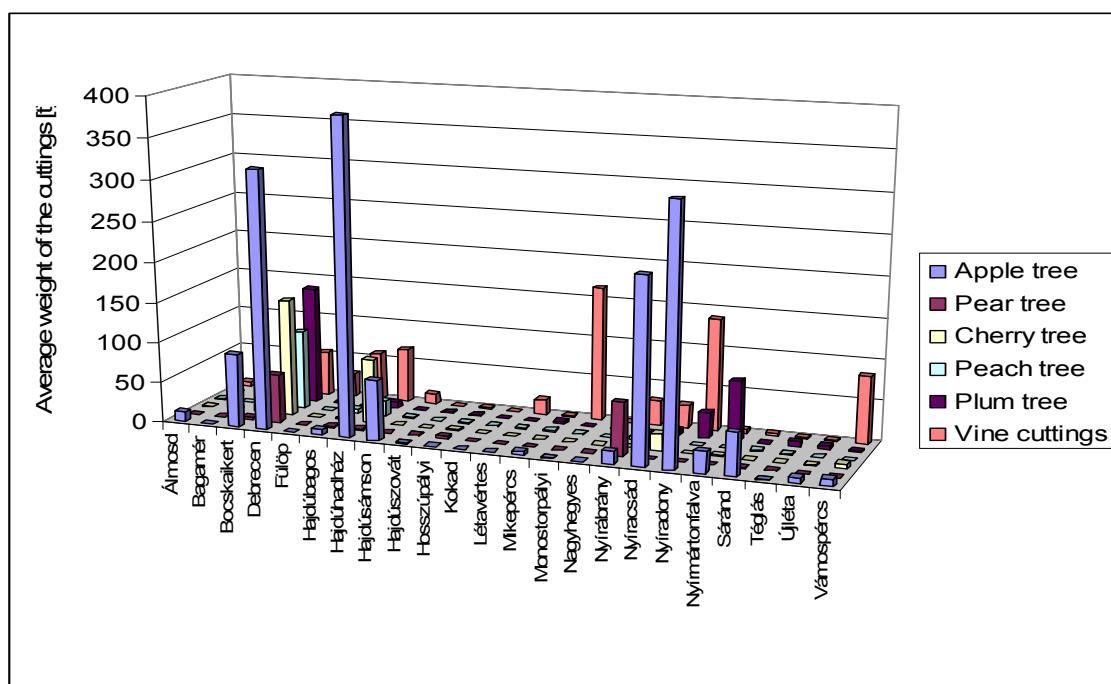


Fig. 9. Average, estimated weight data of cuttings produced yearly in the examined communities

The average, estimated air-dry weight of cuttings produced yearly in the administrative area of the examined communities is 3.1 thousand tons. About 90% of the cuttings are produced in nine communities, of which are prominent: Debrecen (821 t), Hajdúhadház (564 t), Nyíradony (486 t), Nyírácsád (292t), Nyírábrány (117 t) and Nyírmártonfalva (107 t), but quantities exceeding the average are produced in Bocskai kert (139 t), Monostorpályi (166 t) and Vámospercs (1001 t). In the

Nagyhegyes, Kokad, Bagamér, Hajdúszovát communities the total of cuttings produced yearly does not even reach 6 tons. The greatest weight in the examined region is the cuttings from apple species, but in some communities, e.g. Monostorpályi the vine shoots are dominant.

3.3. The average, estimated weight data of bio-fuels materials produced yearly in the examined communities

The quantity of wooden bio-fuel, regenerating yearly in the examined region is given by the combined weight of the forestry waste, the firewood and the cuttings. Results of the calculations are displayed in fig. 10.

