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MULTIVARIATE ANALISYS OF SPECIES FROM CUCURBITACEAE FAMILY

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Species from *Cucurbitaceae* family are not widely present in Serbia, although because of their morphological and decorative features deserve more attention. The aim of this paper was to study the morphological variability and usage of ten species of the *Cucurbiataceae* family. Based on genetic variability, species were grouped into 8 clusters. Fruit characteristics of most investigated species showed great similarity and the greatest differences were attained for flower and fruit characteristics. The longest was the fruit of *Trichosanthes cucumerina* (46.2 cm), while the shortest of *Cucumis myriocarpus* (3.4 cm) which had the smallest circumference as well (4.4 cm). The largest circumference of fruit was

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recorded for the species *Cucumis aculeatus* (16.4 cm). In terms of fruit color *Momordica balsamina* had a red fruit, allocated from other species whose fruits were in various shades of green. Variability is reflected in large variations in size, shape and color of fruit. Considerating that usages of these species are multiple (food for humans and animals, ornamental) studyed species deserve special attention in their further propagation and use.

Key words: Cucurbitaceae, variability, usage

INTRODUCTION

The *Cucurbitaceae* is one of the most genetically diverse groups of plants in the plant kingdom. In previous studies we investigate variability within collection of one *Cucurbitaceae* species, bottle gourd [*Lagenaria siceraria* Molina (Standl.)] (MLADENOVIĆ *et al*., 2010; MLADENOVIĆ *et al*., 2012) and pumpkin (*Cucurbita maxima* Duch. ex Lam) (MLADENOVIĆ *et al*., 2012). Determination of the degree of relationship and divergence within *Cucurbitaceae* species collection is one of the essential requirements for its exploitation during the selection process. Diversity of initial breeding material of curcumis and another cucurbits species is essential for plant breeding success. Collection of exotic species from the *Cucurbitaceae* family includes ten species. Genus *Cucumis* which has seven of these ten species belongs to the *Cucurbitaceae* family (RENNER *et al*., 2007). Genus *Cucumis* has 32 species. In addition to widely polular cucumber and melon *Cucumis anguria* L. (gherkin), is another important species of *Cucurbitaceae* family, extensively used for consumption in some parts of the world, as well as grown, albeit on a smaller scale for decorative purpose. This type of cucumber is endemic in many parts of America, where it was likely brought from Africa during the slave trade. *Cucumis myriocarpus* Naudin and *Cucumis dipsaceus* Ehrenb. ex Spach are widespread in arid and semi-arid parts of Africa, where they have predominantly decorative function. Teasel gourd (*Cucumis dipsaceus* Ehrenb. ex Spach) have a unusual fruits, which are 7-10 cm long, round in shape and at maturity, are characterized by yellow skin covered with long soft spines. Decorative fruits of *Cucumis africanus* L. and *Cucumis hirsutus* Sond. are usually incorporated in floral arrangements, although they may be used outdoors, for vertical greening on decorative pergolas with vines (STOJILOVIĆ, 2007).

Balsam apple (*Momordica balsamina* L.) is an economically important member of the *Cucurbitaceae* and is widely cultivated in India, China, Malaysia, Africa, and South America (SINGH, 1990). General chemical composition of *M. balsamina* immature fruit is similar to other cucurbits, with high concentrations of ascorbic acid and iron (BEHERA, 2004). In Asia, young balsam apple fruits are predominantly used for consumtion even though their medical properties in particular as a remedy for rheumatism and cough are well known (SUMMIT, 1998). *Momordica balsamina* belongs to the genus *Momordica*. However, as the active substance contained in the fruit of balsam apple has similar effects to insulin, it must be used with extreme caution. In Yucatan, balsam apple leaves are steeped for tea

preparation, whilst young, green fruits can be used in cooking, especially in meat-based dishes. The green color of young balsam apple fruit changes into red at maturity and the fruit splits into three parts, revealing seeds covered with red sticky substance.

Morphological characterization, aided by statistical methods such as principal component analysis (PCA), remains the most reliable initial step in the description and classification of germplasm. The objective of this study is to describe the variability in ten species of *Cucurbitaceae* family, identify the most reliable variables that can be used for discrimination among the genotypes and detect relationships between the species. An evaluation of the above identified characteristics was also conducted in order to assess the cultivation potential of this species for subsequent exploitation in breeding programs.

MATERIALS AND METHODS

This paper presents the results obtained by analyzing ten species of *Cucurbitaceae* family including: bur gherkin (*Cucumis anguria* L.), wild watermelon (*Cucumis africanus* L.), wild cucumber (*Cucumis hirsutus* Sond.), wild cucumber (*Cucumis aculeatus* Cogn.), teasel gourd (*Cucumis dipsaceus* Ehrenb. Ex Spach), snake gourd (*Trichosanthes cucumerina* L.), stuffing cucumber (*Cyclanthera pedata* (L.) Schrad.), balsam apple (*Momordica baslamina* L.), african spiny cucumber (*Cucumis zeyheri* Sond.) and wild cucumber (*Cucumis myriocarpus* Naudin). The samples were grown in the open field of Institute of field and crops in Novi Sad, whereby each species was presented with five repetitions. After germination between two wet sheets of paper, seeds were sown in a substrate. After ten days, young seedlings were planted in an open field and where subsequently hoed, watered and cared for without any treatment specifically aimed at prevention of disease.

