Orchard performance and fruit quality of 50 apple cultivars grown or tested in commercial orchards of the Czech Republic

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ABSTRACT: Tree vigour, occurrence of mildew and scab, yields, yield efficiency, fruit weight, flesh firmness and soluble solids content of apple trees on M 9 rootstock were monitored between 1998–2005 in 42 commercial orchards situated in all the major growing regions of the Czech Republic. Altogether 50 cultivars were included into the evaluation. The characteristics of newly bred or newly introduced cultivars were compared to the cultivars of standard assortment such as Gloster, Golden Delicious, Idared, Jonagold, Melrose, Rubín and Šampion. The group of late ripening cultivars imported from France (Baujade, Early Smith, Granny Smith and Red Winter) proved to be unsuitable for climatic conditions of the Czech Republic. Cultivars of the Rubín group (Bohemia, Gold Bohemia) showed a better quality of fruits than the cultivars of the Jonagold group, but were significantly inferior regarding yields and yield efficiency. The cultivars Rucla, Pinova and Rubinstep seemed to be potential competitors of Jonagold or Rubín; their fruit quality is similar to Rubín, and their yield efficiency is comparable to that of Jonagold. Topaz, which is resistant to scab and has recently spread in the Czech Republic, is specific for its early yield and a very good productivity observed in a majority of the orchards. In addition, characteristics of other evaluated cultivars and their potential prospects for growing in the Czech Republic are briefly discussed.

Keywords: apple trees; cultivars; M 9 rootstock; tree vigour; mildew; scab; yield; yield efficiency; fruit size; flesh firmness; soluble solids

In the Czech Republic 57 apple cultivars were bred between 1977 and 2003, 28 of them appeared during the last decade (Blažek 2004). Many of these novelties were directly included into an extensive practical testing in commercial orchards. Moreover, large-scale trials were established at five locations with selected late cultivars using trees imported from France (Star Fruits Nursery). Cultivars not grown in our country so far were imported as planting material purchased by growers from nurseries in Holland or Belgium. An evaluation of these cultivars in the commercial orchards of the Czech Republic was organised by the Research and Breeding Institute of Pomology Ltd. (RBIP) Holovousy in 1996; however, the regular study started in 1998 and was realised within three successive research projects.

Based on the study, the tree vigour of 31 cultivars was characterised in the first years of observation using the synthetic growth index; it was obtained from the increase of trunk cross-section area (TCA), canopy volume and mean shoot length (Blažek, Varga 2001). Afterwards, these cultivars from orchards with different climatic conditions were ranged in three groups according to their average yield per tree, specific productivity (as a unit of canopy volume), and mean fruit weight (Blažek, Hlušičková 2003).

The present paper is focused on the productivity of apple cultivars; the evaluation was based on tree yields and yield efficiency using data gathered from an additional four-year observation of the enlarged number of cultivars.

MATERIAL AND METHODS

Tree vigour, mildew and scab incidence, yields, fruit weight, flesh firmness and soluble solids content of 50 apple cultivars grown on M 9 rootstock were monitored between 1998–2005 in 42 commercial orchards situated in the major growing regions of

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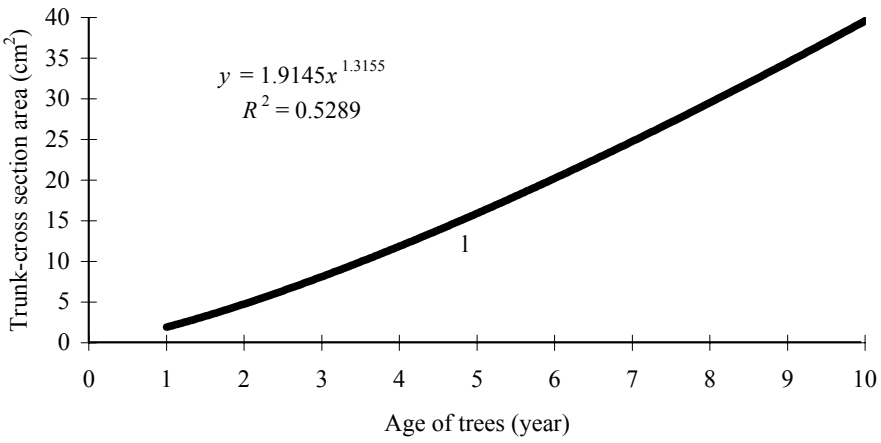

Fig. 1. The growth rate characterising the relation between the age of tree and trunk cross-section area

the Czech Republic. Considering these criteria newly bred or newly introduced cultivars were compared to the cultivars of the standard assortment, such as Gloster, Golden Delicious, Idared, Jonagold, Melrose, Rubín and Šampion. The most typical form used in the orchards was the slender spindle planted in single rows with planting distances corresponding to the density of approximately 2,500 trees per hectare. The age of the trees was usually between two and ten years. For a final analysis only those cultivars were included that were evaluated in at least four different locations and their total number of gathered replications exceeded 16. All data obtained from one orchard (location) and one year were considered as an independent replication.

