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Natural Growth Habit of Sweet Cherry Maiden Trees

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Abstract

Natural growth habit of maiden trees of standard and newly released sweet cherry cultivars grafted on either *Prunus mahaleb* or Giessen rootstocks were examined during two production seasons. Trees on Giessen rootstocks were less vigorous than those on *P.mahaleb.* The performance of the trees, assessed by measuring the total number of lateral shoots (TNS), tree height (TH), and trunk diameter (TD), was qualitatively consistent over the two seasons. Among the ten cultivars on *P.mahaleb* rootstock there were two groups of cultivars distinguished by branching behavior with two outstanding cultivars, namely 'Van' (mean: 8.1 TNS/year) and 'Bing' (mean: 1.9 TNS/year). Comparison of values for these quality characteristics, especially for TNS, between the cultivars grafted on different Giessen rootstocks, showed that the cultivar *per se* was the main factor influencing branching behavior. A morphological description of maiden trees of newly released sweet cherry cultivars from Cornell University is given. For trees of most of the cultivars, the correlations between TNS and TD were significant, whereas those between TNS and TH were not. The possibility of using TD as a parameter for estimating a tree's ability to produce lateral shoots is discussed.

Introduction

It is well established that the degree of branching of nursery trees determines future performance of young orchards (10). Cultivar differences in fruit tree growth-habit, resulting from the variability of such characteristics as internode length, branch angle, branching ability, and basitonic or acrotonic tendencies are horticulturally important as they directly affect tree management and thus orchard profitability (5). An adequate number of well-positioned lateral branches for tree framework is a prerequisite for early cropping since these laterals provide sites for flower bud formation. Branching may be influenced by rootstocks, propagation techniques, cultural practices and environmental factors (11). However, the ultimate determinant of a cultivar's branching ability is under genetic control (10). Temperate fruit species are characterized by rather limited ability to branch; yet there are great differences among the species, and also among the cultivars. Broadly speaking, apples, pears, and sweet cherries do not branch readily, while peach, apricot, sour cherry, and plum cultivars do (1,4,10). The work reported here focused on branching behavior and corresponding vegetative growth characteristics of sweet cherry cultivars grown in the Great Lakes fruit growing region in the USA.

Materials and Methods

These studies were conducted in two large commercial nurseries located in different parts of the state of New York. In each nursery there was an experiment carried out over two seasons (1994 and 1995). Maiden trees of sweet cherry grafted on several rootstocks were used, to which routine fertilizer, pest, and weed control programs were applied. No practices to promote lateral branch formation were applied.

Nursery production protocols

Sweet cherry trees on Prunus mahaleb L.: The trees were spaced 120 *x* 30 cm and budded at 5 cm above the soil line using T - budding technique. Maiden sweet cherry trees of 'Bing', 'Black Tartarian', 'Emperor Francis', 'Giant Hedelfingen', 'Kristin', 'Napoleon', 'Schmidt', 'Stella', 'Van', and 'Windsor' were tested.

Sweet cherry trees on Giessen series rootstocks: The trees were planted at 100 *x* 30 cm. They were chip-budded at the height 30 cm from the soil line using the rootstocks of Giessen series: Gi 148/1 (Gisela 6), Gi 148/8 (Gisela 7), and Gi 195/1 (Gisela 11). The cultivars examined were 'Lapins', and also those recently released from Cornell

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University, namely 'Hartland', 'Royalton', and 'Somerset'.

Data recording and analysis

The trees for every treatment were selected from one row or two adjacent nursery rows of the same cultivar/rootstock combination. Upon completion of each growing season the measurements of tree height (TH), trunk diameter (TD) taken at 15 cm above the bud union, the number of sylleptic shoots < 30 cm (NL30), ≥ 30 cm (NM30), and their total number (TNS = NL30 + NM30) were recorded. For 'Hartland', 'Royalton', and 'Somerset', visual observations on the magnitude of crotch angles, length of laterals, and the location of primary area of lateral's formation, where most of sylleptic shoots suitable for tree training emerged (PALF), were performed. The experiments were established using completely randomized design with 30 and 18 single-tree replicates per cultivar/rootstock combination in 1994 and 1995, respectively. The data were subjected to analysis of variance, and a Duncan's multiple range test at $P= 0.05$ was used for mean separation. Mutual relations between the quality characteristics such as TH, TD, and TNS were evaluated by Pearson's product moment correlation at $P= 0.05$.

