Research activities and analyses connected with the project

„Biogas station and green logistic centre Tvrdošín“

In the frame of
„Green innovation in industry “
co-financed from Norway financial mechanism and national budged SR

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Register

1 INTRODUCTION

1.1 **Forest in Slovak republic**

The forest has a lot of function which can be divided to the production and welfare, in general. Product function of forest is his ability produce wooden mass, what is function forestry. Welfare function of forest is a forest ability to create and protect soil, catch and accumulated water, produce oxygen, filtered air, absorb dust and exhalants and provide relax for people.

The main aim of forestry is planning and sustainable Slovak forest maintenance and their development. Forestry has several particularity compared with the other sectors of national economy. Forest are also environment and production resource, renewable natural resource and resource of freely available benefits, produce wooden mass and the other market forest products but also a provider of welfare services which are not economically recover.

Forests grow usually in places where was different using of soil and land in past including sloping and stony lands. It brings problems mainly in limited possibilities using in modern forest technology and significant claim on manual work.

Another present development of forestry is proportionally depend on range of factors including politician, economics and nature character as an e.g. changes in significance of forest functions, conflict between „ecology „and „economy „farming in forest, development of wooden mass price in the world market, increasing of using forest biomass on energetic purpose, increasing of amount calamity situation in forests and also influence of climatic changes and their impact on forest ecosystems. There is evidenced 1 996 400 ha forest soil in Slovakia what is 49,9 % from total land area. In Table 1 are presented individual type of soil in Slovakia.

Table 1 Acreage of land resources in Slovak republic

Land type	Acreage in hectares	Proportion in % from total area of SR
Agricultural land	2 439 408	49,9
Forested land	1 996 400	40,8
Other land	150 600	9,6

Source: Ministry of Agriculture and Rural Development of the Slovak Republic 2015

The owner of main part of forest in Slovakia is state what is 42,1%, the other biggest part is urban what representing 24,4% and private forest with the part 14,6%. Owners are not usually also users, what means that part of forest users is not the same with part of forest owners. The structure of owners and users of forests in SR are in Table 2. Significant part of small private forest owners creates the urban societies who have a mutual aim to farm in mutual forests. The forests of urban societies were in fifty years in previous century nationalized and after the politician changes in 1989 these societies started to again establish. They were established mainly in towns and villages, e.g. in Banskobystrický region is registered more than 42.

The biggest owner and user of forest in Slovakia is state that is owner of 42,1%, but use 59,4% of forests in Slovakia. Their part is also Army forests and property of SR which farming in training centre of Slovak army.

Table 2 Structure of property and forest using in the Slovak republic

Forest type	Proportion in % of property	Usage in %
National	42,1	59,4
Urban	24,4	23,0
Private	14,6	6,2
Ecclesiastical	3,4	2,5
Municipal	9,9	8,7
Agricultural	0,2	0,2
Unknown	5,4	0

Source: A.B.E. 2015

1.2 Forests in Tvrdošín region

The urban societies carry about forests in cadastre area of Tvrdošín. The history dates back in 1991 when members of urban societies recovered activities after 33 years. These members are successor of subject of urban property which is written in cadastre area of Tvrdošín and Oravice. The society was gradually modified and after the area societies law adoption in 1996 is society written as a society with own legal subjectivity.

Whole area of urban land is 2.064,22 ha including forest areas 1.871,89 ha and other agriculture areas include arable soil and permanent grasslands, which have 192,33 ha. Forest areas of society are in frame of territorial subdivision integrated in forest farm unit Trstená with 25% of forest area and in Forest farm unit Oravice with 75% of forest area. The composition of forest cover created from 85% of spruces, 10% of firs and 5% of beeches.

2. METHODOLOGY

The aim of research is divided to three parts which are connected and followed each other. They are talking about farming in forests in Tvrdošín region and energetic using of part forest production. Single parts should to have following aim:

- Research in forest recovery after wood logging in Tvrdošín region effective using of wooden mass during the wood logging and processing wood to biofuel
- Composition of mixture from wooden chips for maximal efficiency using as an energy source

The methodology will be separated on several parts according to established aim:

- Work in terrain – sampling of soil in specific areas, sampling of tree for measurement of basic energetic parameters – heat values, photo documentation
- Work in laboratory – soil sample analyses, measurements of physical properties of several types of biomass
- Collection of technical, operating, economic and statistic data – urban society Tvrdošín, city office Tvrdošín, Slovak hydrometeorological Institute, Statistic office of SR, Ministry of agriculture and rural development SR, ATTI
- Preparation of proposal technological line for wood tree cultivation, collection and processing biomass for energetic purposes
- Calculation of economic indicators of energetic tree cultivation based on energetic potential and proposal of cultural practises

- Data processing in table and graphic form

3 RESEARCH OF REFORESTATION AFTER LOGGING IN TVRDOŠÍN REGION

3.1 Present logging of forest

The wood logging is nowadays realized by urban society Tvrdošín, by its own stuff, volunteers, self-employers and extern companies. They logged in average 33 000 m^3 of wood per year. The overview of wood logging in 2007 is in Table 3.

Table 3 Wood logging in m^3 since 2007

Year	2007	2008	2009	2010	2011	2012	2013	2014
Wood logging in m^3	47 096	52 513	34 977	31 157	29 876	22 164	17 888	31 000

Source: Tvrdošín urban, 2015

The whole wood logging was in 2014, 31 000 m^3, from this amount was processed 1 628 m^3 of wooden logs on their own saw and 29 191 m^3 of wooden logs were sold. The older technology of their own saw allowed to sell just 5,3% of logged wood processed on timber. From these percentage, the wooden logs for industry processing (KZP) consistent 11 624,35 m^3, what is 37,5%. The other part 7,9%, 2 445,9 m^3 of wooden logs was sold as a fuel. In Table 4 and Figure 1, you can see overview of wooden logs selling on separate assortments. More than 1/3 of logging was trees thrown down by strong wind. These trees were mainly spruces. Trees dried out on roots represent 18,7% from whole amount of wooden logs. The wooden mass on wood store in forest represents 361 m^3.

