QUANTITATIVE ANALYSIS OF THE BERRY SIZE IN GRAPEVINE CULTIVAR 'ITALIA'

Digital image analysis of the grapevine

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Quantitative evaluation of the horticultural crops has high importance to identify cultivars, describe the effect of the growing location and cultivation technology or define consumer's preference regarding the size and shape. Fruit traits of the grapevine (*Vitis vinifera* L.) are mainly described by the bunch and berry morphology notably bunch and berry size, weight and shape. Ampelographers particularly evaluate the berry based on the seed number as it influences size and consumers' decision. In this study berry morphological traits of the grapevine cultivar 'Italia' was investigated based on digital image analysis. Samples were collected from two vineyards in Hungary with different ecological and cultivation circumstances. Altogether 12 traits were investigated: weight, seed number, size and shape attributes. Results showed that berry morphological traits are not differing between the two sampling location. In accordance with previous studies seed number - ranging from 0 to 4 - had noticeable effect on the size attributes and correlates with the berry size.

Keywords: uvometry, size, shape, image analysis

Introduction

Vegetable and fruit species have numerous quality parameters. The consumers are mainly affected by the size, the typical color and the shape (PREDIERI et al, 2004). Grapevine (*Vitis vinifera* L.) is one of the most important horticultural crops where appearance, for example bunch size and compactness, berry size, shape and color highly influence the table grape consumers' decision. Description of the berry size already appeared in literature in the 16th Century. SZIKSZAI (1590) mentioned "*uva spionia*" ("*nagyszemű szőlő*" = large-berried grape). PARKINSON (1650) introduced "*small blacke grape*", which according to the illustration referred to the berry size. DUHAMEL (1768) described many cultivars in his novel book: *Traité des arbres fruitiers* for example 'Chasselas doré', 'Muscat blanc' and 'Cornichon blanc'. The colorful paintings showed divers berry shapes and sizes and in some cases, parthenocarpy-like berries are possible to identify on the figures, which is a widely investigated phenomenon in

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grapevine and causes divers berry sizes within bunches. Today both ampelographic literatures (BARBAGALLO et al., 2011) and official descriptors detail berry size classes (OIV, 2009), which measured for example with ruler (FREGE, 1804), with caliper (KIRCHERER et al., 2013) or with digital image analysis (ROSCHER et al., 2014). There are several image analysis softwares, which are dealing with mostly the size of different parts of horticultural crops. "Tomato Analyzer" for example evaluates the perimeter and the area, the maximum width and height, the width at mid height and the height at mid width also. The program can evaluate different fruit shape indexes, the "Fruit shape index external I" which is the ratio of the maximum height and maximum width and "Fruit shape index external II" being the ratio of the height mid width and width mid height. The "Proximal fruit blockiness" and "Distal fruit blockiness" show the ratio of the upper (proximal) and the lower (distal) thirds ratios to the width mid height. Furthermore, the asymmetry of the fruit can be described with the help of the software (RODRÍGUEZ et al., 2010). The purpose of this study was to evaluate the berry morphological traits of the grapevine cultivar 'Italia' influenced by the seed number of the berries, and compare samples collected from two different vineyards.

Materials and Methods

Samples of *Vitis vinifera* L. cv. 'Italia' were collected from the Institute for Viticulture and Oenology of the Hungarian University of Agriculture and Life Sciences (Kecskemét, Hungary) and from the Kun Szőlő Nursery and Table Grape Plantation (Kővágótöttös, Hungary). Ten bunches were collected and of each bunches 15-15 berries were randomly sampled from the middle third of the bunches. The chosen berries were numbered after that pedicels and receptacles were gently removed. Samples were individually weighted on an Ohaus Explorer Pro EP114C analytical balance (Ohause Corporation, Pine Brook, NJ USA), and then the berries were halved. Seeds of the halved berries were then counted and noted. Digitalization of one section per each berry was carried out with Epson V370 scanner (Seico Epson Corporation, Japan) at 200 dpi. TIFF images were then analysed with the 'Tomato Analyser' software according to the protocol reported by BREWER et al. (2006). In this study, 10 traits were evaluated with the 'Tomato Analyzer' as basic measurements (Perimeter, Area, Width Mid-height, Maximum Width, Height Mid-width, Maximum Height, Curved Height), fruit shape indices (Fruit Shape Index External I, Fruit Shape Index External II, Curved Fruit Shape Index. Detailed description of the investigated traits provided by HURTADO et al. (2013). Statistical analysis of the data: summary statistics and ANOVA was carried out with the PAST (Hammer et al, 2001) software.

