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SHORT COMMUNICATION

Comparative investigation of *Ocimum basilicum* L. accessions from the collection of IPGR – Sadovo, aiming to their classification and practical use

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ABSTRACT

The importance of The Sweet Basil (*Ocimum basilicum* L.) as medical, ornamental and spice plant is well known from ancient times. It`s origin is in Africa and Asia. In the regions with moderate climate are grown more than 150 varieties. The aim of this study is describing and classifying the Basil accessions in the collection of IPGR - Sadovo with the view of their practical use. The experiment is carried out in the experimental field of PGRI - Sadovo during the period 2011-2012. The following biometric indices are reported: plant - height, width, number of branches, stem – length and diameter; branching first order - length and diameter; leaf - length and width; inflorescence - diameter, height and color; type of inflorescence. Phenological observations were made and the following inter-phase periods are recorded: sowing, germination, sprouting, blossoming, flowering period, growing season. The results shows that accessions A7E0284, which is with longest flowering and growing periods, very well-leaved and long inflorescence is very suitable for ornamental purposes and in home gardens. Accession A9E0452, which is with maximum number of branches, consequently with maximum leaf mass is most suitable for spice and medical purposes. Hierarchical cluster analysis based on intergroup connections is used to determine the homogeneous groups was made. Thus the accessions are divided into groups (clusters) based on a study of 16 indices. The comparative cluster analysis of Basil accessions in the collection of IPGR - Sadovo shows complete uniformity in the results for the grouping based on morphological parameters and using cluster analysis.

Keywords: *Ocimum basiliscum*, Basil, Collection, Classification, Use

INTRODUCTION

The Sweet Basil (*Ocimum basilicum* L.) is one of the most famous medicinal plants. It`s origin is in Africa and Assia. In the regions with moderate climate are grown more than 150 varieties.

Genus *Ocimum* belongs to *Lamiacea* family and includes 100 grass and bushes species (Simon, et al., 1999).

The importance of Basil as ornamental, medical and spice plant is well known from ancient times. The essential oils of Basil are used widely in cosmetics and in medicine, and some species have marked antioxidant properties (Exarchou, et al., 2002). *O. basilicum* could be used as natural fungicide. It possesses antifungal and fungicidal effects and reduces the mycelial growth of the plant pathogenic fungus *Botrytis fabae* (Oxenham et al., 2005). Sweet Basil also possesses insecticidal potential. Extract from the leaves was used in formulating an aerosol and mosquito coil. The plant can serve as a substitute for some expensive synthetic insecticides which have toxic residual effects (Umerie et al., 1998).

The relatively easy cross-pollination of Basil is a prerequisite for the existence of subspecies and varieties with ornamental qualities (Svecova, and Neugebauerova, 2010). The same authors in their morphological study show that the plant high vary from 14.3 to 57 cm, the plants have semi erect habit, semi- dense brunching and sparse stem. The leaves are lanceolat in shape.

Simon (1999) has studied Basil cultivars and has established that they have a wide diversity in growth habit, flower, leaf and stem colors, and aromas and could be used as edible and ornamental herb. The genetic diversity in Basil cultivars can be established by using molecular markers (Vieira et al., 2003).

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The plant is reproduced by seeds, which can preserve their germinating potential up to 4 years (Kabatliiska, 2005). The flowers are short-lived, bisexual, zygomorphic, and chasmogamic with anthers dehiscing in the bud stage. The open flowers offer nectar and pollen as rewards and are visited and sternotribically pollinated by day-flying animals. The blossoms are flag-shaped, and the reproductive organs are close to the lower corolla lip. The stamens and stigma show movements immediately after anthesis and remain for 20–30 minutes and this may cause self-pollination and reproduce primarily through autogamy (Solomon, 2010). The aim of this study is describing and classifying the Basil accessions in the collection of IPGR - Sadovo with the view of their practical use.