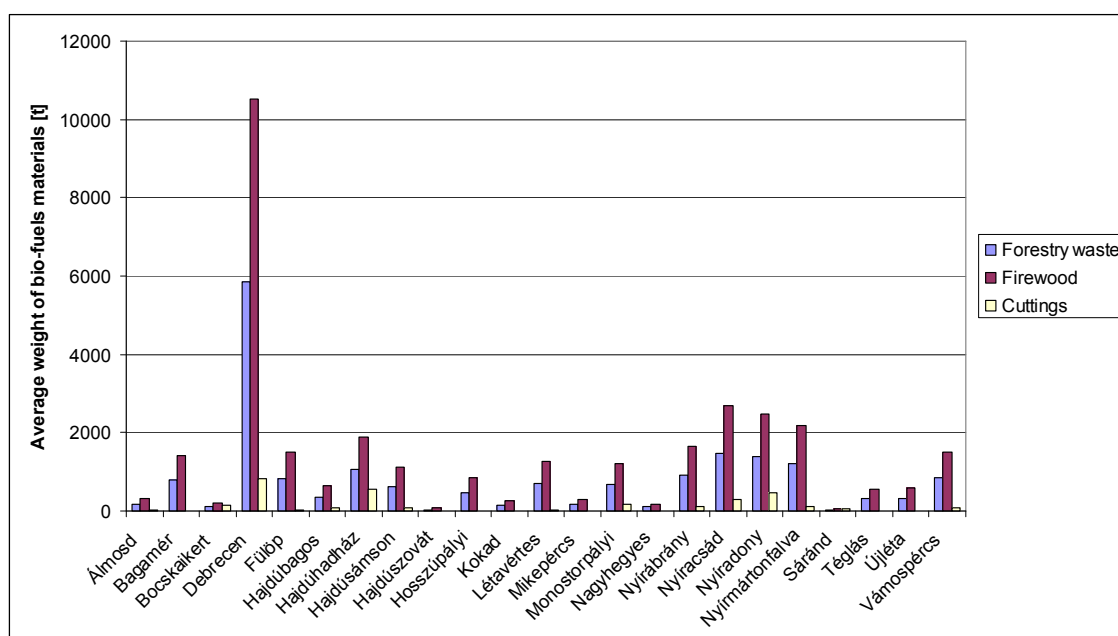


Fig. 10. Average, estimated weight data of wooden bio-fuels materials produced yearly in the examined communities

The average, estimated weight of wooden bio-fuel produced yearly in the examined region is 55.4 Thousand tons, of which 60.6 % is the firewood and 33.8 % the forestry waste. From the data it is seen that in regard to make up of the region's wooden bio-fuel the firewood is dominant, which exceeds value of cuttings by a magnitude. Significant increase in utilisation for energy, of waste remaining in the forest – mainly due to its collection being uneconomical – cannot be expected in the future either.

4. NEW SCIENTIFIC RESULTS

1. With measurements and calculations I determined the physical characteristics of vine and fruit tree cuttings produced in the region important from the energy point of view, the cuttings' moisture content at time of pruning, ash content and combustion heat. On the basis of the combined data of the vine and fruit species' cuttings: the gross moisture content at time of pruning was 47.4 %; the average value of ash content was 2.7 %, and the average value of combustion heat was 18.7 MJ/kg. I established that from the heating technology point of view the vine and fruit tree cuttings are homogenous independent of species and type and can be regarded as equivalent to the forest bio-heating materials..
2. With measurements and calculations I determined the average wet weight produced yearly, relating to one tree/stock, of the vine and fruit tree cuttings characteristic for the examined region. The average estimated of cuttings produced yearly derived at 2.05 kg/tree for the apple trees, 7.18 kg/tree for the pear trees, 7.43 kg/tree for the sour cheery trees, 7.07 kg/tree for the peach trees, 7.74 kg/tree for the plum trees, while this was 0.66 kg/stock for the vine stocks. I established with the help of the specific weight data relating to the species, that in the case of vineyards and fruit tree orchards of similar age and method of cultivation the quantity of cuttings produced on the area can be estimated well.
3. In knowledge of the cultivation method characteristic for vineyards and orchards in the examined region, the measured weight data and physical characteristics I determined the values of air-dry weight of vine and fruit tree cuttings related to unit area: apple tree cuttings 0.88 t/ha; pear tree cuttings 1.59 t/ha; sour cherry tree cuttings 1.71 t/ha; peach tree cuttings 1.92 t/ha; plum tree cuttings 1.79 t/ha and vine shoots 1.4 t/ha. On the basis of the results I established that the vineyards and fruit orchards can provide a quantity of wooden bio-fuel of reliable quality yearly for a period characteristic of the species, in a calculable manner, exceeding the specific value of firewood,.
4. The average, estimated air-dry weight of cuttings produced yearly in the administrative area of the examined communities is 3.1 thousand tons. I

