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Principal component analysis of a canning determinate tomato collection in the IPGR, Sadovo – Bulgaria

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Summary

The success of a tomato breeding programme largely depends on the study of initial material and symptoms studied as well as manifestations of dependence between them. The study was conducted during the period 2008-2011 in the IPGR, Bulgaria. The objects of the study were 37 canning tomato accessions with an oval shape of the fruit. The collection included 11 local and 26 accessions of foreign origin. Using factor analysis by applying the PCA methodology, a relationship was established between 15 morphological and biochemical parameters of the accessions studied and their effects on indicators of fruit weight and dry matter content. The investigated parameters were grouped into four general factors affecting the mass change by 73.4%. Applied to dry matter content, the same method identifies four factors with a total impact of 71.7% on this trait.

Key words: tomato collection, morphological and economical traits, evaluation, PCA

Introduction

Preservation, collection and evaluation of genetic diversity is a major factor in the successful selection of tomatoes in relation to the proper choice of initial material within potential characteristics such as productivity, disease resistance, etc., and the study of dependence among the traits [3, 8].

The national tomato collection, subject to full biosystematic, morphological and agrobiological evaluation, has been created in the Institute of Plant Genetic Resources (IPGR) through free international exchange and enhanced expeditions [6, 7].

The aim of the study was to measure the individual influence of each factor on performance change in the mass of the fruit and dry matter content in the tomato collection being evaluated through factor analysis by the method of Principal Component Analysis (PCA) [1, 2, 4].

Materials and methods

The survey was conducted during the period 2008-2011 in the experimental vegetable field of the IPGR - Sadovo.

The object of the study was a collection of 37 determinate tomato accessions with an oval - elongated fruit shape for processing, and the Bulgarian cultivar Bella as a standard. 26 introduced accessions and 11 local forms collected during expeditions in the country were studied as valuable genetic sources (Fig. 1, 2, 3).

The plants were grown based on a common technology of middle – early field production of the IPGR - Sadovo [5].

The evaluation was conducted according to the international descriptor of IPGRI (1966) for tomato [9]. The accessions were characterised by 15 morphological and biochemical indicators of economic importance to the culture.

The survey data were processed with the SPSS 13.0 statistical package [10].

Factor analysis was applied by using the PCA methodology.

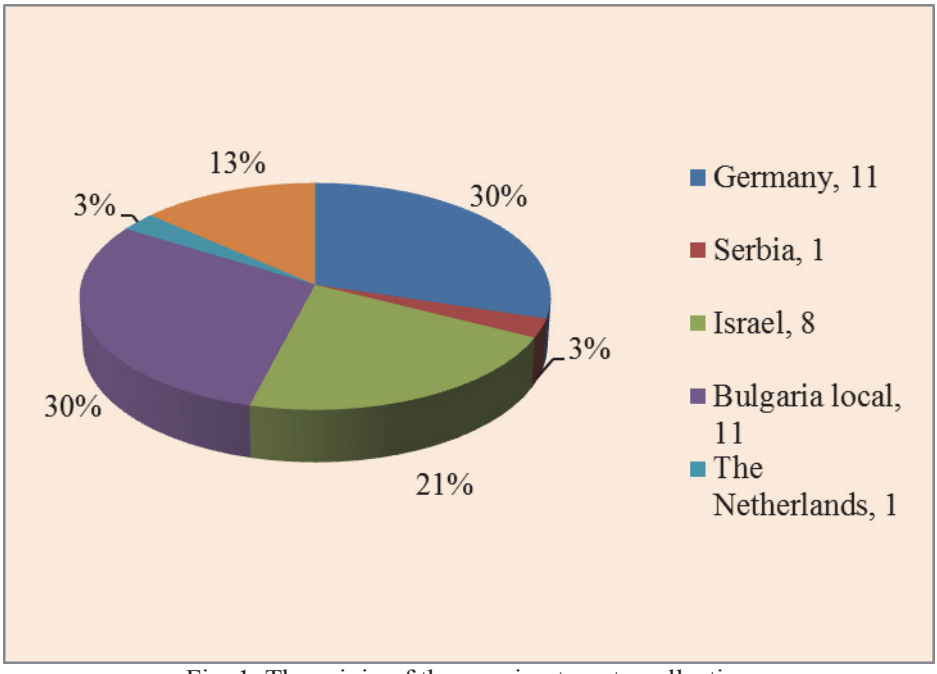

Fig. 1. The origin of the canning tomato collection
Porijeklo kolekcije paradajza za preradu

Fig. 2. Introduced tomato accession from Israel
Uvedene prinove paradajza iz Izraela

Fig. 3. Local plant genetic resources from expedition in Bulgaria
Lokalni biljni genetički resursi iz ekspedicije u Bugarskoj

Results and discussion

The results presented in Table 1 show that the models of the study regarding the influence of morphological and biochemical parameters on fruit mass and dry matter content will be based on four factors.