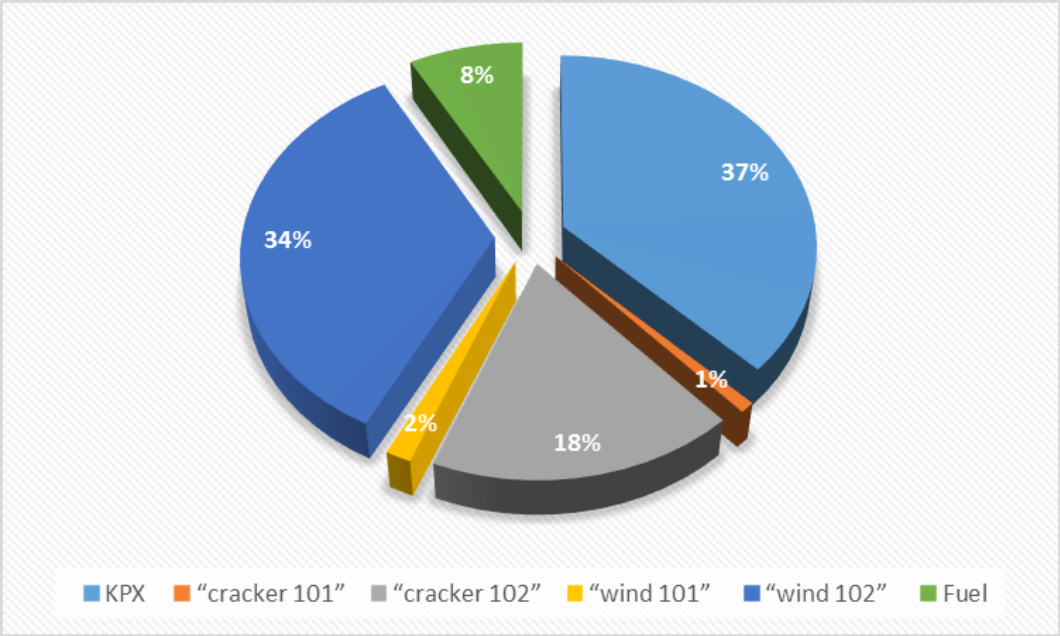
Table 4 Sale of wooden logs as assortments per year 2014

Assortment	**Sale in m^3**	**Proportion in % from the wood logging**
KPZ - wooden logs for industry processing	11 624,35	37,7
"cracker 101" – dried out tree with roots in worse quality	297,95	0,9
"cracker 102" – dried out tree with roots in better quality	5 471,57	17,8
"wind 101" – the tree knocked down by the wind in worse quality	463,59	1,5
"wind 102" – the tree knocked down by the wind in better quality	10 516,50	34,2
Fuel	2 445,90	7,9
Summary	30 819,86	100

Source: Tvrdošín urban and A.B.E., 2015

The wood in form of tops, branches and other waste stays in forest after wood logging. This material represents around 16% from logging wood what is overall 3 470 ton. This amount of wood waste after logging is used for energetic purposes by societies. Rough tree parts are used by urban´s members for heating of their houses. The other material is processed on wooden chips. The extern company processes the wooden chips and move it in Nižná na Orave boiler.

Graph no.1 Sale of wooden logs as assortments per 2014



Source: A.B.E. 2015

3.2 Present production work and reforestation

The other responsibility of Tvrdošín urban society is care about forest cover and reforestation. Production work start in spring by preparation forest areas on reforestation branching out after logging and follow bush cutting. 5908 ha of forest areas was prepared by these methods in 2014. Restoration of forest trees by reforestation of prepared clearings will start in April. 33 ha of clearings were prepared in 2014 for reforestation by spruces, firs and beeches. There were reforested 17 ha more and planted 54 000 more plants in 2014 than in 2013. Reforestation is realized by hand.

All over forest area using after finishing reforestation of clearings from undesirable weeds and shrubs afforested in two previous years, were secured. Young trees in area 137 ha were all over weeded and treated by chemicals against of wild animals. Overview of production work since 2007, you can find in Table 5.

Table 5 Overview of production works since 2007

Activity	Measure units	Year							
		2007	2008	2009	2010	2011	2012	2013	2014
Pre-treatment of areas before afforesting	ha	51	53	45	20	35	17	15	60
Seedlings	thousands of pieces	131	156	131	150	138	100	81	134
reforested areas	ha	30	39	31	33	27	20	16	33
Weeding and chemical protection	ha	138	164	158	152	160	148	117	137

Source: Tvrdošín urban, 2015

The cultivation work was realized by own employers of society, seasonal employees, helpers and students of Forest school. The society using mainly mechanization of extern companies and self-employers during the work associated with forest cultivation and wood logging. Wheeled tractor, disc scythe and telescopic manipulator were purchased from Norway fond in frame of program "Green innovation in industry".

3.3 The soil analyses

The fast growing trees (FGT) could be cultivated in select areas in size 50 ha for energetic purposes as declared members of urban society. The areas will be smaller, about 2-3 ha. Suitable areas for cultivation of FGT are situated in cadastre Tvrdošín as well as in cadastre Oravice, mainly around the creeks and in the edge of forests. Nowadays these areas are without trees and they are covered by weed and different trees, e.g. alder (*Alnus*).

The soil sampling was realized and their follow analyses for suitability specifying of soil to FGT cultivation. Climatic conditions including average annual temperatures and average annual rainfalls were also identified. The suitable technology and FGD species were purposed based on these parameters. These species were chosen for cultivating in mentioned areas. The soil sampling was realized in two chosen localities. One was in cadastre Tvrdošín and the other in cadastre Oravice.

The 1,9 ha parcel situated between the forest and road was chosen in cadastre Tvrdošín as shown Fig. 1. It is area with rugged slope 10 – 12 ° and waterlogged in some places. Mechanized planting of tree will not be possible. All works connect with tree cultivation have to be realized manually. The parcel is situated in high 780 m.a.s.l. The parcel is marked by red hatching on satellite map n.1. The soil sampling places for analysis 1 to 6 are marked in the map. In Fig. 2 you can see soil sampling by soil auger.

