

THE VARIABILITY STUDY OF MORPHOLOGICAL CHARACTERS ON SOME *SALIX SPP.* GENOTYPES

PĂNIȚĂ OVIDIU¹, SOARE MARIN¹, CORNEANU MIHAELA², IANCU PAULA¹

¹University of Craiova, Faculty of Agronomy

²USAMVB Timișoara, Faculty of Horticulture

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ABSTRACT

The present study followed the analysis of some characters of 14 Romanian and Swedish genotypes of energy willow in different ecological conditions. Thus, they were analyzed the next characters: stem diameter on the base, total grow/pl., grow/stem, plant height and. no. of stems/pl. The analyzed factors were: the area and the genotype. The area factors had three levels: Radovan (medium fertility soil - Control), Tâmburești (sandy soil on irrigation) and Ișalnița (antropomorphic soil formed from coal ash). The recorded date shows the diversity and the genetic potential of the biological material, emphasizing the well behaviour of the local genotypes RO 1077, RO 1082 and RO 892 created on ICAS Bucharest in the three location. The foreign genotypes with good results were Inger și Torhild. Analyzing the average values recored in the three location, the best results were obtained in the Tamburesti area under irrigation conditions, no matter the studied character, the humidity level from the soil being a key factor for the success of the energy willow crop, no matter the soil type or genotype.

INTRODUCTION

Worldwide, according to the latest research in the field, there are concerns about the use of biomass for energy purposes. Rapid growth trees in short-lived crops are able to produce high yields over short periods. Since the 1980s, willow have become recognized as biomass crops (Karp, 2015).

In-depth knowledge of biological systems has contributed to the development of the biotechnological revolution. Its main purpose is to solve some stringent problems at the global level, especially in the field of agriculture, energy and environmental protection (Bonciu Elena, 2014).

Biomass willow crops increase the diversity of experimental habitats in poor agricultural areas for annual plants and not in areas of forest holdings. These crops can exploit on the sloping land, fix the soil and improve its quality, and can play the role of bioremediation of polluted soils by extracting excess ions and can be used to exploit heavily polluted soils such as tailings dumps, ash, soils, eroded soils, sand etc.

In Romania, SRC-type crops have been developed in 2005, exclusively on non-agricultural and non-forest land. Inger is the most cultivated Swedish commercial clone in Romania (Hernea et al., 2015, 2016), but experimental studies have been conducted with other Swedish and Romanian clones.

The advantages of using SRC willow for biomass production include rapid growth and high biomass production, regeneration capacity after multiple crops, ease of vegetative propagation from latent woody cuttings. The willow crops of SRC is considered a sustainable source of biomass because of its potential to fix carbon (C) in the soil. Short-term crops are an option for solving the demand for bioenergy. But slopes are also important for the phytoremediation of degraded lands because of salicylic acid content (Hernea et al., 2016).

MATERIAL AND METHOD

This study analyzed the variability of some characters from 14 Romanian and Swedish energy willow genotypes in different ecological conditions. Thus, there were analyzed the next characters: stem diameter on the base; total grow/plant; grow/stem; plant height and no. of stems/pl.

The analyzed factors were: the ecological area and the genotype. The area factors had three levels: Radovan (medium fertility soil - Control), Tâmburești (sandy soil on irrigation) and Ișalnița (antropomorphic soil formed from coal ash).

Concerning the humidity level, all three areas are in the same range, the weather date collected from Craiova Weather Station being relevant for them. Thus, in year 2017 the rainfall from spring and summer didn't surpass 161 mm. If in the spring months those cumulated 87 mm, in June, July, August and September there were recorded a total of 19 mm. The only exception was in July, when there were recorded 55 mm cumulated in 48 hours. In Tâmburești area the crops were under irrigation conditions during this period.