In the subsequement analysis, nine quantitative and three qualitative plant, flower and fruit characteristics were measured. Qualitative traits included: flower length (FLL) in cm, flower diameter (FD) in cm, leaf blade length (LL) in cm, leaf blade width (LW) in cm, plant height (PH) in cm, handle length (HL) in cm, handle circumference (HC) in cm, fruit length (FL) in cm and fruit circumference (FC) in cm. Measured qualitative traits comprised color of flower (CF) (W-white, Y-yellow), fruit color (C) (G-green, LG-light green, R-red) and presence of spines (S) (+ with spines, - without spines).

Coefficients of variation were used as indicators of variability. PC and Cluster analysis was performed using the program STATISTICA 10 (StatSoft, Inc., Tulsa, OK, USA) in order to establish the presence of relationships among species.

RESULTS AND DISCUSSION

Differences among the species were observed in the fruit characteristics, as well as those related to flower and leaf revealing great variability among ten species of *Cucurbitaceae* family in terms of fruit shape and size. Characteristics of these species with an emphasis on the parts of the plant that exhibited the most significant

variation were given in Table 1. Coefficient of variation was the highest for fruit length, flower characters and handle length (CV=57.52-130.85%), whereas for leaf length and width it was the lowest (CV=13.72-18.35%).

Table 1. Mean values and coefficients of variation (CV) for 12 traits of Cucurbitaceae species

Species	FLL[a]	FD	LL	LW	PH	HL	HC	FL	FC	CF	C	S
Cucumis anguria	4	1	6.04	6.06	169	7.9	0.4	5.6	11.2	Y	LG	+
Cucumis africanus	4	1.5	6.1	8.08	178	1.24	0.4	8.6	11.6	Y	G LG	+
Cucumis hirsutus	2	1	9.06	9.96	448	3.04	0.38	4.2	6.2	Y	LG	+
Cucumis aculeatus	3.5	1	9.94	8	272	4.02	0.52	9.4	16.4	Y	LG	+
Cucumis dipsaceus	5.5	1	8.06	8.02	386	9.02	0.54	5	11	Y	LG	+
Trichosanthes cucumerina	8	3	9.08	10.1	442	3.5	0.78	46.2	12.2	W	G	-
Cyclanthera pedata	0.2	0.2	7.14	8.3	230	0.42	0.2	5	6.8	Y	G	-
Momordica balsamina	2	2.5	8.12	8.96	220	3	0.2	6	10.6	Y	R	-
Cucumis myriocarpus	4	1	6.04	7.96	414	3.04	0.28	3.4	4.4	Y	G LG	+
Cucumis zeyheri	3.5	1	7.1	8.06	444	4.06	0.3	5.2	8.2	Y	LG	+
Mean	3.67	1.32	7.66	8.35	3.20	3.92	0.40	9.86	9.86	-	-	-
Minimum	0.20	0.20	6.04	6.06	1.69	0.42	0.20	3.40	4.40	-	-	-
Maximum	8.00	3.00	9.94	10.1	4.48	9.02	0.78	46.20	16.40	-	-	-
CV %	57.52	62.45	18.35	13.72	36.53	67.90	44.35	130.85	35.50	-	-	-

[a]for explanation of character, see ''Materials and methods''

Principal component analysis (PCA) was used to identify the most significant variables in the data set. The results (Table 2) indicate that the first four components explain about 92.60% of the total variability observed. Variables with higher scores on PC1 are related to flower size (FLL, FD), handle circumference and fruit length. The highest contribution on PC2 corresponded to variables related to leaf width, fruit circumference and handles length, and whereas, on PC3 and PC4 the highest scores are due to plant length and leaf length.

Table 2. Eigenvalues, proportion of total variability and correlation between the original variables and the first four components

Variable	PC1	PC2	PC3	PC4
FLL[a]	**-0.82**	0.35	-0.31	0.29
FD	**-0.74**	-0.09	0.28	0.39
LL	-0.62	-0.25	0.21	**-0.70**
LW	-0.55	**-0.79**	0.08	-0.09
PH	-0.43	-0.49	**-0.72**	-0.16
HL	-0.19	**0.72**	-0.50	-0.26
HC	**-0.90**	0.27	-0.11	-0.06
FL	**-0.89**	-0.09	0.12	0.31
FC	-0.51	**0.59**	0.53	-0.28
Eigenvalue	4.00	2.02	1.31	1.00
%Var.	44.45	22.43	14.56	11.16
%Cum.	44.45	66.88	81.44	92.60

[a]for explanation of character, see ''Materials and methods''