Fig.1 Part of area in cadastre Tvrdošín

Fig. 2 The soil sampling

The other parcel is situated in cadastre Oravice. In map n. 2 is shown forests farmed by urban society Tvrdošín. Colour distinguish areas are divided as follows.

- Yellow till 20 years
- Red from 20 to 40 years
- Green from 40 to 60 years
- Blue from 60 to 80 years
- Brown from 80 to 100 years
- Grey from 100 to 120 years

The second sampling parcel of soil for analyses is marked in map n. 3 by red hatching. The other sampling places of soil from 1-6 and the other parcel where is possible to cultivate FGT are marked in map n. 4. The parcel had the acreage 1,5 ha and was situated in area after re-cultivation of watercourse between the river and forest (Fig.3). Parcel is plain and before the re-cultivation it was a meadow, but after removal of the top layer the stones moved to the surface. The parcel is covered by weed and alders (Fig.5). The work connected with FGT cultivation has to be realized manually in regard to access in parcel. More areas suitable for FGT cultivation is around the river flow (Fig. 6).

Fig. 3 Area in Oravice

Fig. 4 The hole after soil sampling

Fig. 5 the parcel is weeded

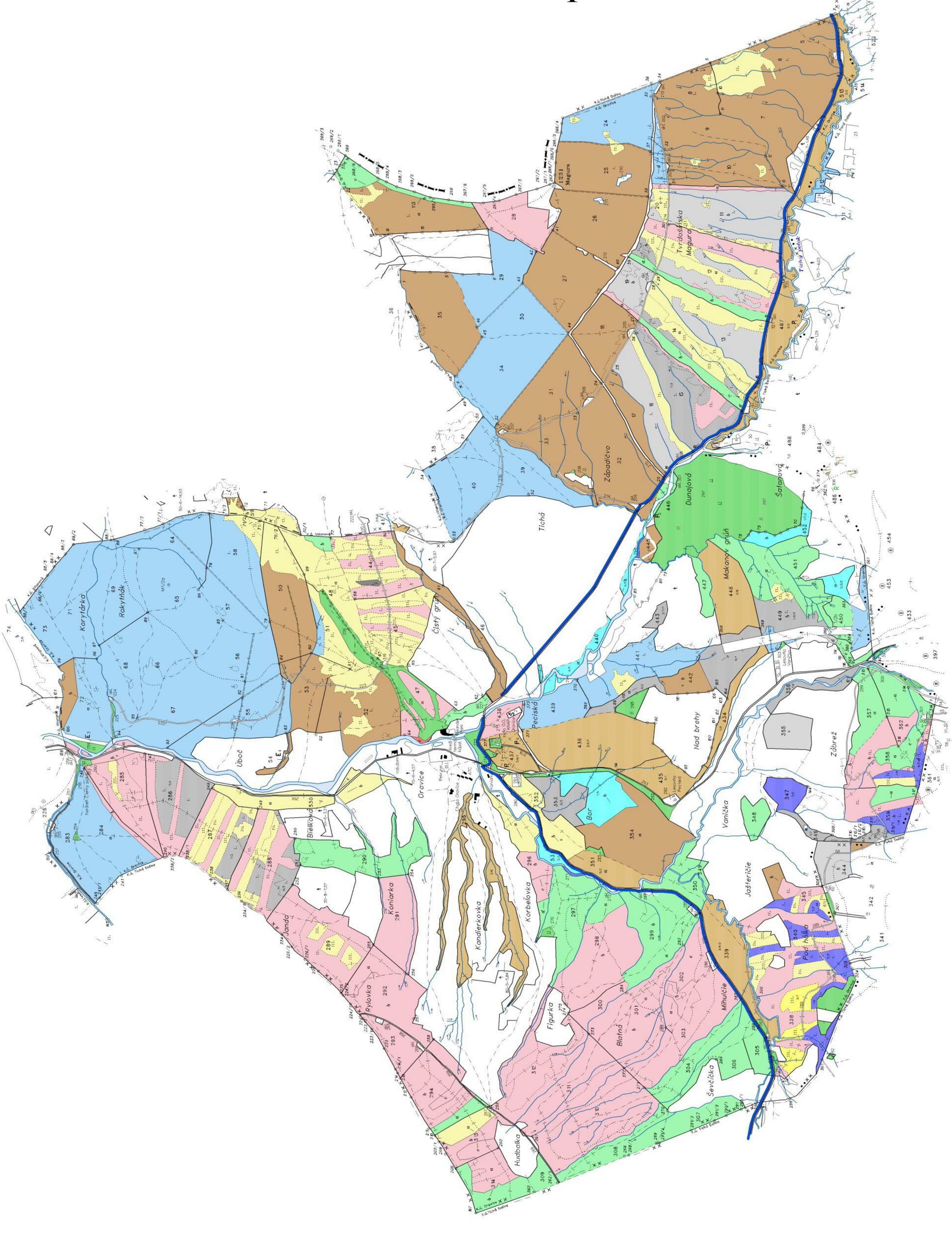
Fig. 6 Areas for FGT cultivation

The soil samples from two localities were analysed in accreditation laboratories and average results of analyses are in Tab. 6. The soil in first locality was loamy and in second sabulous-loamy what was the result of top soil layer removal during the re-cultivation creek.

The results of soil sample analyses from two localities more than 20 km far of each other show that soil samples in whole cadastre farmed by Urban Tvrdošín are similar and will be suitable for cultivation of same FGT species.


