PARTIAL RESULTS CONCERNING THE BEHAVIOR OF ENERGY WILLOW GENOTYPES IN CULTIVATED IMPROPER AREAS

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ABSTRACT
The paper presents partial results recorded on some experimental fields with energy willow (Salix viminalis) for recovery of land unfit for agriculture. Lately appeared the need for comprehensive studies to identify optimal solutions for these lands, namely the selection of genotypes to exploit their productive potential, but also to be adapted on summers with high temperatures (above 35°C) and extremely dry, and the cold winters. This was an attempt to test in the conditions of 2015 Swedish energy willow genotypes approved for cultivation in Romania, genotypes that were compared to some Romanian clones and hybrids. The main goal of the experience is to identify genotypes that possess tolerance/resistance to biotic and abiotic stress factors, in the specific area of southern Romania and introduce the current range of energy that crop plants.

INTRODUCTION

Once with the concern of mankind to find new unconventional energy sources, researches were directed towards different variations of unconventional energy sources, for perennial crops that represent a safe energy source. Areas that have been tried and have achieved remarkable results are diverse, from solar energy, wind energy, heat pumps, biomass.

Worldwide there is trying to replace energy sources fossil (coal, oil, etc.) with alternative sources (wind, solar, burning energy crops, etc.). Biomass is considered a renewable source of energy for both heat production and electricity.

From this point of view, energy willow (*Salix viminalis*) is an alternative source of energy, like fossil fuels, coal as fuel oil, oil, etc. The big difference between energy willow and coal are emissions that are released into the atmosphere; thus burning energy willow unwrought or pelletized has near-zero emissions (http://www.salciaenergetica.ro/).

Energy willow is a crop that pays off on medium and large areas, starting 5-10 to 150-200 hectares and as it exists, for example, in countries like Germany, Austria, Hungary, Poland, Ukraine and Lithuania. In Sweden, the country where they were approved and registered the first energy willow varieties, there were established crops of thousands of hectares. In Romania, both individuals and companies and institutions have already invested in energy willow land from a few hectares to 200-300 ha, with even projects for plantation 800-1000 hectares (http://agrointel.ro/).

Making an investment in the energy willow crop is justified by the fact that the *Salix viminalis* species has a growth rate very fast (in summer can grow to 3 cm/day), has a high energy power (4,900 kcal/kg) and especially, it has very low costs. For example, a hectare of land planted with energy willow requires a cost of about 1700-2000 euros

The lifespan of this investment is 25-30 years. Average yield per hectare is 30-40 tons, can reach up to 60 tons under irrigation. In this context, a pelletisation plant requires approx. 1000 hectares of crops in order to ensure the heating of 145,000 conventional apartments annually (TUCU et al., 2011).

Biomass from energy willow is one of the most important types of biomass worldwide and it is expecting it to contribute to achieving the targets in terms of the proportion of electricity and thermal energy coming from renewables. Leaf area can be a good predictor of future amounts resulting biomass. In fact, leaf area index is closely correlated with the amount of biomass from species *Salix viminalis* (Cunniff, 2015).

The optimum time for planting is from late March to mid-May. Seedlings suitable for planting will be planted by hand or by machine planted seedlings. Machinery plant capacity is between 3 and 4 hectares/day, depending on the type, but the best growth can be ensured by manual planting, which can be achieved on large areas. The crop will have good yields only the crop is maintained free of weeds the first year (http://www.revista-ferma.ro/).

Plantation Energy willow is an investment not just cheap, but from the second year, the invested money is recovered quickly. It is important to note that the EU, energy willow crops are subsidized crops. Grants may be of various kinds (annual subsidies, grants ventures, etc.). Since 2008, energy willow crops of Romania joined the grant program.
Water stress is one of the most important factors responsible for limiting plant growth and productivity. Long-term predictions of global climate change include very frequent episodes of drought.

Many of degraded land that could be planted with energy willow are subject to desertification due to climate change and cutting windbreaks, which occurred in the last 20 years. Soil water deficit becomes critical and thus need to be selected for these regions hybrids tolerant to water stress.

