CLASSIFICATION MODEL OF SOME VARIETIES OF FODDER BEET BASED ON STUDY OF CHARACTERS

Luminița COJOCARIU, A. MOISUC, D. V. LALESCU
I. SAMFIRA, M. HORABLAGA, F. MARIAN

U.S.A.M.V.B. TIMIŞOARA, Calea Aradului, nr. 119
E-mail: luminitacojocariu@yahoo.com

Abstract: *The fodder beet (Beta vulgaris L. var. crassa) is cultivated presently in almost all European countries, and in Romania on large surfaces in West Plain. Vest. This crop is used as a valuate source of cattle food. Due to its high content of water and sugar, it increases the milk production and is an appropriate fodder for the dairy cows (ALBAYRAK S. and NECDET Ç., 2007, LAUWERS T., 2009)***.*** *Usually, the fodder beet is administrated chopped and mixed with straws. The goal of this paper is to find a mathematical model which will allow to analyze the studied varieties of fodder beet under aspect of some quantitative characteristics (by correlation method) and then to classify them considering the similitude degree (in this case considering the first two factors). The biological material that was studied is represented by 16 varieties of fodder beet and it represents a valuable and highly diversified material from ecological viewpoint (Belgium, Germany, Poland, Romania), reason why there was considered useful to see what is their behaviour in conditions of Banat. The variability study of the root characteristics (root weight, root length, maximum diameter of the root) and of the leaf characteristics (leaf number, green leaf number and foliar surface) was made basing on biometric determinations. There were determined the linear correlations between the morphological characters up mentioned and then, basing on these correlations, there was realised an analysis of the main components and a cluster analysis (using the Euclidian distance and Ward method) which revealed that the varieties Angoba, Troya, Feldher and Ketil; Monro, Polifuraj 2, Beta Rosa and Ursus; Gonda, Tamara and Kyros I; Brigadier and Marshal; Fumona, Zentaur and respectively Tamon formed clusters, showing a strong similarity between them. The values of the genetic potential in fodder beet are manifested only if the variety is maintained in genetic equilibrium and whether it will receive appropriate condition of cultivation.*

Key words**:** *fodder beet, production characteristics, correlations, analysis in main components.*

INTRODUCTION

The plant species can considerably differ as relative growth rate. This thing can be caused by the habitat, variation of the abiotic factors, like temperature, water, light, or biotic factors like competition and diseases (POORTER H.,1989).

The high temperatures (17-19°C) together with soil humidity accelerate the development of the fodder beet in the first stages of vegetation, but exert a negative effect on leaf growth in a first phase and then the root growth, in June, July and August, when temperatures exceed the multiannual mean, in the Banat area (LUMINITA COJOCARIU and MOISUC AL., 2005).

Until present, there were few attempts to describe the relation between the increase of the main production characteristics in fodder beet and temperature, and also light intensity. Completion of these studies were made in limited framework by ALBAYRAK S. and NECDET Ç. (2007), who sustain the idea that some features of the fodder beet can be influenced to some extent by temperature, and in small measure by light intensity.

The main production characteristics in fodder beet are highly influenced by the regime of the nutritive elements. The root weight, the foliar surface, and the leaf weight increase by application of the mineral fertilisers, cattle manure and some foliar biostimulators

(LUMINITA COJOCARIU., et al., 2010; MOISUC AL., et al., 2004).

MATERIAL AND METHODS

Researches were settled during 2002-2010, each variety being consecutively cultivated for five years. The area is located in the West Plain of Romania. After Koppen, the climate of the mentioned perimeter is framed into the climatic province c.f.b.x., being a temperate climate, with precipitation all over the year, excepting the summer months when is recorded a deficit. The soil where the experiments were developed is a low gleyed cambic chernozem.

The biological material that was studied is represented by 16 varieties of fodder beet belonging to the monogerm and plurigerm forms of fodder beet, with different origins, cultivated and studied for five years in the collection campus of the Didactic and Experimental Station of U.S.A.M.V.B Timisoara. In the second and next years, there was used for sowing the seeds obtained in our field of seed production. The seeding was realised in plots, at 50 cm distance between rows and 20 cm distance between the plants of the same row. The observations and the biological measurements were made for a number of 30 plants.

The correlation and the analysis in main components were the principal analyzing methods used in the paper. The study of correlations is an indispensable process which offers the possibility to combine into a mathematical methodology the biological and dimensional aspects of the fodder beet plants. Analysis in main components offers the possibility to group the studied varieties considering the similitude criterion.