For each cultivar in the orchard, usually six randomly chosen trees were evaluated at the time of their harvest. Circumference of tree trunk (for calculating trunk cross-section area) was measured about 0.5 m above ground level. Tree vigour was characterised by mean trunk cross-section area. To facilitate mutual comparison of cultivars with different age, the growth curve was computed from all pooled data (Fig. 1). Using this curve, the TCA of each cultivar was adjusted according to its difference from total mean age (4.3 year). The canopy volume was calculated using the Neumann's formula, with three characteristics measured – height, longitudinal width and transversal width.

For the assessment of infestation a modified rating scale 1–9 was used with grade 9 for symptomless status and grade 1 for the strongest degree of infestation. Yield per tree was estimated as a number of fruits per tree multiplied by their average weight (obtained from weighing a sample of 10 randomly collected fruits). Flesh firmness of all sampled fruits was measured by the hand penetrometer (Model FT 327; R. Byrce, Alfosine, Italy). Soluble solids content was measured by the digital refractometer (PR-101 produced by Atago Co. Ltd., Japan). All data were processed by simple ANOVA analysis, and LSD ($P \geq 0.05$) estimated the differences between the means.

RESULTS AND DISCUSSION

Extent of evaluation

The chosen cultivars were evaluated in altogether 42 different locations (Table 1). Approximately a half of them were evaluated regularly every year, whereas the others were assessed only in some years, mainly for technical reasons. The number of locations for particular cultivars varied from 4 to 17 and the number of replications (locations × years) from 17 to 81. Cultivars Idared, Topaz, Rubín and Rubinola were the most frequent in the monitored orchards. The total number of all data sets included in this study was 1,665.

Tree vigour

From all cultivars included into this study Rubinola was the most vigorous followed by Bohemia, Melrose, Rubín, Jonagold, Florina and Gloster (Table 2); Rosana was the least vigorous followed by Goldrush, Nabella, Delor, Selena, Dublet, Denár and Rubinstep. These rankings mostly comply with the results of our previous study (Blažek, Varga 2001). A greater discrepancy was observed only with Braeburn and Karmína cultivars, which had been ranged as very weakly-growing in previous studies, but presently grew somewhat more.

Gold Bohemia, a new mutant of Bohemia cv. with yellow fruits, showed a significantly weaker growth than its clonal ancestors Bohemia or Rubín; a similar tendency was observed in the case of King Jonagold and the original cultivar Jonagold.

Table 1. Survey of evaluated cultivars and total number of replications (orchards × years)

Item	Cultivar	No. of locations	No. of replications
1	Akane	5	23
2	Angold	8	61
3	Baujade	5	27
4	Bohemia	6	25
5	Braeburn	6	27
6	Delor	4	17
7	Denár	4	20
8	Diadém	6	24
9	Dublet	5	22
10	Early Smith	5	25
11	Elstar	6	27
12	Florina	12	52
13	Gala	5	23
14	Gala Must	8	31
15	Gloster	9	30
16	Gold Bohemia	5	25
17	Golden Delicious	7	31
18	G. D. Reinders	6	22
19	G. D. Smoothee	6	42
20	Goldrush	4	18
21	Goldstar	7	38
22	Granny Smith	4	17
23	Idared	17	81
24	Jarka	5	21
25	Jonagold	12	50
26	Jonagored	9	46
27	Jonalord	5	22
28	Julia	5	24
29	Karmína	4	19
30	King Jonagold	4	20
31	Lord Lambourne Red	4	21
32	Melodie	10	45
33	Melrose	8	30
34	Meteor	4	19
35	Nabella	4	21
36	Otava	14	47
37	Pinova	5	25
38	Produkta	5	22
39	Rajka	6	30
40	Red Winter	5	24
41	Resista	12	59
42	Rosana	14	57
43	Rubín	15	66
44	Rubinola	14	63
45	Rubinstep	5	21
46	Rucla	4	19
47	Selena	13	58
48	Šampion	7	33
49	Topaz	14	67
50	Zuzana	6	28
Total		42	1,665

Occurrence of mildew

The most susceptible to mildew proved to be Jonalord, closely followed by Goldrush and Idared (Table 2). The second group includes cultivars that were more or less susceptible; there belong Otava, Florina, Angold, Baujade, Resista, Florina, Jonagold, Red Winter, Early Smith, Braeburn and Granny Smith.

On the contrary, relatively the most resistant cultivars were Šampion, Gloster, Gold Bohemia, Rajka, Julia, Lord Lambourne, Rubinola and Bohemia. All remaining cultivars had an intermediate incidence of the disease.