MATERIAL AND METHODS

The experiment is carried out in the experimental field of PGRI - Sadovo during the period 2011-2012. Seeds of 16 accessions were planted in the middle of April to prepare the seedlings. At the beginning of the May the plants are planted in their permanent location. During full blossoming and maturity are reported biometric indices as follows: plant - height, width, number of branches, stem – length and diameter; branching first order - length and diameter; leaf - length and width; inflorescence - diameter, height and color; type of inflorescence. Phenological observations were made and the following inter-phase periods are recorded: sowing, germination, sprouting, blossoming, flowering period, growing season.

At the end of the vegetation seeds from all accessions are collected.

Hierarchical cluster analysis based on intergroup connections is used to determine the homogeneous groups. Thus the accessions are divided into groups (clusters) based on a study of 16 indices. As a measure of similarity is used Euclidean distance. Data processing is performed by the statistical program SPSS. Clustering is done graphically represented by dendrogram, which shows the sequence of combining objects and formed clusters.

RESULTS AND DISCUSSION

The results from the biometric measurements of Sweet Basil accessions are given in Table 1. With highest plant is accession A7E283 - 51.33 cm ± 1, 25 (43-54,5). Lowest plant height has accession A700095 - 33.4 cm ± 0, 82 (30-36). The width of the plant is at maximum in A7E0284 - 46.6 cm ± 0, 82 (43-51), and minimum in A9E0548 - 32.1 cm ± 1,57 (26-38). The number of branched in the studied samples varies quite widely - from 5 ± 0,26 (4-6) in accession A9E1023 to 13,4 ± 0,43 (12-16) in accession A9E0452. Stem is shortest in A7E283 - 3.47 cm ± 0,4 (2-6), and longest in A9E0486 - 13.3 cm ± 0,67 (10-15). There is no significant variation of the stem diameter between the accessions. With a minimum value, 0.84 cm ± 0,05 (0,7-1,24) is A9E1044 accession and with maximum - A9E0548 - 1.54 cm ± 0,06 (1,2-1,77). The length of the branches of the first order is directly proportional to the height of the plant. A7E283 accession, with maximum plant height has also the maximum length of the branches of the first order - 40.73 cm ± 1,1 (34,5-46), and the accession A70095, with minimum plant height has shortest branches of the first order - 16 cm ± 0,6 (13-19). The diameter of the branches of the first order is the smallest in accession A9E0548 - 0.26 cm ± 0,02 (0,19-0,33) and greatest - in A9E0452 - 0.69 cm ± 0,09 (0,1-1 ,12).

All investigated *Ocinim* accessions are very well-leaved. Leaf size (optimally developed leaves from the middle part of the plant are measured) varies relatively little. Leaf length varies from 4.62 cm ± 0,12 (4-5,2) in accession A9E1023 to 7.6 cm ± 0,47 (6-9,6) in accession A7E283. Leaf width varies in the narrow range of 2.07 cm ± 0,03 (2-2,2) in accession A62007 to 3.72 cm ± 0,11 (3,2-4,3) in A9E0378 accession. A strong variability was observed in the size of the inflorescence, and especially in its length. It varies from 2.45 cm ± 0,2 (1,7-3,5) accession A8E0343 to 13.27 cm ± 0,68 (9-17) in A7E02840. In the studied samples the inflorescence color is white, only in accession A8E0263 it is purple. However it is established a wide variation of the inflorescence type – spica (loose or compressed), glabrous and semi glabrous.

No correlation is observed between the studied indices. Accession A7E283 has maximum values of 3 indicators - plant height, length of the branches of the first order and leaf length. Two accessions (A7E0284 and A9E045) have maximum values in two of the studied parameters.

Of particular importance for practical use of medicinal and ornamental plants are their phenological indicators, especially the interphase periods sowing - germination, sprouting - flowering, as well as flowering and growing periods. Fig. 1 shows the data for the duration of these periods (in days) for Basil accession in the collection IPGR - Sadovo.