Mapa č.1
1
2
3
4
5
6

Mapa č. 2



Magura
Tvrdošínska Magura
Západičvo
Tichá
Dunajová
Šatanová
Makanov grúň
Korytárka
Rakytňák
Čistý grúň
Uboč
Pecisko
Nad brehy
Oravice
Bor
Bielkova
Zábrež
Vanička
Janda
Koniarka
Kandierkovka
Korbelovka
Jašteričie
Podhaľka
Figurka
Blatná
Mihulčie
Rylovka
Ševčička
Hudbalka


Mapa č. 3
tanova
Trstená
2

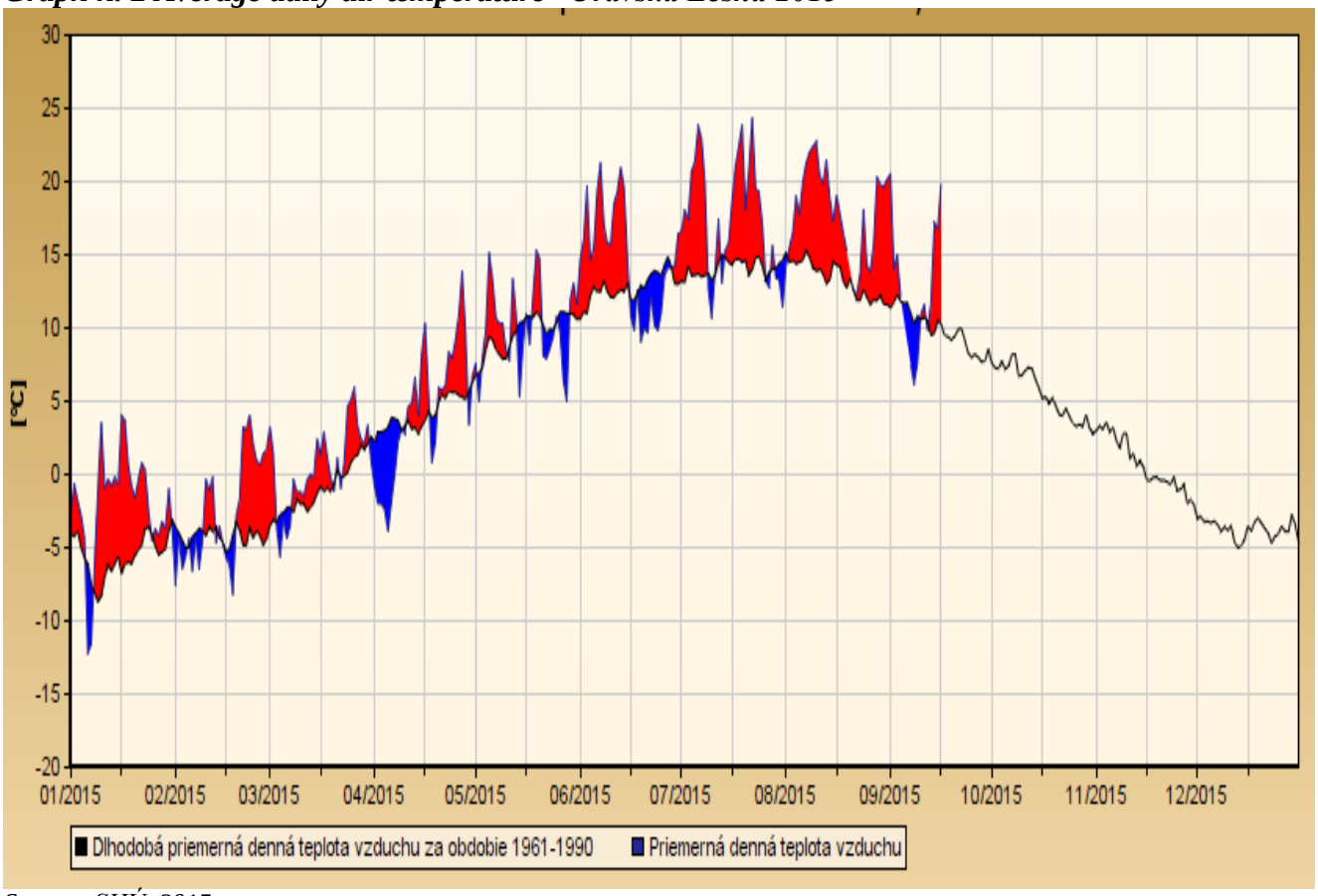

Mapa č. 4
1
2
3
4
5
6

Temperatures and rainfalls measured in nearest meteorological station in Oravská Lesná are shown in Gr. 2-4. This station is by bee-line far from Tvrdošín 19 km.