Occurrence of scab

All 12 cultivars with resistance to scab (Baujade, Florina, Goldrush, Goldstar, Karmína, Melodie, Otava, Rajka, Resista, Rosana, Selena and Topaz) observed in the orchards until 2005 were completely free of any symptoms of the disease (Table 2). No symptoms of scab were also found on Julia and Produkta, cultivars known to be only partially resistant to the disease. In both cases, the number of observations was rather limited and hence this characteristic was probably not enough screened. On the contrary, in one of the replications, very seldom-distributed small flecks of scab with sporulation were observed on the scab resistant cultivar Rubinola; practically negligible occurrence of scab was also noticed on Angold. Among cultivars with partial resistance to scab, Zuzana, Nabella and Rucla can be further included.

In some orchards and in some years, where the protection against scab was not perfect for various reasons, severe incidence of the disease was reported on Braeburn, Šampion, Red Winter, Early Smith, Elstar, Golden Delicious (and its mutants), Gloster, Idared and Jonagold (and its mutants). The other listed cultivars can be considered as moderate susceptible to the disease.

Yields per tree

The lowest yields were recorded with cultivars Julia, Diadém, Bohemia and Early Smith; on the other hand, Produkta was distinguished by the absolutely highest yields followed by Šampion, Jonalord, Florina, Jonagold, Topaz and King Jonagold (Table 3). Moreover, the standard cultivars Golden Delicious and Idared reached practically the same level of yields. All the late cultivars imported from France (Early Smith, Baujade, Granny Smith and Red Win-

Table 2. Tree vigour (TCA), susceptibility to mildew and scab

Cultivar	TCA (cm^2)	Mildew (1–9)		Scab (1–9)	
		mean	max	mean	max
Akane	13.1				
Angold	13.0	7.8	4	9.0	7
Baujade	17.7	7.8	6	9.0	9
Bohemia	20.0	8.9	7	8.8	7
Braeburn	13.1	7.8	5	8.1	3
Delor	11.5	8.5	6	8.5	6
Denár	12.3				
Diadém	14.1				
Dublet	12.2				
Early Smith	16.6	7.8	5	8.4	3
Elstar	17.9	7.9	4	8.4	4
Florina	18.3	7.7	4	9.0	9
Gala	12.7	8.7	6	8.7	6
Gala Must	13.6	8.7	6	8.6	6
Gloster	18.3	9.0	8	8.5	5
Gold Bohemia	15.5	8.9	8	8.8	7
Golden Delicious	15.5	8.6	6	8.4	5
G. D. Reinders	13.1	8.6	6	8.4	5
G. D. Smoothee	14.5	8.4	5	8.6	4
Goldrush	11.2	6.5	3	9.0	9
Goldstar	13.9	8.8	7	9.0	9
Granny Smith	17.1	7.8	5	8.2	6
Idared	15.3	6.9	2	8.6	3
Jarka	14.7	8.7	7	8.6	5
Jonagold	18.4	7.7	4	8.6	4
Jonagored	16.2	8.0	5	8.6	3
Jonalord	13.1	6.3	4	8.7	7
Julia	15.3	8.9	8	9.0	9
Karmína	16.1	8.4	6	9.0	9
King Jonagold	15.8	8.0	6	8.6	5
Lord Lambourne Red	14.3	8.9	8	8.9	8
Melodie	16.1	8.6	6	9.0	9
Melrose	19.0	8.6	6	8.7	6
Meteor	12.4	8.3	6	8.6	6
Nabella	11.2	8.8	7	8.9	8
Otava	13.1	7.5	4	9.0	9
Pinova	13.7	7.9	5	8.7	6
Produkta	12.5	8.6	7	9.0	9
Rajka	16.3	8.9	8	9.0	9
Red Winter	13.0	7.8	5	8.3	4
Resista	14.5	7.6	5	9.0	9
Rosana	11.0	8.2	5	9.0	9
Rubín	18.9	8.8	6	8.7	5
Rubinola	21.1	8.9	7	9.0	8
Rubinstep	12.3	8.5	7	8.8	7
Rucla	13.2	8.3	6	8.9	8
Selena	12.0	8.4	6	9.0	9
Šampion	17.2	9.0	8	8.3	4
Topaz	14.0	8.7	6	9.0	9
Zuzana	16.0	8.7	7	9.0	8
Total	14.8	8.3	–	8.7	–
LSD $P \geq 0.05$	2.4	0.38	–	0.23	–

ter) brought inferior yields in the climatic conditions of the Czech Republic.

Yields per hectare

The yields related to the unit of the orchard area mostly correspond to those expressed per tree. Still, several exceptions were reported. They were caused by different tree spacing in the orchards (Table 4). For example, Gold Bohemia was mostly planted in orchards with looser spacing and it was therefore ranged as a cultivar with the poorest yield per orchard area; likewise, cultivars Karmína, Rajka, Lord Lambourne and Jarka were ranged among cultivars with the highest yields per orchard area, even if their yields per tree were not exceptionally high.

