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EVALUATION OF TALL FESCUE (*Festuca arundinacea*) GENETIC RESOURCES FOR BREEDING ACTIVITY

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Abstract

The breeding program involves new objectives and approaches for adapting to changing climatic conditions by creating productive varieties with increased tolerance to drought. The aim of research is the evaluation of the germplasm through observations and measurements to choose valuable resources of initial breeding material. Were analyzed 20 accessions. The studied genotypes can be grouped into three categories from precocity point of view, difference between the earliest variety, Kerestelny (28.04) and the latest, Luna (25.05) was 27 days. The abundance of vegetative shoots was combined with the abundance of generative shoots, to break the existing negative correlations between seed production and DM production. Regarding plant height a large inter-varietal and intra-varietal variability was found, with average values above 100 cm in the varieties: Krasnodarska 115.2 cm and with values below 50 cm in the Luna variety 48.5 cm. The most resistant genotypes to Puccinia.sp. with the frequency of over 80% resistant plants are: Luna: 90%, Bronson: 89.5%, Prolate 86.7% and the most sensitive are Szarkad 5: 20% and Bull 20.5% unattached.

Key words: *disease resistance, genotype, generative shoots, plant height, tall fescue, vegetative shoot.*

INTRODUCTION

The tall fescue is a perennial grass with an extremely complex biology, characterized by good adaptation both in conditions of excess moisture and drought. At the same time, it grows normally on acid soils and on salty soils (Moga I. and Schitea Maria, 2000; Popa et al., 2008).

It withstands high temperatures, but also low ones, as well as periods of prolonged drought, thanks to the more developed and deeper root system compared to other perennial grasses, favoring the use of water and nutrients from the deeper layers of the soil and at the same time preventing soil compaction (Mocanu et al., 2021).

In Romania, tall fescue has been introduced into culture in the last 25 years, but the current breeding program involves new objectives for adapting to changing climatic conditions and reducing the impact on the environment by creating productive varieties with increased tolerance to drought.

The success in plant breeding, obtaining new genotypes, superior to the existing ones and adapted to the new environmental conditions, depends on the wealth of valuable genes and the genetic diversity of the germplasm.

In general, the selection applied to allogamous species leads to the achievement of genotypes differentiated from the initial forms (not subject to the selection process), as a result of the continuous recombination of genes in each generation (Savatti et al, 2004).

The aim of this research is the evaluation of the germplasm in the selection field through observations, measurements and determinations in order to know the morphological and physiological characteristics of the genotypes to choose valuable sources of initial material.

MATERIALS AND METHODS

In the selection field within the breeding laboratory of the Grassland Research and Development Institute - Brașov, 20 tall fescue genotypes of different eco-geographic origin were used as research material. These were planted individually in the field in autumn 2023, 10 plants per row of 5 rows. Appreciated number of generative and vegetative shoots, with notes from 1 to 5, carried out on a scale of 5 steps: 1 - very few ... 5 - very many, and the assessment of the degree of rust attack (*Puccinia graminis* and *Puccinia striiformis*) was carried out on the scale of 5 steps: 1 - 0% … 5 - >100% of the leaf surface. Measurements were made on the plant's height, the heading date and observations were made on the form of the plant

(L - lax, S - semi-erect, E - erect). All information was collected from the field between April and July 2024.

The purpose of these observations and measurements is to identify the most valuable genotypes that could be the basis for the creation of new qualitatively and quantitatively superior synthetic combinations and the highlighting and selection of the parental forms of *Festuca arundinacea*, which meet the breeding objectives: increasing the forage and seed production, disease resistance, fineness of leaves and method of usage.

The meteorological conditions of the years 2023 and 2024 (Table 1) had positive deviations, compared to the multiannual average from the point of view of temperatures, and negative deviations, from the point of view of precipitation. Average annual temperatures were higher than the multiannual average with 2.3°C, respectively 3.6°C.