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Results

Morphological characteristics of the grapevine cultivar 'Italia' in different locations: Results showed that in case of the investigated size traits there were no significant differences of the values of the two locations. The mean berry weight was 6,13 g, while the mean value of the samples of Kecskemét was 5,95 g and 6,29 g of Kővágótöttös. The mean value of perimeter was 77,18 mm, 77,64 mm of Kecskemét and 76,78 mm of Kővágótöttös. There were differences yet not significant in case of the area, the mean value was 416,72 mm^2, the mean of Kecskemét's representatives was 418,1 and 415,78 mm^2 of Kővágótöttös's. The average values of Width mid-height and Maximum width were very similar (WMH: 20,87 mm, MW: 21,18 mm), furthermore in case of Kecskemét and Kővágótöttös there were no dissimilarity of the two traits, also. The mean of Height Mid-width was 24,35 mm, while the average of Kecskemét valued 24,73 mm and Kővágótöttös's was 24 mm, respectively. The Maximum Height of the samples was 24,95 mm in average, and it was 25,44 mm and 24,55 mm of the two different locations. The mean of Curved Height was 28,08 mm, and the two locations had 28,57 mm and 27,62 mm in average. On the other hand, the examined shape traits, namely Fruit Shape Index External I and II had significant differences according to the growing sites, the mean value of Fruit Shape Index External I was 1,15, while those of Fruit Shape Index External II was 1,17. The average of the samples of Kecskemét was 1,21 and 1,2, as they were 1,15 and 1,14 of the Kővágótöttös's values. The growing sites had no significant effects on the samples in case of the third researched shape trait- Curved Fruit Shape Index. The mean value was 1,33, Kecskemét valued 1,37, whilst Kővágótöttös's average was 1,3.

The effect of the seed number on the morphological traits: Results showed that investigated samples had 0 to 4 seeds per berry. Seedlessness were present in 6.04% of the samples while 4 seeds were also rare (3.35%). Most berries had 1 or 2 seeds (37.58% and 33.89% of the sample set respectively). Data showed that seed number had significant effect on the size and shape traits of the 'Italia' grapevine cultivar (Figure 1). According to the investigation seed number had significant effect ($p<0,05$) on the berry weight. Differences were noticeable among the group of berries with different seed number except for the 3 and 4 seeded berries. Smallest berries were the seedless group with 2.8 g in average while those with 4 seeds had 8.01 g. Coefficient of variability was the largest in the case of seedless berries (38.51%) meaning that this group was the most divers in weight. The most uniform berry weight was observed in the case of 4 seeded berries (11.64%). Size traits showed the same tendency. Perimeter was the smallest in the case of seedless berries (63.69 mm) while the largest were the 4-seeded ones

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(84.94mm). Variability of the perimeter was the highest in the case of seedless berries (Coeff. var.: 10.05%) while the lowest Coeff. var. value was observed in the case of the 4 seeded ones (5.6%). Area of the berries also significantly changed caused by the different seed numbers. Trend in the change was the same as in the case of weight and perimeter. Size was evaluated according to the width and length too. These traits showed the same tendency as above. Lowest values were recorded in the case of seedless berries while the highest values in the case of the 4-seeded ones. Variability of the values within each groups (Coeff. var. values) were the lowest in the 4-seedes berries while the highest values were recorded in the case of the seedless ones. Shape of the berries were evaluated according to the fruit shape index calculated by the ratio of the width and length at different positions of the berries. Low variability was observed in the fruit shape index, Coeff. var. values ranged from 5.21% to 9.93% and there was no significant difference among the samples with different seed numbers.

Table 1: Summary statistics of the different seed number groups of the 'Italia' grapevine cultivar

Morphological trait	Seed number	Mean	Min	Max	Stand. dev	Coeff. var
		Size traits				
Berry weigth (g)	0	2,8[a]	1,09	5,23	1,08	38,51
	1	5,14[b]	2,45	9,46	1,08	21,09
	2	6,59[c]	3,4	9,67	1,09	16,56
	3	8[d]	4,92	11,16	1,38	17,31
	4	8,01[d]	6,17	9,41	0,93	11,64
Perimeter (mm)	0	63,69[a]	55,5	74,4	6,4	10,05
	1	72,51[b]	59,8	95,74	6,17	8,51
	2	79,34[c]	63,8	93,34	5,42	6,83
	3	83,56[d]	72,69	91,9	4,67	5,59
	4	84,94[d]	80,18	93,84	4,76	5,6
Area (mm^2)	0	274,11[a]	216,64	387,77	53,97	19,69
	1	365,82[b]	226,61	513,55	51,94	14,2
	2	437,78[c]	287,84	549,58	49,8	11,38
	3	495,43[d]	375	593,64	54,96	11,09
	4	496,69[d]	447,93	588,63	42,65	8,59
Width Mid-height (mm)	0	17,08[a]	14,86	19,94	1,71	10,01
	1	19,6[b]	14,86	24,51	1,69	8,6
	2	21,25[c]	17,27	24,77	1,51	7,1
	3	23,01[d]	19,43	27,69	1,61	7
	4	22,96[d]	20,57	24,51	1,29	5,61
Maximum Width (mm)	0	17,3[a]	15,11	20,07	1,74	10,05
	1	19,96[b]	15,24	24,77	1,64	8,22
	2	21,57[c]	17,65	24,77	1,46	6,77
	3	23,2[d]	19,81	27,69	1,57	6,77

