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INVESTIGATIONS ON THE FRUIT RESISTANCE TO DEFORMATION IN SOME SWEET CHERRY TREE VARIETIES

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ABSTRACT – The knowledge of sweet cherry resistance to deformation was important for a good choice of means and methods of packing, storage and transportation of fresh fruits for consumption, both on internal market and for exportation. In this paper, the authors have shown the results of some determinations on fruit deformation, carried out on seven sweet cherry varieties (Cetățuia, Cătălina, Maria, Golia, Ştefan, Bucium and Tereza), harvested at three maturation stages: before ripening (10 days before ripening), almost ripe (five days before maturity) and at maturity. We have recorded the fruit resistance to deformation at a weight below 500 g, using an original device made by the Fruit Growing Research and Development Station of Iaşi. This mechanical device can be used for measuring the resistance to deformation of the fruit belonging to some fruit species or of grapes. The fruit deformation was determined for a certain weight (in our determinations, below the weight of 500 g). By comparing the varieties between them, we found that Maria and Bucium varieties were the most resistant to deformation, at all the three harvest stages, significant differences being found, compared to the other varieties. We have used these determinations for the statistical calculation by the analysis of variance for bifactorial trials, in order to establish the most resistant varieties to fruit deformation at different harvest stages.

Key words: sweet cherry tree, fruit deformation, firmness, variety

REZUMAT - Cercetări privind rezistența la deformare a fructelor la unele soiuri de cireş. Cunoaşterea rezistenței la deformare a cireşelor este importantă pentru o bună

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alegere a mijloacelor şi metodelor de ambalare, depozitare şi transport în vederea consumului în stare proaspătă, atât pe piaţa internă, cât şi pentru export. În această lucrare, autorii prezintă rezultatele unor determinări privind deformarea fructelor, efectuate la şapte soiuri de cireşe (*Cetăţuia, Cătălina, Maria, Golia, Ştefan, Bucium* şi *Tereza*), recoltate în trei faze de maturare: faza de prepârgă (10 zile înainte de maturitatea de recoltare), faza de pârgă (5 zile înainte de maturitatea de recoltare) şi faza de maturitate. S-au făcut înregistrări privind rezistenţa la deformare sub o greutate de 500 g, utilizând un dispozitiv original, realizat la S.C.D.P. Iaşi. Acest dispozitiv mecanic poate fi utilizat pentru măsurarea rezistenţei la deformare a fructului la diferite specii pomicole sau la struguri. Deformarea fructului este determinată sub o anumită greutate (în cazul determinărilor noastre, sub o greutate de 500 g). În cazul comparării soiurilor între ele, s-a constatat că *Maria* şi *Bucium* sunt cele mai rezistente la deformare, în toate cele trei faze de recoltare înregistrându-se diferenţe semnificative faţă de celelalte soiuri. Determinările au fost utilizate în calculul statistic prin analiza varianţei pentru experienţe bifactoriale, pentru a stabili cele mai rezistente soiuri la deformarea fructului în faze diferite de recoltare.

Cuvinte cheie: cireş, deformare fruct, fermitate, soi

INTRODUCTION

The means and methods of packing, storing and distributing the fresh fruits for internal consumption or exportation are improved due to the detailed knowledge of fruit physical and technological characteristics (Albertini and Brozik, 1992; Petre et al., 2007).

The knowledge of fruit resistance to deformation is important for a good choice of these means and is a continuous concern for research, both at national and international level (Predieri, 2005; Beceanu and Sîrbu, 2007; Sîrbu et al., 2007, Buret and Fils-Lycaon, 1990). The fruit resistance to deformation also shows the elasticity degree of tissues and the apartness of cherry varieties to the Bigarreau type (Sîrbu et al., 2007, Buret & Fils-Lycaon, 1990), which was preferred for fresh sweet cherry consumption (Webster & Looney, 1996, Raimondo et al., 2006).

Although, while the fruit reaches the full maturity, the firmness of fruit pulp decreases (Webster et al., 1996; Tudela et al., 2005), the great firmness varieties have at harvest a high resistance to deformation, recording a Durofel index over 70 (Millan and Charlot, 2005; San Martino et al., 2008; Simard, 1998).

In this paper, the authors proposed a mechanical device for measuring the fruit resistance to deformation; this device may be used at different variants of weights applied on the fruit in various fruit species or grapes (Sîrbu et al., 2007). The determinations were done on seven sweet cherry varieties found at three harvest stages, at an interval of 5 days. Thus, the stage before ripening for early varieties (*Cetăţuia* and *Cătălina)* was of 36 days after the end of flowering, while for mean season varieties (*Maria, Golia, Ştefan,*

Bucium and *Tereza*), of 40-46 days after the end of flowering. The stage of ripeness was established at 42 days after the end of flowering, while for the mid-season varieties, this stage was established at 45 – 51 days after the end of flowering. The maturity stage for early varieties was found at 49 days after the end of flowering, while in the mid-season varieties, at 50-59 days after the end of flowering.