Results

Sweet cherry trees on Prunus mahaleb L.: The trees produced in 1995 outperformed those of 1994 in examined quality characteristics. The mean values for 1994 quality characteristics (computed across all cultivars) were 71, 64, 64, 90 and 72% of those in 1995 for the NL30, NM30, TNS, TD and TH, respectively. There were some significant differences between the cultivars in examined characteristics (Table 1). There were two groups of cultivars distinguished by branching ability based on total number of shoots per tree/year with TNS ≥ 4.0, and < 4.0, for the 1st and 2nd group, respectively. The 1st group included: 'Van', 'Emperor Francis', 'Schmidt', 'Windsor' (mean for the group: 6.1 shoots/year); and the 2nd group was: 'Bing', 'Black Tartarian', 'Giant Hedelfingen', 'Kristin', 'Napoleon' and 'Stella' (mean for group: 3.0 shoots/year). 'Van' was most efficient in inducing laterals (8.1 shoots/year), while 'Bing' produced on average of 2.0 shoots/year. The correlations of TD *x* TNS, and TH *x* TNS, averaged for two years, demonstrated significance in 90% and 30% of all tested correlations, respectively (Table 2). The correlation of TD *x* TH ranged from moderately to highly positive, yet there was some inconsistency for some cultivars when the results of both years were compared (Table 2). The cultivars 'Emperor Francis' and 'Schmidt' (Figure 1A and 1B) and 'Black Tartarian', 'Giant Hedelfingen', 'Kristin', 'Napoleon' and 'Stella' exhibited some basitonic growth habit. 'Van' and 'Royalton' (not reported in this experiment) demonstrated mesotonic growth habit, characterized by relatively even distribution of axillary shoots along the parent shoot (Figure 1C and 1D).

Sweet cherry trees on Giessen series rootstocks: The trees in 1994 significantly outperformed those produced in 1995 in TD and TNS, but not in TH (Table 3). In both years the TNS for various cultivars performed in similar way, which means that regardless of rootstock, 'Somerset' produced significantly higher TNS than either 'Hartland' or 'Royalton' (Table 3). Comparison of annual TNS means for both years among the cultivars (across the rootstocks), and among the rootstocks (across the cultivars), indicated that much greater variation existed between the cultivars *per se* (mean max. and mean min. of TNS for 'Somerset' and 'Royalton' was 4.79 *vs.* 1.61, and 3.26 *vs.* 0.23, in 1994 and 1995, respectively) - (Table 3) than when those values were averaged across the cultivars (mean max. and mean min. of TNS for Gi 148/1 and Gi 148/8 was 2.54 *vs.* 2.16, and 1.93 *vs.* 1.00,in 1994 and 1995, respectively) – (Table 3). No such differences were found for TD or TH if the same computing formula was applied (Table 3). 'Lapins' hardly produced any feathers. The interaction effects (cultivar *x* rootstock) are given in Table 3. Except for 'Lapins', in both years, the performance of trees assessed by values of tested characteristics was qualitatively consistent, which means that the order of TH, TD and TNS values for particular cultivars was the same over the entire period of investigation (Table 3). This was particularly true for trees grafted onto Gi 148/1, and to lesser extent for those on Gi 148/8. Most correlations of TD *x* TH, TD *x* TNS were significant and fairly consistent during this study, whereas those of

Table 1. Quality characteristics of maiden sweet cherry trees on *Prunus mahaleb* L.

