Tree growth and some other characteristics of new columnar apple cultivars bred in Holovousy, Czech Republic

J. Blažek, J. Křelinová

Research and Breeding Institute of Pomology Holovousy, Ltd., Holovousy, Czech Republic

Abstract

Blažek J., Křelinová J., 2011. **Tree growth and some other characteristics of new columnar apple cultivars bred in Holovousy, Czech Republic**. Hort. Sci. (Prague), *38*: 11–20.

Several characteristics related to tree growth, their fruitage and resistance against scab and powdery mildew were assessed during 2007–2008 on five new cultivars in comparison with the ancestral McIntosh Wijcik, in which 4 out of 5 had their pedigree. In several plots established between 1998 and 2006, the trees, which were on different rootstocks predominantly planted in spacing 4 × 0.5 m, were grown as vertical cordons practically without any pruning or shaping. Besides the first years after the planting these columnar trees generated very limited side branching. The cultivars mutually differ in tree vigour, spurring density, and size of fruiting spurs. Mean annual prolongation of central axes in the case of the trees on vigorous rootstocks varied within 30.8–57.5 cm, however, on M 9 rootstock it was distinctly shorter (23.4–34.1 cm). Beyond cultivar and rootstock the length of the annual prolongation was also significantly influenced by fruit set level. Trees of the Kordona cultivar were generally the most vigorous while those of Pidi were the weakest. The biennial pattern of bearing observed to an extent on nearly all the cultivars was connected with tendency to over-crop the trees. The highest annual yield equal to 10.3 kg was generated on trees of Kordona on MM 106, which corresponds to a total harvest of 25.7 t/ha. Cultivars Herald and Slendera possessed combined resistance both to scab and powdery mildew, whereas Kordona and Cumulus were resistant only to scab, but were in different degrees susceptible to mildew.

Keywords: apple; cultivars; columnar growth; tree vigour; yields; scab; powdery mildew; resistance

The history of apple cultivars possessing columnar tree growth habit started in 1960 when a mutant of the characteristic was found in a McIntosh orchard in Canada and according to the name of the owner was named McIntosh Wijcik (Fisher 1970). Shortly afterwards it was included in extensive testing and also in numerous breeding programmes as a remarkable donor in North America and Europe (Lapins 1974, 1976; Looney, Lane 1984; Lespinasse et al. 1985; Tobutt 1985, 1991; Kesley, Brown 1992; Kellerhals, Meyer 1994).

Although the first cultivars possessing columnar tree growth that originated from these programmes were not yet comparable to standard ones regarding their fruit quality and some other important characteristics (e.g. Tobutt 1988a, b), some cultivars of subsequent generations were much better and worthwhile for some systems of commercial growing (Khanizadeh et al. 2000; De Wit et al. 2004; Ikase, Dumbravsm 2004; Inomata et al. 2004, 2005; Gelvonauskienė et al. 2006; Gelvonauskis et al. 2006). Columnar apple cultivates of the latest

Supported by the Ministry of Agriculture of the Czech Republic, Projects No. QH81235 and QH81142.

Table 1. Origin and history of evaluated cultivars

Cultivar	Selection number	Parents (parental cross)	Year of			
			crossing	first step of selection	final selection	breeders right protection
Cumulus	HL175	Selena × McIntosh Wijcik	1992	1999	2006	2007
Herald	HL5	Florina × Telamon	1993	1999	2006	2007
Kordona	HL 393	McIntosh Wijcik × Florina	1991	1997	2001	2006
Pidi	HL 75-26-18	Britemac × Prima	1974	1985	2000	2005
Slendera	HL4	Florina × Telamon	1993	2000	2008	2009

generation include also resistance to diseases and additional desirable features (Braniste et al. 2008).

In the Czech Republic, researchers have been breeding apples focused on very compact and columnar tree growth habit since 1971. Our first promising selections were included in trials and testing during the early eighties (Blažek 1983, 1985, 1992). The first cultivar possessing a typical columnar growth from this programme, which was named Kordona, was submitted for cultivar registration in 2001 (Blažek 2001). Additional cultivars of this type were released shortly afterwards (Blažek 2005, 2006).