Sowing-germination period is 11 days for 11 accessions, and 7 days for 5 accessions. Germination - flowering period varies from 54 to 59 days. For 5 accessions it is 54 days, and in 4 – the maximum of 59 days. The flowering period is 76-88 days and the vegetation period ranges from 132 to 142 days. The shortest growing season was observed in the accessions

Table 1: Results from the biometrical studies of *O.basilicum* L. accessions from the collection of IPGR – Sadovo

O.basilicum accessions	Plant			Stem		First order branching		Leaf		Inflorescence			Inflorescence type
	Height (CM)	Width (CM)	No of branches	Length (CM)	Diameter (CM)	Length (CM)	Diameter (CM)	Length (CM)	Width (CM)	Diameter (CM)	Height (CM)	Color	
A9E1044													
x±Sx	38.2±0.9	34.7±1.26	10±0.49	10±0.47	0.84±0.05	35.6±0.96	0.52±0.02	6.41±0.3	2.92±0.1	1.487±0.04	6.8±0.54	White	Spica
Min	34	30	8	8	0.7	30	0.37	5.4	2.4	1.26	4.5		
Max	44	40	12	12	1.24	41.5	0.62	8.5	3.4	1.64	9.2		
CV	8.18	16.01	2.44	2.22	0.02	9.21	0.005	0.88	0.1	0.01	2.9		
A8E0263													
x±Sx	41.3±0.37	44.2±0.84	11.4±0.43	4.1±0.57	1.2±0.04	35.93±0.66	0.51±0.01	6.96±0.19	2.74±0.06	1.49±0.02	3.27±0.14	Lilac	Glabrous
Min	40	40	9	2	1.04	33.5	0.46	6	2.5	1.36	3		
Max	43	48	13	7	1.4	39	0.6	7.9	3	1.55	4.5		
CV	1.34	7.07	1.82	3.21	0.01	4.44	0.002	0.36	0.03	0.003	0.2		
BGR995													
x±Sx	37.8±1.08	33.8±0.87	8.4±0.4	4.2±0.33	1.22±0.08	30.3±1.35	0.5±0.03	5.08±0.14	2.88±0.1	1.53±0.1	2.76±0.26	White	Semi glabrous
Min	32	30	7	3	0.88	24	0.31	4.5	2.5	1	1.4		
Max	42	38	11	6	1.76	37	0.66	5.8	3.6	2.15	4.2		
CV	11.73	7.51	1.6	1.07	0.06	18.23	0.01	0.19	0.1	0.12	0.67		
A7E283													
x±Sx	51.33±1.25	44.22±1.86	13.33±0.66	3.47±0.4	1.13±0.04	40.73±1.1	0.54±0.02	7.6±0.47	3.44±0.16	1.54±0.07	8.9±0.44	White	Spica (loose)
Min	43	35	12	2	1	34.5	0.48	6	3	1.3	7		
Max	54.5	52	18	6	1.36	46	0.64	9.6	4.2	1.8	10.7		
CV	14.06	31.19	4	1.47	0.01	10.9	0.004	2.02	0.23	0.04	1.82		
A9E0548													
x±Sx	38.2±1	32.1±1.57	11.6±0.4	7±0.37	1.54±0.06	20.42±1	0.26±0.02	5.13±0.04	2.44±0.03	0.61±0.14	5.58±0.17	White	Glabrous
Min	31	26	10	5	1.2	15	0.19	5	2.3	0.21	4.5		
Max	42	38	14	8	1.77	23.5	0.33	5.3	2.6	1.31	6.1		
CV	10.18	4.95	1.6	1.33	0.04	10.18	0.003	0.02	0.009	0.2	0.3		
A9E0486													
x±Sx	42.3±1.01	36.9±1	10.6±0.43	13.3±0.67	1.04±0.13	34.7±0.91	0.56±0.02	4.84±0.11	2.33±0.05	1.124±0.08	4.95±0.31	White	Semi glabous
Min	38	32	9	10	0.58	30	0.43	4.4	2.1	0.69	3.6		
Max	48	43	12	15	1.74	39	0.67	5.3	2.5	1.52	6.2		
CV	10.23	10.1	1.82	4.46	0.16	8.23	0.005	0.12	0.03	0.07	0.99		
BGR9958													
x±Sx	39.5±1.12	35.4±0.92	6±0.63	5.85±0.4	1.24±0.07	33.4±0.8	0.53±0.02	5.33±0.3	3.1±0.18	1.11±0.06	6.34±0.67	White	Spica
Min	34	32	3	4	0.95	29	0.44	4	2.4	0.89	2.2		
Max	46	40	9	8	1.72	37	0.64	7	4.4	1.5	9		
CV	12.5	8.49	4	1.61	0.05	6.49	0.005	0.85	0.33	0.04	4.45		
A9E1428													
x±Sx	42.5±1.36	38.8±1	8±0.33	8.25±0.52	1.35±0.08	34.75±1.31	0.46±0.03	5.23±0.13	2.82±0.09	1.1±0.04	8.44±0.56	White	Spica
Min	34	35	7	5.5	0.94	25.5	0.38	4.7	2.4	0.85	6.4		
Max	47	45	10	10.5	1.72	39	0.68	6	3.3	1.27	12.4		