Cultivar	Number of feathers												Tree diameter (cm)				Tree height (cm)			
	< 30 cm				≥ 30 cm				Total											
	1994		1995		1994		1995		1994		1995		1994		1995		1994		1995	
	Sign[w]	Sign[y]	Sign[w]	Sign[y]	Sign[w]	Sign[y]	Sign[w]	Sign[y]	Sign[w]	Sign[y]	Sign[w]	Sign[y]	Sign[w]	Sign[y]	Sign[w]	Sign[y]	Sign[w]	Sign[y]	Sign[w]	Sign[y]
Bing	0.13 ab	a	0.00 c	a	1.73 e	a	2.06 e	a	1.86 de	a	2.06 f	a	1.97abc	a	1.95 c	a	195 b	b	246 fg	a
Black Tartarian	0.17 ab	a	0.11 bc	a	3.73 bc	a	4.17 cd	a	3.90 bc	a	4.28 de	a	2.02 ab	a	2.11 bc	a	189 b	b	266 d	a
Emperor Francis	0.07 b	b	0.33 b	a	4.20 b	b	7.28 ab	a	4.27 b	b	7.61 b	a	2.10 a	a	2.26 ab	a	169 c	b	269 cd	a
Giant Hedelfingen	0.00 b	a	0.06 bc	a	2.83 cd	b	4.22 cd	a	2.83 cd	b	4.28 de	a	1.92 bc	b	2.21 ab	a	190 b	b	260 e	a
Kristin	0.10 ab	a	0.07 bc	a	1.90 de	b	3.13 de	a	2.00 de	a	3.20 ef	a	1.85 bc	b	2.13 bc	a	177 c	b	253 ef	a
Napoleon	0.10 ab	a	0.06 bc	a	1.47 e	b	4.39 cd	a	1.57 e	b	4.45 de	a	1.67 d	b	2.26 ab	a	174 c	b	253 ef	a
Schmidt	0.17 ab	a	0.00 c	a	4.10 b	b	6.83 b	a	4.27 b	b	6.83 b	a	1.83 cd	b	2.08 bc	a	147 d	b	238 g	a
Stella	0.07 b	a	0.11 bc	a	1.57 e	b	4.22 cd	a	1.64 e	b	4.33 de	a	1.99 abc	b	2.26 ab	a	194 b	b	279 bc	a
Van	0.33 a	a	0.83 a	a	6.33 a	b	8.67 a	a	6.66 a	b	9.50 a	a	2.14 a	a	2.30 ab	a	207 a	b	286 ab	a
Windsor	0.10 ab	a	0.17 bc	a	4.10 b	a	5.00 c	a	4.20 b	a	5.17 cd	a	2.02 ab	a	2.09 bc	a	213 a	b	296 a	a
mean	0.12 a[z]		0.17 a[z]		3.20 b[z]		5.00 a[z]		3.32 b[z]		5.17 a[z]		1.95 b[z]		2.17 a[z]		186 b[z]		265 a[z]	
%[x]	71				64				64				90				72			

Values followed by the same letter are not significantly different at P = 0.05. The comparisons are valid: **w** - within each column separately for each year; **y** – between 1994 and 1995 values for the same characteristic of a given cultivar; **z** – between 1994 and 1995 mean values for the same characteristic; **x** – in % of 1995 mean values.

Table 2. Correlation coefficients for quality characteristics of maiden sweet cherry trees on *Prunus mahaleb* L.

Cultivar	Correlation coefficient					
	TD[z] *x TH*[y]		*TD x TNS*[x]		*TH x TNS*	
	1994	1995	1994	1995	1994	1995
Bing	0.30 ns	0.72 *	0.29 ns	0.70 *	0.01 ns	0.04 ns
Black Tartarian	0.63 *	0.25 ns	0.71 *	0.72 *	0.31 ns	0.08 ns
Emperor Francis	0.70 *	0.07 ns	0.66 *	0.87 *	0.31 ns	0.10 ns
Giant Hedelfingen	0.31 ns	0.62 *	0.81 *	0.86 *	0.18 ns	0.64 *
Kristin	0.54 *	0.75 *	0.83 *	0.93*	0.41 *	0.64 *
Napoleon	0.73 *	0.44 ns	0.77 *	0.67 *	0.30 ns	0.13 ns
Schmidt	0.42 *	0.59 *	0.59 *	0.50 *	0.36 ns	0.10 ns
Stella	0.44 *	0.30 ns	0.67 *	0.90 *	0.01 ns	0.14 ns
Van	0.49 *	0.75 *	0.04 ns	0.74 *	0.48 *	0.69 *
Windsor	0.59 *	0.50 *	0.77*	0.76 *	0.50 *	0.14 ns

* - all values are significant at P = 0.05; **ns** – not significant; **z** – trunk diameter; **y** – tree height; **x** – total number of shoots.