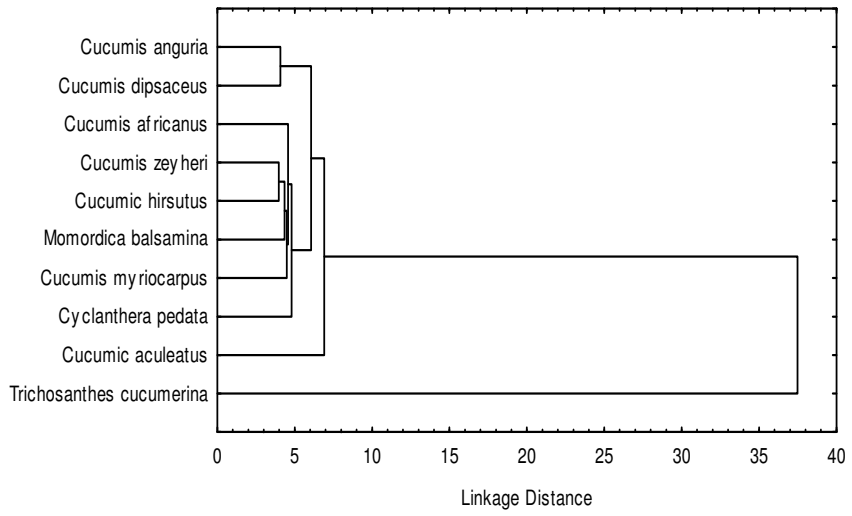

Figure 1. Dendrogram for complete linkage of investigated accessions, expressed in Eucledean distances

Based on cluster analysis, the species at the highest hierarchical level can be divided into two new clusters (Fig. 1), with the first further subdivided into two groups. The first group of this cluster included eight species (*Cucumis anguria*, *Cucumis dipsaceus*, *Cucumis africanus*, *Cucumis zeyheri*, *Cucumis hirsutus*, *Momordica balsamina*, *Cucumis myriocarpus* and *Cyclanthera pedata*), leaving *Cucumis aculeatus* isolated from this grouping due to the large fruit circumference (16.4 cm). The first group consisted of two further subgroups based on the handle length, whereby *Cucumis dipsaceus* and *Cucumis anguria* with long handle (7.9 cm - 9.02 cm) were separated from other species in this group. Similary, *Cyclanthera pedata* was characterized by the smallest flower diameter (0.2 cm), which was the basis for its separation from the remaining seven species. Finally, *Cucumis miriocarpus* with long flowers (4 cm) was separated from *Momordica balsamina,* which has short length of the flower (2 cm).

The second cluster consisted of only one species, *Trichosanthes cucumerina*, as its fruit was much longer (46.2 cm) than that measured for other species (3.4-9.4 cm).

CONCLUSION

Cluster analysis showed a great variability of exotic species that were included in the study presented here. This is a great advantage of this collection, as it enables a variety of uses of those species, thus promoting their widespread growth and application. Variable geographical and climatic conditions characterizing Vojvodina suggest that these species can be grown without need for special care, as watering in dry periods is typically sufficient for their normal growth and development. All species that comprised analyzed collection can be grown as both creepers climbers, whereby the latter method requires additional support.

Decorative value of these species stems primarily in their fruit characteristics, even though flowers and leaves with particular traits can find ornamental applications. Fruit of unusual and interesting shape or color can be used in flower arrangements or as a base material for indoor decoration. Given that the fruits of these species remain fresh for up to 30 days, durability of such arrangements typically exceeds that of other materials used for that purpose. In the field of landscape architecture, decorative gourds and cucumbers can be used as climbers on fences or pergolas. Thus, these species represent wealth of *Cucurbitaceae* family only matched by *Cucurbita pepo* and *Lagenaria siceraria*.

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MULTIVARIJACIONA ANALIZA VRSTA IZ FAMILIJE CUCURBITACEAE

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Egzotične vrste iz porodice Cucurbitaceae slabo su zastupljene u Srbiji ali s obzirom na njihove morfološke osobine i dekorativnost zaslužuju veću pažnju. Cilj rada je bio proučavanje varijabilnosti i upotrebne vrednosti deset vrsta iz porodice Cucurbiataceae. Na osnovu genetičke varijabilnosti, vrste su grupisane u 8 klastera. Osobine ploda kod većine vrsta pokazale su veliku sličnost dok su se najveće razlike pokazale kod osobina cveta i lista. Najduži plod bio je kod vrste *Trichosanthes cucumerina* (46.2 cm), dok je najkraći plod imala vrsta *Cucumis myriocarpus* (3.4 cm) koja je imala i najmanji obim ploda (4.4 cm). Najveći obim ploda zabeležen je kod vrste *Cucumis aculeatus* (16.4 cm). U pogledu boje ploda izdvojila se vrsta *Momordica balsamina* koja je imala plod crvene boje za razliku od ostalih vrsta čiji su plodovi bili u različitim nijansama zelene. Budući da je upotreba ovih vrsta višestruka (ishrana ljudi i stoke, dekorativnost) navedene vrste zaslužuju posebnu pažnju u svojoj daljoj proizvodnji i upotrebi.

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