The present paper is focused on tree growth characteristics, yields, and resistance to diseases of our columnar apple cultivars, which were studied for 3 years (2007–2009), and on all their fruiting trees presently available in selection plots and trial plantings in Holovousy, Czech Republic. Our main aim was an evaluation of these characteristics using the oldest trees as possible and different rootstocks. Besides the columnar cultivars, the cultivar Pidi which grew extremely weakly and possesses similar tree growth although it is not related to the McIntosh Wijcik, was also included in this study. The cultivar McIntosh Wijcik itself was evaluated as well to be used for comparison with the new cultivars.

MATERIAL AND METHODS

All the evaluated trees were located in several experimental orchards in Holovousy, Ltd., Czech Republic. Climatic conditions of the location are characterised by an average annual temperature of 8.1°C and the average annual rainfall of 650 mm. The soil was medium loam sandy with a rather deep cultivated layer on gravely substrate. All plots were located at an altitude close to 300 m a.s.l.

Basic information on the origin and course of the evaluated cultivars development are presented in Table 1. The complete survey of evaluated material according to the variants of cultivar-rootstock combinations, their age and numbers of trees are provided in Table 2. Trees in experimental orchards established in 1998 were planted in the spacing of 4 × 1 m and all of them were planted afterwards in spacings of 4 × 0.5 m. One year old budded non branched trees were mostly used for the planting and only in cases in which they were too small (e.g. Pidi), two year old trees were planted instead. The trees after planting were mostly individually bound to wooden stakes to keep an upright position during their subsequent growth but were not pruned. In some plots trees on vigorous rootstocks were planted without support but during the following years were adjusted to a desirable position, where they were attached to a wire drawn in the direction of each row 2 m above the ground.

No irrigation was applied in the experimental plots. Clean strips were kept under the trees by contact herbicides, whereas frequently cut sod was kept in alleys between the tree rows. Fertilisers were applied according to soil analyses. Spraying treatments against pests and diseases were applied according to recommendations of the monitoring service for plant protection in the institute. The only exception to this approach was the omission of fungicide treatments that in some plots and in some years was carried out to assess cultivar resistance against diseases. No tree pruning was applied except the removal of side shoots and branches that sometimes appeared on the central axis of trees.

The present study took place between 2007 to 2009, when the following characteristics were annually evaluated on each tree: length and thickness

Table 2. Survey of evaluated cultivars, rootstocks, final age and numbers of trees and their basic growth parameters

Cultivar	Rootstock	Year of planting	Final tree age	Number of trees	High of trees (m)				Trunk cross-section area (cm^2)				Side shoots or branches	
					mean	IS (P = 0.05)	Min	Max	mean	IS (P = 0.05)	Min	Max	annual mean number	Max number per tree
Cumulus	J-TE-E seedling	1998	12	3	4.35	0.28	4.1	4.6	37.4	8.0	29.8	43.9	0.67	1
		2002	8	8	3.17	0.26	2.6	3.7	17.3	3.2	12.6	25.2	0.78	2
		2006	4	3	2.33	0.08	2.0	2.5	9.3	1.5	5.7	7.5	1.55	3
Herald	J-TE-E	1998	12	1	3.62	–	–	–	20.4	–	–	–	0.33	1
	M 9 seedling	2005	5	1	1.55	–	–	–	3.8	–	–	–	0.67	1
		2002	8	3	2.84	0.39	2.5	3.1	19.1	2.9	16.5	24.4	0.50	2
		2005	5	7	2.20	0.15	1.7	2.4	15.1	3.3	11.8	17.4	0.64	2
Kordona	J-TE-E	1999	11	21	5.56	0.26	3.9	5.7	39.2	3.7	28.2	45.3	0.84	2
	M 26	2002	8	11	3.85	0.34	2.5	4.4	10.3	2.6	6.6	15.9	0.75	3
	M 9	2003	7	8	2.81	0.21	2.4	3.2	5.2	1.5	3.8	7.5	0.41	1
	MM 106	2003	7	5	4.13	0.19	3.8	4.3	23.2	2.7	20.4	25.5	1.27	2
	seedling	2006	4	3	2.95	0.19	2.3	2.6	5.9	2.2	3.1	6.2	1.77	3
McIntosh Wijcik	M 26	2003	7	5	2.51	0.10	2.4	2.6	10.7	3.9	8.0	14.5	0.80	2
	M 9	2002	8	10	2.06	0.17	1.4	2.1	4.7	1.1	2.0	4.5	0.53	2
	seedling	2006	4	3	1.90	0.25	1.7	2.2	5.0	2.0	4.2	6.6	1.22	2
Pidi	M 9	2002	8	5	1.81	0.09	1.7	2.0	3.9	1.1	3.5	4.5	1.73	3
		2003	7	10	1.87	0.08	1.7	2.1	5.0	1.5	3.5	6.6	2.10	4
Slendera	M 9 seedling	2006	4	5	1.92	0.06	1.9	2.4	3.1	0.6	2.3	4.5	0.93	2
		2002	8	7	3.55	0.30	3.9	4.8	20.5	2.5	15.9	22.2	0.71	2
		2006	4	22	2.73	0.25	2.5	3.6	11.1	3.8	10.5	15.3	1.06	3