MATERIALS AND METHODS

For testing, we have used the fruits harvested from seven sweet cherry tree varieties: *Cetăţuia, Cătălina*, *Maria, Golia, Ştefan, Bucium* and *Tereza*. The samples, made of 100 fruits/variety, were harvested before ripening (36-46 days after the end of flowering), at the stage of ripeness (42-51 days after the end of flowering) and at the stage of maturity (49-59 days after the end of flowering). The varieties are found in two competition crops with fruit trees grafted on stock, planted at distances of 5 x 4 m, trained under the shape of free palmette without support system. The applied management technique was typical of cherry tree growing.

For measuring the fruit resistance to deformation, we have used an original device (Sîrbu et al., 2007), which did records in cherry samples, submitted to deformation by weights of 500 g.

Determinations were used at the data statistical processing by the analysis of variance for bifactorial trials, using Microsoft Excel. The A Factor was represented by the harvest stage, while the B Factor was the variety.

RESULTS AND DISCUSSION

The records were introduced in a statistical calculation by the analysis of variance for bifactorial trials.

For the A Factor, represented by the harvest stage, there were three variants: a_1= before ripening; a_2= stage of ripening and a_3= maturity stage. For the B Factor, represented by variety, there were seven varieties: b_1= *Cetăţuia*; b_2= *Cătălina*; b_3=*Golia*; b_4= *Maria*; b_5=*Tereza*; b_6= *Ştefan* and b_7= *Bucium* (*Table 1*).

According to the obtained data shown in Table 1, we have calculated the difference and significance for the A Factor, represented by the harvest stage (*Table 2*).

We have noticed very significant positive differences between the three harvest stages, which were comprised between 0.34 mm and 0.98 mm, the highest difference being found between the stage before ripening and the maturity (a_3-a_1). A very significant difference of 0.34 mm was found between the stages of ripeness and before ripening (a_2-a_1) and a difference of 0.64 mm was recorded between the maturity and ripeness stages (a_3-a_2).

Table 1 – Mean fruit deformation in some sweet cherry varieties (in mm)

Variant	Replicate				V
	r_1	r_2	r_3	r_4	
a_1b_1	0.81	1.19	0.94	1.05	3.99
a_1b_2	2	1.08	1.67	2.3	7.05
a_1b_3	1.6	1.6	1.5	1.33	6.03
a_1b_4	1.25	1.13	1.4	1.1	4.88
a_1b_5	1	3	2.5	1.5	8
a_1b_6	2.33	1.5	2.25	2	8.08
a_1b_7	1.2	1.3	1	1.5	5
Total	10.19	10.8	11.26	10.78	43.03
a_2b_1	2.14	1.93	1.93	1.86	7.86
a_2b_2	2.75	2.25	2.8	1.9	9.7
a_2b_3	1.7	2.2	2.17	2.17	8.24
a_2b_4	1.33	1.22	1.22	1.22	4.99
a_2b_5	1.9	2	1.8	1.75	7.45
a_2b_6	1.33	2.17	1.92	2	7.42
a_2b_7	1.8	1.6	1.8	1.83	7.03
Total	12.95	13.37	13.64	12.73	52.69
a_3b_1	2.14	2	2.43	2.5	9.07
a_3b_2	2.67	2.69	3.25	2.51	11.12
a_3b_3	2.63	2.63	2.33	2.11	9.7
a_3b_4	1.8	1.4	1.5	1.6	6.3
a_3b_5	3.41	3.21	2.85	3.65	13.12
a_3b_6	2.98	3.48	2.62	2.52	11.6
a_3b_7	2.07	2.74	2.61	2.33	9.75
Total	17.7	18.15	17.59	17.22	70.66
R	40.84	42.32	42.49	40.73	166.38

Table 2 – Deformation difference and significance for the A Factor (harvest stage)

Specification	Differences (mm)	Significance
a_2-a_1	0.34	***
a_3-a_1	0.98	***
a_3-a_2	0.64	***

$LSD_{5\%}$=0.08 mm; $LSD_{1\%}$=0.12 mm; $LSD_{0.1\%}$=0.19 mm

We have calculated the fruit deformation difference and the significance for each variety compared between them and we have found that the lowest difference was of 0.07 mm and the greatest one, of 0.59 mm (*Table 3*). However, we found positive significant differences between *Cătălina* and *Cetățuia,* between *Tereza* and *Cetățuia* and

between *Ştefan* and *Cetăţuia* varieties. Very significant positive differences were also found between *Tereza* and *Maria* and between *Ştefan* and *Maria* varieties. The negative significant differences were found between *Maria* and *Golia*, between *Bucium* and *Tereza*, while between *Maria* and *Cătălina* varieties, the recorded differences were very significant and negative.

