A COMPARATIVE ANALYZE OF WILLOW SHORT ROTATION COPPICE BIOMASS IN DIFFERENT SITES FROM THE WEST OF ROMANIA

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Abstract

Willowsare trees and shrubs species important for their wood and wood products but also for their role in environmental protection. In the context of energy crises, woody biomass for short rotation coppice could be one of important energy resource. Willows hybrids RO-892, RO-1077 and RO–1082 developed by National Institute for Research and Development in Forestrywere used to establish short rotation coppice on different sites, even marginal areas like saline soil or ash pods. Biometric characteristics, diameter at 1.0 m, and the maximum height of each shoot, and also the number of shoots per stool were evaluated and the biomass potential was estimated. The research highlighted the capacity of willow to grow on difficult site conditions like saline soil or ash pods. The yield production was significantly lower than on agricultural land but the culture can be considered and the others benefits should be evaluated in future researches.

***Key words**: biomass, short rotation coppice, willow*

INTRODUCTION.

There are more than 300 species of Salix genus spread all over the world. In Romania there are about 40, tree species or shrubs (Stănescu, 1979). Willows are important wood and wood products but also in pharmaceutical industry, for the production of salicylic acid, in soil phytoremediation, and like pioneer species by their role in ecosystem restoration. Willows for biomass (Fisher et. Al, 2005) are produce in short rotation coppice and like other woody crops is a renewable energy resource (Trimble eual., 1984) which is expected to increase (Scarlat et al., 2019)

In our country willow research has developed especially by National Institute for Research and Development in Forestry. 38 trees and schrubs willow clones were omologated between 1966 and 2006, all of them selected in Romania (Filat et al., 2009). The three clones analyzed are *Salix alba* (RO-892) and hybrid of *S. fragilis x S. matsudana* (RO-1077 and RO-1082). The hybrids

were recomanded in short rotation coppice (Filat et. Al, 2009)
The aim of this study is to analyze the biometric characteristic and evaluate the biomass production of three Romanian clones in different sites, even marginal ones.

MATERIALS AND METHODS

Willows hybrids RO-892, RO-1077 and RO–1082 developed by National Institute for Research and Development in Forestryrepresent the biological material for this research. Four experimental trials were established in different sites: on ash pond Timisoara (N 45°41'26", E 21° 7'50", elevation 83 m asl), saline soil Ghilad, (N 45027’116”, E 21010’261”, elevation 92m, asl), Control Ghilad (N 45028’719”, E 21002’199”, elevation 86m asl, alluvial soil) and Control Timisoara (N 45078’, E 21022’ E longitude, 90m asl, chernozem soil, pH=6.01 humus content 1.92%, nitrogen content 101%, potassium 93.0 ppm, and P=15.7 ppm).
The climate is continental with South-Mediterranean influence. The mean annual temperature is 11^0C and the total annual precipitation is 600 mm based on the observation made to Timisoara Meteorological Station.
The experimental trail was established in 2015 using 20 cm cuttings. The land was prepared by ploughing and disking and a systemic herbicide was used. No chemical or organic fertilizer and no irrigation have been applied in experimental years. A number of 500 cuttings (46 in Timisoara Control) from each clone were manually planted in double rows. The distance within and between double rows was 0.75m respectively 1.5m and. along the row, the distance between cuttings was 0,8m. During the establishment phase, a pre-emergent residual herbicide was applied in order to keep the crop clean and contact herbicides were over-spraying. Manual and mechanical weed control using inter-row cultivators were also used to control weeds.
In 2016 (February), before the starting of the growing season, half of the plants (the second row of each hybrid) was cut-back in order to highlight the sprouting capacity. The evaluation of quantitative characteristics was made in March 2021 by measurement of diameter at 1,0m (0,01mm precision), height of every plant (1 cm precision) and the number of the shoots for 30 plants (all plants in Timisoara Control). To asses biomass production, the material was cutted, fresh matter content was weighted in the field and transported to the laboratory where dry matter content was determined by drying material at 105ºC, until constantweight.

RESULTS AND DISCUSSIONS

Considering the three analyzed clones in four locations and two experimental variants, the analyses of variance revealed that the site and experimental variants are very significant (Table 1). It cannotbe said the same about genotype. No significant differences were recorded for the character ”the number of shoots” and ”the diameter at the base of the shoot”, and only a significant difference for the character ”shoot height”(Table 1)
The character”number of shoots” was strongly influenced by location. The highest values were registered for locations with difficult site conditions, ”Ash pond Timisoara” followed by ”Saline soil Ghilad, both sites (Table 2).
Only the character ”the height of the shoot” was significant influened by genotype.

The clones RO 892 and RO 1077 belong to the same group (letter a) with the specification that the standard deviation in the case of the two clones is different, smaller in the case of RO 892 (Table 3).