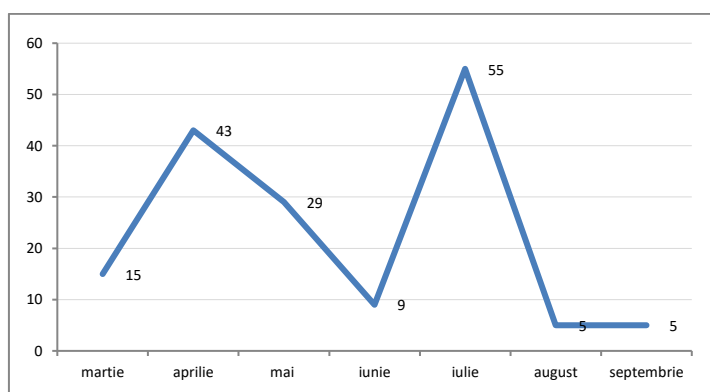


Chart 1- The rainfall recorded during March-September 2017, on Craiova Weather Station

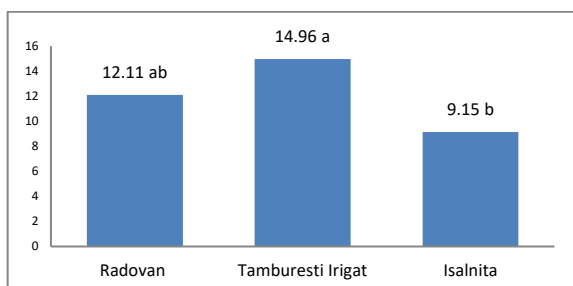
The Romanian genotypes were: RO 892, RO 1077, RO 1082, Cozia, Fragisal, Pesred and Robisal. The Swedish genotypes were: Torhild, Sven, Inger, Olof, Jorr, Tora and Tordis.

From statistical point of view, there were studied: the influence of the area factor over each character; the influence of the genotype over each character and the factors interaction over each character. The significance of the differences between samples was established using the LSD, calculated for $p=0.05$.

RESULTS AND DISCUSSIONS

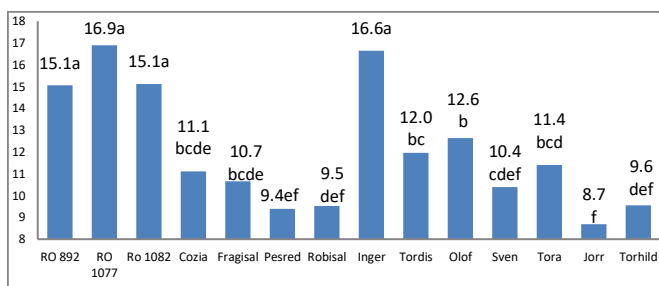
On the stem diameter on the base analysis for each location, the highest value was recorded in Tâmburești area with an average of 14.96 mm followed by the value recorded in the Radovan area (12.11 mm). Between values recorded in Tâmburești and Radovan area, there were no statistical difference, the only statistical difference being recorded between value recorded in Tâmburești and value recorded in Ișalnița (5.8 mm) (Chart 2).

Concerning the influence of the genotype for this character, the best result was recorded on the RO1077 genotype, with a value of 16.9 mm, followed by Inger genotype. There are no statistical differences between first four genotypes, those ones being statistical different from the rest. The last one, Jorr genotype, is statistical different from the first nine ranked genotypes (Chart 3).



LSD 5%=4.02 mm

Chart 2-The variation analysis of the stem diameter on the base character according to location (mm)



LSD 5%=1.91 mm

Chart 3-The variation analysis of the stem diameter on the base character according to genotype (mm)

In the case of comparative analysis of genotypes by location, statistical differences were found between values by locations. For all genotypes, the best result was obtained on the Tâmburești area location, the second was obtained at the Radovan area, all genotypes having the lowest values in the Ișalnita area.

Table 1

The variation analysis of the stem diameter on the base character according to location and genotype (mm)

