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COLUMNAR APPLE TREES AND THEIR VARIETIES

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Abstract

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The objective of the study was to evaluate selected varieties of columnar apple trees. The trees were monitored over a 3-year period and the focus was on growth, yield and health data. At the same time the quality of the harvested fruit was evaluated after short storage. The varieties Polka, Bolero, Charlotte, Mc. Intosh Wijcik, Waltz and the control variety Golden Delicious were grown on rootstock M 9. The decisive data characterising the variety were: the height of the elongation, formation of the lateral fruiting spurs, number of flowers and the amount of harvested fruit. No less important for growth was the health condition of the leaf area and particularly the incidence of fungus diseases; here the monitoring was carried out on six dates and was focused on apple scab and powdery mildew of apple. Infestation of the variety Charlotte with powdery mildew of apple was significantly heavier than infestation of the other varieties. The variety Charlotte was also significantly more affected with apple scab and differed from the other less infested varieties. The highest number of ripe fruit was produced by the variety Polka; significantly less fruit was produced by the varieties Bolero, Mc. Intosh Wijcik and Waltz. The least number of fruit but the heaviest was produced by the variety Charlotte; the weight of the fruit of this variety was significantly the highest. The variety Polka gave the highest yields. Evaluations of the organoleptic qualities included the appearance of the fruit; highly appraised in this respect was the control variety Golden Delicious, followed by Bolero and Mc. Intosh Wijcik. In terms of the appearance the variety Waltz received the lowest scores.
The varieties Mc. Intosh Wijcik and Charlotte had the thickest skin, while the skin of varieties Polka, Golden Delicious and Waltz were of no concern. In terms of the consistence of the flesh the highest-ranking variety was Golden Delicious, followed by Bolero and Charlotte. The juiciest variety was Golden Delicious, followed by Mc. Intosh Wijcik and Waltz; the least juicy was the variety Charlotte. The tastiest variety was the control variety Golden Delicious, followed by Mc. Intosh Wijcik and Waltz; the least tasty was the variety Bolero. In the overall sum of points appraising the fruit, flesh and taste the variety Golden Delicious was at the top of the list, followed by Mc. Intosh Wijcik and Waltz.

columnar apple trees, growth types, fruit-bearing, apple scab, powdery mildew

As to their importance apple trees are the most widely spread and the most demanded fruit. Their successful cultivation is affected by a number of factors; along with conditions of the site it is the selection of a suitable and demanded variety, rootstock, shape, age of plantation and overall level of cultural practice (BLAŽEK, 2011).

Perspective methods of cultivation are focused on closer spacing, on the use of poorly growing and early fruit-bearing rootstocks, including regular fruit-bearing. Important is also the demand for good-quality and healthy fruit. At the present time columnar apple trees are the most frequently used shapes and methods of growing; they are upright growing cylindrical trees with a terminal and fruiting spurs along the main leader which bear the fruit. They are easy to grow; they need minimal pruning and are easy to shape. They are becoming popular especially for small-scale gardeners, on small spaces, gardens, balconies and also in containers.

Complex genetic, ontogenetic and environmental factors play a role in determining apple tree

architecture and many quantitative trait loci (QTLs) of significant effect on tree form have been detected (KENIS and KEULEMANS, 2007; SEGURA *et al*., 2008, 2009). Despite the tremendous variations, apple tree architecture has been categorized into four types based on its overall growth habit and fruiting type: columnar (I), spur (II), standard (III) and tip bearing (IV) (COSTES *et al*., 2006; LESPINASSE and DELORT, 1986; PEREIRA-LORENZO *et al*., 2009).

In the 1960s a columnar mutation of the Mc. Intosh apple was discovered and indicated as Mc. Intosh Wijcik (LAPINS, 1969; FISHER, 1970). With ongoing research and breeding activities this dwarfism trait was indicated as the genetic base for further breeding; its inheritance is monogenic and its character is dominant (BLAŽEK, 1992; LAPINS, WATKINS, 1973; TOBUTT, 1985). Using this donor helped to breed a number of varieties of a new growth type indicated as "ballerina" (1st generation) (LAPINS, 1976; TOBUTT, 1985, 1991; ZAHRADNÍK, 2008). Instrumental in introducing and further spreading of this group of varieties (Polka, Flamenco, Charlotte and Waltz) was East Malling Research (EMR) in the UK (TOBUTT, 1985). Trees of the "ballerina" type have a tendency to excessive and alternate fruit-bearing and they require the fruit to be sorted on a regular basis. MEZEY (2008) reported that disease and pest control is the same as with traditional apple tree varieties. The 2nd generation showed a higher resistance to fungus diseases and better quality of fruit; the 3rd generation was even more resistant, the quality of the fruit was better as well as the shelf life. This is the way breeding was directed abroad as well as at breeding facilities in the Czech Republic (BLAŽEK, KŘELINOVÁ, 2011; OGNJANOV *et al*., 1998; IKASE, DUMBRAVS, 2004; ZAHRADNÍK, 2008; CEPOIU *et al*., 2008).

A numerous group of varieties of CATS (Columnar Apple Tree Systems) classed in the series Proficatsserie (Procatsserie, Specialprocatsserie) was produced by Professor Jacob at the Research Institute in Geisenheim in Germany (JAKOB, 2007). A great improvement was the inclusion of resistance against fire blight. Important are the breeding activities of breeding workplaces in the Czech Republic (Research and Breeding Institute of Pomology Holovousy and Institute for Experimental Botany Střížovice); they breed a numerous group of resistant varieties of high quality (ZAHRADNÍK, 2008).