Table 3. Selected growth characteristics of prolonging shoots from 2007–2009

Cultivar	Root-stock	Age of trees in 2009	2007							2008							2009						
			prolonging shoot						length of internodes (mm)	prolonging shoot						length of internodes (mm)	prolonging shoot						length of internodes (mm)
			length (cm)				thickness (mm)			length (cm)				thickness (mm)			length (cm)				thickness (mm)		
			Ø	IS	Min	Max	Ø	IS		Ø	IS	Min	Max	Ø	IS		Ø	IS	Min	Max	Ø	IS	
Cumulus	J-TE-E	12	39.2	6.6	33	43	11.3	1.9	19.0	33.7	1.9	32	35	10.4	4.14	19.9	45.7	6.5	42	52	11.3	1.6	22.2
	seedling	8	42.5	3.9	36	60	11.7	1.0	20.4	51.0	4.9	42.9	64.1	12.5	1.2	20.4	42.2	5.6	39	58	10.5	1.0	20.6
		4	44.7	2.3	33	54	12.3	0.5	18.3	49.9	3.3	37.2	59.8	11.8	0.6	18.3	49.3	3.7	40	62	12.3	0.9	18.3
Herald	J-TE-E	12	38.3	–	–	–	11.8	–	21.2	31.4	–	–	–	10.4	–	20.1	45.0	–	–	–	12.9	–	18.7
	M 9	5	22.7	–	–	–	10.9	–	19.4	25.0	–	–	–	10.6	–	17.5	22.5	–	–	–	9.7	–	17.9
	seedling	8	39.4	4.3	26	47	13.7	1.6	22.9	34.5	6.9	30	38	12.9	1.4	18.6	40.5	5.9	37	47	12.5	1.9	15.5
		5	40.8	6.2	32	49	13.2	1.2	20.5	35.8	3.4	29	41	13.2	1.5	19.4	39.9	4.1	33	46	12.3	1.7	16.9
Kordona	J-TE-E	11	46.3	4.1	38	54	9.5	1.3	19.5	57.5	5.5	20	79	11.1	0.6	18.6	48.3	4.8	35	87	11.8	0.9	19.2
	M 26	8	34.8	4.5	27	42	7.1	0.9	18.3	48.9	4.7	38	73	9.1	0.8	18.0	30.6	6.1	19	45	6.6	0.8	18.3
	M 9	7	26.4	3.4	22	35	6.0	0.7	16.0	35.6	7.2	32	49	6.9	1.2	17.3	20.8	4.9	16	35	7.0	1.2	15.3
	MM 106	7	54.8	5.0	43	65	9.2	0.9	19.6	76.4	6.9	64	86	11.8	1.9	20.8	40.2	5.6	29	57	11.0	1.9	20.9
	seedling	4	60.3	7.2	32	77	11.6	1.9	21.8	62.3	3.6	42	77	10.5	1.7	22.3	71.0	7.7	63	82	11.7	1.7	22.9
McIntosh Wijcik	M 26	7	26.4	5.8	26	40	11.1	1.3	18.8	35.6	6.0	37	53	11.6	2.6	18.0	34.6	5.3	26	41	11.2	1.6	18.0
	M 9	8	21.2	3.6	7	29	6.9	2.8	15.3	19.0	3.7	12	29	6.3	1.1	15.6	18.0	4.8	9	25	6.2	0.9	14.6
	seedling	4	18.5	5.3	40	46	8.8	0.5	19.3	33.5	2.3	31	57	10.3	0.7	17.4	40.3	3.5	37	46	10.3	0.7	20.4
Pidi	M 9	8	11.2	3.8	6	19	6.7	0.9	10.8	15.6	2.6	11	19	7.4	0.9	12.8	10.8	1.5	8	13	7.4	1.0	7.8
		7	19.0	4.4	7	28	9.2	1.8	12.9	18.2	2.0	15	25	7.2	0.7	11.4	11.9	1.8	9	17	7.2	0.5	8.4
Slendera	M 9	4	34.4	4.9	22	38	8.5	0.5	16.9	30.6	5.9	23	42	10.1	0.7	15.1	37.4	7.3	17	52	11.6	0.5	15.5
	seedling	8	51.2	5.73	30	60	9.9	0.8	17.9	54.3	5.6	29	60	11.4	1.7	17.3	56.9	6.3	29	65	12.8	2.1	18.7
		4	59.5	4.0	42	72	10.1	1.3	18.2	50.2	5.3	35	56	10.9	1.1	18.1	59.5	5.9	42	69	12.9	0.3	18.4