In Romania there are degraded areas as a result of anthropogenic activities especially non-ferrous mineral waste dumps or from coal mining, which could be recovered and decontaminated using Salix plantations.
Willow species posse the capacity for development in degraded areas, natural or anthropic, as swamps, abandoning crops areas, sandy dune, riparian sandy areas, gravels (Corneanu Mihaela and all., 2014)

MATHERIAL AND METHOD

Testing locations have been in the Radovan village respectively DS Tamburesti, both locations being located in Dolj country, calculating the average of the two locations. Also, the registered results refer only to one (2015). Biological material was composed of 14 Romanian and foreign willow genotypes.

In the present study, it was analyzed a series of indexes such as:

1. The percentage of survival of the cuttings which entered into vegetation;
2. The high average of the plants determined during vegetation (data from July)
3. The standard deviation of the arithmetic average for the plant height;
4. The range of standard deviation to the arithmetic average for the height of plants character for each genotype in part, interval of which lower limit is the difference between the arithmetic mean and limit standard deviation called and height average limit and the upper limit is the amount of the arithmetic mean and standard deviation value, limit called and upper height average.
5. The coefficient of variation for the plant height character;
6. The maximum height of the plants recorded by determination in the field for each genotype;
7. The percentage of plants taller than height maximum average (for the calculation see section 4) as the percentage ratio between the number of plants taller than maximum height average and total number of plants examined;
8. The percentage of plants of height greater than 1 meter, as the percentage of the number of plants with a height greater than 1 meter and the total number of plants examined;
9. The correlation coefficient between calculated indexes.

RESULTS AND DISCUSSIONS

The main indices calculated for the plant height are shown in Table 1. In the analysis of the height variance, the value range was between 20.19 cm on genotype 5 and respectively 54.23 cm on genotype 8.

The variability coefficient calculated based on standard deviation of the average was situated between 12.63% and 23. 46%, which indicate a medium or high variability. Thus genotypes 1, 2, 3, 4, 5, 7, 8, 12 and 14 have a variability coefficient ranged from 12.63% to 18.45%, which represents an average variability, while genotypes 6, 9 10, 11 and 13 have a variability coefficient ranged from 20.34% to 23.46%, which represents a high variability.

For all genotypes, the vast majority of plants are found within the standard deviation of the plant height average, the percentage of plants ranging from 58.86% on genotype 2 to 87.42% on genotype 9.

Also, for all genotypes the percentage of plants with a height greater than the upper limit of the standard deviation of the average is low, varying between 5.45% to genotype 14 and respectively 19.02% for genotypes 2.

The maximum height of the 14 genotypes ranged from 70 cm on genotype 5 to 200 cm on genotype 9. However, in all genotypes, the percentage of plants with the height greater than 1 m was very low, in some case there was none. Thus, two genotypes, 4 and 5, have no plants higher than 1 m, while genotype 8 and genotype 10 had the highest percentage of plants with height greater than 1 m respectively 9, 4% and 10.98%.

In the case of survival rates, it ranged from 35.72% on genotype 14 to 72.73% on genotype 3.