Yield efficiency

Mean yield efficiencies (calculated per m^3 of canopy volume) for the evaluated cultivars ranged between 5.4 kg/m^3 (Early Smith) and 13.7 kg/m^3 (Jonalord) as shown in Table 5. Besides this cultivar, Rubinstep, Produkta and Karmína were outstanding in this parameter. The highest potential for yield efficiency was noticed in Selena with 17.7 kg/m^3, recorded as its maximum value; however, its high yields were frequently accompanied by some biennial bearing and thus its mean values were significantly lower. A similar pattern was observed in the case of other two very productive cultivars – Produkta and Otava.

Weight of fruits

Fruit weight in total means varied between 137.4 g for cultivar Baujade, and 231.2 g for Angold (Table 6). Julia, Denár, Karmína, Akane and Otava belonged among the cultivars with fruit size below average. Except these, fruits of a very small weight were sometimes recorded with cultivars Lord Lambourne and Florina. Cultivars Melrose, Diadém, Rubín, Bohemia and Meteor belonged to the cultivars with the highest values of mean fruit weight. Fruits of extremely large size were most frequently recorded in the case of Angold and Melrose, and sometimes they occurred among samples of Rubín, Jonagold and their mutants.

Flesh firmness

The span of mean flesh firmness of the evaluated cultivars at the time of harvest fluctuated from 5.9 kg/cm^2 (Nabella) to 12.7 kg/cm^2 (Baujade). Besides Nabella, the other cultivars with flesh indicated as rather too soft were Diadém, Melodie, Denár and Selena (Table 6). On the contrary, in addition to Baujade, which possessed very firm flesh, the following cultivars were also outstanding in this respect: Goldrush, Granny Smith, Zuzana, Red Winter and Braeburn.

Soluble solid content

Mean content of soluble solids ranged between 11.0% for Baujade and 15.1% for Nabella (Table 6). Low contents of soluble solids were further recorded in Diadém, Red Winter, Granny Smith and Idared. In contrast, remarkable contents of soluble solids indicating high fruit quality were primarily found with the cultivars Rucla, Gold Bohemia, Rubinola, Meteor, Elstar, Bohemia, Pinova and Rubín.

Remarks on particular cultivars and conclusions

A group of late ripening cultivars imported from France (Baujade, Early Smith, Granny Smith and Red Winter) proved to be unsuitable for the climatic conditions of the Czech Republic. Except for Red Winter, they resulted in poor yields and had very low yield efficiency. Furthermore, apart from Early Smith, the fruit size of these cultivars was frequently too small and the content of soluble solids was low. The only advantage of these cultivars was their flesh firmness. Baujade was generally the worst among the group regarding all respects, whereas Early Smith could be considered as an interesting substitute for Granny Smith in some regions.

Cultivars of the Rubín group (Bohemia, Gold Bohemia) overcame somewhat the cultivars of the Jonagold group in the quality of fruits but were significantly inferior regarding yields and yield efficiency. Despite certain progress in productivity of Rubín when compared to the initial years of the evaluation (Blažek, Hlušičková 2003), many growers still have serious problems in this respect. A considerable improvement of cropping of the cultivar was achieved in the orchards where summer heading of very long shoots was applied or the "Solax" system of tree training was used. Similar demands for tree training and pruning were noticed in the new cultivar Rubinola, which is resistant to scab and is remarkable as to its fruit quality. The present evaluation of the cultivar largely complies with previous results from Switzerland (Goerre, Kellerhals 2000).

Rucla, Pinova and Rubinstep appeared to be potential competitors to the cultivars of the groups of Jonagold or Rubín. Their fruit quality is similar to