Tab 6 Physic-chemical soil analyses

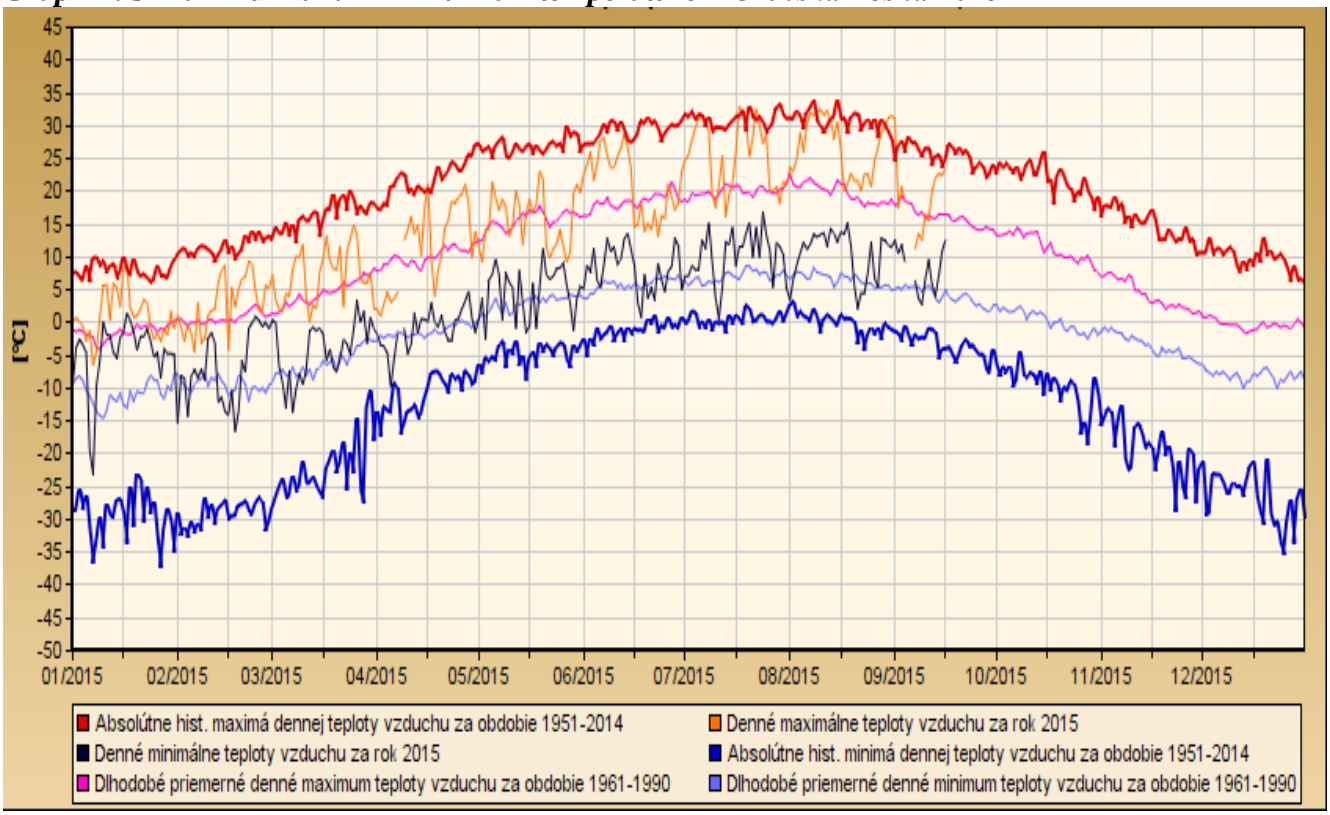
Measured parameter	Unit	Value	
		Locality 1	Locality 2
pH	-	7,7	6,26
humus	%	3,55	3,42
N	%	0,169	0,154
$CaCo_3$	%	4,0	0,5
P (phosphor)	$mg.kg^{-1}$	1,71	7,32
K (potassium)	$mg.kg^{-1}$	201	54,6
Ca (calcium)	$mg.kg^{-1}$	1 835	9 401
Mg (magnesium)	$mg.kg^{-1}$	263	394
granularity F1 (2 – 0,25 mm)	%	9,598	20,061
granularity F2 (0,25 – 0,05 mm)	%	8,577	37,002
granularity F3 (0,05 – 0,01 mm)	%	46,687	19,880
granularity F4 (0,01 – 0,001 mm)	%	24,247	15,069
granularity F5 (< 0,001 mm)	%	10,891	7,988