Table 3 - Deformation difference and significance for the B Factor (variety)

Specification	Differences (mm)	Significance
b_2-b_1	0.34	*
b_3-b_1	0.15	-
b_4-b_1	-0.22	-
b_5-b_1	0.37	*
b_6-b_1	0.3	*
b_7-b_1	0.05	-
b_3-b_2	-0.19	-
b_4-b_2	-0.56	ooo
b_4-b_3	-0.37	o
b_5-b_2	0.03	-
b_5-b_3	0.22	-
b_5-b_4	0.59	***
b_6-b_2	-0.04	-
b_6-b_3	0.15	--
b_6-b_4	0.52	***
b_6-b_5	-0.07	-
b_7-b_2	-0.29	-
b_7-b_3	-0.1	-
b_7-b_4	0.27	-
b_7-b_5	-0.32	o
b_7-b_6	-0.25	-

$LSD_{5\%}$=0.30 mm; $LSD_{1\%}$=0.41 mm; $LSD_{0.1\%}$=0.53 mm

Table 4 showed the results on the deformation difference and the significance for the B Factor (variety) at the same graduation of the A Factor (harvest stage). We have noticed significant positive differences between *Bucium* and *Maria* and between *Ştefan* and *Maria* varieties, at the stage of ripeness (a_2). Distinctively significant positive differences were found between *Cătălina* and *Cetăţuia* and between *Ştefan* and *Maria* varieties before ripening (a_1), while in case of fruit harvest at maturity, the same differences were found between *Tereza* and *Golia* and between *Bucium* and *Maria* varieties.

Very significant positive differences were found before ripeness, between *Tereza* and *Cetăţuia*, *Bucium* and *Maria* and between *Ştefan* and *Cetăţuia* varieties.

Table 4 – Deformation difference and significance for the B Factor (variety) at the same graduation of the A Factor (harvest stage)

Specification	Differences (mm)	Signif.	Specification	Differences (mm)	Signif.	Specification	Differences (mm)	Signif.
a1b2-a1b1	0.77	**	a2b2-a2b1	0.46	-	a3b2-a3b1	0.52	-
a1b3-a1b1	0.51	-	a2b3-a2b1	0.09	-	a3b3-a3b2	-0.35	-
a1b3-a1b2	-0.26	-	a2b3-a2b2	-0.37	-	a3b4-a3b1	-0.68	oo
a1b4-a1b1	0.22	-	a2b4-a2b1	-0.72	oo	a3b4-a3b2	-1.2	ooo
a1b4-a1b2	-0.54	o	a2b4-a2b2	-1.18	ooo	a3b4-a3b3	-0.85	oo
a1b4-a1b3	-0.29	-	a2b4-a2b3	-0.81	oo	a3b5-a3b1	1.02	***
a1b5-a1b1	1	***	a2b5-a2b1	-0.11	-	a3b5-a3b2	0.5	-
a1b5-a1b2	0.24	-	a2b5-a2b2	-0.57	o	a3b5-a3b3	0.85	**
a1b5-a1b3	0.49	-	a2b5-a2b3	-0.2	-	a3b5-a3b4	1.7	***
a1b5-a1b4	0.78	***	a2b5-a2b4	0.61	*	a3b6-a3b1	0.64	*
a1b6-a1b1	1.02	***	a2b6-a2b1	-0.11	-	a3b6-a3b2	0.12	-
a1b6-a1b2	0.26	-	a2b6-a2b2	-0.57	o	a3b6-a3b3	0.47	-
a1b6-a1b3	0.51	-	a2b6-a2b3	-0.2	-	a3b6-a3b4	1.32	***
a1b6-a1b4	0.8	**	a2b6-a2b4	0.61	*	a3b6-a3b5	-0.38	-
a1b6-a1b5	0.02	-	a2b6-a2b5	0		a3b7-a3b1	0.18	-
a1b7-a1b1	0.25	-	a2b7-a2b1	-0.21	-	a3b7-a3b2	-0.34	-
a1b7-a1b2	-0.51	-	a2b7-a2b2	-0.67	o	a3b7-a3b3	0.01	-
a1b7-a1b3	-0.26	-	a2b7-a2b3	-0.3	-	a3b7-a3b4	0.86	**
a1b7-a1b4	0.03	-	a2b7-a2b4	0.51	-	a3b7-a3b5	-0.84	oo
a1b7-a1b5	-0.75	oo	a2b7-a2b5	-0.1	-	a3b7-a3b6	-0.46	-
a1b7-a1b6	-0.77	oo	a2b7-a2b6	-0.1	-			