RO			SWE		
Genotype	Area	stem diameter on the base	Genotype	Area	stem diameter on the base
RO 892	RADOVAN (Mt.)	15.88ab	Inger	RADOVAN (Mt.)	17.15b
	TÂMBUREȘTI	16.64a		TÂMBUREȘTI	20.68a
	IȘALNIȚA	12.64c		IȘALNIȚA	12.11c
RO 1077	RADOVAN (Mt.)	18.53a	Tordis	RADOVAN (Mt.)	11.52b
	TÂMBUREȘTI	19.17a		TÂMBUREȘTI	15.26a
	IȘALNIȚA	13.00b		IȘALNIȚA	9.11b
RO 1082	RADOVAN (Mt.)	14.99b	Olof	RADOVAN (Mt.)	12.47b
	TÂMBUREȘTI	18.38a		TÂMBUREȘTI	16.34a
	IȘALNIȚA	12.00b		IȘALNIȚA	9.12c
Cozia	RADOVAN (Mt.)	10.80b	Sven	RADOVAN (Mt.)	10.80a
	TÂMBUREȘTI	14.28a		TÂMBUREȘTI	13.23a
	IȘALNIȚA	8.28b		IȘALNIȚA	7.15b
Fragisal	RADOVAN (Mt.)	10.40ab	Tora	RADOVAN (Mt.)	10.10b
	TÂMBUREȘTI	13.30a		TÂMBUREȘTI	14.31a
	IȘALNIȚA	8.26b		IȘALNIȚA	9.80b
Pesred	RADOVAN (Mt.)	9.11ab	Jorr	RADOVAN (Mt.)	9.91a
	TÂMBUREȘTI	11.79a		TÂMBUREȘTI	9.98a
	IȘALNIȚA	7.26b		IȘALNIȚA	6.15b
Robisal	RADOVAN (Mt.)	8.11b	Torhild	RADOVAN (Mt.)	9.79ab
	TÂMBUREȘTI	14.32a		TÂMBUREȘTI	11.77a
	IȘALNIȚA	6.13b		IȘALNIȚA	7.11b
Average		12.54			11.61

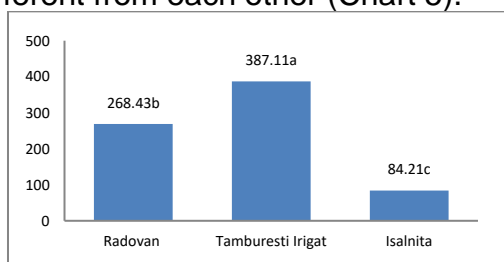
LSD 5% = 3.32 mm

Statistically speaking, in the case of three genotypes (RO1077, Sven and Jorr), the first two values are significantly different from the third rank, in the case of 8 genotypes (RO1082, Cozia, Fragisal, Pesred, Robisal, Tordis, Tora and Torhild), the first value is significantly differentiated from the other two, while for three genotypes (RO892, Inger and Olof) all three values differ significantly between them (Table 1).

On the grow/stem character analysis for each location, the highest value was recorded in Tâmburești area with an average of 387.11 cm followed by the value recorded in the Radovan area (268.43 cm). From statistical point of view, all three values are statically differentiated between them (Chart 4).

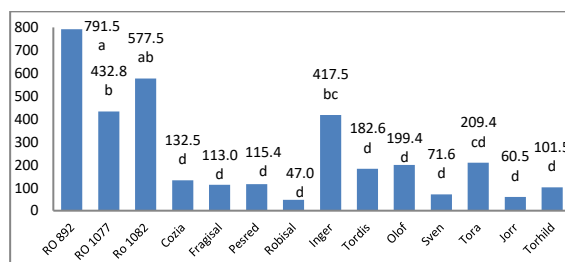
Concerning the influence of the genotype for this character, the best result was recorded on the RO892 genotype, with a value of 791.5 cm, followed by RO1082 genotype. From a statistical point of view, the RO892 genotype differs from all other, without

differentiating from the second one. The last 10 classified genotypes are not statistically different from each other (Chart 5).



LSD 5% = 43.78 cm

Chart 4 - The variation analysis of grow/stem character according to location (cm)



LSD 5% = 215.86 cm

Chart 5 - The variation analysis of grow/stem character according to genotype (cm)

In the case of comparative analysis of genotypes by location, for 8 genotypes there are no statistically differences between variants. For 5 genotypes the first classified value was recorded in the Tâmburești area (Table 2).

Table 2

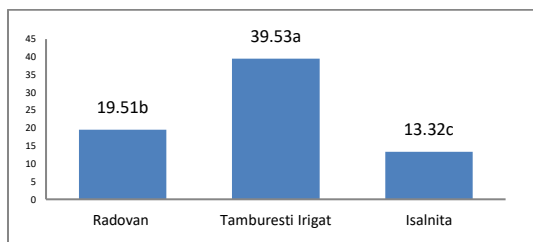
The variation analysis of grow/stem character according to location and genotype (cm)