Table 3. Quality characteristics of maiden sweet cherry trees on Giessen rootstocks

Year	Characteristic	Cultivar	Interaction effects Rootstock Gi 148/1	 Gi 148/8	 Gi 195/1	Mean [z]	Grand mean [x]
1994	Tree height [w] (cm)	Hartland	172 c	165 bc	181 d	173 c	
		Lapins	165 bc	164 bc	164 bc	164 b	
		Royalton	163 bc	162 b	161 b	162 ab	
		Somerset	162 b	152 a	162 b	159 a	
		Mean	166 b[y]	161a[y]	167 b[y]		166 a
	Trunk diameter [w] (cm)	Hartland	2.01 e	1.81 abc	1.96 de	1.93 b	
		Lapins	1.91 bcde	1.80 ab	1.88 abcde	1.86 ab	
		Royalton	1.95 cde	1.85 abcd	1.84 abcd	1.88 ab	
		Somerset	1.87 abcde	1.87 abcde	1.76 a	1.83 a	
		Mean	1.93 b[y]	1.83 a[y]	1.86 a[y]		1.87 b
	Total number of shoots [w]	Hartland	2.56 cd	1.83 bc	2.67 cd	2.35 c	
		Lapins	0.22 a	0.12 a	0.72 a	0.35 a	
		Royalton	2.22 c	0.89 ab	1.72 bc	1.61 b	
		Somerset	5.16 e	5.78 e	3.45 d	4.79 d	
		Mean	2.54 a[y]	2.16 a[y]	2.14 a[y]		2.28 b
1995	Tree height [w] (cm)	Hartland	249 d	216 b		232 b	
		Royalton	235 c	201 a	n.d	218 a	
		Somerset	205 a	205 a		205 a	
		Mean	230 b[y]	207 a[y]			218 b
	Trunk diameter [w] (cm)	Hartland	1.91 d	1.60 a		1.76 a	
		Royalton	1.88 cd	1.59 a	n.d.	1.73 a	
		Somerset	1.74 b	1.76 bc		1.75 a	
		Mean	1.84 b[y]	1.65 a[y]			1.75 a
	Total number of shoots [w]	Hartland	1.73 b	0.39 a		1.06 b	
		Royalton	0.28 a	0.17 a	n.d.	0.23 a	
		Somerset	3.78 d	2.73 c		3.26 c	
		Mean	1.93 b[y]	1.10 a[y]			1.52 a

Means followed by the same letter are not significantly different at P= 0.05. The comparisons are valid for: **w** – interaction effects within three (1994) or two (1995) columns of the same characteristic; **y** – means of rootstocks (across cultivars) separately for 1994 and 1995; **z** – means of cultivars (across rootstocks) separately for 1994 and 1995; **x** – grand means of the characteristics between 1994 and 1995; **n.d.** – no data.

Table 4. Values of correlation coefficients for quality characteristics of maiden sweet cherry tree on Giessen rootstocks

Cultivar	Rootstock	Correlation coefficients					
		TD[z] *x* TH[y]		TD *x* TNS[x]		TH *x* TNS	
		1994	1995	1994	1995	1994	1995
Hartland	Gi 148/1	0.83 *	0.60 *	0.64 *	0.82 *	0.28 ns	0.57 *
	Gi 148/8	0.81 *	0.41 ns	0.79 *	0.64 *	0.68 *	0.16 ns
	Gi 195/1	0.50 *	N	0.61 *	N	0.20 ns	N
Lapins	Gi 148/1	0.61 *	0.67 *	0.32 ns	0.0 ns	0.10 ns	0.0 ns
	Gi 148/8	0.82 *	N	0.24 ns	N	0.06 ns	N
	Gi 195/1	0.61 *	N	0.80 *	N	0.10 ns	N
Royalton	Gi 148/1	0.61 *	0.56 *	0.70 *	0.49 *	0.30 ns	0.15 ns
	Gi 148/8	0.50 *	0.69 *	0.77 *	0.07 ns	0.33 ns	0.11 ns
	Gi 195/1	0.45 ns	0.22 ns	0.60 *	0.60 *	0.01 ns	0.30 ns
Somerset	Gi 148/1	0.46 ns	0.42 ns	0.25 ns	0.39 ns	0.13 ns	0.22 ns
	Gi 148/8	0.71 *	0.52 *	0.64 *	0.65 *	0.42 ns	0.17 ns
	Gi 195/1	0.26 ns	N	0.34 ns	N	0.27 ns	N

* - all values are significant at P =0.05;**ns** – not significant; **N** – no shoots for this combination; **z** – trunk diameter; **y** – tree height; **x** – total number of shoots.

