

Morphological and antioxidant characteristic of (*Ziziphus jujuba* Mill.) fruits

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INTRODUCTION

Regarding the climate change in recent years, many countries have focused their attention to the introduction and expansion of the *Ziziphus jujuba* Mill. which delivers fruits and other plant parts containing major biologically active components (Huang et al., 2007), and therefore is useful in nutrition (Van Wyk & Wink, 2005; WHO, 2007), pharmacy (Mukhtar et al., 2004; Peng et al., 2000; WHO, 2007; Thanatchapranee, 2011), medicine (Ambasta, 1986; Erenmemisoglu et al., 1995; Hao et al., 2010; Motevali et al., 2012) and other areas. In process of breeding new varieties, the attention is focused, besides other traits, on the size of the fruit. For this reason, the research activities are aimed to find genetic resources with different shapes and sizes of fruit. Ecevit et al. (2008) evaluated collection of *Ziziphus jujuba* Mill. genotypes and found the average weight of fruit in the range from 4.52 to 6.12 g, the height of fruit from 16.86 to 25.23 mm and the width of the fruit in the range from 17.27 to 23.65 mm. Brindza et al. (2011) found in their experiments the average weight of fruit in the range from 0.66 to 4.68 g, the height of fruit from 0.77 to 21.67 mm and the width of the fruit in the range from 0.67 to 16.97 mm.

THE AIM OF THE STUDY

For the countries of Central and Eastern Europe, zizifus jujuba (*Ziziphus jujuba* Mill.) represents an unknown species. Usually, it is grown only in botanical gardens or arboreta. Recently, this plant has become the object of research in many workplaces for high nutritional and therapeutic value of its fruit and adaptability to difficult growing conditions. The objective of this study was to evaluate genetic resources of zizifus jujuba fruit collections, focusing on their morphological characteristics and antioxidant activity.

MATERIAL AND METHODS

In the experiment, we have evaluated the fruits of 20 genetic resources obtained from the Research Unit in New Kachovka at Nikitsky Botanical Garden in Yalta. Antioxidant activity was determined using DPPH method used by Brand-Williams et al. (1995) and Kutlu et al. (2011).

RESULTS

Evaluating the obtained results, we have found the average weight of fruit in the range from 3.99 g (ZJ-1/9) to 14.10 g (ZJ-1/15), the length of fruit 20.20 g (ZJ-2/18) to 41.01 mm (ZJ-1/25) and the width of fruit in the range from 17.29 mm (ZJ-2/11) to 28.49 mm (ZJ-1/15) (Table 1). Using variance analysis, we have confirmed significant differences between genotypes in all characteristics. For the fruit weight we have determined, for the vast majority of genotypes, middle level of variability, for the height and width of the fruit we have determined very low degree of variability.

Antioxidant activity was determined in water extracts in the range from 5.70 % (ZJ-1/25) to 55.76 % (ZJ-1/6) and in methanol extracts in the range from 3.95 % (ZJ-1/24) to 48.74 % (ZJ-1/6). In general, genotypes showed higher antioxidant activity in the water extracts than in the methanol extracts (Table 2)

Rated genotypes from a collection of zizifus jujuba were characterized by the significant variability in the shape and colour of the fruit (Figure 1) and flowers (Figure 2).

Table 1 The variability in selected characteristics of genetic resources of zizifus jujuba (*Ziziphus jujuba* Mill.) fruit collections.

Genotypes	n	Fruit weight (g)		Fruit length (mm)		Fruit width (mm)	
		x	V%	x	V%	x	V%
ZJ-1/1	50	6.59	11.91	23.37	5.91	23.04	6.51
ZJ-1/2	43	9.11	25.38	30.47	6.80	24.51	7.85
ZJ-1/3	47	8.81	13.29	29.46	4.29	23.86	6.12
ZJ-1/4	25	10.92	14.21	35.71	8.29	25.79	5.93
ZJ-1/5	33	6.94	29.89	30.86	9.66	20.38	11.74
ZJ-1/6	37	10.02	13.80	31.61	5.48	25.51	6.05
ZJ-1/7	29	12.91	20.98	38.77	7.25	26.52	8.05
ZJ-1/9	49	3.99	16.99	21.15	6.64	18.31	6.88
ZJ-1/12	28	12.83	15.30	38.30	7.38	27.19	6.36
ZJ-1/13	41	13.21	12.65	39.11	6.81	27.39	6.13
ZJ-1/14	28	12.87	15.76	39.06	8.18	27.35	6.36
ZJ-1/15	30	14.10	16.65	40.74	6.58	28.49	6.02
ZJ-1/17	23	12.81	22.65	38.28	7.74	28.31	8.43
ZJ-1/23	42	6.50	14.59	34.17	6.71	18.66	4.68
ZJ-1/24	41	6.91	15.37	37.37	6.00	18.88	6.51
ZJ-1/25	39	8.64	13.91	41.01	6.38	20.55	6.70
ZJ-2/10	50	5.94	17.67	35.66	6.00	17.56	7.17
ZJ-2/11	37	5.94	19.82	35.86	6.75	17.29	8.25
ZJ-2/14	27	12.61	18.48	35.69	5.29	27.26	6.93
ZJ-2/18	31	4.95	16.01	20.20	6.59	20.84	5.94

Legend: n – number of fruits; Mean – average; Min. – minimum value measured in the file; Max. – maximum value measured in the file; V% – coefficient of variation.