RO			SWE		
Genotype	Area	Grow/stem	Genotype	Area	Grow/stem
RO 892	RADOVAN (Mt.)	1631.70a	Inger	RADOVAN (Mt.)	365.38b
	TÂMBUREȘTI	492.75b		TÂMBUREȘTI	763.13a
	ÎȘALNIȚA	250.00b		ÎȘALNIȚA	124.00b
RO 1077	RADOVAN (Mt.)	428.32ns	Tordis	RADOVAN (Mt.)	101.75ab
	TÂMBUREȘTI	570.21ns		TÂMBUREȘTI	423.10a
	ÎȘALNIȚA	300.00ns		ÎȘALNIȚA	23.00b
RO 1082	RADOVAN (Mt.)	414.01b	Olof	RADOVAN (Mt.)	117.21ab
	TÂMBUREȘTI	1068.38a		TÂMBUREȘTI	453.95a
	ÎȘALNIȚA	250.00b		ÎȘALNIȚA	27.00b
Cozia	RADOVAN (Mt.)	111.00ns	Sven	RADOVAN (Mt.)	40.25ns
	TÂMBUREȘTI	211.46ns		TÂMBUREȘTI	162.63ns
	ÎȘALNIȚA	75.00ns		ÎȘALNIȚA	12.00ns
Fragisal	RADOVAN (Mt.)	105.00ns	Tora	RADOVAN (Mt.)	115.88b
	TÂMBUREȘTI	208.95ns		TÂMBUREȘTI	500.28a
	ÎȘALNIȚA	25.00ns		ÎȘALNIȚA	12.00b
Pesred	RADOVAN (Mt.)	125.00ns	Jorr	RADOVAN (Mt.)	72.08ns
	TÂMBUREȘTI	199.21ns		TÂMBUREȘTI	88.33ns
	ÎȘALNIȚA	22.00ns		ÎȘALNIȚA	21.00ns
Robisal	RADOVAN (Mt.)	50.00 ns	Torhild	RADOVAN (Mt.)	80.46ns
	TÂMBUREȘTI	76.00 ns		TÂMBUREȘTI	201.18ns
	ÎȘALNIȚA	15.00 ns		ÎȘALNIȚA	23.00ns
Average		315.67			177.50

LSD 5% = 373.87 cm

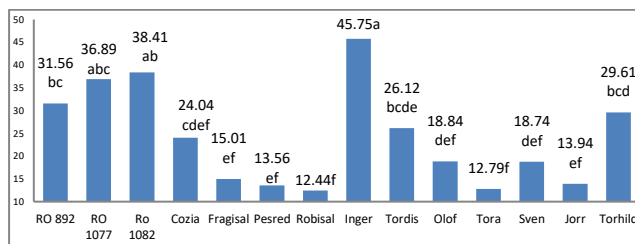
In the case of total grow/pl. character, the highest value was recorded in the Tâmburești area with a value of 39.53 cm, the second place being the value recorded in the Radovan area (19.51 cm), the last quantified value being in the Îșalnița area (13.32 cm), statistically, the three recorded values differing significantly between them (Chart 6).

On comparative analysis of genotypes, the best result was recorded by the Inger genotype, with a value of 45.75 cm, followed by the RO1082 genotype. From the statistical point of view, the first three genotypes are distinguished from all other genotypes but are not differentiated between them. The last eight classified genotypes are not different from each other (Chart7).



LSD 5% = 2.56 cm

Chart 6 - The variation analysis of total grow/pl. character according to location (cm)



LSD 5% = 12.62 cm

Chart 7 - The variation analysis of total grow/pl. character according to genotype (cm)

On the analysis of genotypes by location, there were identified 8 statistical differences between locations. For all genotypes, the highest value was obtained at the Tâmburești location, the second one being obtained at the Radovan location, all the genotypes having the lowest values in the Isalnița location (Table 3).