Table 1. Meteorological conditions from Brașov stationary, 2023-2024

Years	Annual average I-XII	Deviation	Vegetation period IV-IX	Deviation during vegetation period
Temperature (°C)				
2023	10.1	+2.3	14.8	+0.6
2024	11.4	+3.6	17.6	+2.7
Average 59 years	7.8	0	14.2	0
Precipitation (mm)				
2023	570.4	-182.8	407.8	-121.3
2024	730.6	-22.6	485.9	- 43.2
Average 25 years	753.2	0	529.1	0

From the point of view of precipitation, the year 2023 recorded a deficit of -182.8 mmm compared to the multiannual average, and in the year 2024 a deficit of -22.6 mm was recorded. During the vegetation period, there was a deficit of precipitation, in both studied agricultural years. The plants were irrigated only in 2023.

The recorded data were statistically processed in the Statistica 7 software package, using ANOVA, corelation , principal component and cluster analysis.

RESULTS AND DISCUSSIONS

Regarding the heading date, the analysed genotypes can be grouped into three categories: early (28.04 - 6.05), intermediate (7.05 - 15.05) and late (16.05 - 25.05), allowing the selection of genotypes for the creation of varieties with different earliness. The difference between the earliest variety, Kerestelny (28.04) and the latest, Luna (25.05) was 27 days. To ensure the homogeneity of the variety, phenotypically similar plants were chosen. The abundance of vegetative shoots determines the forage production, the main criterion for evaluating agronomic performance in order to certify a variety, grades of 5 and 4 indicating a rich foliage. By combining with the abundance of generative shoots (along with the other elements of fruiting: number of seeds / inflorescence, MMB) it is aimed to create varieties that can put a high biological potential of fruiting and breaking the existing negative correlations between seed production and forage production.

Plant height, correlated with the abundance of vegetative shoots, is a selection criterion for forage production as well as for use. A large inter-varietal as well as intra-varietal variability was found, with average values above 100 cm in the varieties: Krasnodarska: 115.2 cm, Terros and Visuki: 104 and 103.7 cm, respectively, and with values below 60 cm in the Prolate varieties: 57 cm, Luna: 48.5 cm and Jotvincs: 53.5 cm.

Disease resistance is an essential factor in obtaining qualitatively and quantitatively high forage production without negative impact on seed quantity and quality.

Among the diseases specific to perennial grasses, rust, transmitted by *Puccinia* sp., is the most damaging, both in terms of frequency and intensity. The attack frequency notes were made on each plant in the selection field, in order to select resistant genotypes, the table showing the average attack on each genotype. The most resistant genotypes, with the frequency of over 80% resistant plants are: Luna: 90%, Bronson: 89.5%, Prolate 86.7% and the most sensitive are Szarkad 5: 20%, Bull 0.5% and Terros II: 30% unattacked plants (Table 2).

The results obtained from the observations and biometry (genotypes) from the selection fields were processed statistically, through several tests, to validate the respective results. The graphical representation of the correlation relationships ensured with a statistical significance by the Pearson correlation can be found in the following graph (Figure 1).

Table 2. Morphological observations in the selection field

Genotype	Heading date	P. form	V. shoot	G. shoot	Plant H (cm)	Dis. resist (%)	Use
Szeveleny 4	1.05	SE	**4**	4	92.7	50.0	M
Albena	8.05	L	**4**	3	89.0	41.0	M
Kereteleny	28.04	SE	**4**	4	89.5	32.5	M
Szarkad 5	2.05	E	**3**	4	96.7	20.0	M
Bull 2021	3.05	SE	**4**	4	97.0	20.5	M
Proba	6.05	SE	**5**	5	98.7	67.5	M
Koreta	12.05	L	**5**	3	80.5	87.2	G
Bronson	6.05	E	**5**	5	100.5	89.5	M
Fawn	5.05	SE	**4**	4	99.7	73.7	M
Prolate	20.05	L	**5**	4	57.0	86.7	G
Luna	25.05	L	**3**	3	48.5	90.0	G
Adela 2021	10.05	SE	**4**	4	67.0	77.5	M
5.. - 6..	12.05	SE	**4**	4	67.0	66.7	M
Terros I	10.05	SE	**4**	4	89.7	60.0	M
Vio Jucu	10.05	SE	**3**	4	97.7	60.0	M
Terros II	10.05	SE	**4**	4	104.0	30.0	M
Krasnodarska	5.05	SE	**4**	5	115.2	37.5	M
Visuki	10.05	SE	**4**	4	103.7	53.3	M
Jotvincis	24.05	L	**5**	3	53.5	50.0	G
Grebalovska	15.05	L	**4**	3	60.2	70.0	G