Table 2 The variability in antioxidant activity of zizifus jujuba (*Ziziphus jujuba* Mill.) fruit collections.

Sample	n	Water extrakt				Methanol extrakt			
		Min.	Max.	x	V%	Min.	Max.	x	V%
ZJ-1/1	5.00	36.36	37.31	36.68	1.05	20.10	20.65	20.35	1.28
ZJ-1/2	5.00	20.70	21.93	21.09	2.48	8.57	9.17	8.89	2.74
ZJ-1/3	5.00	16.28	17.92	16.80	3.85	9.41	9.62	9.51	0.89
ZJ-1/4	5.00	12.32	13.15	12.73	2.40	4.34	5.49	4.85	3.85
ZJ-1/5	5.00	11.75	16.69	15.33	13.42	8.81	9.34	9.15	2.19
ZJ-1/6	5.00	54.97	56.44	55.76	1.18	48.32	49.09	48.74	0.68
ZJ-1/7	5.00	12.05	12.95	12.44	3.52	6.09	6.51	6.29	2.49
ZJ-1/9	5.00	11.75	15.74	15.09	3.24	9.33	10.44	9.91	4.13
ZJ-1/12	5.00	14.27	15.99	15.29	4.32	4.61	5.13	4.85	3.99
ZJ-1/13	5.00	7.74	9.62	8.84	10.05	6.44	7.19	6.80	4.39
ZJ-1/14	5.00	5.52	6.16	5.76	4.81	4.10	4.88	4.64	6.71
ZJ-1/15	5.00	11.01	11.95	11.44	3.70	7.34	7.60	7.49	1.52
ZJ-1/17	5.00	7.28	7.91	7.55	3.21	3.70	4.35	3.98	6.30
ZJ-1/23	5.00	9.31	11.26	10.40	9.06	5.25	5.53	5.41	2.09
ZJ-1/24	5.00	9.14	10.70	9.88	7.58	3.77	4.28	3.95	6.24
ZJ-1/25	5.00	5.45	5.99	5.70	3.52	4.03	4.60	4.26	5.09
ZJ-2/10	5.00	8.45	8.99	8.76	2.26	4.08	4.96	4.43	8.59
ZJ-2/11	5.00	7.55	7.93	7.73	1.87	5.52	5.77	5.67	1.80
ZJ-2/14	5.00	15.46	16.18	15.76	1.83	10.37	10.64	10.50	1.16
ZJ-2/18	5.00	29.08	29.77	29.37	1.07	26.48	26.96	26.66	0.70

Sample	n	Min.	Max.	x	V%
1/1	15	0.28	0.45	0.36	14.82
1/2	13	0.38	0.73	0.56	16.51
1/3	16	0.44	0.71	0.55	14.18
1/4	7	0.47	0.62	0.55	12.17
1/5	10	0.24	0.53	0.38	23.40
1/6	12	0.47	0.67	0.58	12.41
1/7	7	0.49	0.69	0.60	11.34
1/9	20	0.16	0.26	0.22	12.11
1/12	10	0.50	0.82	0.67	13.54
1/13	12	1.00	1.23	1.10	6.47
1/14	11	0.44	0.79	0.65	17.54
1/15	9	0.28	0.64	0.44	24.00
1/17	8	0.23	0.41	0.35	18.65
1/23	17	0.14	0.24	0.16	14.04
1/24	14	0.17	0.26	0.20	11.72
1/25	15	0.17	0.26	0.20	11.55
2/10	14	0.13	0.27	0.19	19.36
2/11	13	0.11	0.23	0.19	22.21
2/14	7	0.44	0.80	0.57	21.30
2/18	20	0.12	0.22	0.17	17.04

Table 3 The variability in seeds of zizifus jujuba (*Ziziphus jujuba* Mill.) fruit collections

Figure 2 The variability in shape and color of zizifus jujuba (*Ziziphus jujuba* Mill.) flower