Table 3

The variation analysis of total grow/pl. character according to location and genotype (cm)

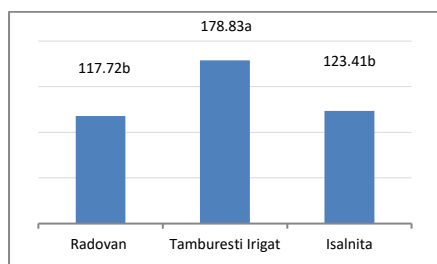
RO			SWE		
Genotype	Area	total grow/pl.	Genotype	Area	total grow/pl.
RO 892	RADOVAN (Mt.)	26.88b	Inger	RADOVAN (Mt.)	38.79b
	TÂMBUREȘTI	56.11a		TÂMBUREȘTI	78.25a
	ÎȘALNIȚA	11.70c		ÎȘALNIȚA	20.22b
RO 1077	RADOVAN (Mt.)	30.17b	Tordis	RADOVAN (Mt.)	18.13b
	TÂMBUREȘTI	62.11a		TÂMBUREȘTI	42.11a
	ÎȘALNIȚA	18.40b		ÎȘALNIȚA	18.12b
RO 1082	RADOVAN (Mt.)	34.75b	Olof	RADOVAN (Mt.)	14.11ns
	TÂMBUREȘTI	60.25a		TÂMBUREȘTI	30.27ns
	ÎȘALNIȚA	20.22c		ÎȘALNIȚA	12.14ns
Cozia	RADOVAN (Mt.)	20.11b	Sven	RADOVAN (Mt.)	8.45ns
	TÂMBUREȘTI	42.12a		TÂMBUREȘTI	20.12ns
	ÎȘALNIȚA	9.89c		ÎȘALNIȚA	9.80ns
Fragisal	RADOVAN (Mt.)	11.48ab	Tora	RADOVAN (Mt.)	13.45ns
	TÂMBUREȘTI	28.14a		TÂMBUREȘTI	28.27ns
	ÎȘALNIȚA	5.40b		ÎȘALNIȚA	14.50ns
Pesred	RADOVAN (Mt.)	12.11ns	Jorr	RADOVAN (Mt.)	12.46ns
	TÂMBUREȘTI	22.11ns		TÂMBUREȘTI	20.22ns
	ÎȘALNIȚA	6.47ns		ÎȘALNIȚA	9.14ns
Robisal	RADOVAN (Mt.)	9.78ns	Torhild	RADOVAN (Mt.)	22.48b
	TÂMBUREȘTI	18.27ns		TÂMBUREȘTI	45.12a
	ÎȘALNIȚA	9.28ns		ÎȘALNIȚA	21.22b
Average	24.56			23.68	

LSD 5% = 21.86 cm

Concerning the total height character according to the location, the highest value was recorded in the area of Tâmburești with a value of 178.83 cm, the second place being the value recorded in the Radovan area (123.41 cm), the last value (117.72 cm) (Chart 8).

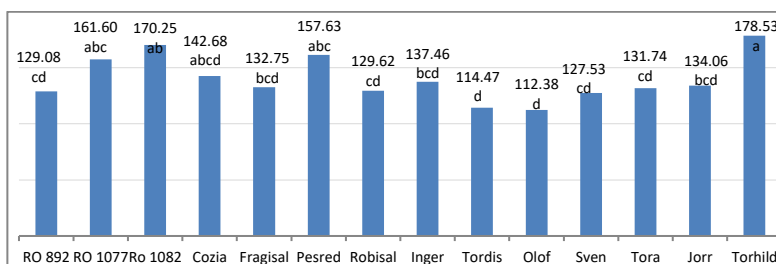
The smaller increase in the Isalnița area is due to the installation of the drought and the reduced water retention capacity of ash, so the willow finds favorable growth conditions only during the first part of the vegetation period (Soare, M., 2017).

In the case of comparative analysis of genotypes, the best result was recorded by the genotype Torhild, with a value of 178.53 cm, followed by the genotype RO1082. Note that the last nine genotypes are not statistically different from each other, while the first ranked genotype does not statistically differ from the following four (Chart 9).



LSD 5% = 7.75 cm

Chart 8 - The variation analysis of the plant height character according to location (cm)



LSD 5% = 38.21 cm

Chart 9 - The variation analysis of the plant height character according to genotype (cm)

In the case of comparative analysis of genotypes by location, statistically significant differences were recorded in 6 of the genotypes studied. In the case of these, the highest values were registered in the Tâmburești area, with the second position being recorded in the Radovan area (Table 4).