Statistical analysis have been perfomed by STATISTICA 8 package (PETERSEN R.G., 1994 ; MEAD R. et al., 2002). The cases of our statistical analysis were the Angoba, Monro, Brigadier, Gonda, Ketil, Tamara, Marshal, Kyros I, Fumona, Beta Rosa, Troya, Feldher, Polifuraj II, Tamon, Zentaur, Ursus genotype of beet. The variables NrFr, GrFr, SF, GrRad, LRad, DMax analyzed denote respectively the leaf number, the leaf weight, the foliar surface, the root weight, the root length and the root maximum diameter of the above genotypes.

RESULTS AND DISCUSSIONS

The values of the genetic potential in fodder beet are manifested only if the variety is maintained in genetic equilibrium and whether it will receive appropriate condition of cultivation. Whether the multiplication process is long, the genotypes tend to modify, and certainly detrimental to the valuable features.

The basic descriptive statistics, namely the mean, the minimum, the maximum, the variance, the standard deviation, the skewness and the kurtosis, are presented in Table 1.

Table 1

Basic descriptive statistics of the variables

	Descriptive Statistics						
Variable	Mean	Minimum	Maximum	Variance	Std.Dev.	Skewness	Kurtosis
NrFr	20,648	14,193	26,053	11,2	3,3458	-0,093903	-0,69124
GrFr	135,205	83,667	175,280	846,7	29,0984	-0,128012	-1,26876
SF	3379,515	2216,207	4799,540	496823,1	704,8568	0,754025	0,15142
GrRad	1120,942	783,330	1705,550	64647,7	254,2591	0,787538	0,36104
LRad	21,271	16,410	24,930	5,2	2,2874	-0,365261	-0,10214
DMax	9,174	6,710	11,410	1,8	1,3326	-0,460818	-0,52193

Positive linear correlations have been observed between the leaf number, the leaf weight and the foliar surface. It has been also remarke positive linear correlations between the root weight, the root length and the root maximum diameter (see Table 2).

Table 2

Correlation matrix between the studied variables

	Correlation matrix					
Variable	NrFr	GrFr	SF	GrRad	LRad	DMax
NrFr	1,000000	0,266827	0,378041	0,314148	0,034857	0,035760
GrFr	0,266827	1,000000	-0,070255	0,174886	-0,024576	0,302211
SF	0,378041	-0,070255	1,000000	0,085726	0,051775	0,408536
GrRad	0,314148	0,174886	0,085726	1,000000	0,837405	0,577586
LRad	0,034857	-0,024576	0,051775	0,837405	1,000000	0,628459
DMax	0,035760	0,302211	0,408536	0,577586	0,628459	1,000000

Principal component analysis (PCA) has been performed on the leaf number, the leaf weight, the foliar surface, the root weight, the root length and the root maximum diameter of the Angoba, Monro, Brigadier, Gonda, Ketil, Tamara, Marshal, Kyros I, Fumona, Beta Rosa, Troya, Feldher, Polifuraj 2, Tamon, Zentaur, Ursus biotypes of beet. The results of PCA are shown in Table 3 to Table6 and Figure 1 to Figure 3. The eigenvalues of the correlation matrix, the percentage of the total variance, the cumulative eigenvalues, and the cumulative percentage are shown in Table 3. There are six eigenvalues arranged in decreasing order, indicating the importance of the respective factors in explaining the variation of the data.

Table 3

Eigenvalues of the correlation matrix

	Eigenvalues of correlation matrix			
Value number	Eigenvalue	% Total variance	Cumulative Eigenvalue	Cumulative %
1	2,549075	42,48459	2,549075	42,4846
2	1,326133	22,10221	3,875208	64,5868
3	1,079284	17,98807	4,954493	82,5749
4	0,805107	13,41845	5,759599	95,9933
5	0,137991	2,29985	5,897590	98,2932
6	0,102410	1,70683	6,000000	100,0000

Let us observe (see Figure 1) that the largest eigenvalue (2,54) accounts for approximately 42,48% of the total variance and the second factor corresponding to the second eigenvalue (1,32) accounts for approximately 22,10% of the total variance, so the first and the second factors explain approximately 64,5% cumulative variance.

