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Post-harvest fruit rot incidence depending on apple maturity

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Abstract. The effect of fruit maturity on apple storage ability and rot development was investigated in 2003–2004 at the Lithuanian Institute of Horticulture. Two apple cultivars 'Ligol' and 'Lodel' on M.26 rootstock were tested. Fruits were harvested 5 times at weekly intervals and were stored for six months in cold storage. Maturity index was calculated at each harvesting.

Fruit quality parameters and rot incidence were evaluated after 90, 150 and 180 days of storage. While in storage 'Lodel' apple rot was caused by *Monilinia* sp., *Gloeosporium* spp., *Penicillium* spp., *Alternaria* spp. and *Botrytis* sp. Cv. 'Ligol' apples were infected by *Monilinia* sp., *Gloeosporium* spp. and *Penicillium* spp. Both tested cultivars were mostly infected by fungus of *Gloeosporium* genus. Cv. 'Lodel' was more sensitive to fungal rots.

The time and intensity of rot incidence depended on cultivar, harvest date and climatic condition during the vegetation. More rot injuries were detected on apples picked later. A significantly smaller number of rotten apples was recorded in apples picked at optimum maturity. Cold and wet weather during the ripening period determined an earlier and significantly higher occurrence of fungus during storage.

Key words: *Malus x domestica*, fruit rot, harvest date, maturity index, storage

INTRODUCTION

Development of rots during ripening and storage of apples depends on a range of pre-harvest factors. The most important of these is maturity of fruits at harvest (Kvikliene, 2001; Ferguson et al., 1999). Identification of optimal harvest time raises a possibility of growing fruits less predisposed to rots and post-harvest disorders (Kvikliene, 2004). Decay caused by fungal plant pathogens can lead to considerable post-harvest losses, varying widely with cultivar, production area, and season, but is well known that these losses can be significant (McCollum, 2002). Of the >100,000 species of fungi, < 10% are plant pathogens and < 100 species of fungi are responsible for the majority of post-harvest diseases (Eckert & Ratnayake, 1983). The most significant are blue mold, caused by *Penicillium expansum* Link; brown rot, caused by *Monilinia fructigena* Honey, *Gloeosporium* rot, caused by *G. album* Osterw and *G. frugtigenum* Berk. (Dennis, 1983; Amiri & Bompeix, 2005).

MATERIALS AND METHODS

The effect of fruit maturity on apple storage ability and rot development was investigated in 2003–2004 at the Lithuanian Institute of Horticulture. Two apple

cultivars - 'Ligol' and 'Lodel' on M.26 rootstock - were tested. Fruits were harvested 5 times at weekly intervals. At each picking, 10 fruits from each replication were taken for laboratory measurements: firmness (kg cm^{-2}, measured with penetrometer FT-327 with 11 mm diameter probe), soluble solids concentration (%, with refractometer), starch index. Maturity index was calculated as F/RS (F- firmness, R – soluble solids concentration, S - starch conversion). With each picking, 100 fruits from each replication were taken in order to measure storability (firmness, soluble solids concentration, weight loss, storage disorders and rots). Fruit quality parameters and rot incidence were evaluated after 90, 150 and 180 days of storage.

The incidence (%) of fruit-rot was established according to the following formula: A = B / C*100%; A – incidence of fruit-rot; B – the number of samples exhibiting rot, C – total number of investigated samples.

The climatic conditions in 2003 were close to the yearly average. September was dryer, but three times more precipitation was recorded in the 1st decade of October. The year 2004 was colder and wet. Twice the amount of precipitation was recorded in August and at the end of September.

Experimental data were subjected to analysis of variance. For mean separation a LSD test at $P = 0.05$ was used. Data was analyzed by 'ANOVA' statistical program.

RESULTS AND DISCUSSION

All tested fruit quality indices changed according to the time of harvest. However, the rate of change was dissimilar for each cultivar and depended on yearly climatic conditions. The calculated maturity index indicated earlier ripening of fruits in 2003 (Tables 1, 2). The incidence of rot was closely connected to fruit maturity. Apples picked later were more sensitive to rot. Similar results were recorded with other apple cultivars (Dris & Niskanen, 1999; Elgar et al., 1999; Ingle et al., 2000; Kvikliene, 2001).

While in storage 'Lodel' apple rot was caused by *Monilinia* sp., *Gloeosporium* spp., *Penicillium* spp., *Alternaria* spp. and *Botrytis* sp. Cv. 'Ligol' apples were infected by *Monilinia* sp., *Gloeosporium* spp. and *Penicillium* spp. Both tested cultivars were primarily infected by the fungus of *Gloeosporium* genus (Tables 1, 2).

Significantly lower damages by fungal rot diseases of both cultivars were observed in 2003, probably due to more favourite climatic conditions. The highest percentage (7%) of damaged apples of cv. 'Ligol' was recorded at the 4th and 5th harvest times (Table 1). 85% of apple rots were caused by *Gloeosporium* spp. and 15% by *Penicillium* spp. *Monilinia* sp. affected only apples picked at the 1st and 5th harvest. In 2004 a high incidence of rot was observed at the 3rd (optimal) harvest time because of the high rate of precipitation. A 7.4% of 'Ligol' apples were damaged after only 90 days of storage; the damage increased up to 13.8% after 180 days. *Penicillium* spp. was most frequently recorded during the first 90 days of storage, while the incidence of *Gloeosporium* spp. generally increased with longer apple storage. Similar results are recorded by Amiri & Bompeix (2005). Cv. 'Lodel' was more sensitive to fruit-rot pathogens and, additionally, two species, *Alternaria* spp. and *Botrytis* sp., were found in 2004 (Table 2). Overall tendencies of rot development and their dependency on fruit harvest and storage time were analogous to cv. 'Ligol'.