V. shoot = vegetative shoots.: 13.05.2024 - 1 - very few; 5 - very many
G. shoot = generative shoots: 30.05.2024 - 1 - very few; 5 - very many
Dis. resist.= disease resistance: 03.08.2024 – 1 - 0% attack; 9 - 100% attack
Use = Usage mode : M - mixt, G - turf,
P. Form = Plant form - L - lax, S - semi-erect, E - erect
Plant H = Plant heigh

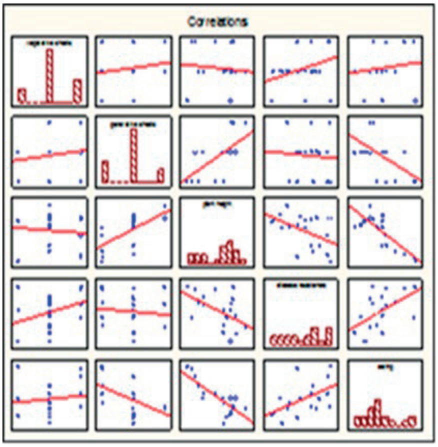


Figure 1. Graphic representation of correlation relations

In the graphic representation is the expression of the correlation between the five studied characters.

On a general analysis of all the graphs, several genotypes stand out as the best, depending on the analyzed character.

In Table 3, the correlation coefficient highlights the following statistically ensured interdependencies in the expression of morphoproductive characters in genotypes selected from the selection fields: the height of the plant shows a distinctly significant positive correlation (0.65) with generative shoots and significantly negative with disease resistance (-0.49) and very significantly negative with the heading date (-0.79).

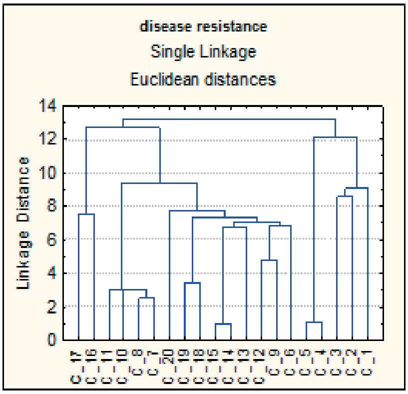
Generative shoots was correlate significantly negatively (-0.56) with the heading date, while disease resistance correlates significantly with the heading date(0.59).

The morphoproductive characters investigated in the selection and breeding process of *Festuca arundinacea* were analyzed through the correlation matrix to estimate the correlation of the analyzed genotypes.

Also, through this procedure, the null hypothesis that the population correlation between pairs of variables is equal to 0 was tested and statistically invalidated.

Table 3. Correlation matrix

	Vegetative shoots	Generative shoots	Plant H. (cm)	Disease resistance	Heading
Vegetative shoots	1.00	0.15	-0.10	0.34	0.13
Generative shoots		1.00	**0.65****	-0.10	**-0.56 ****
Plant H (cm)			1.00	**-0.49***	**-0.79 *****
Disease resistance				1.00	**0.53***
heading date					1.00
$r_{5\%} = 0.44$; $r_{1\%} = 0.55$; $r_{0.1\%} = 0.67$					



C1-Szeveleny 4, C2-Albena, C3-Kereteleny, C4-Szarkad 5, C5-Bull 2021, C6-Proba, C7-Koreta, C8-Bronson, C9-Fawn, C10-Prolate, C11-Luna, C12-Adela 2021, C13- 5.. - 6, C14-Terros I, C15-Vio Jucu, C16-Terros II, C17-Krasnodarska, C18-Visuki, C19-Jotvincis, C20-Grebalovska

Figure 2. The dendrogram for the representation of disease resistance

Studying the dendrogram of the hierarchical cluster analysis performed on the 20 studied genotypes (Figure 2), we can conclude that they are grouped according to the rust resistance of each one. Thus, two cluster groups are formed, with great similarity, the first being made up of genotypes C 1-4 (Szeveleny 4, Albena,, Kereteleny, Szarkad 5), and the second with the other 16 genotypes.