TH *x* TNS in most cases were not (Table 4). Field observations during this investigation, using a large number of maiden trees, indicated distinct differences in growth habit existing among cultivars. 'Somerset' exhibited semi-acrotonic growth habit. When the scions of this cultivar were grafted onto Gi 148/8 the feathers emerged at acute angles (< 45^0); but when they were grafted onto Gi 148/1, the feathers emerged at wider angles. 'Royalton' on Giessen rootstocks demonstrated basitonic growth in contrast with some mesotonic type of growth if grafted on *Prunus mahaleb* L. Irrespective of rootstock, most of 'Royalton's sylleptic shoots emerged at the angle < 45^0. Length of most of these shoots ranged from 50 to 90 cm. This cultivar exhibited some scion overgrowth if grafted onto Gi 148/1. 'Hartland' showed mesotonic growth habit. Its sylleptic shoots emerged at wide angle (80 - 90^0) and were evenly distributed along the parent shoot. Approximate length of these laterals were about 80 cm. Lateral shoots of 'Somerset' were inserted at an acute crotch angle (< 45^0), except for the trees on Gi 148/1, which shoots were characterized by angles about 60^0. PALF for 'Somerset' was concentrated about 100 cm from the ground with the shoots about 60 cm long. PALF did not apply to other cultivars since they did not have sufficient number of shoots suitable for canopy training (Table 3).

Discussion

The results of this research showed that the sequence of tested cultivars relative to quantity of sylleptic shoots induced in each year was consistent over the investigation period. Climatic factors play an important role in syllepsis (11). In both years there were minor differences in weather conditions between experimental sites (data not shown). It is likely that year-to-year variation in tree quality, mostly in TNS, was caused by the other factors than climate. One of the most likely reasons for this variation could be a soil factor since nursery crops are grown using field rotation. Glacial-derived soils, which were present at both sites are known to be heterogeneous in comparison with alluvial deposited soils. Also, a genetic factor, especially involved in generative propagated rootstocks, such as *Prunus mahaleb* L., should not be overlooked. The differences in branching found among examined cultivars may be mainly attributed to their genetics (10). Trees on Giessen rootstocks were less vigorous than those on *Prunus mahaleb* L. Walther and Franken-Bembenek (12) noted that sweet cherry trees on Giessen rootstocks were less vigorous than those on *Prunus avium* L. Lang *et al.* (6) reported that trees on Gi 148/1 and Gi 148/8 branched poorly. There were probably several reasons for poor branching of trees on Giessen rootstocks in our experiments. These may be related to either cultivar (10), rootstock (6, 12) or such management practices as budding height (2). Analysis of cultivar and/or rootstock effects on quality characteristics of nursery trees showed that a cultivar was the main determinant in this respect. Rootstock, however, may modify branching behavior by influencing the vigor of the scion (3). There was less variation in tree height and/or trunk diameter than in the number of lateral shoots in the examined cultivar/rootstock combinations. Ostrowska and Chelpinski (8, 9) and Chelpinski *et al.* (1) found that correlation between the trunk cross-sectional area and either TNS or total shoot extension growth was true for young apple, pear, and sour cherry, but not for plum trees. In our experiments, the observed TD *x* TNS correlation showed the relationship that existed between these two quality characteristics after completion of tree growth; however, it did not describe relationships that might have existed between TD and TNS at different stage of active tree growth. Kowalik (4) reported that in sweet cherry maidens of cv. 'Regina', the correlation between TD and TNS was highly positive during different stages of growth development. Comparison of two types of correlations (TD *x* TNS) *vs.* (TH *x* TNS) in this experiment and others (1,7,8,9) clearly indicated that the magnitude of trunk diameter or trunk cross-sectional area were better related to the number of sylleptic shoots than tree height. Thus, TD may better express the ability of a tree to branch than does TH. It is assumed that the degree of correlation of TD *x* TNS may depend upon the vigor of a maiden tree, since it was found that correlation between TD and TNS was stronger in profusely branched apple cultivars than in those with a low-branching potential (7). The results of this study of multiple sweet cherry cultivars and rootstocks at two commercial nurseries suggest that because of the significant correlation between total number of sylleptic shoots and trunk diameter, TD may be used as a quality indicator for maiden sweet cherry trees. These results support an earlier proposal by Lipecki and Janisz (7), who applied TD as a quality indicator for apple maiden trees.