Table 4. Rates of spurring and basic parameters of spurs

Cultivar	Rootstock	Age of trees	Annual shoots			Old part of axis fruiting spurs							
			share of trees with spurs	spur		2nd year				3rd year			
				number	length (mm)	mean number	length (mm)			mean number	length (mm)		
			%	Ø	Ø		Ø	Min	Max		Ø	Min	Max
Cumulus	J-TE-E	12	0	0	0	14.0	12.6	10	27	13.0	25.6	8	31
	seedling	8	12.5	1	8	17.4	10.9	9	19	10.2	28.1	20	35
		4	33.3	2	12.5	19.5	9.7	9	21	14.7	26.3	7	38
Herald	J-TE-E	12	0	0	0	10.0	15.5	11	23	8.0	30.8	12	52
	M 9	5	0	0	0	10.0	13.0	7	28	8.0	23.7	11	34
	seedling	8	33.3	2	16.5	14.3	18.4	8	33	8.9	35.4	10	56
		5	28.6	2.33	13.3	14.8	17.1	15	20	10.1	28.8	19	40
Kordona	J-TE-E	11	0	0	0	25.0	16.1	10	21	14.1	28.2	17	41
	M 26	8	0	0	0	22.4	14.9	8	19	8.9	26.2	15	42
	M 9	7	0	0	0	17.2	13.1	11	15	8.0	21.9	13	26
	MM 106	7	0	0	0	30.6	15.8	12	22	9.5	27.4	14	45
	seedling	4	0	0	0	22.2	14.6	11	23	24.2	20.8	14	29
McIntosh Wijcik	M 26	7	20	1	6	13.7	12.4	12	13	11.7	25.3	8	37
	M 9	8	0	0	0	9.3	11.5	7	17	7.4	22.2	9	35
	seedling	4	0	0	0	14.5	10.3	9	16	14.5	18.3	10	21
Pidi	M 9	8	20	1	9	5.2	11.8	8	15	3.2	19.6	16	22
		7	0	0	0	6.6	11.4	6	18	2.3	19.7	15	24
Slendera	M 9	4	0	0	0	15.2	12.8	4	25	15.5	12.8	8	33
	seedling	8	14.2	2	10.5	18.8	14.4	8	25	16	23.4	10	44
		4	13.6	1.3	8.3	17.5	17.5	4	30	17.5	23.1	12	39

of prolonging shoots, length of their internodes, number of side shoots, number and length of spurs on annual shoots, fruit set (1–9), scab and mildew incidence on leaves and shoots (1–9). Furthermore, total weights of all harvested fruits were recorded for each evaluated variant (cultivar, rootstock, age). Fruit set was recorded on a 1–9 rating scale where 1 is equal to no and 9 to maximal fruit set. In a similar rating scale used for disease incidence the number 1 corresponds to maximal and 9 to no infestation. From 2008, the numbers and length of spurs on second and third year old parts of central axis of each tree were also recorded. All measurements and counting of shoots and spurs were done after the end of the growing season. At the end of 2009, the total height of trees and basic trunk cross-section area of each tree were measured. All data were statistically evaluated by an analysis of variance.

RESULTS

Tree vigour

Figures on parameters of total tree performance presented in Table 2 roughly indicate the influence of cultivars, rootstocks, and tree age on this characteristic. These figures have to be compared in relation to tree age. The most vigorous were young trees at the beginning of bearing on seedling rootstock. Older trees grew much less obviously in relation to higher levels of cropping. Regarding cultivars, the highest vigour was generally promoted by Kordona followed by Cumulus, Slendera and Herald, whereas trees of Pidi grew the weakest. Regarding trunk cross-section area, the relatively highest values of this characteristic were promoted by the rootstock J-TE-E followed by the seedlings, MM 106 and M 26. On the other hand, the lowest values of the param-