In terms of the health status the apple trees are the most demanding of all fruit trees and this applies not only to commercial varieties but also to columnar trees. The most severe fungal disease of apple trees is apple scab (*Venturia inaequalis* Cke. Wint.) which appears in humid regions. The pathogen overwinters in the leaf litter left over from the previous vegetation. In the spring the fruit bodies mature and release ascospores which spread under favourable weather conditions. In warmer regions the second most severe disease is powdery mildew (*Podosphaera leucotricha* Ell. Et Everk. Salm.). Powdery mildew favours warm weather and higher or alternate air humidity; also rainfall, dew, fog as this ensures the required humidity of the air. In modern breeding the resistance to powdery mildew is combined with resistance to apple scab. A number of marker types are used for the identification and selection of genotypes. In breeding practice the most frequently applied are PCR markers enabling rapid and univocal detection of the genes and/or selection of genotypes during the very early stages of ontogenesis (MELOUNOVÁ *et al*., 2005). The breeding of new varieties is focused on the use of polygenic sources of resistance and at the same time on the highest degree of tolerance to fire blight (*Erwinia amylovora* GUERILL, WINSLOW) and to a number of other fungal diseases.

Present knowledge on columnar shapes has shown that they require simple pruning and thus also the overall cultivation; also the development of fully automated machines for harvesting this shape of apple trees. Pruning is most frequently focused only on nipping off the annual shoots in summer (late July, early August). Using genotypes with spontaneous regulation of fruit setting has a favourable effect on the quality of fruit on the surface parts of the crown. If firmly anchored in the soil, using a suitable rootstock will reduce the costs for individual support. Rapid onset into fruit bearing is also taken into account as it means early return in investment costs (short-term return 10–12 years). Negative evaluations point out that there is a greater tendency to alternate fruit bearing and to a great variability in the quality of external and internal pomology traits, including the length of the shelf life. The degree of the foliage is also different, as is the distribution of the fruit, total yields and resistance to diseases and pests. The objective of the study was to evaluate the growth, yield and health parameters in some varieties (1st generation) of columnar apples. The planting was established in 2000, spacing was 2.5 × 1.0 m, plated as a screen.

MATERIALS AND METHODS

Columnar apple varieties were evaluated during a three-year period (2009–2011) at the experimental demonstration plot of the Department of Breeding and Propagation of Garden Plants, the School Farm in Žabčice. The planting established in 2000 with traditional varieties (Polka, Bolero, Charlotte, Mc. Intosh Wijcik, Waltz) and the control variety Golden Delicious on rootstock M 9 was evaluated. The planting has the form of a fruiting hedge, the in-between-row space was kept as bare fallow and the space around the stems was treated with herbicides.

Yearly treatment consisted in keeping the space around the stems free of weeds and applying supplementary fertilisation in spring (Cererit Z, 40 g . m^{-2}). Oleoekol, Pirimor DP 50 and Calypso 480 SC were applied as pest control.

Evaluations of the experimental plantings were focused on some growth, yield and pomology data. We evaluated the height of the tree and the length of annual shoots; at the same time the length of the fruiting spurs, and basing on the length they were divided into 4 length categories. The internodes length was detected on the terminal elongation shoot by measuring the distances between buds.

In spring we monitored the number of flowers and then gradually the fruit set and the harvested fruit. During harvest we monitored the number of fruit and the average weight. During the entire vegetation period the incidence of fungal diseases was monitored with a focus on apple scab (*Venturia inaequalis* Cke. Wint.) and on powdery mildew (*Podosphaera leucotricha* Ell. Et Ew. Salm). Evaluations were conducted on 6 dates every year (12 May, 12 June, 2 July, 30 July, 15 August and 24 August) according to the classification table giving a 1–9 point scale (1 point – heavy attack; 9 points – no attack, entirely healthy leaves (BLAŽEK, PAPRŠTEIN, 1997).

During harvesting (every year in mid-September) samples were taken to assess the pomology traits. The samples were stored in a cold-storage facility at a constant temperature of 4 ^{0}C and 90% air humidity. Evaluations of organoleptic properties were based on the demands for objectivity (in the 1st half of December). Evaluation of the samples was anonymous, the order was random and the appraisers were selected on the basis of their previous practical knowledge. The control variant was ´Golden Delicious´. The following individual characters were evaluated: appearance of the fruit, aroma of the fruit, character of the skin, consistency and juiciness of the flesh, taste according to acidity and sweetness of the flesh and taste based on the overall impression.

RESULTS AND DISCUSSION

Significant differences among the varieties and years were discovered in terms of the infestation of the leaves and fruit with powdery mildew of the apple tree and scab infection (p = 0.05) (Tab. I).

The infection of variety Charlotte (6.8) with powdery mildew of apple was significantly higher than the infection of other varieties (6.6–7.8 of the 9-point classification scale). The variety Charlotte was also infected by apple scab significantly more (6.2) and differed from the other less infected varieties (Polka 7.2), Bolero (6.9), Mc. Intosh Wijcik (7.0) and Waltz (7.14) (Tab. II).