Graph n. 2 Average daily air temperature– Oravská Lesná 2015



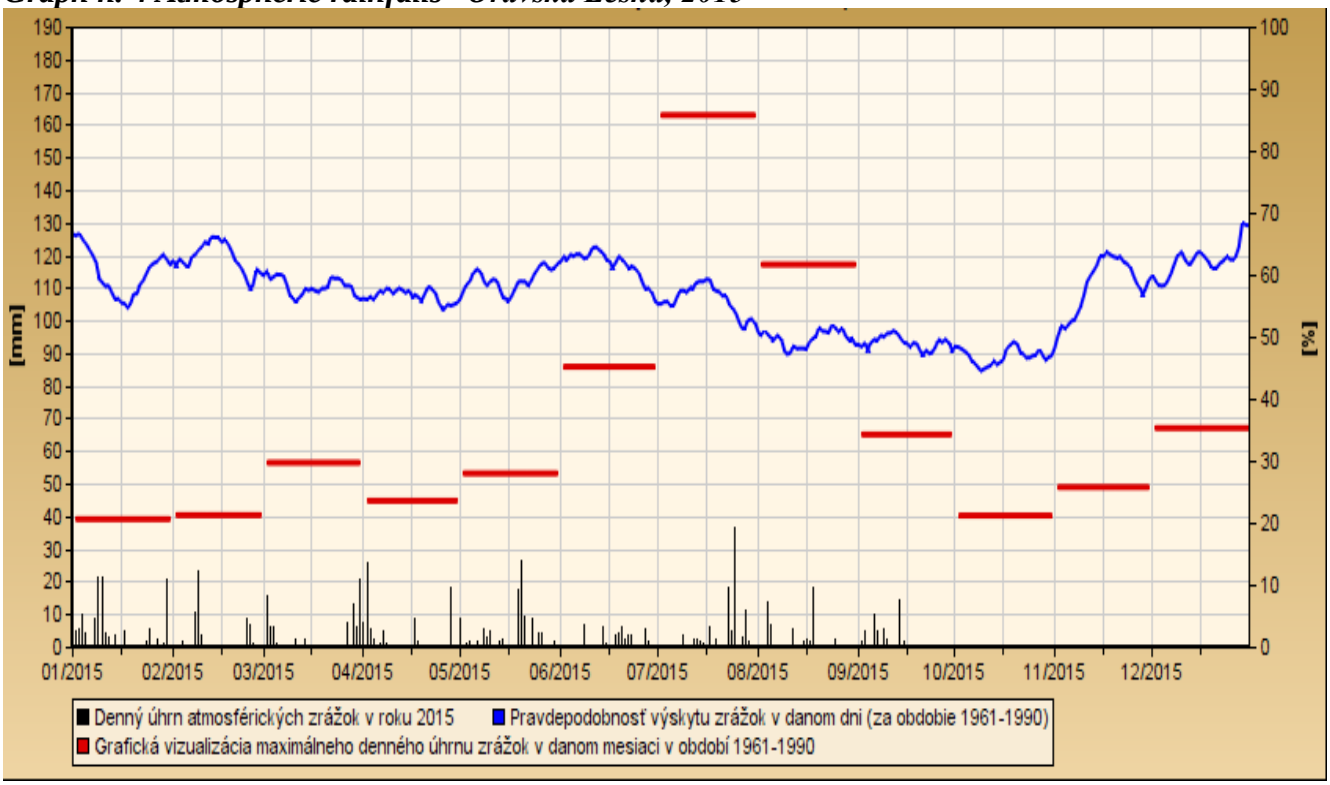
Source: SHÚ, 2015

Graph n. 3 Maximum and minimum air temperature – Oravská Lesná 2015



Source: SHM, 2015

Graph n. 4 Atmospheric rainfalls– Oravská Lesná, 2015



Source: SHM, 2015

4 EFFECTIVE USING OF WOODEN MASS DURING THE WOOD LOGGING AND PROCESSING OF WOOD TO BIOFUEL

4.1 Wood processing to biofuel in 2014

Nowadays is wood logging realized by owner society of forest Tvrdošín through their own employees, helpers, self-employers and external companies. About 31 000 m^3 of wood in the form of wood logs were logged in 2014. 2445,9 m^3 of wood logs were sold as a fuel, what is 7,9% from whole logging. The wood suitable for energetic purpose stays in forest in form of tops, branches and other waste after logging. These material is around 16% from all logged wood, what is 3 470t. Part of this amount of wood waste the society uses for energetic purposes. Thicker tree parts using of urban members for heating in their own houses. Remain material is processing to wooden chips. Wooden chips process the extern company that is transferred it in boiler for biomass in Nižná na Orave. The urban sawmill for wooden logs processes have older technology that is not able to process the wooden logs for lumbers today. The society are planning renew this activity after the modern technology purchasing. This technology will allow obtaining not just main product, logged wood – lumber but also the wood for fuel in form of offcuts and sawdust. 1 628 m^3 of wood logs were processed in 2014. More than half of logged wood will be processed after the modernizing of sawmill. The other 5 000 m^3 of wood for fuel will be produced.

Fig. 7 Wooden chips parts of tree after logging

Fig. 8 Wooden chipper with tractor

4.2 Proposal to maintrance of fast growing tree (FGT)

According to statement of management of urban Tvrdošín it is possible in future allocate 50 ha of area in cadastre Tvrdošín and Oravice for cultivation of energetic trees. It would be smaller areas maximum 2-3 ha. Suitable areas for energetic tree cultivation are situated mainly around the creeks and at the edge of forest. Nowadays in these areas are not cultivated trees and they are covered by weeds and by raid of shrubs and trees.

The results of soil sample analysis and climatic conditions in regard to locality (Orava) for fast growing tree cultivation, during the proposal of cultivation energetic FGT came also from results of production and energetic potential of more FGT Swedish varieties of *Salix* species that was realized in Krivá na Orave.

Characteristics of production properties of Swedish varieties suitable for cultivation in soil-climatic condition in Slovakia:

- Ulv – is a variety bred in Sweden. Her genetic basis is natural vegetation from Siberia from river basins of Ob, Jenisej and Amur.

- Tora *(Salix schwerinii x Salix viminalis).* Tora is a cross of Siberia willow and Swalov ´s variety *Orm.* This variety has long branches. Her yield is the biggest from all available varieties. Tora is almost resistant against of rust and pests attack. It is also less looked for by forest animals.
- Sven *(Salix viminalis x (Salix schwerinii x Salix viminalis). Sven* is a hybrid between of varieties *Jorunn* a *Björn*. It has lanceolate leaves and straight phylum and fewer branches as a *Tora*. This variety gives a big yields and it is resistant against of leaves rust.
- Gudrun *(Salix dasyclados)* is a hybrid between Russian variety *Helga* and clones from Sweden. This variety is highly resistant against of frosts and also against of leaves pests. Their leaves are wide and thick connect. The forest animals look for this variety.
- Sherwood *(Salix viminalis x Salix eriocephala) x (Salix schwerinii x salix viminalis). Sherwood* is a hybrid between the clones *SW 930887* that contain genes from *Salix eriocephala* and variety *Björn* that is a female sibling of *Tora*.

Planting material came from certified producers. Planting material are parings and one year rods. Shorts are obtained from rods by cutting to length 0,18-0,20 m. Rods are collected out of vegetation period (December-March). They have to be stored in dormancy before the planting. The dormancy can be achieved by store at -4ºC to 0ºC for several months. Plants can not to start germinate and dry out during the store of plant material. Plants are taken from warehouse just before the planting. It is very necessary do not cause thermal shock to plants.

Preparation of soil before planting– if FGT are cultivating in agricultural soil, the soil has to be prepared by tillage and soil aeration. Removing of weeds and shrubs are import on the rugged forest areas.

Planting are usually realized in months March-April. It could be manual or mechanized. Manual work is supposed in localities Tvrdošín and Oravice because of unsuitable conditions for machines using in rugged area. Trees are planted to density 0,65 x 0,70m (distance in layer and between layer). 18-20 cm length shorts are planted straight down to soil. The planting are realized by growing of plant directly in soil or using of metal spike with the possibility of leg turning to soil. One worker makes a holes and the other put plants inside. Plants have to stay 2-3 cm over-ground with buds up. Manual work is more quality but more laborious. It is usually used in smaller areas. 1-3 shoots grow in year of planting.

Care about plants is one of main assumption of successful planting. Willow is very sensitive on weeds in first year of planting. FGP in early period (first 12-16 weeks) grow very slow. Weed removing is necessary in this phase. Root growing and over-ground shoots creation in FGT is very slow in first few weeks. Weeds and grass grow faster. Weed can stop growing of FGT. Mechanical destroying of weed is necessary around after 8 weeks. After rooting of FGT is weed grow slower.