established that the distribution of cuttings production in the examined region shows a great deviation for each community. About 90% of the cuttings are produced in nine communities, of which are prominent: Debrecen (821 t), Hajdúhadház (564 t), Nyíradony (486 t), Nyírac nád (292t), Nyírábrány (117 t) but there are some communities - Nagyhegyes, Kokad, Bagamér, Hajdúszovát - where the total of cuttings produced yearly does not even reach 6 tons. In knowledge of the results I established that the quantity of cuttings produced yearly in the examined region, by itself could be recommended for only local – e.g. heating plant - utilisation.

5. With measurements and calculations I determined the average, estimated weight and energy content of wooden bio-fuels (forestry waste, firewood, vine and fruit tree cuttings) produced yearly in the examined region. The combined average, air-dry, estimated weight of bio-fuel is 55.4 thousand tons, of which the energy content is 116.2 TJ. Of this the forestry waste is 33.8 %, the firewood is 60.6 %; the vine and fruit tree cuttings are 5.6 %. At present from among these only the firewood is utilised for energy production.
6. With measurements I determined the largest diameters of the vine and fruit tree cuttings characteristic for the region. The largest diameter of cuttings was 32 mm for the pear, 86 mm for the peach, and 10 mm for the vines. On the basis of the measured data I established that the examined vine and fruit tree cuttings can be regarded as homogenous from the chopping point of view independent of species and type, thus they can be processed with an identical chopping machine.

5. RECOMMENDATIONS FOR INCREASING PRACTICAL UTILISATION

1. Knowledge of the energy content of wooden biomass produced yearly in the examined region reinforces those earlier research results (*GRASSELLI – SIPOS, 2002; GRASSELLI, 2001, 2004*), which see the possibility for the establishment of a smaller (2-5 MW), power plant suitable for production of electrical energy and heat, in so far as utilisation of the heat can be solved.

2. The present customary burning up of the fruit tree cuttings, polluting the environment also justifies the organising of use of the cuttings for energy production. I recommend that a chopping machine with established features should be acquired for the vineyards and orchards, which is selected taking the diameter and quantity of the cuttings and the existing machine park into account. While the copings can be used not only for heating but also for mulching or reinforcing soil power.
3. For the purpose of using the cuttings for energy production, I recommend the formation of a manipulation area within an economic transportation distance – which would also make possible the drying of cuttings in a natural way.