Table 1. **The effect of site, genotype and experimental variant on the main characteristics – analysis of variance**

The analyzed character	Factor	**Analysis of variance** 1- site; 2- genotype; 3- experimental variant Marked effects are significant at p < .05000		
		F	p	Significance
Number of shoots	1	41.61048	0.000000	***
	2	2.482491	0.084509	
	3	19.63516	0.000011	***
	1 x 2	12.11693	0.000000	***
	1 x 3	21.90267	0.000000	***
	2 x 3	5.710458	0.000038	***
	1 x 2 x 3	7.561331	0.000000	***
Diameter at the base of the shoot	1	34.47174	0.000000	***
	2	0.040921	0.959908	
	3	96.23738	0.000000	***
	1 x 2	9.947304	0.000000	***
	1 x 3	33.64799	0.00	***
	2 x 3	19.44925	0.000000	***
	1 x 2 x 3	11.44197	0.00	***
Shoot height	1	74.43207	0.00	***
	2	3.355713	0.035630	**
	3	70.26245	0.000000	***
	1 x 2	24.58123	0.00	***
	1 x 3	50.82922	0.00	***
	2 x 3	16.92612	0.000000	***
	1 x 2 x 3	20.18417	0.00	***

Tabelul 2 **The mean values per sites of the analyzed characteristics of willow trials in 2022**

Site	No of shoots			Diameter at the base of the shoot (mm)			Shoot height (cm)		
	Mean	St.dev.	TD	Mean	St.dev.	TD	Mean	St.dev.	TD
Control Timisoara	1.419355	0.631124	bc	34.83151	15.13581	ab	484.8172	113.9225	a
Control Ghilad	1.271605	0.474667	**c**	32.06580	15.39232	**ab**	415.4321	111.3352	**b**
Saline soil Ghilad	1.706897	0.854830	**b**	27.79328	13.39122	**b**	473.9914	146.2916	**a**
Ash pond Timisoara	2.672199	1.677180	**a**	20.38909	11.50937	**b**	318.0000	97.5220	**c**

TD = Duncan test – the significant differences between sites, the general mean per genotypes (a = the highest value; b = significant < a; c significant < b)

Table 3 **The mean values per genotype of the analyzed characteristics of willow trials in 2022**

Genotypes	Shoot height (cm)		
	Mean	St.dev.	TD
RO 892	411.4630	117.2894	a
RO 1077	402.4433	156.7638	**a**
RO 1082	375.0171	126.4849	**b**

TD = Duncan test – the significant differences between genotypes, the general mean per genotypes (a = the highest value; b = significant < a)

The experimental variant ”cut back” reveal higher value for the character”number of shoots” but lower value for characters ”the diameter at the base of the shoot” and ”the shoot height” (Table 4)

Table 4 **The mean values per experimental variants of the analyzed characteristics of willow trials in 2022**

Experimental variants	No of shoots			Diameter at the base of the shoot (mm)			Shoot height (cm)		
	Mean	St.dev	TD	Mean	St.dev	TD	Mean	St.dev	TD
Uncut	1.725664	1.109537	b	32.89451	15.98147	a	450.3761	138.5342	a
Cut back	2.252459	1.510447	**a**	21.44357	10.89682	**b**	355.9803	120.1770	**b**

TD = Duncan test – the significant differences between genotypes, the general mean per genotypes (a = the highest value; b = significant < a)

The number of shoots per stool was between 1 and 9 and range widely like in Danemark where in a research of 25 varieties of willow range from 1.4 to 9.9 (Nord-Larsen et al., 2015) and in another research from Poland range from 1,8 to 6,6 (Stolarski et al., 2020).

The mean value varied according with experimental variant, between 1,09 (RO 1077, Control Ghilad) and 2.74 (RO 1077, Ash pond Timisoara) for uncut variant and between 1.17 (RO 1077, Control Ghilad) and 3.25 (RO 1082 Ash pond Timisoara) (Figure 1). The number of shoots varied between the control trial and trials from marginal areas where even the uncut plats developed many shoots per stool. In terms of biometric observation, we can see large diameters for all uncut plants, especially for Control trials. For height, the trend is the same, with higher shoots for uncut variants. We can notice good performance for all hybrids on saline soil Ghilad.