$LSD_{5\%}$=0.53 mm; $LSD_{1\%}$=0.70 mm; $LSD_{0.1\%}$=0.92 mm

Table 5 – Deformation difference and significance for the A Factor (harvest stage) at the same graduation of the B Factor (variety)

Specification	Differences (mm)	Signif.	Specification	Differences (mm)	Signif.	Specification	Differences (mm)	Signif.
a2b1-a1b1	0.97	***	a3b1-a1b1	1.26	***	a3b1-a2b1	0.29	-
a2b2-a1b2	0.67	**	a3b2-a1b2	1.02	***	a3b2-a2b2	0.35	-
a2b3-a1b3	0.55	*	a3b3-a1b3	0.92	***	a3b3-a2b3	0.37	-
a2b4-a1b4	0.03	-	a3b4-a1b4	0.36	-	a3b4-a2b4	0.33	-
a2b5-a1b5	-0.14	-	a3b5-a1b5	1.28	***	a3b5-a2b5	1.42	***
a2b6-a1b6	-0.16	-	a3b6-a1b6	0.88	***	a3b6-a2b6	1.04	***
a2b7-a1b7	0.51	*	a3b7-a1b7	1.19	***	a3b7-a2b7	0.68	**

$LSD_{5\%}$=0.49 mm; $LSD_{1\%}$=0.65 mm; $LSD_{0.1\%}$=0.85 mm

The same differences were found at the fruit harvest at maturity (a_3), between *Tereza* and *Cetățuia*, *Bucium* and *Maria* and between *Ştefan* and *Maria* varieties.

Negative significant differences were found between *Maria* and *Cătălina* varieties, before ripening, while at the stage of ripeness, these differences were found between *Tereza* and *Cătălina*, *Ştefan* and *Cătălina* and between *Bucium* and *Cătălina* varieties. Distinctively significant negative differences were found between *Bucium* and *Tereza* and between *Bucium* and *Ştefan* varieties, harvested before ripening. At the stage of ripeness, these differences were found between *Maria* and *Cătălina* and *Maria* and *Golia* varieties. At maturity, the same differences were found between *Maria* and *Cetățuia*, *Maria* and *Golia* and between *Bucium* and *Tereza* varieties. Very significant negative differences were found between *Maria* and *Cătălina* varieties, both at the stage of ripeness and at maturity.

The observations on fruit deformation at different harvest stages within the same variety have shown only positive differences with different significance degrees. Thus, very significant differences were found between the maturity stage and before ripening in most of the varieties, except *Maria* Variety. Between the stage of ripeness and before ripening (a_2-a_1), these differences were found only in *Cetățuia* Variety, while between maturity and ripeness stages (a_3-a_2), in *Tereza* and *Ştefan* varieties.

Distinctively significant positive differences were found between the stage of ripeness and before ripening (a_2-a_1) in *Cătălina* Variety and between maturity and ripeness stages (a_3-a_2) in *Bucium* Variety. Significant positive differences were found between the stage of ripeness and before ripening (a_2-a_1) in *Golia* and *Bucium* varieties.

CONCLUSIONS

The device made by the Fruit Growing Research and Development Station of Iaşi is a very simple solution for determining the resistance to deformation of fruits belonging to different fruit species or of grapes.

Compared to the empiric determinations (tasting, touch and crushing between fingers), this device gives the opportunity of concrete determinations of fruit characteristics on tissue firmness, elasticity and compactness.

Although the obtained data confirm the previous estimates on the quality of studied varieties, due to this method we carried out measurements that are more accurate and precise comparison of each variety, as well as the statistical interpretation of results.

By comparing the varieties between them, we found that Maria and Bucium varieties were the most resistant ones to the deformation at all the three harvest stages, significant differences being found compared to the other varieties.

By comparing different harvest stages, significant differences were found between the maturity stage (49-59 days after the end of flowering) and before ripeness (36-46 days after the end of flowering). A difference of 0.98 mm was found because the time interval between these stages was the highest (10 days); thus, the changes of fruit consistency were more visible in most of the studied varieties.

The differences were not statistically assured in Maria Variety, between the three harvest stages, showing a constant fruit firmness during the studied period.

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