II: *Apple mildew and scab infection according to varieties (mean, standard error of the mean, different letters indicate significant differences between varieties, p = 0.05)*

Variety	Powdery mildew (points)	Scab (points)
Golden Delicious	7.79 ± 0.16 b	6.77 ± 0.285 ab
Polka	7.81 ± 0.22 b	7.18 ± 0.401 b
Bolero	7.72 ± 0.28 b	6.89 ± 0.401 b
Charlotte	6.80 ± 0.37 a	6.20 ± 0.368 a
Mc. Intosh Wijcik	7.68 ± 0.28 b	7.01 ± 0.356 b
Waltz	7.66 ± 0.22 b	7.14 ± 0.364 b

III: *Apple mildew and scab infection according to year (mean, standard error of the mean, different letters indicate significant differences between varieties, p = 0.05)*

Year	Powdery mildew (points)	Scab (points)
2009	7.66 ± 0.16 b	7.84 ± 0.154 b
2010	6.69 ± 0.18 a	5.14 ± 0.179 a
2011	8.38 ± 0.12 c	7.61 ± 0.140 b

In terms of the individual years the most severe infection with powdery mildew and scab was discovered in 2010 and the weakest in 2011. This corresponds with the course of weather; in 2010 we saw frequent and long-lasting rainfall in April to August (Tab. III and Figs. 1–3).

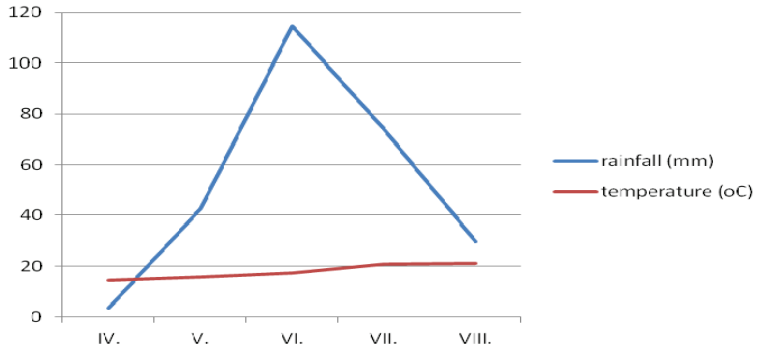
In terms of the number of flowers, number of mature fruit, yields and weight of one fruit significant differences (p = 0.05) were discovered among the varieties and in interactions among the individual factors (Tab. IV).

The variety Mc. Intosh Wijcik had the significantly highest number of flowers (322) followed by Polka (306) and Waltz (292). The variety Charlotte had significantly the least flowers (125) (Tab. V).

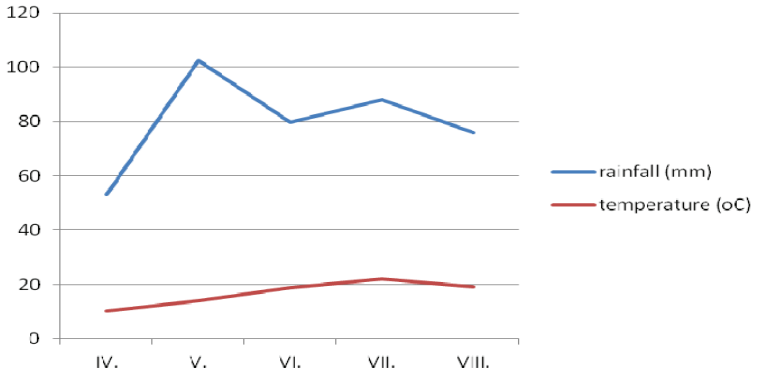
The variety Polka produced the highest number of mature fruit (77). The varieties Bolero, Mc. Intosh Wijcik and Waltz produced significantly less fruit (62, 58 and 62, respectively). The variety Charlotte produced the least number of fruit (30) but the weight of the fruit was significantly the highest (197 g). The weight of the fruit of the other varieties was significantly lower and ranged between 129 and

I: *Analysis of variance results for apple mildew and scab infection*

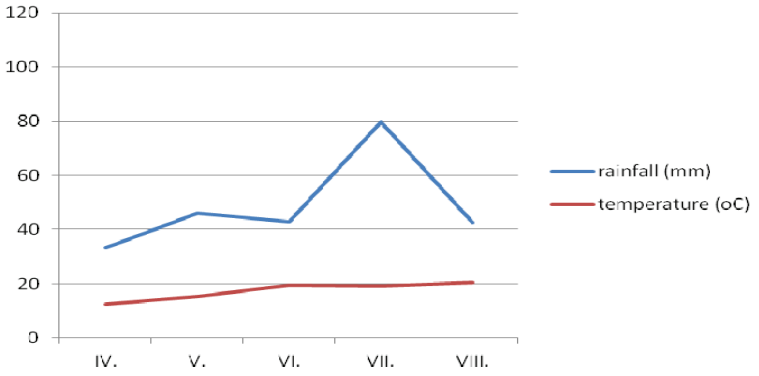
	df	Powdery mildew (points)		Scab (points)	
		MS	p	MS	p
Variety	5	2.670	0.008	2.331	0.016
Year	2	25.674	0.000	80.401	0.000
Variety*Year	10	0.696	0.555	1.248	0.123
Error	90	0.792			



1: *Average temperature and rainfall from April to August in Žabčice in 2009*



2: *Average temperature and rainfall from April to August in Žabčice in 2010*



3: *Average temperature and rainfall from April to August in Žabčice in 2011*

IV: *Analysis of variance results for the number of flowers, number of fruits, yield and weight of one fruit*

	df	Number of flowers		Number of fruits		Yield (kg)		Weight of one fruit (g)	
		MS	p	MS	p	MS	p	MS	p
Varieties	5	46050	0.000	2202	0.000	26.77	0.000	5827	0.000
Year	2	60832	0.000	2950	0.000	19.78	0.000	8499	0.000
Varieties*Year	10	9884	0.000	672	0.000	5.26	0.003	1221	0.000
Error	36	281		68		1.55		223	

144 g. Thus the correlation between the amount and weight of the fruit was confirmed.