Table 1

The variation of the analyzed indices for the plant height character

No. crt.	Genotype	Average Height	Plant height standard deviation	Variability Coefficient	The limits of the Plant height standard deviation interval		The values of the Plant height standard deviation interval	% plant survival	The percentage of plants taller than height maximum average	The percentage of plants from the plant height standard deviation interval	Maximum plant height	The percentage of plants taller than 1 m
					Min.	Max.						
1	Genotype 1	44.55	8.22	18.45	36.33	52.77	16.44	71.62	14.45	70.11	160	3.12
2	Genotype 2	38.94	4.92	12.63	34.02	43.86	9.84	66.76	19.02	58.86	150	1.55
3	Genotype 3	35.60	4.99	14.02	30.61	40.59	9.98	72.43	13.13	71.76	120	1.50
4	Genotype 4	21.62	3.94	18.22	17.68	25.56	7.88	44.05	14.82	77.17	80	0
5	Genotype 5	20.19	3.56	17.63	16.63	23.75	7.12	61.44	9.06	85.13	70	0
6	Genotype 6	23.25	4.73	20.34	18.52	27.98	9.46	47.52	13.19	62.50	100	0.11
7	Genotype 7	26.39	4.24	16.07	22.15	30.63	8.48	65.51	9.77	68.43	100	0.08
8	Genotype 8	54.23	8.97	16.54	45.26	63.2	17.94	71.87	13.10	74.33	180	10.98
9	Genotype 9	28.21	5.89	20.88	22.32	34.1	11.78	56.10	12.05	87.42	200	1.72
10	Genotype 10	47.44	10.93	23.04	36.51	58.37	21.86	55.41	15.93	77.35	160	9.40
11	Genotype 11	44.72	10.49	23.46	34.23	55.21	20.98	43.48	11.79	73.30	150	1.98
12	Genotype 12	46.00	7.33	15.93	38.67	53.33	14.66	41.50	14.13	74.70	160	6.19
13	Genotype 13	48.90	10.09	20.63	38.81	58.99	20.18	43.74	17.14	70.20	140	7.02
14	Genotype 14	52.07	8.36	16.06	43.71	60.43	16.72	35.72	5.45	74.32	160	1.14

Regarding the analysis of the links between calculated indices, this calculation was based on correlation. Thus, from Table 2 it can be seen that only four values of correlation coefficient are large enough to express a strong bond between the indices, the link being between:

- The average height and standard deviation of the average height
- The maximum plant height and standard deviation of the plant height average.
- The average height of the plants and the percentage of the plants higher than 1 m
- The standard deviation of the height average and the percentage of plants with height greater than 1 m.

From the indices that there were not identified strong bonds, we remained:

- Percentage of plants with height greater than 1 m and the percentage of plants with height greater than the maximum range of the height average of standard deviation, which implies that most plants that have a height greater than the maximum interval of standard deviation have less than 1 m.
- The maximum height and percentage of plants with height greater than 1 m, which means that plants that have height over 1 m, maximum height does not approach on maximum height, those plants being rather singular.
- Between the percentage of survival and average height, percentage of plants with height greater than 1 m and maximum height, in other words, the genotypes with high potential not being necessarily biologically more sensitive to environmental conditions.
- The percentage of plants in the range of plant height standard deviation on the one hand and the average height of plant height average and standard deviation of the same index on the other hand.

Table 2

The variation of the correlation coefficients between the analyzed indices for the plant height character

Index	Average Height	Plant height standard deviation	% plant survival	The percentage of plants taller than height maximum average	The percentage of plants from the plant height standard deviation interval	Maximum plant height
Plant height standard deviation	**0.857**					
% plant survival	-0.091	-0.256				
The percentage of plants taller than height maximum average	0.128	0.146	0.201			
The percentage of plants from the plant height standard deviation interval	-0.153	0.036	-0.123	-0.407		
Maximum plant height	**0.711**	0.638	0.028	0.141	0.108	
The percentage of plants taller than 1 m	**0.736**	**0.726**	0.093	0.380	0.076	0.565

CONCLUSIONS

Based upon the recorded and processed data, were detached the following conclusions:

- For the height average variance analysis, the value of these index was between 20.19 cm for the clone number 5 and respectively, 54.23 cm for the clone number 8.
- For all genotypes, the percentage of plants with a height greater than the upper limit of the standard deviation of the arithmetic average it is low, varying between 5.45% for the clone number 14 and respectively, 19.02%, for the clone number 2.
- For all genotypes, the percentage of the plants with height greater than 1 m of total number plant has been reduced or even 0 (zero) in some cases.
- In the case of survival rates, this one ranged from 35.72% for the clone number 14 and respectively, 72.73% for the clone number 3.

- It was identified a strong correlation between the average of height and standard deviation of the arithmetic mean, in other words, with increasing of the average height increases the variability.

- Also, were identified a strong link between the standard deviation of the arithmetic mean and maximum height and respectively between the standard deviation of the arithmetic mean and the percentage of plants with height greater than 1 m, which means that the genotypes with high biologic potentially can presence of high genetic variability.

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