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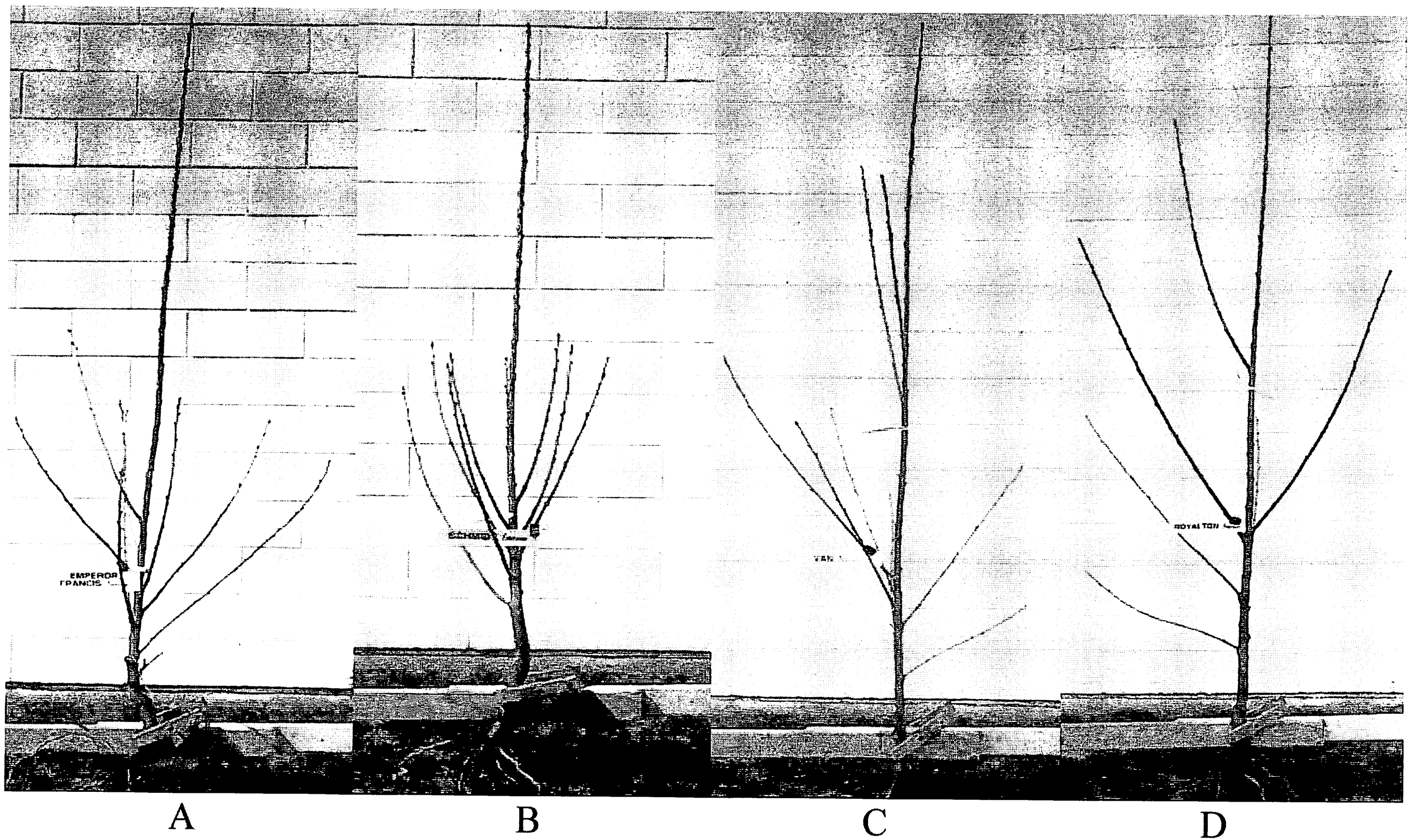

Figure 1. Basitonic branching pattern of sweet cherry maiden tress of cvs 'Emporer Francis' (A), and 'Schmidt' (B), and mesotonic pattern of 'Van' (C) and 'Royalton' (D) on *Prunus maheleb* rootstock.