The variety Polka produced the significantly highest total yields (10.9 kg), followed by the control variety Golden Delicious (9.3 kg) and the variety Bolero (8.1 kg). The yields of the variety Charlotte were the lowest (6.0 kg) even though the weight was the highest (Tab. V).

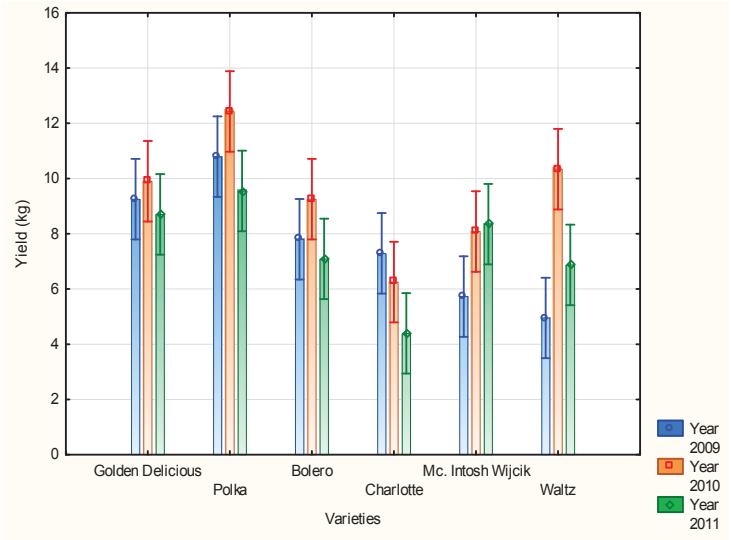
In terms of the individual years the numbers of flowers and fruit showed an increasing tendency,

V: *Number of flowers, number of fruits, yield and weight of the fruit according to varieties (mean, standard error of the mean, different letters indicate significant differences between varieties, p = 0.05)*

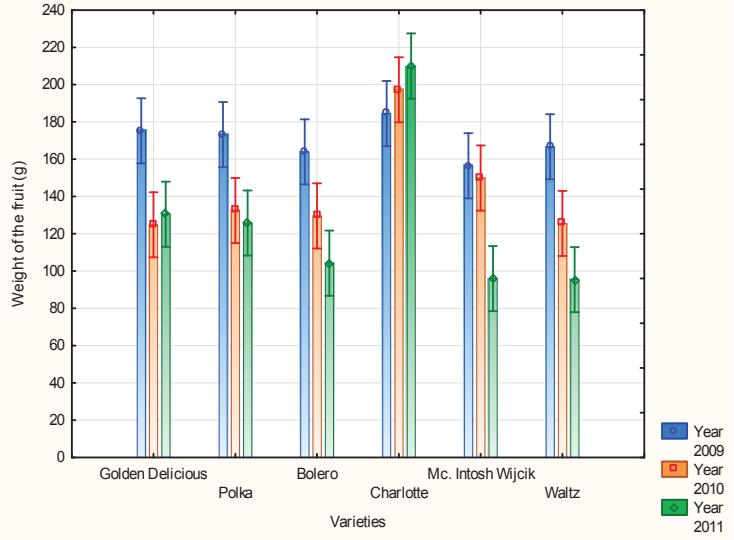
Varieties	Number of flowers	Number of fruits	Yield (kg)	Weight of the fruit (g)
Golden Delicious	242.6 ± 10.9 b	66.11 ± 4.91 bc	9.28 ± 0.43 cd	143.6 ± 10.1 a
Polka	306.4 ± 20.9 de	76.56 ± 4.88 c	10.92 ± 0.63 d	143.8 ± 7.7 a
Bolero	266.9 ± 14.8 c	62.00 ± 4.06 b	8.05 ± 0.58 bc	132.6 ± 9.7 a
Charlotte	125.1 ± 8.8 a	29.89 ± 2.94 a	5.98 ± 0.47 a	197.3 ± 6.2 b
Mc. Intosh Wijcik	321.9 ± 35.4 e	58.44 ± 8.14 b	7.39 ± 0.51 ab	134.1 ± 10.4 a
Waltz	292.4 ± 33.2 d	61.78 ± 8.37 b	7.39 ± 0.81 ab	129.2 ± 10.7 a

VI: *Number of flowers, number of fruits, yield and weight of the fruit according to years (mean, standard error of the mean, different letters indicate significant differences between varieties, p = 0.05)*