Contd...

Table 1: ***(Continued)***

O.basilicum accessions	Plant			Stem		First order branching		Leaf		Inflorescence			Inflorescence type
	Height (CM)	Width (CM)	No of branches	Length (CM)	Diameter (CM)	Length (CM)	Diameter (CM)	Length (CM)	Width (CM)	Diameter (CM)	Height (CM)	Color	
CV	18.5	10.18	1.11	2.74	0.07	17.18	0.008	0.16	0.07	0.02	3.13		
A9E1032													
x±Sx	41.9±1.26	36.9±0.69	6.8±0.36	9.1±0.9	1.27±0.12	38.35±0.82	0.43±0.01	5.15±0.19	3.07±0.16	1.14±0.09	11.05±0.77	White	Spica
Min	36.5	34	5	5	0.8	33	0.34	4.4	2.5	0.68	7.2		
Max	47	39	8	15	1.91	41	0.48	6.5	3.8	1.52	13.4		
CV	15.82	4.77	1.29	8.10	0.15	6.67	0.00	0.36	0.25	0.08	5.98		
A7E0284													
x±Sx	41.2±0.93	46.6±0.82	10.4±0.50	7.4±0.4	1.24±0.03	18.8±0.81	0.64±0.03	6.43±0.24	3.49±0.13	1.43±0.04	13.27±0.68	White	Spica
Min	37	43	8	6	1.1	15	0.4	4.9	3	1.3	9		
Max	45	51	12	10	1.41	22	0.71	7.2	4.3	1.8	17		
CV	8.62	6.71	2.49	1.6	0.01	6.62	0.01	0.56	0.17	0.02	4.59		
A9E0452													
x±Sx	35.7±0.88	40.9±1.1	13.4±0.43	5.1±0.29	1.35±0.02	18.6±0.65	0.69±0.09	5.57±0.12	2.4±0.1	0.99±0.1	5.12±0.07	White	Glabrous
Min	31	35	12	4	1.29	15	0.1	5	1.9	0.21	4.9		
Max	39	45	16	6.3	1.41	21	1.12	6	2.9	1.24	5.5		
CV	7.79	12.10	1.82	0.86	0.00	4.27	0.09	0.14	0.11	0.09	0.05		
A9E0378													
x±Sx	47.2±1.65	41.8±0.84	7.7±0.45	10.95±1.1	1.47±0.1	38.35±0.53	0.5±0.04	5.93±0.13	3.72±0.11	1.3±0.05	10.57±0.79	White	Spica
Min	40	38	5	4.5	1.2	36	0.32	5.2	3.2	1	4		
Max	55	45	9	15	1.98	41	0.68	6.4	4.3	1.46	12.7		
CV	27.29	7.07	2.01	12.03	0.1	2.84	0.02	0.17	0.13	0.02	6.24		
A62007													
x±Sx	38±0.58	33±1	7.7±0.4	12.81±0.53	1.24±0.07	28.1±0.46	0.62±0.03	4.69±0.1	2.07±0.03	1.27±1.27	9.54±0.33	White	Spica (dense)
Min	36	28	6	11	0.91	26	0.42	4.2	2	0.99	8.2		
Max	42	38	9	17	1.77	30	0.77	5.1	2.2	1.58	11.4		
CV	3.33	10	1.57	2.77	0.05	2.10	0.01	0.11	0.01	0.03	1.08		
A8E0343													
x±Sx	38.8±1.12	39.3±1.75	11±0.68	7.08±0.47	1.35±0.09	26.2±1.12	0.51±0.04	4.78±0.13	3±0.16	1.539±0.07	2.45±0.2	White	Glabous
Min	33	35	8	5	0.91	19	0.34	4.2	2.1	1.25	1.7		
Max	43	54	14	9.5	1.88	31	0.71	5.4	3.8	1.89	3.5		
CV	12.62	30.68	4.67	2.25	0.07	12.62	0.01	0.18	0.27	0.05	0.39		
A70095													
x±Sx	33.4±0.82	35.6±1.09	10.2±0.42	4.93±0.12	1.28±0.12	16±0.6	0.51±0.01	5.94±0.11	3±0.06	1.67±0.02	10.51±0.21	White	Spica
Min	30	30	9	4	0.88	13	0.49	5.2	2.6	1.59	9.8		
Max	36	39	12	5.5	1.72	19	0.55	6.6	3.2	1.8	11.51		
CV	6.71	11.82	1.73	0.14	0.14	3.56	0.00	0.12	0.04	0.00	0.43		
A9E1023													
x±Sx	36.9±1.44	35.9±1.66	5±0.26	4.4±0.27	1.26±0.06	31.3±1.31	0.47±0.03	4.62±0.12	2.64±0.09	1.17±0.03	6.05±0.33	White	Spica (dense)
Min	29	27	4	3	0.89	23	0.34	4	2.3	1	4		
Max	42	45	6	5.5	1.47	37	0.68	5.2	3.1	1.32	7.5		
CV	20.77	27.66	0.67	0.71	0.04	17.12	0.01	0.15	0.07	0.01	1.08		