6. LIST OF PUBLICATIONS ISSUED IN THE SUBJECT MATTER OF THE DISSERTATION

1. GRASSELLI, G. – **JUHÁSZ, GY.** 2001. Megújuló energiaforrások alkalmazása a mezőgazdaságban. Mezőgazdasági üzemek energiahatékonyságának felmérése. Szakmai Konferencia, Debrecen
2. GRASSELLI, G. – **JUHÁSZ, GY.** 2001. Megújuló energiaforrások regionális bemutatóközpontjának kialakítása. Vidékfejlesztés környezetgazdálkodás mezőgazdaság, Tudományos Konferencia, Keszthely, 1140-1143. o.
3. GRASSELLI, G. – **JUHÁSZ, GY.** 2001. Megújuló energiaforrások a mezőgazdaságban. Innováció, a tudomány és a gyakorlat egysége az ezredforduló agráriumban, Szakmai Konferencia, Gödöllő, 439-447. o.
4. GRASSELLI, G. – **JUHÁSZ, GY.** 2001. A stratégia kialakításához szükséges információk a megújuló energiák területéről. Kisvállalkozások energia- és környezettudatos stratégiájának kialakítása, Szakmai Konferencia, Debrecen
5. **JUHÁSZ, GY.** 2002. A megújuló energiák kutatásának legújabb eredményei: A napenergia felhasználásának lehetőségei régiókban. A METESZ Hajdú-Bihar megyei szervezete és az Oktatási Minisztérium által szervezett Tudományos Konferencia, Debrecen
6. GRASSELLI, G. – **JUHÁSZ, GY.** 2002. Fafeldolgozó üzem hulladékának energetikai hasznosítása. Innováció, a tudomány és a gyakorlat egysége az ezredforduló agráriumban, Tudományos Konferencia, Debrecen, 172-177. o.

7. GRASSELLI, G. – **JUHÁSZ, GY.** 2002. Megújuló energiaforrások alkalmazása egy tehenészeti telepen. MTA-AMB Kutatási és Fejlesztési Tanácskozása, Gödöllő
8. **JUHÁSZ, GY.** 2002. Fahulladékok energetikai hasznosítása. EU Konform Mezőgazdaság és Élelmiszerbiztonság, Szakmai Konferencia, Debrecen, 375-380. o.
9. GRASSELLI, G. – **JUHÁSZ, GY.** 2003. Energiatermelésre hasznosítható fahulladékok mennyiségének meghatározása Debrecen térségében. MTA XXVII. Kutatási és Fejlesztési Tanácskozás, Gödöllő
10. **JUHÁSZ, GY.** 2003. Nyesedékek energetikai potenciálja Debrecen agglomerációjában. A megújuló energiák kutatása és hasznosítása az Észak-alföldi régióban. A Magyar Szélenergia Társaság kiadványa, No.2. 37-40. o.
11. **JUHÁSZ, GY.** 2004. Biomassza tüzeléstechnikai hasznosítása Debrecen agglomerációjában. Debreceni Műszaki Közlemények 3. évf. 1. sz. 39-49. o.
12. **JUHÁSZ, GY.** 2005. Nyesedékek energetikai hasznosítása Debrecen agglomerációjában. Energetikai növénytermesztés az Alföldön, Hajdú-Bihar megyei Fórum, E-misszió Egyesület
13. **JUHÁSZ, GY.** 2005. Nyesedékek felmérése és hasznosítási lehetőségei, „Energia és mezőgazdaság” fórum, Balmazújvárosi Környezetvédelmi Csoport
14. **JUHÁSZ, GY.** 2005. Nyesedékek tüzeléstechnikai hasznosításának lehetőségei, XI. Épületgépészeti és Gépészeti Szakmai Napok, Tudományos ülészak, Debrecen
15. **JUHÁSZ, GY.** 2005. Measurement and utilization abilities of biomass, New Trends in Technology System Operation, 7th Scientific Conference Presov, p. 219-220.
16. **JUHÁSZ, GY.** 2005. Gyümölcsfanyesedékek tömegadatainak meghatározása. Debreceni Műszaki Közlemények. 4. évf. 2. sz. 83-87. o.
17. **JUHÁSZ, GY.** 2005. Nutzung von Abschnitten zur Energiegewinnung auf dem Ballungsgebiet von Debrecen. Manufacturing Engineering. IV/4. p. 57-59.
18. **JUHÁSZ, GY.** (2006): Nyesedékek tömegadatainak mérési lehetőségei. Magyar Épületgépészet, LV. évf. 2. sz. 28-29. o.