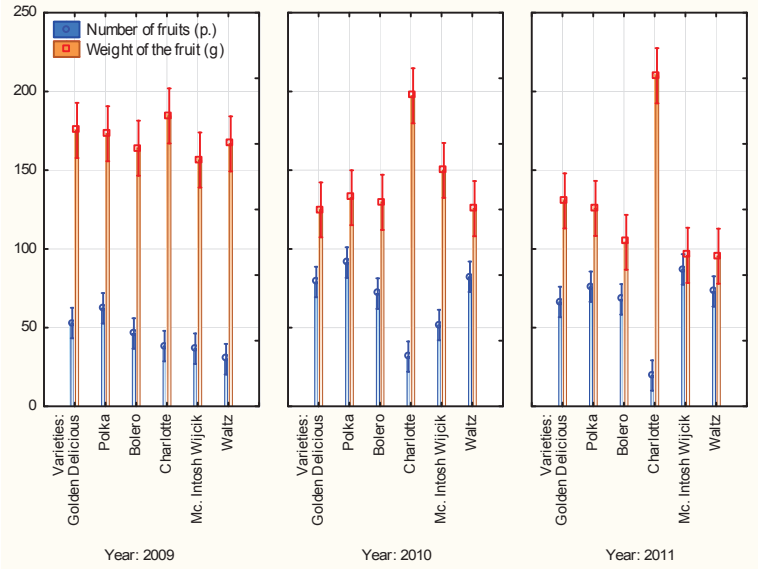
Year	Number of flowers	Number of fruits	Yield (kg)	Weight of the fruit (g)
2009	196.9 ± 8.2 a	44.44 ± 2.77 a	7.63 ± 0.51 a	170.0 ± 3.0 c
2010	268.7 ± 16.9 b	67.94 ± 5.18 b	9.38 ± 0.55 b	143.3 ± 6.7 b
2011	312.1 ± 27.5 c	65.00 ± 5.60 b	7.49 ± 0.48 a	127.0 ± 10.4 a



4: *Yields in the individual years of the experiment*



5: *Weight of the fruit in the individual years of the experiment*



6: *Relation between the number of fruit and their weight (in g) in the individual years of the experiment*

VII: *Analysis of variance results for height of plant, annual increments and number of fruit spurs*

	df	Height (m)		Annual increments (m)		Number of fruit spurs in length (mm)							
						0–50		51–100		101–150		151–200	
		MS	p	MS	p	MS	p	MS	p	MS	p	MS	p
Varieties	5	2.33	0.000	6.37	0.000	341.9	0.000	2568	0.000	172.1	0.000	753.5	0.000
Year	2	1.67	0.000	0.03	0.059	399.3	0.000	414	0.000	166.9	0.000	170.9	0.000
Varieties*Year	10	0.09	0.023	0.11	0.000	62.6	0.000	572	0.000	38.4	0.000	112.0	0.000
Error	36	0.04		0.01		2.3		6		3.091		0.857	

while the weight of the fruit gradually decreased year by year (Tab.VI).

Under detailed illustration of the yields and weight of the fruit in the individual years we saw that the yield of most of the varieties was the highest in 2010 due to favourable rainfall conditions (Fig. 4). Apart from the large-fruited variety Charlotte the weight of the fruit was the highest in the 1st year (Fig. 5). Graph 6 shows the correlation between the amount and weight of the fruit in the individual years; the more fruit, the more their weight decreased.

In terms of the height of the plant, length of annual increments, including the number of fruit spurs of given length, a significant difference (p = 0.05) was discovered among the varieties and years as well as in the interaction of these factors (Tab. VII).

The tallest plants were significantly the variety Polka (3.55 m), followed by Mc. Intosh Wijcik (2.84 m) and Bolero (2.86 m). The significantly smallest plants in height were plants of the variety Golden Delicious (2.02 m).

The variety Golden Delicious showed the significantly highest sum of all the increments (2.58 m) and was followed by the variety Polka (0.72 m) and other varieties – Bolero (0.57 m), Charlotte (0.51 m) and Mc. Intosh Wijcik (0.47 m). The variety Waltz had the shortest annual increments (0.41 m) (Table VIII). Blažek (2011) reported that the length of the increment of the variety Mc. Intosh Wijcik was 0.53 m; this corresponds with results obtained on rootstock M9.

The variety Golden Delicious markedly differed in this parameter from the other columnar shapes; apart from its elongation terminal the variety produced a great amount of lateral elongations on the skeletal branches and formed a typical crown which is imposingly spreading and differs from the columnar trees.

VIII: *Height of plant and annual increments according to varieties (mean, standard error of the mean, different letters indicate significant differences among varieties, p = 0.05)*

Variety	Height (m)	Annual increments (m)
Golden Delicious	2.02 ± 0.07 a	2.58 ± 0.108 c
Charlotte	2.43 ± 0.14 b	0.51 ± 0.041 ab
Waltz	2.67 ± 0.13 bc	0.41 ± 0,054 a
Mc. Intosh Wijcik	2.84 ± 0.11 c	0.47 ± 0.034 ab
Bolero	2.86 ± 0.13 c	0.57 ± 0.056 ab
Polka	3.55 ± 0.08 d	0.72 ± 0.037 b

We divided the number of annual increments according to their length; in the category of the 0–50 mm length the variety Charlotte and the variety Waltz had the highest numbers of fruit spurs (22.57 and 21.73, respectively). The variety Golden Delicious had the least number of increments of this length (7.37). The variety Bolero had the highest number of shoots in the 51–100 mm category (53.97) followed by the variety Polka (41.30); in contrast the variety Golden Delicious had the least number of shoots in this category (14.61) along with Charlotte (15.40) and Mc. Intosh Wijcik (13.72) (Table IX). Charlotte and Mc. Intosh Wijcik had the highest number of 10–150 mm shoots (23.45 and 24.05, respectively); in contrast Golden Delicious, Bolero and Polka had the least number of shoots in this category (14.77, 15.83 and 14.23, respectively). The variety Golden Delicious had the highest number of shoots in the 151–200 mm category (27.00) followed by Mc. Intosh Wijcik (17.97). The varieties Charlotte and Bolero had the least number of shoots in this category (4.47 and 4.97, respectively) (Tab. IX). Fig. 7 gives a survey of the length of the fruit-bearing wood on which the individual varieties bear fruit; it is quite evident that dominant are varieties Mc. Intosh Wijcik and Waltz which bear fruit on 51–100 mm long fruit spurs.