Table 5. Fruit set and yields per tree from 2007–2009

Cultivar	Rootstock	Age of trees in 2009	2007				2008				2009			
			fruit set (1–9)			Ø yield per tree (kg)	fruit set (1–9)			Ø yiel per tree (kg)	fruit set (1–9)			Ø yield per tree (kg)
			Ø	Min	Max		Ø	Min	Max		Ø	Min	Max	
Cumulus	J-TE-E	12	3.7	1	7	4.1	6.0	5	7	10.1	4.3	4	5	6.8
	seedling	8	2.4	1	4	0.9	4.4	1	6	3.0	5.0	3.0	7	5.0
		4	1.0	1	1	0	1.0	1	1	0	6.7	5	8	2.2
Herald	J-TE-E	12	5.0	–	–	4.2	8.0	–	–	9.2	6.0	–	–	7.7
	M 9	5	3.0	–	–	0.5	5.0	–	–	1.1	9.0	–	–	3.5
	seedling	8	2.3	1	3	0.8	4.4	2	5	2.6	7.6	4	9	6.7
		5	2.2	1	3	0.3	5.0	4	6	1.3	7.8	7	8	3.9
Kordona	J-TE-E	11	5.5	1	8	9.8	4.8	1	8	9.4	2.4	1	8	4.2
	M 26	8	5.7	2	9	5.7	5.4	2	6	6.4	5.7	2	9	8.5
	M 9	7	5.6	5	6	4.2	4.3	2	7	3.6	7.4	3	8	8.6
	MM 106	7	4.1	2	6	3.8	3.6	2	5	4.2	5.8	3	8	10.5
	seedling	4	1.0	1	0	0	1.7	1	2	0.5	3.7	2	5	2.6
McIntosh Wijcik	M 26	7	2.2	1	7	0.5	6.4	3	8	3.1	2.8	1	8	1.3
	M 9	8	6.6	4	8	1.4	4.6	1	7	1.1	7.8	7	8	2.8
	seedling	4	1.0	1	1	0	1.0	1	1	0	3.5	2	5	1.0
Pidi	M 9	8	6.9	2	9	2.8	5.8	2	7	2.6	4.8	2.0	6	2.5
		7	7.8	6	9	3.0	5.0	3	6	2.4	4.2	2.0	6	2.2
Slendera	M 9	4	2.5	1	4	0.7	6.4	4	8	3.2	5.8	1	9	3.9
	seedling	8	6.2	3	7	3.4	3.3	3	4	2.3	7.1	5	9	8.7
		4	1.0	1	1	0	1.6	1	3	0.3	3.8	1	6	2.3

eter were recorded on trees growing on M 9. In comparison of the cultivars, the highest values of trunk cross-section area were induced by Cumulus followed by Herald and Kordona. In the case of Slendera, extremely contradictory values of the parameter were found depending on the rootstock used (very low on M 9 and high on seedling).

All the evaluated cultivars possessing columnar growth habit had a limited tendency for producing side shoots and branches. Generally, younger trees produced the higher number of shoots, while on older trees their occurrence was lower. More shoots were promoted by vigorous rootstocks and the least on M 9. Their production was relatively the highest on Kordona, whereas on seedlings the value was 1.8 and on tree year old trees on MM 106 on average 1.3 side shoots was recorded. A somewhat smaller tendency for side branching was recorded on trees of Cumulus, followed in this characteristic by Slendera and Herald. On the contrary, the highest tendency towards side branching was observed in Pidi, which however, does not posses a typical columnar tree habit.

Prolonging shoots

The growth performance of annual prolonging of the tree central axis for all the studied variants and years is presented in Table 3. The longest shoots during the entire evaluated period both in mean and maximal values were recorded in Kordona, followed in decreasing order by Slendera, Cumulus, Herald, McIntosh Wijcik, and Pidi. Regarding rootstocks, the order was the following: seedling, MM 106, J-TE-E, M 26, and M 9. Kordona was

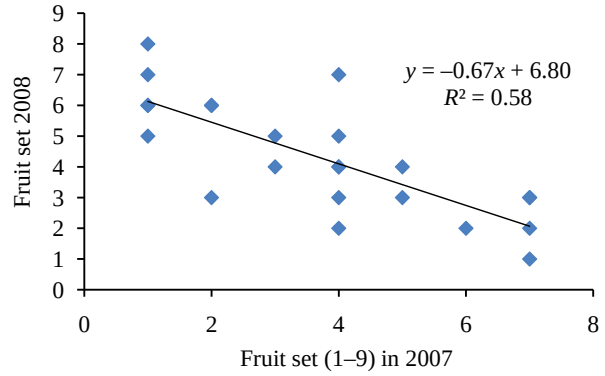

Fig. 1. Fruit set impact of Kordona on J-TE-E rootstock in 2007 on its values in 2008