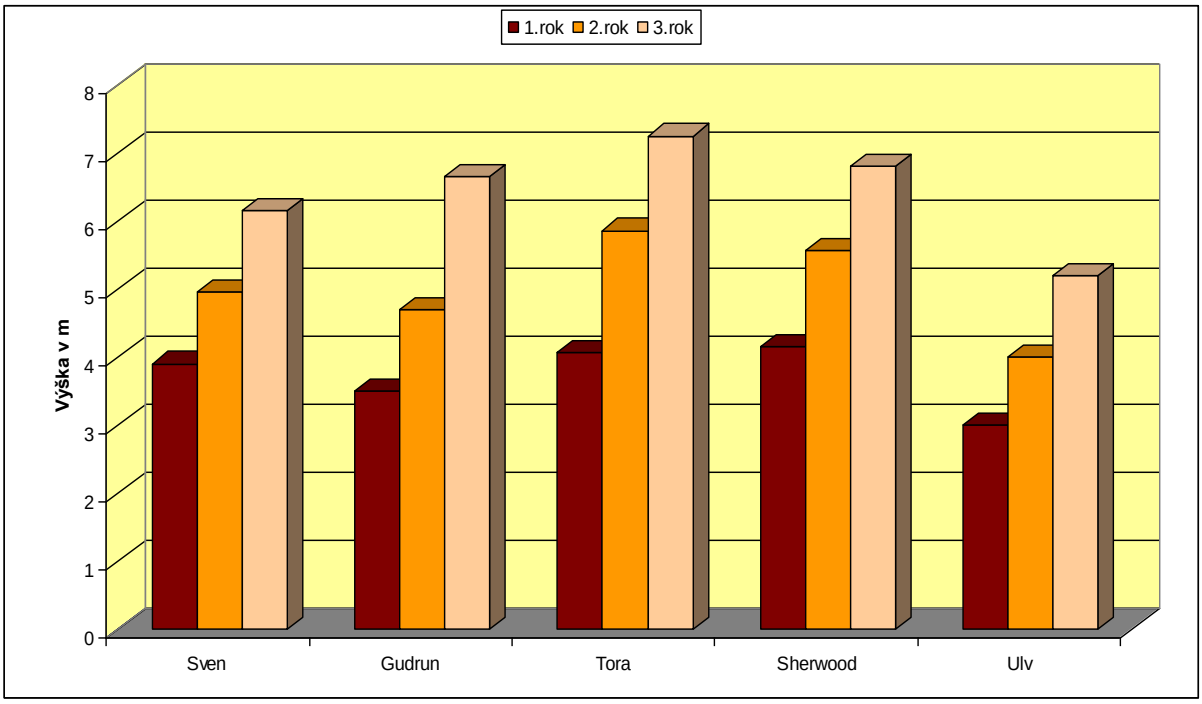
Undergrowth farming of fast growing willow in hewing maturity – planted trees are usually grown 25-30 years and harvest each four years. Younger varieties are harvesting each three years. These plants create 3-5 cm tribe that is high 5,5-7 m with the week branches. 3-8 tribes is in one root in harvesting time. The most suitable time for harvest is dormancy time (November-March). Type of harvest could be mechanized or manual. Mechanized in case of urban Tvrdošín is not suitable. Manual is practise in smaller areas. Harvest is realized by chainsaw. On the edge of parcel harvested tribes are pile on vehicle and move to place of

processing. They can be processed by wooden chipper directly in place if the condition are suitable.

The dendromass production is the most important indicator in cultivation of FGT for energetic purposes. Four young varieties, *Sven*, *Tora*, *Gudrun*, *Sherwood* and the most produced variety *Ulv* from experiment from 1994, were grew in field experiment in 2004. Altitude of experimental area is 550m. The soil is sandy-loam. Average annual temperature in this area is 6°C and average temperature of vegetation period is 12,7°C. Average annual rainfalls are 895 mm and average rainfalls during the vegetation period are 551 mm. The conditions of FGT cultivation during the field experiments are similar as in urban Tvrdošín. The distance from Tvrdošín experimental fields is 10 km.

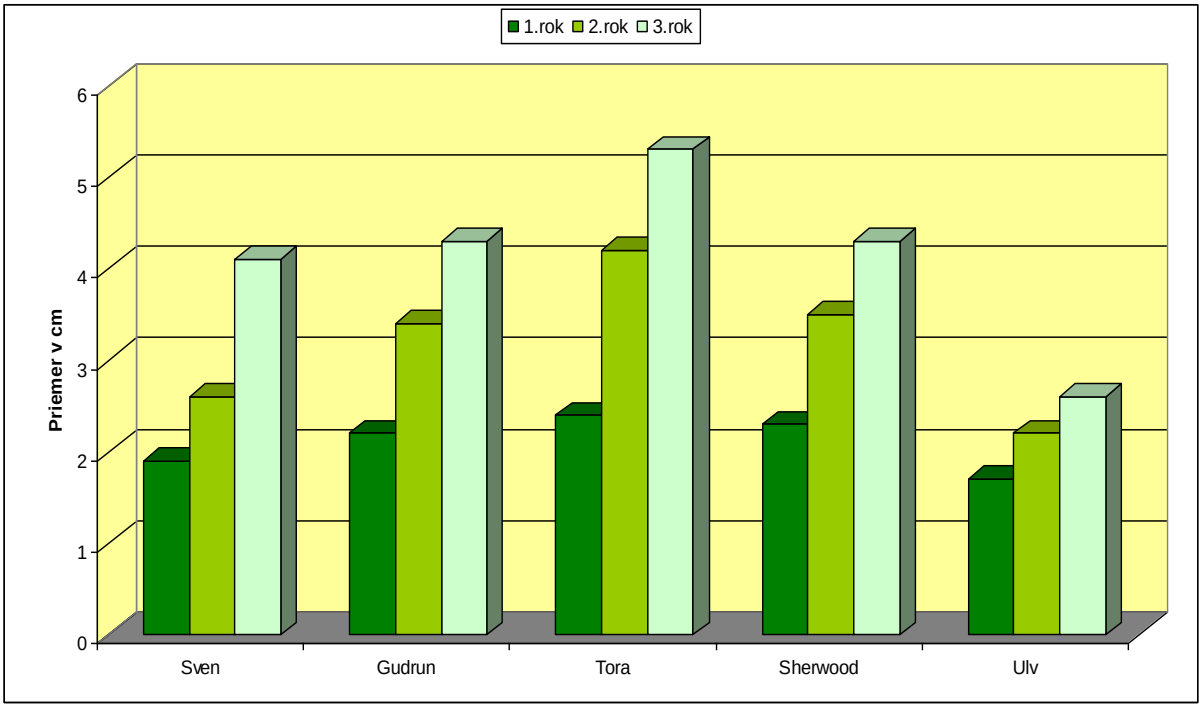
Growth parameters of one, two and three year's varieties were compared. The maximum achieved height, tribe average and biomass production in $t.ha^{-1}$ were compared. Maximal growth parameters of one, two and three year's trees are shown in Gr. 5, 6 and 7.