Comparisons of the plant height, length and number of annual increments in the individual years show an increasing tendency in growth (Tab. X).

X: *Height of plant and annual increments according to years (mean, standard error of the mean, different letters indicate significant differences among varieties, p = 0.05)*

Year	Height (m)	Annual increments (m)
2009	2.41 ± 0.08 a	0.838 ± 0.156 a
2010	2.76 ± 0.14 b	0.877 ± 0.223 ab
2011	3.01 ± 0.13 c	0.926 ± 0.187 b

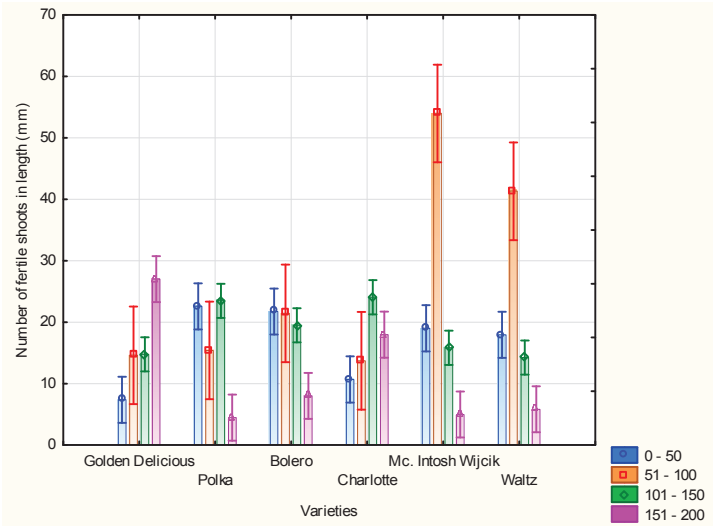
XI: *Average length of internodes in the studied varieties in mm*

Variety	Average length of internode (mm)
Bolero	10.89
Charlotte	11.12
Mc. Intosh Wijcik	12.30
Polka	9.94
Waltz	10.58

Comparisons of the length of internodes of the individual varieties did not reveal any statistically significant differences; however, on average the longest internode was that of the variety Mc. Intosh

IX: *Number of fruit spurs in various lengths according to varieties (mean, standard error of the mean, different letters indicate significant differences among varieties, p = 0.05)*

Variety	0–50	51–100	101–150	151–200
Golden Delicious	7.37 ± 1.37 a	14.61 ± 1.37 a	14.77 ± 1.63 a	27.00 ± 2.28 e
Charlotte	22.57 ± 0.63 d	15.40 ± 0.63 a	23.47 ± 0.92 c	4.47 ± 0.42 a
Waltz	21.73 ± 1.11 d	21.43 ± 1.11 b	19.50 ± 0.38 b	8.00 ± 0.26 c
Mc. Intosh Wijcik	10.67 ± 2.92 b	13.72 ± 2.92 a	24.05 ± 0.96 c	17.97 ± 3.65 d
Bolero	19.00 ± 2.64 c	53.97 ± 2.64 d	15.83 ± 1.14 a	4.97 ± 1.29 ab
Polka	17.93 ± 1.40 c	41.30 ± 1.40 c	14.23 ± 2.38 a	5.82 ± 0.53 b



7: *Number of fruit spurs in given lengths of the studied varieties*

Wijcik (12.30 mm), followed by the variety Charlotte (11.12 mm). The variety Polka had the shortest internode (9.94 mm) (Tab. XI). These data are in accordance with the data of Blažek (2011); the length of the average internode of the variety Mc. Intosh Wijcik cultivated on rootstock M9 was almost the same, i.e. 12.1 mm.

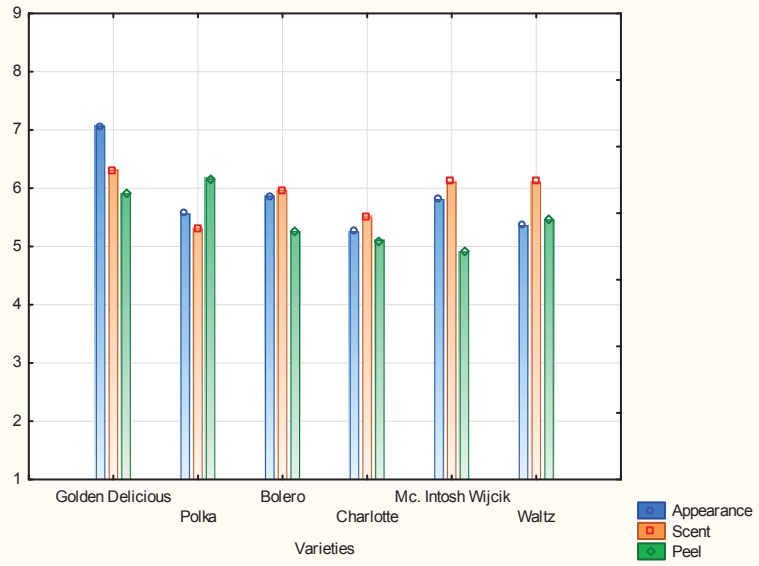
We assessed the organoleptic properties of the fruit, its flesh and overall taste on a scale from 1 to 9. The best score in the appearance of the fruit was achieved by the variety Golden Delicious (7.05 points) followed by Bolero (5.85 p) and Mc. Intosh Wijcik (5.8 p). The variety Waltz had the lowest score in terms of the appearance of the fruit (5.35 p). Concerning the aroma of the fruit the variety Golden Delicious had the best score (6.3 p) followed by Mc. Intosh Wijcik and Waltz (both 6.1 p) and Bolero (5.95 p). The varieties Mc. Intosh Wijcik and Charlotte had the thickest peel (4.9 p and 5.1 p, respectively); in contrast the peels of the varieties Polka, Golden Delicious and Waltz were the thinnest (6.15 p, 5.9 p and 5.45 p, respectively). The variety Golden Delicious had the best consistence of the flesh (6.55 p) followed by Bolero (5.85 p) and Charlotte (5.4 p). The worst consistence of all the varieties was seen in the variety Mc. Intosh Wijcik (5.25 p). The variety Golden Delicious scored the best juiciness (6 b) followed by Mc. Intosh Wijcik (5.85 p) and Waltz (5.75 p); the least juicy variety appeared to be Charlotte (4.75 p). In terms of the taste the sweetest varieties were Golden Delicious (6.2 p), Mc. Intosh Wijcik (6 b) and Waltz (6 b); the varieties Charlotte and Bolero were slightly more acid (5.3 p and 5.45 p, respectively). The control variety Golden Delicious achieved the highest score in terms of the total taste (6.35 p) followed by Mc. Intosh Wijcik (5.95 p) and Waltz (5.85 p); the variety Bolero achieved the lowest score in taste (5.25 p). In the total sum of points evaluating the fruit as a whole, the flesh and the taste, the variety Golden Delicious received most points (44.35 p) followed by Mc. Intosh Wijcik (40.05 p) and Waltz (39.6 p). The variety Charlotte scored the least number of points (36.7 b) (Tab. XI and Figs. 8 and 9).