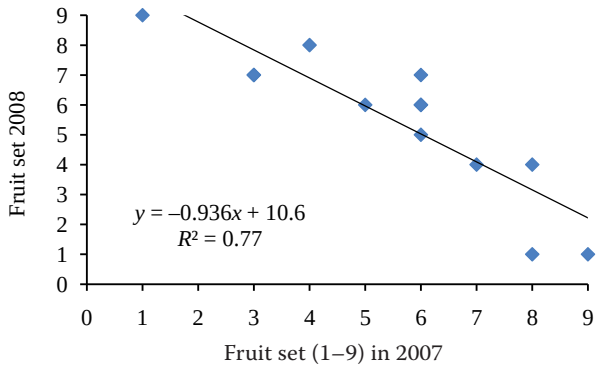

Fig. 2. Fruit set impact of McIntosh Wijcik in 2007 on its values in 2008

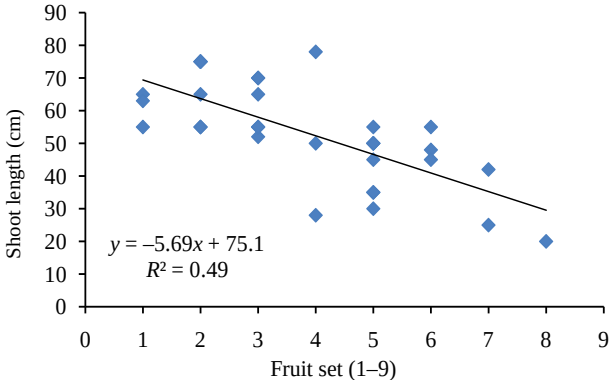

Fig. 3. Impact of fruit set on shoot length of Kordona on J-TE-E in 2008

distinguished from other cultivars by a relatively smaller basal thickness of prolonging shoots. The mean values of the internode lengths were tightly correlated to the length of shoots with the exception of Slendera, which generally had significantly shorter internodes than Cumulus and Herald.

Fruiting spurs

The spurring habit and main parameters of fruiting spurs are presented in Table 4.

The highest tendency for the development of spurs on one year old shoots was present in Herald and Cumulus followed by McIntosh Wijcik, Pidi and Slendera; yet, it was especially evident on vigorous rootstocks.

The efficiency of spurring expressed as a percentage of buds that developed into spurs in the two year old part of the central axis was the highest in Kordona (up to nearly 90%) followed by McIntosh Wijcik, Cumulus, and Herald. Less efficient in this respect were Slendera and Pidi (around 50%). Regarding rootstocks, M 9 generally promoted a higher percentage of spurring whereas the seedling was significantly less effective in this respect. Figures for spurring on the three year old part of the central axis were similar although mostly a little lower.

Mean length of spurs on the second year part of central axis was the longest in Herald and Slendera (up to nearly 19 mm), which also promoted its maximum length of about 30 mm. Behind both cultivars followed in decreasing order: Kordona, McIntosh Wijcik, Pidi, and Cumulus (mean length around 10 mm). Trees on M 9 rootstock had significantly shorter length than those grown on seedling or the more vigorous ones. The length of spurs on the three year old part of central axis was nearly doubled on average and its highest values were recorded in Herald (up to 56 mm). The influence of rootstock was similar as on the younger part of the axis.

Fruit set and yield

Values of fruit set recorded on a 1–9 rating scale and mean yields per tree in kg for the period between 2007–2009 are presented in Table 5. The highest values of fruit set were recorded on the tree of Herald grown on J-TE-E that were followed in decreasing range by McIntosh Wijcik, Pidi, Kordona, and Herald grown on M 9. On the contrary, the lowest fruit sets were recorded on trees Cumulus, Kordona, Slendera, and McIntosh Wijcik, which were planted on seedling in 2006 and in the last year were at the stage of beginning to fruit. The highest total yield per tree during three years was equal to 23.3 kg, it was recorded in Kordona on J-TE-E. Practically the