Because the analysis is based on the correlation matrix, the results displayed in the *Table 4* can be interpreted as the correlations of the respective variables with each factor. Thus we can conclude that the first component (corresponding to the first eigenvalue) is the linear combination

$$Y_1=0,22*NrFr + 0,18*GrFr + 0,23*SF + 0,55*GrRad + \\ + 0,52*LRad + 0,52*DMax$$

and the second component (corresponding to the second eigenvalue) is the linear combination

$$Y_2=0,65*NrFr + 0,31*GrFr + 0,52*SF - 0,17*GrRad - \\ - 0,40*LRad - 0,04*DMax.$$

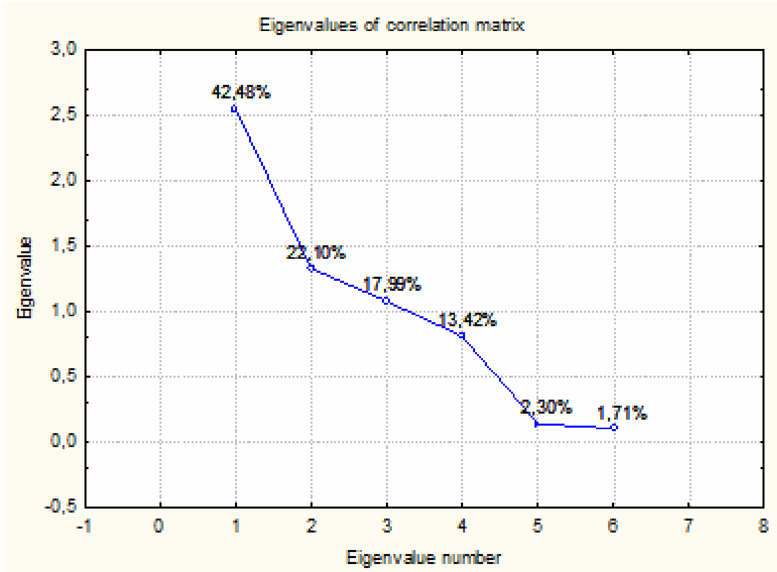

Figure 1: Eigenvalues of the correlation matrix and the variance explained by them

Table 4

Eigenvectors of the correlation matrix

Variable	Eigenvectors of correlation matrix					
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
NrFr	0,225878	0,657004	-0,070425	-0,576647	0,411562	0,102277
GrFr	0,185173	0,318979	-0,783896	0,349101	-0,302898	0,189346
SF	0,233211	0,524606	0,601994	0,307405	-0,453608	0,088016
GrRad	0,558143	-0,170321	-0,091778	-0,350444	-0,388503	-0,614247
LRad	0,524075	-0,400107	0,081068	-0,181368	-0,068548	0,721869
DMax	0,523570	-0,047870	0,056176	0,543511	0,614391	-0,218054

It can be noticed (see Table 5 and Figure 2) that the first factor is positively correlated with all the variables while the second factor is negatively correlated only with the root weight, the root length and the root maximum diameter.

Table 5

Factor coordinates of the variables

Variable	Factor coordinates of the variables					
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
NrFr	0,360633	0,756592	-0,073164	-0,517412	0,152883	0,032730
GrFr	0,295644	0,367329	-0,814379	0,313240	-0,112518	0,060594
SF	0,372340	0,604125	0,625403	0,275828	-0,168502	0,028166
GrRad	0,891121	-0,196138	-0,095347	-0,314445	-0,144318	-0,196568
LRad	0,836728	-0,460755	0,084221	-0,162738	-0,025464	0,231009
DMax	0,835922	-0,055126	0,058361	0,487680	0,228228	-0,069780

The circle in Figure 2 provide a visual indication (scale) of how well each variable is represented by the factors Y_1 and Y_2; the closer a variable in this plot is located to the unit circle, the better is its representation by the current coordinate system. One interesting result shown in Figure *2* is that the leaf number, the leaf weight and the foliar surface are clustering. The same is happening with the root weight, the root length and the root maximum diameter, another proof of the correlation between the variables in the same cluster.