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Trait						
	4	23,33[d]	21,46	24,64	1,02	4,36
Height Mid-width (mm)	0	20,08[a]	17,91	24,51	2,09	10,42
	1	22,72[b]	15,75	26,8	2,36	10,37
	2	25,07[c]	16	29,46	2,37	9,47
	3	26,63[d]	21,97	31,62	1,95	7,31
	4	26,28[cd]	19,05	30,23	2,92	11,11
Maximum Height (mm)	0	20,61[a]	17,91	24,64	2,1	10,19
	1	23,39[b]	19,18	27,94	1,89	8,1
	2	25,85[c]	21,08	31,24	1,86	7,2
	3	26,96[d]	22,61	31,75	1,77	6,57
	4	27,13[cd]	25,53	30,73	1,61	5,93
Curved Height (mm)	0	23,16[a]	19,22	26,58	2,48	10,71
	1	26,35[b]	20,93	32,05	2,46	9,33
	2	28,87[c]	23,44	34,63	2,24	7,76
	3	30,57[d]	25,09	36,2	2,2	7,18
	4	30,62[cd]	28,13	33,82	2,05	6,68
Shape traits						
Fruit Shape Index External I	0	1,2	1,06	1,4	0,08	6,88
	1	1,18	0,97	1,41	0,09	7,28
	2	1,2	0,99	1,45	0,1	8,01
	3	1,17	0,96	1,36	0,09	7,6
	4	1,16	1,09	1,28	0,06	5,21
Fruit Shape Index External II	0	1,19	1,07	1,31	0,07	6,26
	1	1,16	0,85	1,48	0,11	9,15
	2	1,18	0,83	1,49	0,12	9,93
	3	1,16	0,95	1,36	0,1	8,22
	4	1,14	0,93	1,29	0,1	8,56
Curved Fruit Shape Index	0	1,33	1,11	1,58	0,12	9,27
	1	1,33	1,13	1,64	0,11	8,06
	2	1,35	1,09	1,67	0,12	8,79
	3	1,32	1,05	1,57	0,1	7,68
	4	1,32	1,19	1,41	0,08	5,8

Means followed by different letters indicate significant difference ($p < 0,05$)

Discussion

'Italia' is one of the most important and most studied among the grapevine cultivar. Italia has several somatic mutations resulting new cultivars with variable morphological traits (Maia et al. 2009). Beside these bud sports large number of clones are in cultivation. Characterization and discrimination of these sports and clones have high importance (FANIZZA et al., 2003), which can be carried out both morphological and molecular approaches too. There are more than 150 traits in the OIV (2009) descriptor list, within this 20 is dealing with the berry morphology. Size is described by the length and width of the berries where 5 classes are available for length: very short (up to about 8 mm), short (about 13 mm), medium (about 18

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mm), long (about 23 mm) and very long (about 28 mm and more), and for the width too: very narrow (up to about 8 mm), narrow (about 13 mm), medium (about 18 mm), wide (about 23 mm) and very wide (about 28 mm and more). In this study we found that berry size of the 'Italia' grapevine cultivar ranged from medium to large categories. Width can be evaluated at more position of the berry. In the TA there is possible to investigate the width at the half of the height and at the widest position. In the case of 'Italia' we found minor difference between these data but berry shape in many cases are not spherical but ellipsoid, obovoid, ovoid or in extreme cases, horn or finger shaped. In the later categories, these traits can be significantly different. According to this, it would be important to highlight in the reports and descriptor lists at which position the berry width is measured. Grapevine berry size is changing during the development according to a double sigmoid curve. Final size depends on the cultivar (BÉNYEI and LŐRINCZ, 2005), pruning bud-load (INTRIERI et al., 2001), special canopy management treatments (CARREÑO et al., 1998) or for example the seed number. Grapevine berry has usually (0) 1 to 4 (5) seeds. In this study we found that 'Italia' have 0 to 4 seeds in the berries. Authors in the early 18th century were already dealing with the seed number of the cultivars and in some cases highlighted the seedlessness as MILLER (1724) mentioned "*the Currant grape is something larger than the former, is a very good fruit has no seeds*". Today this phenomenon is a central aim of the table grape breeding (ROYO et al, 2018). In this study, we found that 6.04% of the samples had no seeds, while most of the berries had 1 or 2 seeds (37.58% and 33.89% respectively) which result is in accordance with SABIR (2011) who found that seed number ranges from 1.84 to 1.98 per berry according to the pollinator. Calculation of the berry size traits provides primary data (width, length) but further data can help to calculate surface area too. Skin surface of the grapevine have high importance to evaluate for example anthocyanin content, which is key factor of red wine production. DÍAZ-PÉREZ et al. (2007) calculated bell pepper skin surface based on photocopy, while BARBAGALLO et al. (2011) applied a LICOR LI 3100 area meter for the evaluation of the skin surface of Syrah grapevine cultivar. Image analysis of the berry size traits can be a possible way for the skin surface measurements too.

Conclusions

Grapevine berry shape and size are traits affected by many factors. Such factors could be environmental or developmental factors. According to this research it can be stated, that seed number influences significantly the size of the grapevine berries.

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