Table 6. Scab and mildew incidence recorded by 1–9 rating scale on evaluated cultivars 2007–2009

Cultivar	Rootstock	Age of trees in 2009	Protection by fungicides	Scab		Mildew	
				mean score	Max	mean score	Max
Cumulus	J-TE-E	12	yes	9	9	6.3	5
	seedling	8	yes	9	9	7.0	6
		4	no	9	9	5.5	4
Herald	J-TE-E	12	yes	9	9	8.7	8
	M 9	5	yes	9	9	8.5	8
	seedling	8	yes	9	9	8.3	8
		5	no	9	9	8.0	7
Kordona	J-TE-E	11	yes	9	9	5.7	5
	M 26	8	yes	9	9	6.0	5
	M9	7	yes	9	9	5.3	5
	MM106	7	yes	9	9	5.0	4
	seedling	4	no	9	9	4.0	3
McIntosh Wijcik	M26	7	yes	9	9	8.3	8
	M9	8	yes	9	9	8.7	8
	seedling	4	no	4.7	3	7.3	7
Pidi	M9	8	yes	9	9	8.0	8
		7	no	7.3	6	7.3	7
Slendera	M9	4	yes	9	9	8.7	8
	seedling	8	yes	9	9	8.5	8
		4	no	9	9	8.0	7

1 – maximal infestation, 9 – no sign of infestation

same yields were harvested from trees of Herald and Cumulus on the same rootstock. The highest annual yield per tree 10.3 kg was harvested from Kordona on MM 106, which is roughly in level corresponding to 25.7 t/ha.

Mean productivity of trees that were of an older age were more or less negatively influenced by the biennial pattern of their bearing. This is illustrated by two examples of cultivar-rootstock combinations evaluated in a great number of trees (Figs 1 and 2). The correlations between fruit set in the current and subsequent year were highly significantly negative.

Similarly, reverse but less significant was the impact of fruit set level on the length of annual prolongation of the central axis illustrated by statistical analyses of data collected in 2008 on Kordona trees grafted on J-TE-E (Fig. 3).

Disease resistance

Mean data from the evaluation of scab and mildew incidence from the three growing seasons are presented in Table 6. The stability of scab resistance of all new columnar cultivars bred in Holovousy, Czech Republic was confirmed. Slight infection of scab was observed on trees of Pidi cv. in a plot without fungicide protection. To a larger extent, charging by scab both on the leaves and fruits was recorded only on control trees of the control cultivar McIntosh Wijcik, but still it seems that the disease was weaker than is commonly incident on standard McIntosh without protection.

Regarding powdery mildew, the most severe infection was observed on Kordona, even on the plots protected by fungicides. Slightly less infected was

Cumulus. Trees that were much less infected were McIntosh Wijcik, and Pidi. And trees nearly without visible signs of infection were those of Herald and Slendera, which could practically be considered as resistant to the disease.

DISCUSSION

The variability of tree vigour among columnar cultivars evaluated in this study is comparable to the results in similar studies published previously (e.g. Zhang 2002; Ikase, Dumbravs 2004; Inomata et al. 2004). Also, the influence of rootstocks on the vigour and especially the promoting effect of MM 106 in this respect were confirmed by earlier studies (Gelvonauskis et al. 2006).

Rates and frequencies of side branching found in this study are significantly smaller than those found in Latvia (Gelvonauskienė et al. 2006). Generally, this discrepancy could be partly explained by the differences in the age of the materials used for both studies; in our study, the materials were much older. Another reason for the difference is also the fact that limited branching was one of our criteria for the final selection of these new cultivars.

New apple cultivars that combine columnar growth habit with scab resistance were released only during the last few years (Braniste et al. 2008). Unfortunately, their genetic pool is based only on a few cultivars and the results of a multi-year evaluation are not available at present.

Reference

Blažek J., 1983. Inheritance and genetic variation of spurred growth habit in apples. Acta Horticulturae, *140*: 55–62.

Blažek J., 1985. Spur type growth habit in apples. Acta Horticulturae, *159*: 69–76.

Blažek J., 1992. Breeding and general evaluation of spur type or compact growth habits in apples. Acta Horticulturae, *317*: 71–79.

Blažek J., 2001. Nová rezistentní odrůda jabloně 'Kordona' se sloupcovým růstem. (New resistant apple 'Kordona' with columnar growth of trees). Vědecké práce ovocnářské, 17: 171–174.

Blažek J., 2005. Sloupcové jabloně (Columnar apples). Zahradnictví, *12*: 16–17.