with the shortest flowering period. Accordingly, the longest growing season (142 days) have accessions with longer flowering period. There are no established correlations between the length of the inter-phase periods and the morphological characteristics of the accessions. Accessions A9E1032 and A7E0284 with a maximum flowering and growing periods are with white, spica, well-shaped, neither too brief nor too loose. On the base of the above said we could make the conclusion that these accessions could be successfully used for ornamental purposes.

Based on the results from the morphological study comparative cluster analysis was made to the Basil accessions. Clustering is done using 16 indicators. Table 2 shows the Euclidean distances between the groups.

Graphically they are represented by dendrogram (Fig. 2).

It shows that Basil accessions are grouped into three major groups (clusters) as follows:

I. A9E1428 (№8), A9E1032 (№9), BGR9958 (№7), A9E0378 (№12), A9E0486 (№6) and A62007 (№13).
II. A7E283 (№3), A9E1023 (№16), A8E0343 (№14), A9E1044 (№1) and A8E0263 (№2).
III. A9E0548 (№5), A9E0452 (№11), A70095 (№14№ and A9E0284 (№10).

Isolated accession remains BGR995 (№ 4) which does not fall into any cluster group.

The dendrogram shows that all three groups have almost the same degree of metric homogeneity. Inside the groups I and II respectively accessions № 8 and 9 and № 3 and 6 show a high degree of similarity - they are at a little distance from the edge of complete similarity (AD - 43,983 and AD - 53,037). In Group III accessions № 5 and 11 show a relatively low degree of similarity (AD - 112,626). At a little more distance to them merges accession № 5 (AD-148, 102), and accession № 10 shows the least similarity within the group (AD - 301.960). Accession № 4 remains isolated, and joins groups I and II of the rather large distance (AD - 392.129).