The data from an analysis of major components indicate that these four factors are sufficient to explain 73.4 % of the total change in the fruit mass in the collection tested (Fig. 4). The first factor explained 22.8% and included the following indicators: vitamin C, sugars, total acidity and dry matter content. The second factor - 19.7%, included those as follows: plant height, length and shape of the fruit. The third factor - 15.8%, covered the length and width of the leaves. The fourth factor - 15.1%, included the following: the number of locules in the fruit and sugar-acidity coefficient.

As regards the dry matter in the fruit, the analysis of the data summarised four factors influencing its content. The first factor explained 21.8% of total change and included plant height, length and shape of the fruit. The second factor synthesising biochemistry traits - 17.2%. The third factor - 16.6%, included width of the fruit, the number of locules and sugar-acidity coefficient. The fourth one - 16.1% referred to the dry matter change and included length and width of the leaves. The overall impact of the parameters on the dry matter content studied included in the four factors was 71.7% (Fig. 5).

During the analysis, it was found that two morphological characteristics, namely, the number and size of the flowers, according to the method used were statistically insignificant indicators regarding mass and dry matter change in the collection. The study showed that the fruit mass did not significantly affect modification of the dry matter content in the group of small-fruited tomatoes.

Tab. 1. Results from the Principal Component Analysis
Rezultati analize glavnih komponenti

Traits	Components of fruit weight				Components of dry matter content			
	F_1	F_2	F_3	F_4	F_1	F_2	F_3	F_4
Plant hight			0.779		0.765			
Leaf lenght				0.856				0.818
Leaf width				0.857				0.858
Fruit lenght			0.833		0.860			
Fruit width							0.728	
Fruit shape			0.915		0.884			
Number of locules							0.781	
Vitamin C content	0.806	0.806				0.800		
Sugar content	0.813	0.813				0.758		
Total acidity	0.733	0.733				0.732		
Sugar-acidity coefficient				-0.743			-0.708	
Dry matter content	0.930	0.930						

To build a dependence model between the mass and dry matter of received applications summarising factors in the factor analysis, a multivariate linear regression analysis was used. Multiple correlation coefficients reflecting the relationship between the morphological and biochemical parameters studied and mass and dry matter were R=0.68 for the mass and R=0.87 for the dry matter content, respectively (Table 2). The calculated multiple correlation coefficients showed significant influence of the studied parameters, as summarised by the factor analysis into four factors for dependent variables, fruit weight and dry matter content. The highest correlation coefficient (R = 0.55) was recorded between the mass and the second factor, including morphological characteristics: height of the plant, length and shape of the fruit. As for the dry matter, a single correlation was strongest with the second factor (R = 0.86), including fruit biochemistry: vitamin C, sugars and total acidity.