Blažek J., 2006. Jabloně sloupcového růstu (Apple trees of columnar growth). AGRO magazine, *10*: 26–29.

Braniste N., Militaru M., Budan S., 2008. Two scab resistant columnar apple cultivars. Acta Horticulturae, *767*: 351–353.

De Wit P., Cook N. C., Keu1eman S. J., 2004. Characterization of tree architecture in two-year-old apple seedlings populations of different progenies with a common columnar *gene* parent. Acta Horticulturae, *663*: 363–368.

Fisher D.V., 1970. Spur strains of McIntosh discovered in British Colombia. Journal of the American Pomological Society, *24*: 27–32.

Gelvonauskienė D., Gelvonauskis B., Sasnauskas A., 2006. Impact of rootstocks on columnar apple tree growth in a nursery. Scientific Works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture. Sodininkysté ir Daržininkysté, *3*: 51–56.

Gelvonauskis B., Brazaityté A., Sasnauskas A., Duchovskis P., Gelvonauskienė D., 2006. Morphological and physiological characteristics of columnar apple trees. Scientific Works of the Lithuanian Institute of Horticulture and Lithuanian University of Agriculture. Sodininkysté ir Daržininkysté, *3*: 350–356.

Ikase L., Dumbravs R., 2004. Breeding of columnar appletrees in Latvia. Biologija, *2*: 8–10.

Inomata Y., Kudo K., Masuda T., Bessho H., Wada M., Suzuki K., 2004. Growth and fruit productivity habits of columnar type apple selections. Horticultural Research (Japan), *4*: 392–401.

Inomata Y., Kudo K., Wada M., Masu A. T., Bessho H., Suzuki K., 2005. The influence of rootstock on characteristics of tree growth, fruit productivity and dry matter production of 'Maypole' young apple tree. Horticultural Research (Japan), *1*: 41–46.

Kellerhals M., Meyer M., 1994. Aims of the apple breeding program at Wadenswil. Progress in Temperate Fruit Breeding. Dordrecht, Kluwer Academic Publishers: 117–121.

Kesley D.F., Brown S.K., 1992. McIntosh Wijcik: A columnar mutation of McIntosh apple proving useful in physiology and breeding research. Fruit Varieties Journal, *46*: 83–87.

Khanizadeh S., Groleau Y., Cousineau J.L., Granger R., Rouselle G., 2000. New hardy apple selections from the Quebec apple breeding program. Acta Horticulturae, *538*: 715–718.

Lapins K.O., 1974. Spur type growth habit in 60 apple progenies. Journal of the American Society for Horticultural Science, *99*: 568–572.

Lapins K.O., 1976. Inheritance of compact growth type in apple. Journal of the American Society for Horticultural Science, *101*: 133–135.

Lespinasse Y., Lespinasse J.M., Ganne B., 1985. Inheritance of two agronomical characters in the apple tree (*Malus pumila* Mill.): Compact type habit and fruit colour. Acta Horticulturae, *159*: 35–47.

Looney N.E., Lane W.D., 1984. Spur-type growth mutants of McIntosh apple, a review of their genetics, physiology and field performance. Acta Horticulturae, *146*: 31–46.

Tobutt K.R., 1985. Breeding columnar apples at East Mailing. Acta Horticulturae, *159*: 63–68.

Tobutt K.R., 1991. Columnar apple breeding. Annual Report of Horticulture Research International 1990–91: 19–20.

Tobutt K.R., 1988a. Columnar apple tree-Telamon variety. Washington D.C., USA, Plant patent–United States Patent and Trademark Office, *19*: 2.

Tobutt K.R., 1988b. Columnar apple tree-Tuscan variety. Washington D.C., Plant patent–United States Patent and Trademark Office, *19*: 2.

Zhang Wen, Li Guang Chen, Zhu Yuan Di, Zhao Yu Jun, Wang Tao, 2002. Relationship among several morphological indexes and columnar character of hybrid seedling from columnar apple tree. Journal of Fruit Science, *4*: 265–266.

Received for publication March 23, 2010
Accepted after corrections April 5, 2010

Corresponding author:

Ing. Jan Blažek, CSc., Research and Breeding Institute of Pomology Holovousy, Ltd.,
Holovousy 1, 508 01 Hořice v Podkrkonoší, Czech Republic
phone: + 420 495 692 821, fax: + 420 495 692 833, e-mail: blazek@vsuo.cz