It is important that when choosing the plants that will be selected to continue the breeding process, there are phenotypically similar plants with high disease resistance.

They will not choose phenotypically similar plants, and with high productive capacity, but with low disease resistance.

Following the calculations made through the principal components analyses (PCA), two components was resulted, so the first 2 components bring a variance of 78.77%.

It is found that, accepting the expression of the initial causal space, respectively of the variables under study, through a single main component, only 52.75 of the initial variance is explained. Extending the number of main components to 2, the explanation of 78.77% of the total variance is ensured (Figure 3).

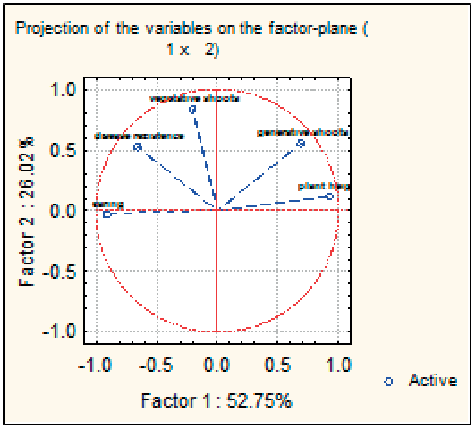
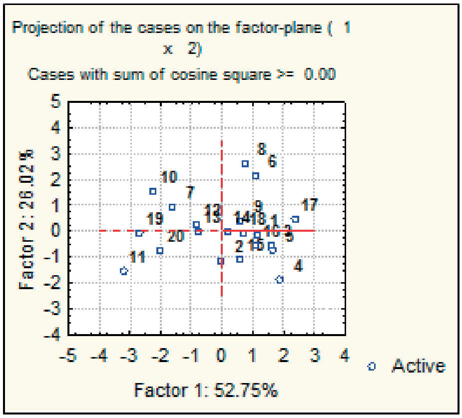


Figure 3. The projection of the variables in the plane of the factorial axes of the two main components (Factor 1/PC 1 and Factor 2/PC 2)

The varieties Krasnodarska, Jotvincis, Prolate, represented in figure 5 with points 17, 19 and 10, are very close to principal component 1 (PC1) namely for heading date, plant height, generative shoots and disease resistance. Bronson, Proba and Szarkad varieties are part of the principal component 2 (PC2) represented here by the morphoproductive character, vegetative shoots (Figure 4).

It is important that in the selection of the most valuable genotypes a balance between the analyzed characters is found, so that the future varieties have high productive potential both in the production of seeds and forage.



1-Szeveleny 4, 2-Albena, 3-Kereteleny, 4-Szarkad 5, 5-Bull 2021, 6-Proba, 7-Koreta, 8-Bronson, 9-Fawn, 10-Prolate , 11-Luna, 12-Adela 2021, 13- 5.. - 6.., 14-Terros I, 15-Vio Jucu, 16-Terros II, 17-Krasnodarska, 18-Visuki, 19-Jotvincis, 20-Grebalovska

Figure 4. The projection of the genotypes in the plane of the factorial axes of the two main components (Factor 1/PC 1 and Factor 2/PC 2)

The genetic variability of all traits important for breeding process represent a basic prerequisite for successful selection (Babic et al., 2018).

The increase in seed production is mainly determined by the number of generative shoots, therefore for the creation of new varieties with a high potential for producing the amount of seeds it is important that in the breeding process the genotypes that produce many generative shoots are selected.