Table 3. Yields in kg per tree in years after planting

Cultivar	Year after planting									Mean
	2	3	4	5	6	7	8	9	10	
Akane		5.6	11.2	13.3	17.7	18.3				13.2
Angold	3.7	9.8	14.6	17.9	19.3	19.9	20.8	16.5	19.7	15.8
Baujade	3.4	5.9	9.1	13.6	15.0	20.4				11.2
Bohemia	0.8	5.3	11.2	15.7	13.0	17.2				10.5
Braeburn	2.5	9.0	12.4	16.9	17.8	19.3				13.0
Delor	5.3	12.7	17.9	19.0	21.3	19.4	16.7			16.1
Denár		5.4	11.0	12.8		15.2				11.1
Diadém	2.5	10.0	11.9	16.3						10.2
Dublet	0.3	8.6	7.3	17.3	21.5	22.1	25.5			14.7
Early Smith	1.9	7.6	5.1	10.9	13.8	19.0	17.6			10.8
Elstar	2.4	8.5	12.7	14.1	19.0		17.2		19.6	13.4
Florina	2.9	8.6	12.5	15.2	23.2	27.2	26.3	25.2	26.0	18.6
Gala	2.1	11.3	13.3	14.5	14.7	23.2		19.7	22.4	15.2
Gala Must	3.2	13.1	13.3	17.4	15.3	25.0				14.5
Gloster	1.2	9.8	17.2	20.3	23.3	23.0				15.8
Gold Bohemia		6.1	13.3	16.0	17.1					13.1
Golden Delicious	3.8	12.0	13.0	21.0	18.3	22.3	25.6		25.9	17.7
G. D. Reinders	3.7	11.4	15.9	18.8	24.2	20.6				15.8
G. D. Smoothee	3.0	9.3	12.0	17.7	16.2	25.4		24.7		15.5
Goldrush	2.5	7.5	12.7	15.1	17.8					11.1
Goldstar	2.3	9.7	15.0	17.3	20.9	22.8	18.4		17.4	15.5
Granny Smith		9.3	8.1	13.8	11.7	15.3				11.6
Idared	2.9	9.0	13.6	15.0	20.0	21.8	20.8	23.9	26.6	17.1
Jarka	2.3	13.6	12.3	18.8	21.2	18.0	23.3	18.0	20.0	16.4
Jonagold	3.7	10.6	16.1	17.3	21.8	21.9	24.8	23.1	27.1	18.5
Jonagored	4.0	13.9	16.6	14.7	19.3		23.7		22.1	16.3
Jonalord			15.3	16.9	22.4	18.0	20.3			18.6
Julia	1.6	5.0	10.2	16.4	17.1					10.1
Karmína	2.9	3.1	19.1	23.3	26.5	25.7				16.8
King Jonagold	4.4	10.3	19.4	18.2	27.2	28.7				18.0
Lord Lambourne		9.8	14.2	16.5	24.5					16.2
Melodie	1.7	8.7	16.1	15.1	20.6	21.7	22.3	18.2	23.4	16.4
Melrose	1.5	4.9	9.7	16.5	22.9	18.3	23.1	20.1	25.7	15.9
Meteor	0.4	8.6		16.8	18.6		22.1			13.3
Nabella		3.2	6.2	14.3	15.9	18.8	19.2			12.9
Otava	2.8	8.4	12.1	16.8	21.6	26.9	17.9	24.3		16.3
Pinova	3.9	4.9	15.6	25.0	23.1					14.5
Produkta	3.5	15.5	18.5	22.7	27.9	30.5	17.2			19.4
Rajka	3.6	6.5	14.1	19.5	18.6	23.0	21.3			15.2
Red Winter	4.0	4.2	13.1	9.5	17.6	19.9		18.8		12.4
Resista	1.5	6.5	13.2	16.7	20.2	20.5	16.8	20.7		14.5
Rosana	2.4	8.1	13.0	14.0	16.6	20.2		24.9		14.2
Rubín	0.5	4.3	8.2	10.4	13.5	14.0	19.2	20.6		11.4
Rubinola	1.2	5.3	9.1	12.2	15.0	18.1	17.8	18.6		12.1
Rubinstep	3.5	7.0	14.8	18.3		23.6	21.7			14.9
Rucla	3.1	8.1	13.7		17.0	19.8	24.3			14.3
Selena	5.9	7.2	13.8	10.7	23.5	19.9	22.9		25.0	16.1
Šampion	4.4	10.7	15.1	22.4	17.8	26.8	25.0	29.2		18.9
Topaz	4.5	8.5	12.5	16.1	25.0	23.1	22.1	32.5		18.0
Zuzana	1.1	7.3	12.8	12.9	13.3	19.3		25.9		13.2
Total	4.0	8.2	12.7	14.2	19.6	18.5	21.1	20.5	27.6	16.2
LSD P ≥ 0.05	1.9	2.5	3.3	3.4	3.7	4.6	4.1	3.8	3.6	2.2