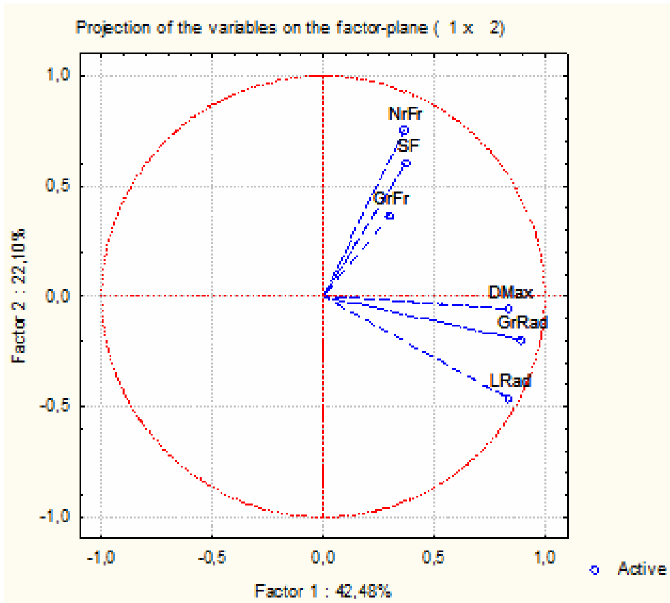

Figure 2: Variable projection on the plane determined by the first two factors

Table 6 reveals the coordinates of the observations corresponding to the new factors associated with the eigenvalues and eigenvectors of the correlation matrix. It can be noticed the relevance of the first two coordinates.

Table 6

Factor coordinates of cases

Case	Factor coordinates of cases, based on correlations					
	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Angoba	2,40754	-1,54115	-1,19622	0,71603	0,010561	-0,070606
Monro	-2,85157	-1,11004	0,78418	0,20040	-0,926693	-0,033788
Brigadier	2,90568	0,48526	-1,31970	-1,20860	-0,327034	-0,143930
Gonda	-2,27836	1,69295	0,14987	-0,16784	0,145307	-0,396510
Ketil	-1,82424	0,02674	-1,65071	-0,54330	0,251402	0,406247
Tamara	0,09296	-1,15404	0,78183	0,76688	0,578803	-0,275139
Marshal	1,26670	-0,75210	1,15584	-0,27371	-0,183730	0,045971
Kyros I	-0,57950	1,19292	-1,07504	0,60463	0,086394	0,211686
Fumona	1,12667	1,55711	1,08256	0,14318	0,004470	-0,107076
Beta Rosa	-0,35672	-1,07301	-0,31015	0,52227	-0,211400	0,603219
Troya	-0,55398	-0,32936	0,73845	-2,63958	0,286171	0,124111
Feldher	-0,01357	-1,59428	0,13906	-0,34107	0,055375	-0,431222
Polifuraj 2	-0,67353	0,09461	-0,41728	0,52217	0,440863	0,191668
Tamon	0,62707	0,21149	1,66387	0,77785	0,345500	0,235932
Zentaur	1,49233	1,83686	0,64159	0,33279	-0,428866	0,226121
Ursus	-0,78747	0,45603	-1,16814	0,58791	-0,127123	-0,586683

The projection of the observations on the plane determined by the first two factors Y_1 and Y_2 is shown in Figure 3. It can be noticed the similarity between the Angoba, Troya, Feldher and Ketil genotypes; between Monro, Polifuraj 2, Beta Rosa and Ursus; between Gonda, Tamara and Kyros I; between Brigadier and Marshal; between Fumona, Zentaur and Tamon genotypes. These similarities have been also highlighted by another method (see Figure 4).

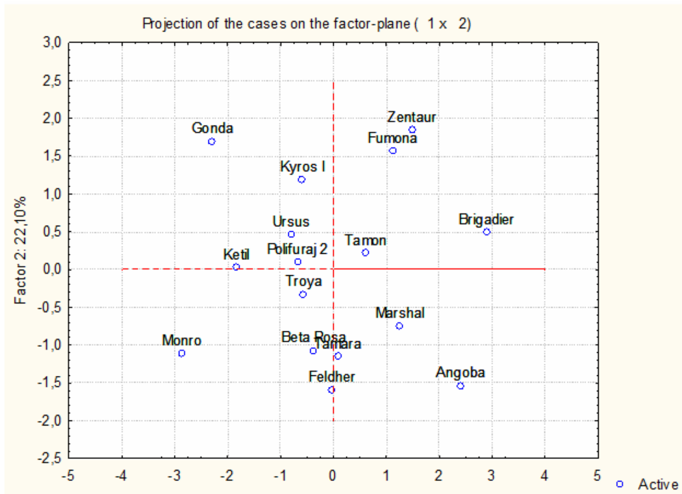

Figure 3: The case projections on the plane determined by the two factors

The principal component analysis given above suggested us to performe a classification of the analyzed biotypes by Ward's method in cluster analysis using the Euclidean distance. Thus the Angoba, Troya, Feldher and Ketil genotypes; the Monro, Polifuraj 2, Beta Rosa and Ursus biotypes; the Gonda, Tamara and Kyros I genotypes; the Brigadier and Marshal genotypes; the Fumona, Zentaur and Tamon genotypes have formed clusters showing strong similarity between them (see Figure 4).