Forage production and its quality is determined by a high percentage of leaves, which imparts better quality and palatability to the forage. Therefore, one of the important breeding objectives is to increase the number of leaves and the size of the leaves in the improved varieties.

Obtaining products with the highest quality and very good quality depends to a large extent on the species and variety used.

The introduction, expansion, as well as the maintenance of valuable varieties in the culture depend to a great extent on the culture conditions, on the economic requirements, but above all on the ecological resources, to which a new genotype must have a high degree of adaptability (Varga et al., 1998)

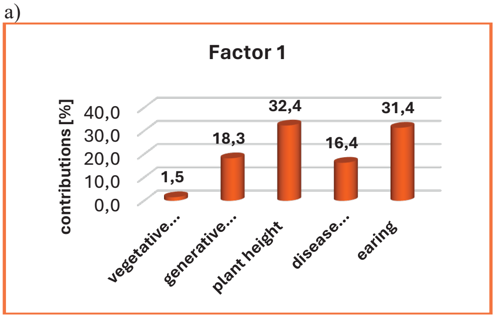
Principal component 1 (PC1) which represented 52.75% of the total variation, includes the variables with the highest correlation coefficients: Height - a very tight, positive correlation (r=0.92), height - a very tight, negative correlation (r=-0.91), Generative shoots – a close correlation (r=0.69), positive correlation and rust resistance a correlation tight (r=-0.66), negative correlation

Principal component 2 (PC2) which represented 26.02% of the total variation includes: vegetative shoots, a very tight correlation (r=0.84), generative shoots (r=0.55), plant height (r=0.12), rust resistance (r=0.53) and tillering (r= -0.03) (Table 4).

Table 4. Factor-variable correlations, based on correlations

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
V. shoots	**-0.202077**	**0.835957**	0.509863	-0.017747	0.008034
G. shoots	0.694431	0.553942	-0.318648	0.309148	-0.117493
P. height	0.924317	0.116685	-0.027679	-0.087551	0.351555
Disease resistance	-0.657033	0.529875	-0.467556	-0.258730	0.044614
Heading date	-0.910289	-0.026965	-0.046903	0.337626	0.233357

a)



b)

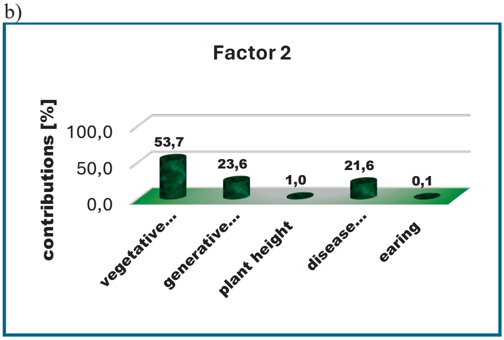


Figure 5. Principal Component Analysis: PCA 1 (a) and PCA 2 (b)

Within PCA 1, the biggest contribution is the height of the plant (32.4%) and the heading date (31.4%), and the number of vegetative shoots influences only 1.5% (Figure 5a).

Within PCA 2, vegetative shoots have the largest contribution, representing 83.7% (Figure 5b).

CONCLUSIONS

The abundance of vegetative shoots combining with the abundance of generative give a high biological potential for break the existing negative correlations between seed production and forage production.

The plant height, correlated with the abundance of vegetative shoots, is a selection criterion for forage production as well as for use. A large inter-varietal as well as intra-varietal variability was found, with average values above 100 cm .

For the selectioned plants, it is important to meet the new breeding objectives, namely: adaptability, perennially, productivity and resistance to diseases and pests, under the conditions of climate change.

The selected genotypes represent valuable material for the development of high-yielding, stress-tolerant cultivars.

The strict choice from the selection field of the most valuable parental forms can lead to high chances of success in order to create synthetic varieties of perennial grasses.

Following the analysis, the following genotypes were selected for polycross breeding activity, in the next year, tall plants from the genotypes with a large number of vegetative and generative shoots with resistant to diseases.

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