CONCLUSIONS

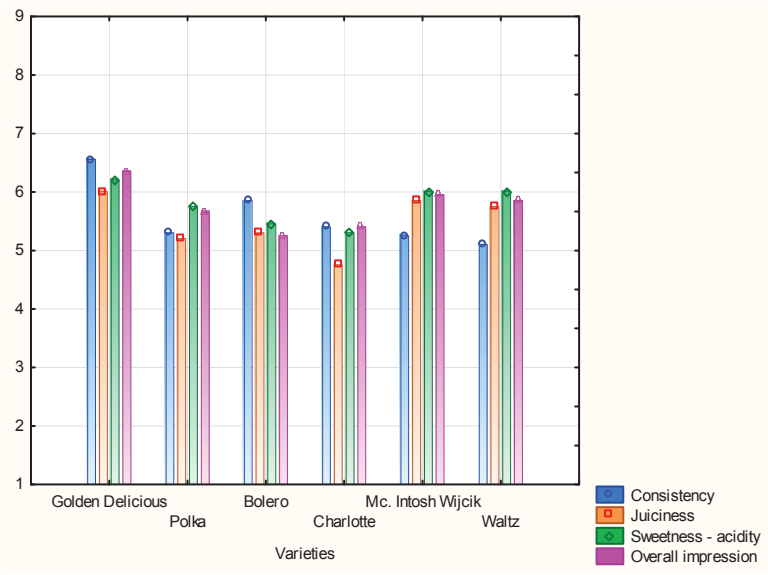
Evaluations of columnar apple varieties were carried out in a three-year period (2009–2011) at the experimental demonstration plot of the Department of Breeding and Propagation of Garden Plants at the School Farm in Žabčice. The planting was

XII: *Averages in organoleptic evaluations of the fruit (1–9)*

Varieties	Fruit			Flesh		Taste		
	Appearance	Aroma	Peel	Consistency	Juiciness	Sweetness – acidity	Overall impression	Number of points
Golden Delicious	7.05	6.3	5.9	6.55	6	6.2	6.35	44.35
Polka	5.55	5.3	6.15	5.3	5.2	5.75	5.65	38.9
Bolero	5.85	5.95	5.25	5.85	5.3	5.45	5.25	38.9
Charlotte	5.25	5.5	5.1	5.4	4.75	5.3	5.4	36.7
Mc. Intosh Wijcik	5.8	6.1	4.9	5.25	5.85	6	5.95	40.05
Waltz	5.35	6.1	5.45	5.1	5.75	6	5.85	39.6



8: *The score in appearance, aroma and peel of the fruit*



9: *The score in consistence, juiciness, sweetness and overall impression*

established in 2000 using traditional apple varieties (Polka, Bolero, Charlotte, Mc. Intosh Wijcik, Waltz) and the control variety Golden Delicious cultivated on rootstock M 9. The infection of the variety Charlotte (6.8) with powdery mildew of apple was significantly higher than infection of the other varieties (6.6–7.8 on the 9-point classification scale). Infection of the variety Charlotte by apple scab was also significantly heavier (6.2) and differed from the other less infected varieties (Polka 7.2), Bolero (6.9), Mc. Intosh Wijcik (7.0) and Waltz (7.14).

The variety Mc. Intosh Wijcik had the most flowers (322) followed by Polka (306) and Waltz (292). The variety Charlotte had the least number of flowers (125).

The variety Polka produced the highest number of mature fruit (77); the amount of harvested mature fruit of the varieties Bolero, Mc. Intosh Wijcik and Waltz was significantly lower (62, 58 and 62 fruits, respectively); the least number of fruits but highest weight were produced by the variety Charlotte (30) and this variety had significantly the highest weight of the fruit (197 g). The weight of fruit of the other varieties was significantly lower and ranged between 129 and 144 g. In this case the correlation between the amount and weight of the fruit was confirmed.