Graph n. 5 The height parameters of FGT



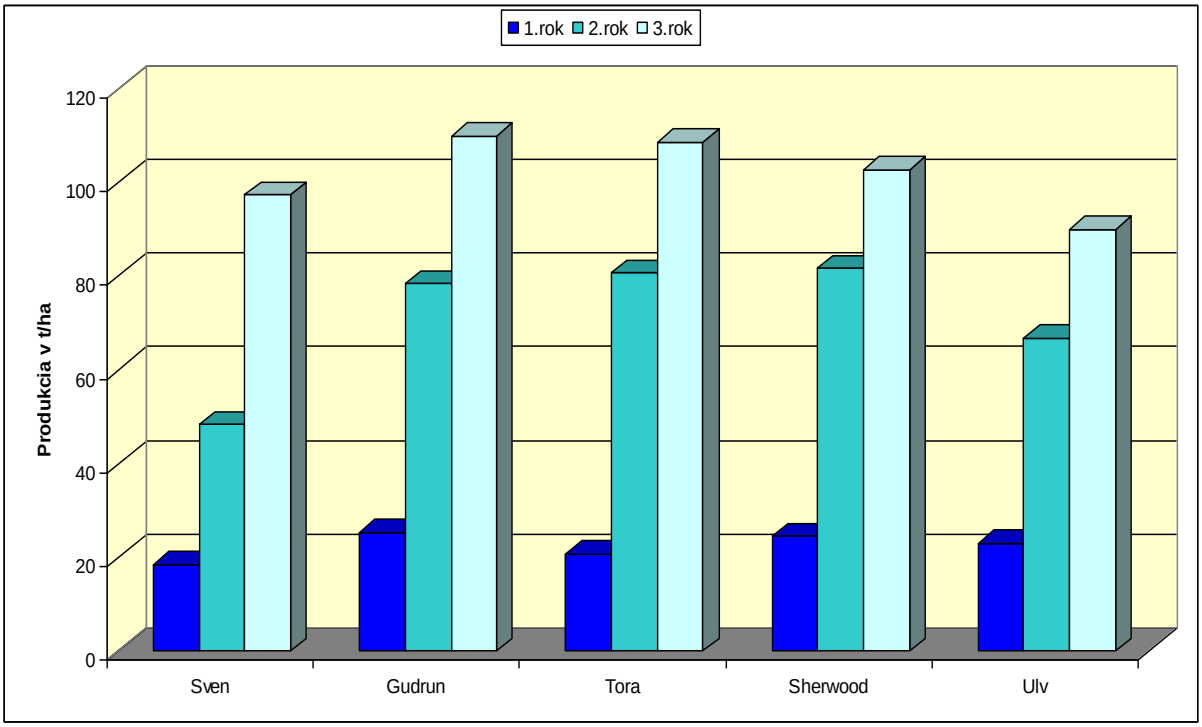
Source: A.B.E., 2015

Graph n. 6 Parameters of tribe average of FGT



Source: A.B.E., 2015

Graph n. 7 Dendromass production of FGT



Source: A.B.E., 2015

From the results is shown that in locality Tvrdošín is suitable to cultivate varieties of energetic willow: Gudrun, Tora a Sherwood, which have comparable production parameters.

Economy of cultivation- indicative costs on planting, cultivation and harvesting of 1 hectare of trees are in Tab. 7.

Table 7 Economy of cultivation energetic willow

Item		**Costs in €**
Planting	Shorts 13 000 pc á 0,07 €	910
	Transport of shorts from grower	150
	Manual planting	1 100
Treatment	Spray by herbicides	150
	Weed cutting	130
Harvest	Manual harvesting	900
	Wood chipping	400
Direct cost together		**3 740**
		Profit in €
Sold of wooden chips	In 1-st year of production 23 $t.ha^{-1}$, profit 50 $€.t^{-1}$	1 150
	In 3-rd year of production 100 $t.ha^{-1}$, profit 50 $€.t^{-1}$	5 000
The economy results in the first harvesting	During the one year cycle	- 2 590
	During the three years cycle	+ 1 260
The economy results in follow harvesting (costs reduced by planting)	During the one year cycle	- 150
	During the three years cycle	3 700

Source: A.B.E., 2015

As shown Table 7 for locality Tvrdošín should be suitable three years cycle of FGT harvesting. The production of dendromass is low during one year cycle and economy result is minus. Three years cycle is shown plus results in 1260 €. In each follow harvesting is result also plus in 3700 €.

5 COMPOSITION OF WOODEN CHIPS MIXTURE FOR MAXIMUM EFFECTIVITY USING AS AN ENERGY SOURCE

5.1 Energetic recovery after realization of FGT planting

Society of urban Tvrdošín uses part of wood production and waste from logging as a part of fuel purposes. Mainly spruce wood is using and less fir and beech wood. Using of willow wood from energetic trees production is assortment of fuel wood supplemented. The heat value is around 17 $MJ.kg^{-1}$.

After FGT planting is supposed for urban production increased of fuel dendromass by 80-100 ton per one planting hectare. 1/3 of area during three years cycle should be harvest at maximal planting in 50 ha. Production would be 1 360-1 700 ton what can bring in profits even 68 000 – 85 000€. Energetic potential presented value about 25 TJ in case of heat value 17 $MJ.kg^{-1}$of

willow wood. Wooden chips from FGT would to increased production of fuel wood produced by urban Tvrdošín. This would ensure to increasing of company profits.

6 CONCLUSIONS

Using of edge forest areas in urban Tvrdošín for cultivation of energetic trees should increase profit of society to fuel wood. It could be created new job position in planting and harvesting of FGT.

Soil samples from two areas and rainfall and temperature ratios were processed. The results shown that in locality Tvrdošín and Oravice would be suitable to cultivate varieties of energetic willow: Gudrun, Tora and Sherwood that have comparable production indicators.

The most suitable is three years cycle of FGT cultivation in Orava region as shown analyses and results. The technology of planting and trees treatment was also processed. The production of dendromass is low during one year cycle and economy result is minus. Three years cycle is shown plus results in 1260 €. In each follow harvesting is result also plus in 3700 €.ha^{-1}.

About 1/3 of area during three years cycle should be harvest at maximal planting in 50 ha. Production would be 1 360-1 700 ton what can bring in profits even 68 000 – 85 000€. Energetic potential presented value about 25 TJ in case of heat value 17 MJ.kg^{-1}of willow wood.

7 REFERENCES

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