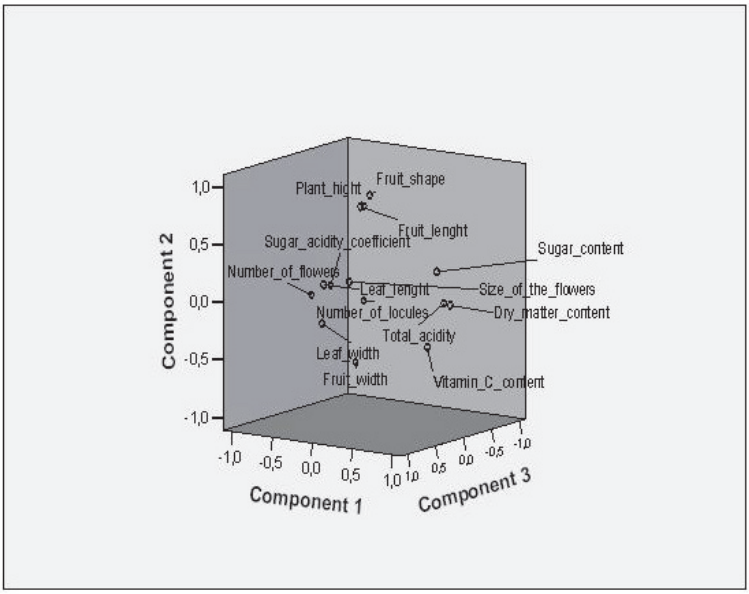

Fig. 4. Components of fruit weight
Komponente težine ploda

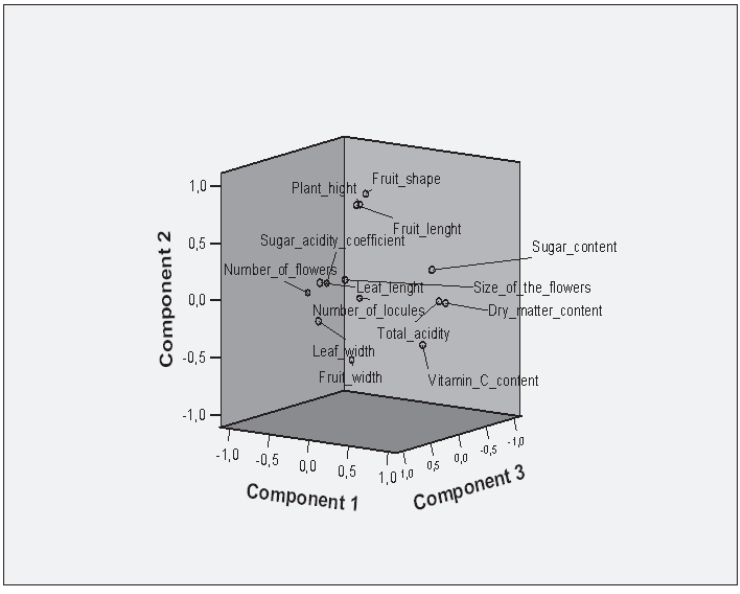

Fig. 5. Components of dry matter content
Komponente sadržaja suve materije

Table 2. Regressive model coefficients
Koeficijenti regresivnog modela

Model	Unstandardized Coefficient	Standardized Coefficient	Correlation
	B	Beta	R
Fruit weight			
Constant	92.17		
F_1	1.64	0.13	0.17
F_2	6.10	0.48	0.55
F_3	4.12	0.32	0.40
F_4	4.16	0.33	0.41
Dry matter content			
Constant	5.38		
F_1	0.02	0.04	0.04
F_2	0.54	0.86	0.86
F_3	0.08	0.13	0.13
F_4	0.001	0.001	0.001

Table 2 shows that the highest regression coefficient (B) for both characteristics tested was the second factor, respectively 6.1 and 0.48. The standardised regression coefficient (Beta) reflected a direct impact of each factor on the tested variables. The mass (0.48) was most directly influenced by the second factor, summarizing the morphological parameters as follows: plant height, length and shape of the fruit. The most direct impact (0.86) on dry matter content was obtained for this composite index factor 2. This factor combined biochemistry traits: vitamin C, sugars and total acidity content. All estimated coefficients of the models were statistically proved at significance level $\alpha = 0.05$.

The analytical representation of dependence between mass and dry matter, respectively, is defined summarising the factors:

$$\mathbf{У_{fruit\ weight} = 92.2 + 1.64}\, F_1 + \mathbf{6.09}\, F_2 + \mathbf{4.12}\, F_3 + \mathbf{4.16}\, F_4$$

$$\mathbf{У_{dry\ matter\ content} = 5.38 + 0.02}\, F_1 + \mathbf{0.54}\, F_2 + \mathbf{0.08}\, F_3 + \mathbf{0.001}\, F_4$$

Conclusion

1. The analysis led to the conclusion that the total fruit mass change of the canning tomato collection tested was most influenced by the factor F_2, including morphological characteristics as follows: height of the plant, length and shape of the

fruit. The dry matter content was most influenced by biochemical parameters such as vitamin C, sugars and total acidity, summarised in the second factor.

2. Morphological and biochemical indicators grouped into summarised factors by applying the factor analysis represent 73.4% of the total change in mass and 71.7% of dry matter content.

3. The results of the analysis could also assist breeders in successful selection of the source material for inclusion in the breeding programmes. Remarkable results could be obtained if the selection is done by considering traits explaining the highest percentage of total variability in the first and second major factor. They might be accepted provisionally as indicators of the selection of first and second level, and the others - of the third level.

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Analiza glavnih komponenti kolekcije žbunastog paradajza za preradu u IPGR, Sadovo – Bugarska

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Sažetak

Uspjeh programa za uzgoj paradajza uveliko zavisi od istraživanja početnog materijala kao i od ispitivanih simptoma i pojave njihove međuzavisnosti. Ovo istraživanje sprovedeno je tokom perioda 2008-2011. godine u IPGR, Bugarska. Predmet istraživanja bilo je 37 prinova paradajza za preradu sa ovalnim oblikom ploda. Kolekcija sadrži 11 lokalnih i 26 prinova stranog porijekla. Korištenjem faktorske analize putem metodologije PCA, otkrivena je veza između 15 ispitivanih morfoloških i biohemijskih parametara prinova i njihovih efekata na indikatore težine ploda i sadržaja suve tvari. Ispitivani parametri grupisani su u četiri opšta faktora koji su uticali na promjenu mase 73.4 %. Primjenom na sadržaj suve tvari, istim metodom su identifikovana četiri faktora sa ukupnim uticajem na ovu osobinu od 71.7%.

Ključne riječi: kolekcija paradajza, morfološke i ekonomske osobine, evaluacija, PCA

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