Table 4

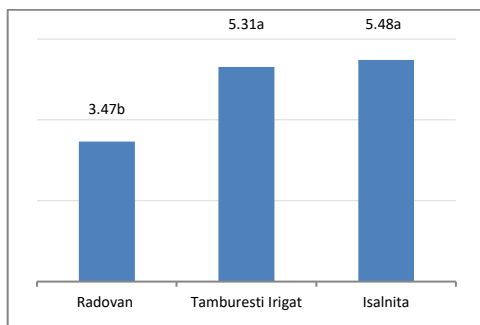
The variation analysis of the plant height character according to location and genotype (cm)

RO			SWE		
Genotype	Area	Height	Genotype	Area	Height
RO 892	RADOVAN (Mt.)	131.3 ^{ns}	Inger	RADOVAN (Mt.)	82.82 ^b
	TÂMBUREȘTI	148.874 ^{ns}		TÂMBUREȘTI	230.28 ^a
	IȘALNIȚA	107.06 ^{ns}		IȘALNIȚA	99.283 ^b
RO 1077	RADOVAN (Mt.)	121.2 ^{ns}	Tordis	RADOVAN (Mt.)	88.88 ^{ns}
	TÂMBUREȘTI	185.032 ^{ns}		TÂMBUREȘTI	141.4 ^{ns}
	IȘALNIȚA	166.6 ^{ns}		IȘALNIȚA	113.12 ^{ns}
RO 1082	RADOVAN (Mt.)	166.65 ^{ab}	Olof	RADOVAN (Mt.)	112.514 ^{ns}
	TÂMBUREȘTI	205.737 ^a		TÂMBUREȘTI	136.35 ^{ns}
	IȘALNIȚA	138.37 ^b		IȘALNIȚA	88.274 ^{ns}
Cozia	RADOVAN (Mt.)	158.57 ^{ns}	Sven	RADOVAN (Mt.)	124.634 ^{ab}
	TÂMBUREȘTI	147.965 ^{ns}		TÂMBUREȘTI	163.62 ^a
	IȘALNIȚA	121.503 ^{ns}		IȘALNIȚA	94.334 ^b
Fragisal	RADOVAN (Mt.)	97.263 ^{ns}	Tora	RADOVAN (Mt.)	78.073 ^b
	TÂMBUREȘTI	142.41 ^{ns}		TÂMBUREȘTI	200.99 ^a
	IȘALNIȚA	158.57 ^{ns}		IȘALNIȚA	116.15 ^b
Pesred	RADOVAN (Mt.)	133.32 ^b	Jorr	RADOVAN (Mt.)	88.88 ^b
	TÂMBUREȘTI	203.01 ^a		TÂMBUREȘTI	198.97 ^a
	IȘALNIȚA	148.47 ^{ab}		IȘALNIȚA	114.332 ^b
Robisal	RADOVAN (Mt.)	93.93 ^b	Torhild	RADOVAN (Mt.)	169.983 ^{ab}
	TÂMBUREȘTI	171.7 ^a		TÂMBUREȘTI	227.25 ^a
	IȘALNIȚA	123.22 ^{ab}		IȘALNIȚA	138.37 ^b
Average	146.23		133.74		

LSD 5% = 66.18 cm

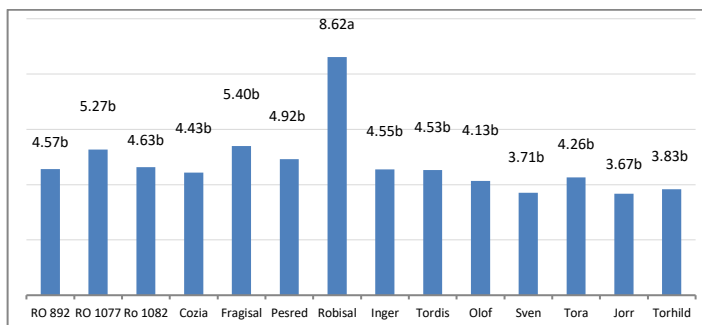
On the analysis of no. of stems/pl. according to the location, the highest value was recorded in the Ișalnița area with a value of 5.48 stems/pl., the second place being the value recorded in the Tâmburești area (5.31 stems/pl.), the last quantified being the one in the Radovan area (3.47 stems/pl.) (Chart 10).

In the comparative analysis of genotypes, the best result was recorded by the Robisal, with a value of 8.62 stems/pl., which is significantly from all other genotypes. Excepting the first one, there were no statistically significant differences between the other studied genotypes (Chart 11).



LSD 5% = 1.15 stems/pl.