This clustering distribution correlates with the results of biometric studies of morphological characteristics of the samples Basil. It is seen that the accessions combined in different clusters have relatively close values of biometric parameters (Table 1). The isolated accession № 4 (BGR995) differs with semi-glabrous inflorescence, which was not observed in any of the other Basil accessions, as well as with close to the minimum values in almost all biometric indices.

Table 2: Euclidean distances between clusters

Agglomeration schedule					
Cluster combined		Coefficients	Stage cluster first appears		Next stage
Cluster 1	Cluster 2		Cluster 1	Cluster 2	
8	9	43,983	0	0	3
3	16	53,037	0	0	7
7	8	62,303	0	1	5
5	11	112,626	0	0	9
7	12	119,124	3	0	6
6	7	121,884	0	5	11
3	14	132,473	2	0	8
1	3	136,946	0	7	10
5	15	148,102	4	0	13
1	2	180,544	8	0	12
6	13	188,605	6	0	12
1	6	255,480	10	11	14
5	10	301,960	9	0	15
1	4	392,129	12	0	15
1	5	469,127	14	13	0

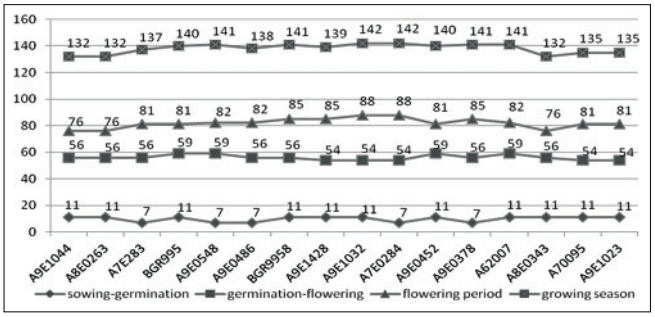

Fig 1. Interphase periods of Ocinum basilicum

CONCLUSIONS

Accessions A7E0284, which is with longest flowering and growing periods, very well-leaved and long inflorescence is very suitable for ornamental purposes and in home gardens.

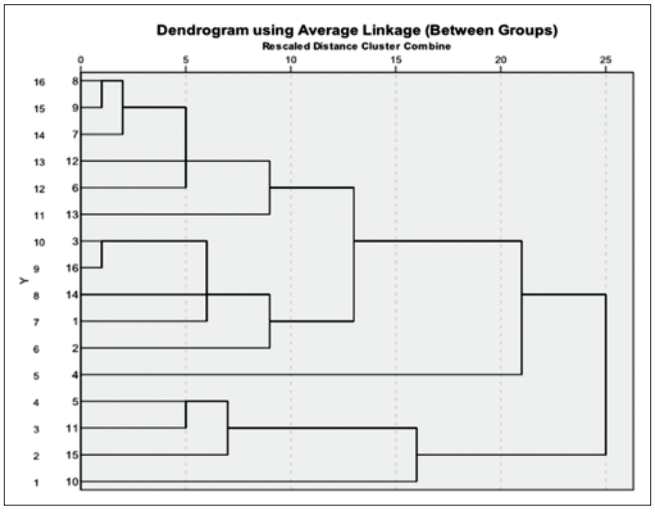

Fig 2. Dendrogram of the sequence of combining objects and formed clusters

Accession A9E0452, which is with maximum number of branches, consequently with maximum leaf mass is most suitable for spice and medical purposes.

The comparative cluster analysis of Basil accessions in the collection of IPGR - Sadovo shows complete uniformity in the results for the grouping based on morphological parameters and using cluster analysis.

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