The variety Polka produced the highest total yield (10.9 kg); the next were the control variety Golden Delicious and Bolero (9.3 and 8.1 kg, respectively). The lowest yields were produced by the variety Charlotte (6.0 kg) in spite of the highest weight of the fruit.

The variety Polka grew to the tallest height (3.55 m) and was followed by the varieties Mc. Intosh Wijcik (2.84 m) and Bolero (2.86 m). The height of the control variety Golden Delicious was the lowest (2.02 m).

The variety Golden Delicious had the highest sum of lengths of all increments (2.58 m), the next was the variety Polka (0.72 m) and varieties Bolero (0.57 m), Charlotte (0.51 m) and Mc. Intosh Wijcik (0.47 m). The shortest annual increments were discovered in the variety Waltz (0.41 m),

No statistically significant differences were monitored when comparing the length of the internodes of the individual varieties. The highest average length of the internode was monitored in the variety Mc. Intosh Wijcik (12.30 mm) followed by the variety Charlotte (11.12 mm); the variety Polka had the shortest internodes (9.94 mm).

Fruit of the control variety Golden Delicious received the best score in appearance (7.05 points) followed by Bolero (5.85 b) and Mc. Intosh Wijcik (5.8 b). The variety Waltz received the worst score for the appearance of the fruit (5.35 p). The highest score in terms of the aroma of the fruit was won by the variety Golden Delicious (6.3 p), the next were varieties Mc. Intosh Wijcik and Waltz (both 6.1 p) and the variety Bolero (5.95 p). The varieties Mc. Intosh Wijcik and Charlotte had the thickest peel (4.9 and 5.1 p, respectively); by contrast the peel of the varieties Polka, Golden Delicious and Waltz was the thinnest (6.15, 5.9 and 5.45 p, respectively). In terms of the flesh the variety Golden Delicious had the best consistence (6.55 p), followed by the varieties Bolero (5.85 p) and Charlotte (5.4 p). The variety Mc. Intosh Wijcik had the worst quality of the consistence of all the varieties (5.25 p). The variety Golden Delicious boosted the highest juiciness (6 b) and was followed by varieties Mc. Intosh Wijcik (5.85 p) and Waltz (5.75 p); the least juicy variety was Charlotte (4.75 p). In terms of the taste the sweetest varieties were Golden Delicious (6.2 p), Mc. Intosh Wijcik (6 p) and Waltz (6 p) a more acid taste was characteristic for the variety Charlotte (5.3 p) and Bolero (5.45 p). The variety with the best total taste was the control variety Golden Delicious (6.35 p) followed by the varieties Mc. Intosh Wijcik

(5.95 p) and Waltz (5.85 p); the least delicious variety was Bolero (5.25 p). In the total score evaluating the entire fruit, flesh and taste, the winner was the variety Golden Delicious (44.35 p) followed by the varieties Mc. Intosh Wijcik (40.05 p) and Waltz (39.6 p). The variety Charlotte received the least number of points (36.7 p).

A general characteristic of columnar shapes is the considerable shortening of the length of elongation shoots at the same time increasing the number of buds; the resulting shape and total height is substantially affected by the growth properties of the rootstock used.

SUMMARY

Evaluations of columnar apple varieties were carried out in a three-year period (2009–2011) at the experimental demonstration plot of the Department of Breeding and Propagation of Garden Plants, at the School Farm in Žabčice. The planting was established in 2000 using traditional apple varieties (Polka, Bolero, Charlotte, Mc. Intosh Wijcik, Waltz) and the control variety Golden Delicious cultivated on rootstock M 9. The achieved results confirmed the growth characteristics of columnar apple varieties. The growth properties of the variety were influenced by the growing capacity of the used rootstock. Infection of the variety Charlotte by powdery mildew was significantly more severe than the infection of the other varieties. Also apple scab infection of the variety Charlotte was significantly higher and differed from the other less infected varieties. The highest number of ripened fruit was produced by the variety Polka; significantly less fruit was produced by varieties Bolero, Mc. Intosh Wijcik and Waltz; the least number of fruit but of highest weight was produced by the variety Charlotte and this variety showed the significantly highest weigh of the fruit. The variety Polka had the highest total yields and was followed by the control variety Golden Delicious and the variety Bolero. The variety Charlotte gave the lowest yield in spite of the fact that the fruit was the heaviest.
The variety Polka grew to the tallest height and was followed by the varieties Mc. Intosh Wijcik and Bolero. The height of the control variety Golden Delicious was the lowest.
Fruit of the control variety Golden Delicious received the best score in appearance followed by Bolero and Mc. Intosh Wijcik. The variety Waltz received the worst score for the appearance of the fruit (5.35 p). The varieties Mc. Intosh Wijcik and Charlotte had the thickest peel; by contrast the peel of the varieties Polka, Golden Delicious and Waltz was the thinnest. In terms of the flesh the variety Golden Delicious had the best consistence of the flesh followed by the varieties Bolero and Charlotte. The variety Golden Delicious boosted the highest juiciness and was followed by varieties Mc. Intosh Wijcik and Waltz; the least juicy variety was Charlotte. The variety with the best total taste was the control variety Golden Delicious followed by the varieties Mc. Intosh Wijcik and Waltz; the least delicious variety was Bolero. In the total score evaluating the entire fruit, flesh and taste the winner was the variety Golden Delicious followed by the varieties Mc. Intosh Wijcik and Waltz.

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