Chart 10 - The variation analysis of the no. of stems/pl. character according to location (cm)



LSD 5% = 2.41 stems/pl.

Chart 11 - The variation analysis of the no. of stems/pl. character according to genotype (cm)

In the case of comparative analysis of genotypes by location, there were identified 11 statistical differences between locations. For all genotypes, the best result was obtained on the Ișalnița location, the second obtained on the Tâmburești location, all genotypes having the lowest values in the Radovan location (Table 5). It seems that this indicator records higher values on lighter soils, under the conditions of Radovan, the variation amplitude being lower for the no. of stems/pl. (Soare, M. 2016)

Table 5

The variation analysis of the no. of stems/pl. character according to location and genotype (cm)

RO			SWE		
Genotype	Area	no. of stems/pl.	Genotype	Area	no. of stems/pl.
RO 892	RADOVAN (Mt.)	3.7ns	Inger	RADOVAN (Mt.)	3.24ns
	TÂMBUREȘTI	5.4ns		TÂMBUREȘTI	4.8ns
	IȘALNIȚA	4.6ns		IȘALNIȚA	5.6ns
RO 1077	RADOVAN (Mt.)	4.1ns	Tordis	RADOVAN (Mt.)	4.5ns
	TÂMBUREȘTI	6.4ns		TÂMBUREȘTI	5.7ns
	IȘALNIȚA	5.3ns		IȘALNIȚA	3.4ns
RO 1082	RADOVAN (Mt.)	4.6ns	Olof	RADOVAN (Mt.)	2.9ns
	TÂMBUREȘTI	5.8ns		TÂMBUREȘTI	4.2ns
	IȘALNIȚA	3.5ns		IȘALNIȚA	5.3ns
Cozia	RADOVAN (Mt.)	3.2ns	Sven	RADOVAN (Mt.)	2.83ns
	TÂMBUREȘTI	4.2ns		TÂMBUREȘTI	4.1ns
	IȘALNIȚA	5.9ns		IȘALNIȚA	4.2ns
Fragisal	RADOVAN (Mt.)	3.1b	Tora	RADOVAN (Mt.)	2.89b
	TÂMBUREȘTI	6.8a		TÂMBUREȘTI	5.2a
	IȘALNIȚA	6.3a		IȘALNIȚA	4.7a
Pesred	RADOVAN (Mt.)	5.1ns	Jorr	RADOVAN (Mt.)	3.1ns
	TÂMBUREȘTI	5ns		TÂMBUREȘTI	3.4ns
	IȘALNIȚA	4.66ns		IȘALNIȚA	4.5ns
Robisal	RADOVAN (Mt.)	2.65c	Torhild	RADOVAN (Mt.)	2.6ns
	TÂMBUREȘTI	9.2b		TÂMBUREȘTI	4.1ns
	IȘALNIȚA	14a		IȘALNIȚA	4.8ns
Average	5.41		4.10		

LSD 5% = 3.12 stems/pl.

CONCLUSIONS

Regarding the statistical analysis of the stem diameter on the base, the best result is obtained in the area of Tâmburești, these having a significant difference compared to the average recorded in the area of Ișalnița. There are also statistical differences between genotypes, regardless of location.

In the case of the analysis of the total grow/pl., the average value obtained in the Tâmbuști area is significantly different from the average recorded in the Radovan and Isalnița areas, those last ones being statistically different. In case of comparative analysis of genotypes by location, for the vast majority of genotypes, the best result was obtained on the Tâmburești area, the second obtained at the Radovan site, all the genotypes having the lowest values at the Isalnița site.

Plant height analysis highlights the results obtained in the Tâmburești area, which is significantly different from the average recorded in the Radovan and Isalnița areas. In the case of comparative analysis of genotypes, the best result was recorded by the Torhild genotype, with a value of 178.53 cm, followed by the genotype RO1082. Regarding the comparative analysis of genotypes by location, statistically significant differences were recorded on five of the genotypes: Torhild, Pesred, Cozia, RO 1077 and RO 1082.

Related to no. of stems/pl. depending on the location, the best result is obtained on the Isalnița location. In the case of comparative analysis of genotypes by location, statistical differences between locations for 11 genotypes were identified. Of all the genotypes in the three locations, the best result was obtained by the Robisal genotype, followed by Fragisal and RO 1077.

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