Table 1. Effect of cv. 'Ligol' apple maturity on fruit rot incidence, 2003–2004.

Harvest	Maturity index		Days of storage	Rots, %							
				Monilinia sp.		*Gloeos porium* spp.		*Penicillium* spp.		total	
	2003	2004		2003	2004	2003	2004	2003	2004	2003	2004
1	0.38	0.70	90	0	0	0.5	0.3	0.3	1.5	0.8	1.8
			150	0	0	1.5	2.5	0.5	0.5	2.0	3.0
			180	0.3	0	0.5	1.8	0	0	0.8	1.8
			total	0.3	0	2.0	5.0	0.8	2.0	3.6	6.5
2	0.16	0.53	90	0	0	0.5	0	0	0.8	0.5	0.8
			150	0	0	0	3.3	0	1.5	0	4.8
			180	0	0	0.8	4.5	0	0.5	0.8	5.0
			total	0 b	0	1.3	7.8	0	2.8	1.3	10.6
3	0.11	0.30	90	0	0.8	0	0.8	0.3	5.8	0.3	7.4
			150	0	0	0.8	7.8	0	1.5	0.8	9.3
			180	0	0.5	0.5	11.8	0	1.5	0.5	13.8
			total	0	1.3	1.3	20.3	0.3	8.8	1.6	32.0
4	0.09	0.22	90	0	0.3	0	0.5	0	1.5	0	2.3
			150	0	0	3.5	6.8	1.0	2.5	4.5	9.3
			180	0	1.0	2.5	16.8	0	0.5	2.5	18.3
			total	0	1.3	6.0	24.1	1.0	4.5	7.0	29.9
5	0.07	0.14	90	0.3	0	0.5	0	0	0.5	0.8	0.5
			150	0	0	1.8	5.5	1.0	1.0	2.8	6.5
			180	0	1.0	6.0	14.3	0	0.8	6.0	16.1
			total	0.3	1.0	8.3	19.8	1.0	2.3	9.6	23.1
LSD 05				0.15	0.56	1.60	2.84	0.38	0.42	1.65	3.6

Table 2. Effect of cv. 'Lodel' apple maturity on fruit rot incidence, 2003–2004.

Harvest	Maturity index	Days of storage	Rots, %					
			Monilinia sp.	Gloeos porium Spp.	Penicillium spp.	Alternaria spp.	Botrytis sp.	total
1	0.31	90	0	0	0	0	0	0
		150	0	0.8	0.3	0	0	1.1
		180	0	2.3	0	0	0	2.3
		total	0	3.0	0.3	0	0	3.3
2	0.20	90	0	0	0	0	0	0
		150	0	0	0	0	0	0
		180	0.5	5.0	0	0	0	6.5
		total	0.5	5.0	0	0	0	6.5
3	0.15	90	0	0	0	0	0	0
		150	0	0	0.5	0	0	0.5
		180	0	1.3	0	0	0	1.3
		total	0	1.3	0.5	0	0	1.8
4	0.11	90	0	0.5	0	0	0	0.5
		150	0	1.5	0.3	0	0	1.8
		180	2.5	5.3	0.5	0	0	8.3
		total	2.5	7.3	0.8	0	0	10.6

	Table 2 continued							
5	0.07	90	0	0	0	0	0	0
		150	0	3.4	2.5	0	0	6.3
		180	2.5	10.0	0.8	0	0	13.3
		total	2.5	13.8	3.3	0	0	19.6
	LSD 05		0.98	1.69	0.53	0	0	2.28
				2004				
1	0.47	90	0	0	0.5	1.0	0.25	1.75
		150	4.3	0	0.3	1.5	0.5	6.6
		total	4.3	0	0.8	2.5	0.8	8.4
2	0.49	90	0.3	0	1.0	0	0	1.3
		150	7.5	0	0.3	3.5	0.5	11.8
		total	7.8	0	1.3	3.5	0.5	13.1
3	0.32	90	2.3	0.8	0	1.5	0.5	5.1
		150	5.5	45.3	2.0	0.8	0	53.6
		total	7.8	46.0	2.0	2.3	0.5	58.6
4	0.19	90	1.0	1.3	1.5	6.5	0	10.3
		150	5.5	59.3	1.0	0	0	65.8
		total	6.5	60.6	2.5	6.5	0	76.1
5	0.16	90	4.0	3.8	0.3	1.8	0	9.9
		150	18.0	17.0	0	0	0	35.0
		total	22.0	20.75	0.3	1.8	0	44.9
	LSD 05		1.58	4.53	0.38	1.67	0.56	4.14

CONCLUSIONS

During storage, apples of cv. 'Ligol' are infected by *Monilinia* sp., *Gloeosporium* spp. and *Penicillium* spp. Cv. 'Lodel' is more sensitive to fungal rots and is infected by *Monilinia* sp., *Gloeosporium* spp., *Penicillium* spp., *Alternaria* spp. and *Botrytis* sp. Both tested cultivars were mostly infected by fungus of *Gloeosporium* genus. *Monilinia* sp. damages only fruits of the earliest and the latest maturity stage.

Significantly fewer amounts of rotten apples were recorded in those picked at optimum maturity.

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