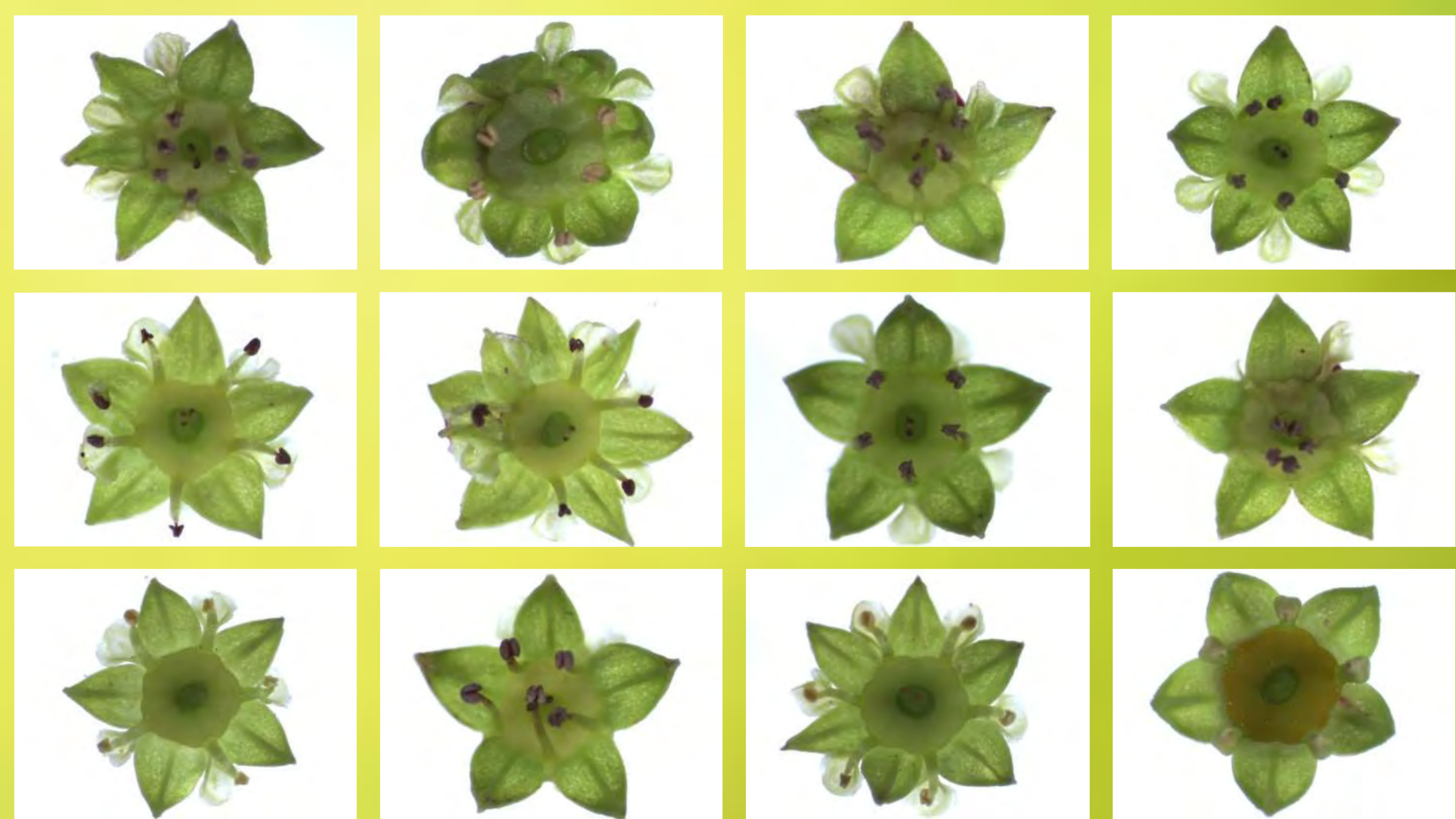
Table 4 Correlation coefficients of linear correlation analysis among the morphological traits of zizifus jujuba (*Ziziphus jujuba* Mill.) by Pearson

r	Sr	Confidence interval $r_{95\%}$	r ²	t	Probability of t (p)
Fruits weight (g) – Fruits length (mm)					
0.6914	4.6509	0.3586<= r >= 0.8683	0.4780	4.0602	0.0007
Fruits weight (g) – Fruits width (mm)					
0.9293	1.4990	0.8267<= r >= 0.9721	0.8635	10.6712	0.0000
Fruits length (mm) – Fruits width (mm)					
0.3900	3.7360	-0.0635<= r >= 0.7100	0.1521	1.7970	0.0891

Legend: r – Pearson's Correlation Coefficient; Sr – Standard Error of the Coefficient; 95% Confidence Interval; r² – Coefficient of Determination; t – Test for the Significance of the Coefficient; Probability of t (p)



Figure 1 The variability in shape and colour of *Ziziphus jujuba* (*Ziziphus jujuba* Mill.) fruit



ACKNOWLEDGEMENTS

This work has been supported by the «Building Research Center "AgroBioTech"» project implemented under the Operational Programme Research and Development, Priority Axis 2 support of research and development, Measure 2.2 Transfer of knowledge and technology from research and development into practice, ITMS 26220220525.

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