Table 4. Yields in tons per hectare in years after planting

Cultivar	Year after planting									Mean
	2	3	4	5	6	7	8	9	10	
Akane		14.7	29.3	34.7	46.1	47.7				34.5
Angold	8.7	23.3	34.6	42.5	45.6	47.2	49.4	39.2	46.8	37.5
Baujade	7.7	13.4	20.7	30.9	34.2	46.6				25.6
Bohemia	2.0	13.2	28.0	39.3	32.6	43.0				26.4
Braeburn	7.2	26.3	36.3	49.3	51.9	56.3				37.9
Delor	12.9	31.0	43.7	46.4	52.0	47.3	40.7			39.2
Denár		12.5	25.6	29.8		35.5				25.9
Diadém	6.8	27.8	33.0	45.4						28.2
Dublet	0.7	21.0	17.8	42.1	52.1	53.8	62.0			35.7
Early Smith	4.4	17.0	11.5	24.7	31.1	42.9	39.7			24.5
Elstar	5.8	20.8	30.9	34.2	46.3		41.9		47.6	32.5
Florina	7.3	21.7	31.4	38.2	58.3	61.4	59.5	56.9	58.8	43.7
Gala	5.6	30.2	35.6	38.7	39.3	61.9		52.6	59.8	40.5
Gala Must	9.1	37.3	37.8	49.6	43.5	71.1				41.4
Gloster	1.2	9.8	45.8	54.1	62.1	61.3				39.0
Gold Bohemia		6.1	19.7	23.8	25.4					18.8
Golden Delicious	9.5	30.1	32.4	52.6	45.7	55.9	64.0		64.8	44.4
G. D. Reinders	8.9	27.4	38.2	45.2	58.1	49.5				37.9
G. D. Smoothee	6.6	20.8	27.0	39.7	36.5	57.0		55.5		34.7
Goldrush	8.3	25.0	42.3	50.5	59.4					37.1
Goldstar	6.7	9.7	43.8	50.4	61.0	66.5	53.8		50.9	42.8
Granny Smith		23.4	20.3	34.7	29.5	38.5				29.3
Idared	2.9	21.9	33.0	36.4	48.6	52.8	50.4	58.0	64.5	40.9
Jarka	6.3	37.3	33.6	51.4	58.0	49.2	63.8	49.4	54.6	44.8
Jonagold	10.3	29.3	44.5	47.8	55.4	55.7	60.6	56.4	66.2	47.4
Jonagored	9.3	32.2	38.4	33.9	44.5		54.8		51.0	37.7
Jonalord			28.4	31.5	41.7	33.6	37.8			34.6
Julia	4.7	14.6	29.6	47.7	49.7					29.3
Karmína	8.1	8.8	53.3	65.0	74.1	71.8				46.9
King Jonagold	10.9	25.7	48.2	45.2	67.7	71.4				44.8
Lord Lambourne		27.5	40.0	46.3	68.8					45.6
Melodie	4.1	20.6	38.3	35.9	48.9	51.5	53.1	43.3	55.6	39.0
Melrose	3.9	12.7	25.4	43.1	59.8	47.8	60.3	52.4	66.9	41.4
Meteor	1.0	21.6		42.3	46.9		55.8			33.5
Nabella		8.5	16.5	38.2	42.5	50.5	51.5			34.6
Otava	7.0	21.1	30.2	42.0	53.9	67.4	44.8	60.9		40.9
Pinova	10.0	12.5	39.5	63.2	58.3					36.7
Produkta	9.6	42.7	51.1	62.5	77.0	73.2	41.1			51.0
Rajka	11.0	20.0	43.3	59.9	57.3	70.5	65.4			46.8
Red Winter	9.9	10.2	32.2	23.2	43.1	48.7		46.1		30.5
Resista	3.4	14.8	30.2	38.2	46.2	47.0	38.3	47.2		33.2
Rosana	6.2	20.8	33.6	36.2	42.9	52.2		64.4		36.6
Rubín	1.3	11.1	20.9	26.7	34.7	35.9	45.7	49.1		28.2
Rubinola	2.9	12.6	21.8	29.1	35.7	43.1	42.5	44.4		29.0
Rubinstep	8.7	17.5	36.9	45.6		58.9	54.1			37.0
Rucla	7.7	20.2	34.2		42.6	49.5	60.6			35.8
Selena	15.2	18.4	35.4	27.3	60.1	50.9	58.7		64.0	41.3
Šampion	11.1	27.2	38.3	56.7	45.2	59.0	55.2	64.4		44.6
Topaz	12.0	22.7	33.2	43.0	66.6	53.4	58.9	65.5		44.4
Zuzana	2.9	18.5	32.3	32.6	33.7	48.7		49.6		31.2
Total	6.9	20.3	32.6	41.1	48.3	52.2	50.8	50.8	54.4	36.9
LSD $P \geq 0.05$	4.1	6.4	7.0	8.3	7.8	7.2	6.9	6.7	6.3	4.9

Rubín, whereas their yield efficiency is comparable to Jonagold. The given characteristics of Pinova are in agreement with the results of other authors (Baab, Zimmer 2002).

Several improvements of standard cultivars Gala, Golden Delicious and Jonagold introduced in our country during the last decade did not differentiate much from the originals, which is in compliance with the results of previously published studies (Faby 1987; Stehr 1996; Meyer 2001).

Topaz, which is resistant to scab and has recently spread in the Czech Republic, proved to be yield precocious and very productive in a majority of the orchards. Its fruits possessed above average or even high quality characteristics and were especially desirable for their level of flesh firmness. The characteristics of this cultivar agree with our previous results (Blažek, Hlušičková 2001; Baab, Zimmer 2002; Blažek et al. 2003). Nevertheless, growers have to be aware that Topaz can suffer from over-cropping, and so trees require regular stronger pruning.

Other scab-resistant cultivars such as Goldstar and Rajka were quite similar to Topaz with regard to their productivity and fruit quality; still they have some other serious limitations. A drawback of Goldstar was a high susceptibility to bitter pit and somewhat less attractive visual aspect of fruits. A serious disadvantage of Rajka was a limited ability of storage.

Meteor, one of the newest cultivars, was remarkable as to its high fruit quality and storage property and it could be therefore considered as a suitable candidate to replace Melrose. Although its yields, and especially yield efficiency, till now were a bit behind the standard cultivars, a marked improvement in this respect might be achieved using similar procedures that were beneficial for Rubín.