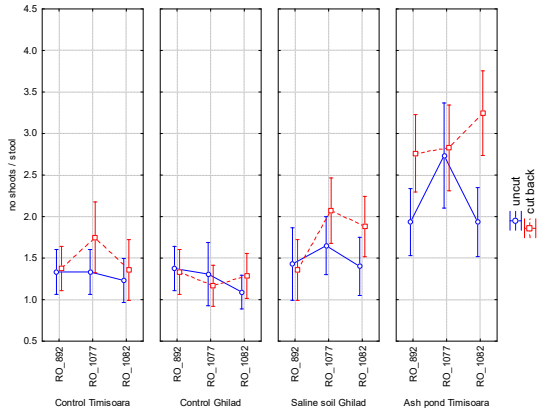

Figure. 1 **The mean values of number of shoots per stool depending on site, genotype and experimental variant of willow trials in 2022**

The diameter and the height are genetically determined characters, but they depend on site conditions. The highest value of diameter at the base of the soot was registered on Control Timisoara (chernozem soil) and Control Ghilad (alluvial soil) (Figure 2). A comparative analysis between the number of shoots per stool and the diameter at the base of the shoot revealed an indirect correlation, as higher the number of shoots as smaller the diameter.

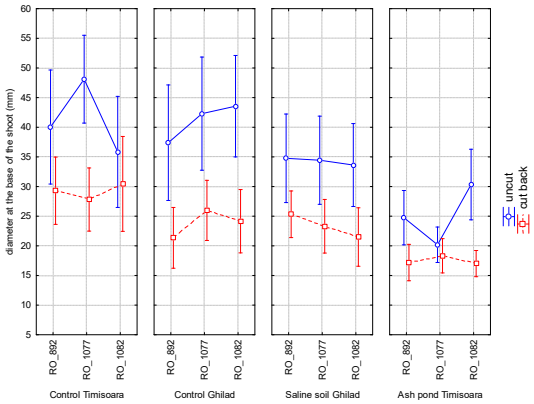

Figure. 2 **The mean values of diameter at the base of the shoot depending on site, genotype and experimental variant of willow trials in 2022**

Not the same can say about the shoot height. High values were recorded, for this character, at the location of Saline Ghilad for both experimental variants (Figure 3).

The hybrid RO 892 revealed poorer performance on all sites.

One of the species used for pellets production are willow. In this context, the willow biomass was estimated. Best results were recorded in Control trials, But we have to notice quite similar yield on Saline Ghilad (Figure 4)

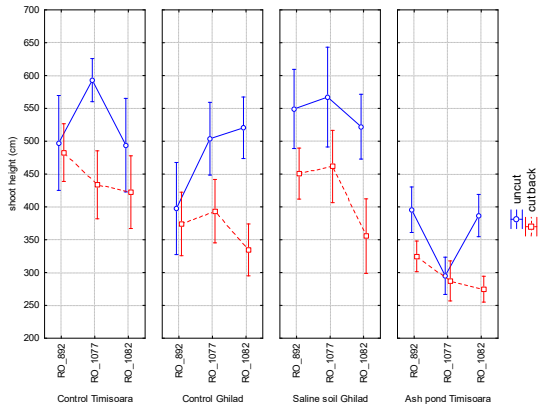

Figure. 3 **The mean values of shoot height depending on site, genotype and experimental variant of willow trials in 2022**

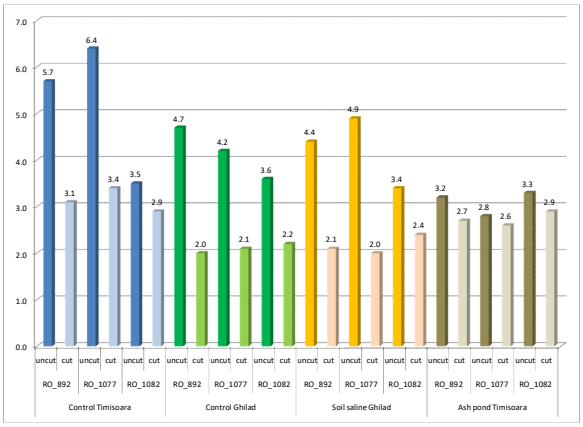

Figure. 4 **The mean values of biomass of willow trials in 2022 (Mg ha^{-1} year^{-1} DM)**

Willow SRC experiments were conducted in different countries and the average yield recorded from experiments was 7.7 Mg ha^{-1} year^{-1} in Sweden (Mola-Yudego et al., 2015). 3,4 Mg ha^{-1} year^{-1} on former agricultural land in Belgium or 5.1 to 10,3 Mg ha^{-1} year^{-1} on poor agricultural land in Poland (Celma et al, 2022).

CONCLUSIONS

The research highlighted the capacity of willow to grow on difficult site conditions like saline soil or ash pods. The number of shoots varied very much between the control trial and trials from marginal areas where even the uncut plats developed a lot of shoots per stool. In terms of biometric observation, we can see large diameters for all uncut stools, especially for Control trials. In terms of height, the trend is the same, with higher shoots for uncut variants. We have to notice the good performance for all hybrids on saline soil Ghilad. The yield ~~production~~ was significantly lower than on agricultural land but the culture can be considered and the others benefits should be evaluated in future researches.

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