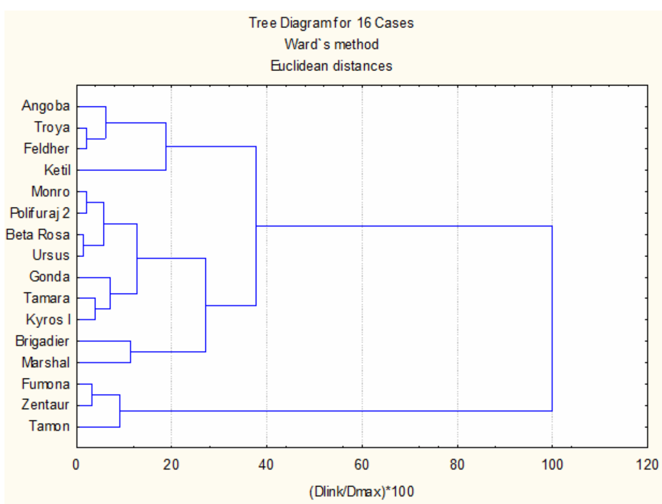

Figure 4: Cluster analysis for the cases

CONCLUSIONS

The goal of this paper is to classify some varieties of fodder beet (Angoba, Monro, Brigadier, Gonda, Ketil, Tamara, Marshal, Kyros I, Fumona, Beta Rosa, Troya, Feldher, Polifuraj 2, Tamon, Zentaur, Ursus) studied over time at the Didactic Station of the University of Agricultural Sciences and Veterinary Medicine of Banat from Timisoara, considering six morphological characters of the leaf and root (green leaf number, green leaf weight, foliar surface, root weight, root length, and root maximum diameter). In this scope there were determined the linear correlations between the morphological characters up mentioned and then, basing on these correlations, there was realised an analysis in main components and a cluster analysis (using the Euclidian distance and Ward method) which revealed that the varieties Angoba, Troya, Feldher and Ketil (form a cluster); Monro, Polifuraj 2, Beta Rosa and Ursus; Gonda, Tamara and Kyros I (form a cluster); Brigadier and Marshal; Fumona, Zentaur and respectively Tamon formed clusters, showing a strong similarity between them.

BIBLIOGRAFY

1. ALBAYRAK SEBAHATTIN, NECDET ÇAMAȘ1, 2007. Effects of temperature and light intensity on growth of fodder beet (*Beta vulgaris* var. *Crassa* mansf.) Bangladesh J. Bot. 36(1): pag.1-12;
2. COJOCARIU LUMINITA, MOISUC ALEXANDRU. 2005. On the influence of climate factors on the behaviour of some quantitative features in forage beet in the Banatului Plain Romania , 60 anniversary Agricultural University-Plovdiv, Jubilee Scientific Conference with International participation. State of the art problems of agricultural science and education, Plovdiv, Bulgaria;
3. LAUWERS THOMAS, JO VICCA, JOOS LATRE, DIDIER HUYGENS, DIRK LIPS, 2009, Valorisation of ensiled fodder beets Bulletin UASVM Agricultue, 66 (2)/2009 Print ISSN 1843-5246; Electronic ISSN 1843-5386 pag.342-349;
4. MEAD R., R.N. CURNOW, A.M. HASTED, 2002. Statistical Methods in Agriculture and experimental Biology, 3rd Edition, Texts in Statistical Science, Chapman & Hall/CRC;
5. MOISUC AL., LUMINITA COJOCARIU, SAMFIRA IONEL, HORABLAGA MARINEL, 2004. The Influence Of Mineral Fertilizer On The Production Elements Of The Fodder Beet Production In The Banat Region Conditions, Lucrări ştiinţifice, Fac. de Agr., vol.XXXVI, Editura Eurobit, ISSN 1221-5279, pp.135-137;
6. MOISUC ALEXANDRU, LUMINITA COJOCARIU, SAMFIRA IONEL, HORABLAGA N. MARINEL, MARIAN FLORIN, 2010. The appraisal of Megafol and Cropmax bio-stimulators influence on production capacity at fodder beet in Timisoara conditions, Romanian Journal of Grassland and Forage Crops, No.1/2010,The Romanian Society of Grassland,pag. 45-55, ISSN 2068 – 3065, Cluj Napoca,Romania;
7. PETERSEN R.G., 1994. Agricultural Field Experiments. Design and Analysis, CRC Press;
8. POORTER H., 1989. Interspecific variation in relative growth rate: ecological causes and physiological consequences. SPB Academic Publishing. The Hague.