Another cultivar appropriate for the enrichment of the apple assortment in the Czech Republic seems to be Braeburn. Its yields were on the average level but its yield efficiency was above average. If this less vigorous cultivar were planted in denser tree spacing, its yields would reach the same values as grown standards. All these characteristics as well as higher flesh firmness are supported by results of a US report (Hampson et al. 2004). Braeburn, however, requires better climatic conditions and should be used only in the warmest growing areas of our country, where it achieves desirable fruit quality.

Among the new introductions Goldrush, another scab-resistant cultivar, can be recommended for a more extensive testing in the country. Its advantage is a very good storage capacity, comparable to or even better than Topaz or Angold, which is usually a problem of cultivars with resistance to scab. Also this

Table 5. Yield efficiency in kg per m^3 of tree canopy volume

Cultivar	Mean	Min	Max
Akane	7.8	3.8	11.5
Angold	10.5	1.0	16.1
Baujade	6.0	2.2	10.3
Bohemia	6.0	0.4	10.6
Braeburn	10.9	3.1	14.5
Delor	10.1	2.9	13.6
Denár	7.6	1.2	10.4
Diadém	8.6	5.0	12.8
Dublet	9.7	0.8	13.0
Early Smith	5.4	0.5	9.6
Elstar	7.7	0.8	13.4
Florina	8.2	0.4	13.6
Gala	10.1	2.2	13.7
Gala Must	8.8	2.1	12.6
Gloster	10.4	1.9	14.8
Gold Bohemia	7.3	1.8	10.5
Golden Delicious	10.9	2.7	13.9
G. D. Reinders	11.1	3.9	14.6
G. D. Smoothee	8.9	1.2	14.2
Goldrush	9.4	2.1	12.8
Goldstar	10.2	1.2	13.0
Granny Smith	7.7	1.3	10.0
Idared	11.4	0.9	16.2
Jarka	11.8	2.8	14.2
Jonagold	9.7	0.6	16.5
Jonagored	11.1	3.5	14.7
Jonalord	13.7	1.9	17.1
Julia	8.3	2.3	10.8
Karmína	12.1	3.5	15.8
King Jonagold	10.9	2.3	14.5
Lord Lambourne	11.5	3.9	13.8
Melodie	11.3	0.8	14.5
Melrose	10.2	2.7	13.0
Meteor	7.0	2.9	11.8
Nabella	10.4	2.5	12.1
Otava	11.7	0.7	17.2
Pinova	11.6	2.8	13.3
Produkta	12.2	1.5	17.1
Rajka	9.2	2.6	13.0
Red Winter	9.5	2.1	12.3
Resista	8.5	1.3	14.2
Rosana	10.7	2.7	15.9
Rubín	6.2	0.4	11.6
Rubinola	6.3	1.1	12.6
Rubinstep	12.6	2.4	16.2
Rucla	9.9	2.5	13.6
Selena	11.9	0.6	17.7
Šampion	11.2	3.8	14.6
Topaz	10.4	0.2	15.4
Zuzana	7.0	1.5	11.5
Total	9.6	0.2	12.4
LSD $P \geq 0.05$	1.8	–	–

Table 6. Fruit weight, flesh firmness and soluble solids content

Cultivar	Fruit weight (g)			Flesh firmness (kg/cm^2)	Soluble solids (Brix%)
	mean	min	max		
Akane	151.1	105.2	224.8	7.2	13.2
Angold	231.2	153.6	352.7	7.4	12.5
Baujade	137.4	99.2	207.5	12.7	11.0
Bohemia	221.0	169.0	326.8	7.9	14.2
Braeburn	179.4	140.1	252.2	10.0	12.3
Delor	211.5	163.0	326.0	7.9	13.4
Denár	139.8	112.4	192.7	6.6	12.6
Diadém	222.3	201.3	293.7	6.1	11.4
Dublet	169.5	124.7	259.8	7.7	13.8
Early Smith	193.5	136.6	263.5	9.2	13.2
Elstar	158.3	119.6	227.6	7.2	14.2
Florina	159.7	97.5	258.9	9.4	12.7
Gala	151.9	114.3	215.7	8.5	13.3
Gala Must	162.8	122.5	235.6	7.8	13.6
Gloster	208.1	133.0	331.4	9.2	12.7
Gold Bohemia	217.6	171.9	250.7	7.6	14.3
Golden Delicious	157.2	114.2	251.6	8.1	13.8
G. D. Reinders	165.1	118.9	230.3	8.5	13.4
G. D. Smoothee	165.7	123.3	272.2	8.6	13.9
Goldrush	154.8	127.3	209.2	11.0	12.8
Goldstar	179.1	126.5	246.6	8.4	13.2
Granny Smith	153.0	123.1	238.1	10.8	11.8
Idared	181.8	103.6	293.7	8.2	11.9
Jarka	199.0	132.2	281.5	7.5	12.8
Jonagold	198.9	138.7	336.8	8.0	13.9
Jonagored	212.0	148.8	335.3	7.9	13.9
Jonalord	182.7	144.5	228.9	7.4	12.1
Julia	139.6	105.3	170.6	7.6	12.3
Karmína	139.8	99.9	207.7	7.7	13.1
King Jonagold	217.1	163.4	331.5	7.6	13.7
Lord Lambourne	147.4	96.5	203.1	7.2	13.9
Melodie	173.1	103.3	278.4	6.4	12.8
Melrose	227.1	144.8	343.7	8.3	12.4
Meteor	220.1	166.9	289.3	7.8	14.2
Nabella	181.2	140.0	258.0	5.9	15.1
Otava	143.0	90.6	229.8	8.6	13.2
Pinova	162.9	143.7	194.6	8.1	14.2
Produkta	193.7	157.9	295.4	7.2	12.1
Rajka	184.0	136.3	252.8	7.3	13.6
Red Winter	166.4	125.5	232.3	10.1	11.7
Resista	175.6	102.1	270.7	9.3	12.9
Rosana	184.8	104.5	328.7	7.7	12.7
Rubín	220.5	155.0	340.5	7.8	14.1
Rubinola	170.6	121.7	298.3	8.7	14.3
Rubinstep	161.5	122.1	243.1	7.8	13.5
Rucla	155.0	119.6	189.8	8.6	14.8
Selena	172.5	114.5	272.4	6.9	12.3
Šampion	178.3	135.3	268.2	7.4	13.0
Topaz	164.6	119.2	259.7	9.0	13.1
Zuzana	209.4	152.7	316.7	10.1	12.6
Total	179.0	129.7	264.4	8.2	13.2
LSD $P \geq 0.05$	15.6	–	–	1.2	1.1

finding can be supported with an experience from US (Miller et al. 2004). Nonetheless, Goldrush has similar requirements for climatic conditions and for the length of the growing season as Braeburn.

Very productive cultivars such as Produkta, Selena and Otava, which possess the highest potential for yield efficiency, frequently suffered from biennial bearing, which was previously reported by Blažek et al. (2003). For this reason, the trees of these cultivars have greater demands for fruit set regulations, especially for stronger pruning and fruit thinning, in order to improve the fruit quality.

A wide range of cultivars (Akane, Angold, Delor, Elstar, Florina, Jarka, Jonalord, Julia, Lord Lambourne, Melodie, Nabella, Resista, Rosana and Zuzana) can be grown in the Czech Republic under certain limitations or for some special purposes. A more detailed discussion on them would definitely exceed the framework and aims of this paper.

Beside the imported cultivars Baujade, Granny Smith and Red Winter mentioned in this study, Denár, Diadém, Dublet and Karmína appeared to be the least interesting for growing in our country.

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Charakteristiky ve výsadbě a kvalita plodů u 50 odrůd jabloní pěstovaných nebo zkoušených v tržních výsadbách České republiky

ABSTRAKT: Vzrůstnost stromů, výskyt padlí a strupovitosti, výnosy, specifická plodnost, hmotnost plodů, pevnost dužniny a obsah refraktometrické sušiny byly hodnoceny u jabloní pěstovaných na podnoži M 9 v letech 1998–2005 ve 42 tržních výsadbách rozmístěných v hlavních pěstitelských oblastech ČR. Do sledování bylo zahrnuto celkem 50 odrůd. Nově vyšlechtěné odrůdy nebo odrůdy nově zaváděné do pěstování byly porovnávány s odrůdami standardního sortimentu, jakými jsou Gloster, Golden Delicious, Idared, Jonagold, Melrose, Rubín a Šampion. Skupina pozdně zrajících odrůd dovezených z Francie (Baujade, Early Smith, Granny Smith a Red Winter) se v místních

klimatických podmínkách neosvědčila. Odrůdy skupiny Rubín (Bohemia, Gold Bohemia) v kvalitě plodů poněkud překonávaly odrůdy skupiny Jonagold, avšak byly v porovnání s nimi významně horší po stránce výnosů a specifické plodnosti. Potenciálními konkurenty odrůd skupiny Jonagold nebo Rubín se zdají být odrůdy Rucla, Pinova a Rubinstep. Jejich kvalita plodů je srovnatelná s odrůdou Rubín a jejich specifická plodnost s odrůdou Jonagold. Odrůda Topaz s rezistencí vůči strupovitosti, která se v posledních letech začala v ČR významně rozšiřovat, se ve většině výsadeb vyznačuje raným nástupem plodnosti a vysokými výnosy. Dále jsou stručně zmíněny charakteristiky ostatních hodnocených odrůd a jejich předpokládaný význam pro pěstování v České republice.

Klíčová slova: jabloně; odrůdy; podnož M 9; vzrůstnost; padlí; strupovitost; výnosy; specifická plodnost; velikost plodů; pevnost dužniny; refraktometrická sušina

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