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EVALUATION OF SOME TRAINING SYSTEMS IN APPLE ORCHARD

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A B S T R A C T

The influence of some tree-training systems on growth, cropping and fruit quality was estimated in the experiment conducted in 1994-2003 at the Fruit Experimental Station near Wrocław SW Poland. The e xperiment was carried out on 'Elstar' and 'Jonagold' trees/M.9 planted in a randomised split-plot design in 4 replications with 3 trees in the form of Mikado (4 leaders), 4 trees as Drilling (3 leaders), 6 trees as Tatura (2 leaders) and 12 trees in V-Güttingen system (1 leader) per plot. Trees were spaced in rows at 2.4 m (Mikado), 1.8 m (Drilling), 1.2 m (Tatura) and 0.6m (V-Güttingen) whereas the distance between rows equalled 3.5 m. In this way, the number of leaders per hectare for each tree form was almost the same. Results showed, that apple trees with 2, 3 and 4 leaders had greater both yields per tree and productivity index values. For 'Elstar', yields per hectare from trees with 2, 3 and 4 leaders were also increased. With increasing tree age fruit quality declined. This experiment showed that planting of trees with a few leaders may be an efficient way to reduce costs related to the establishment of an orchard.

Key words: apple, Mikado, Drilling, Tatura, V-system, growth, yield, quality of fruit

INTRODUCTION

In modern fruit growing, much attention has been given to controlling the balance between tree growth and fruit production in high-density plantings. Although dwarfing rootstocks are of prime importance for controlling the growth, cultural techniques as pruning and orchard design also have an influence on tree development (Elfving, 1988). The planting system in an apple orchard is crucial for yield, fruit quality and profitability. The best way

to increase early yield is to enhance planting density (Robinson et al., 1991). But these super spindle plantings have high investment costs and could not fulfil requirements with regard to sufficient yield and fruit quality (Hornig and Bünemann, 1993; Weber, 1997). The new solution are open forms. The most popular V-shaped systems, recommended for fruit production, are V-Güttingen, Y-trellis (Tatura), Drilling and Mikado (Robinson, 2000). The open forms with slender elements allow optimum light interception and generate good yields with high fruit quality (Monney and Evéquoz, 1999; Mika et al., 2000; Buler et al., 1999; Widmer and Krebs, 2001). The lower investment costs for the open systems with 2, 3 or 4 branch elements (Tatura, Drilling, Mikado) due to a reduced number of trees per hectare are advantageous as compared with the current spindle system in single rows. The somewhat higher costs for the support scaffold frame are a minor disadvantage (Widmer and Krebs, 1997).

The aim of the present study was to compare the growth, yield and fruit quality of some tree training systems in an apple orchard in the Lower Silesia region SW Poland.

MATERIAL AND METHODS

The experiment was established in the spring of 1994 at the Fruit Experimental Station in Samotwór, near Wrocław. The research was carried out on 'Elstar' and 'Jonagold' trees on M.9 rootstock planted in a randomised split-plot design in 4 replications with 3 trees in the form of Mikado (4 leaders – 1190 trees ha^{-1}), 4 trees as Drilling (3 leaders – 1587 trees ha^{-1}), 6 trees as Tatura (2 leaders – 2381 trees ha^{-1}) and 12 trees in V-Güttingen system (1 leader – 4762 trees ha^{-1}) per plot. Trees were spaced in rows at 2.4 m (Mikado), 1.8 m (Drilling), 1.2 m (Tatura) and 0.6 m (V-Güttingen) whereas the distance between rows equalled 3.5 m. In this way, the number of leaders per hectare for each tree form was almost the same. Trees were planted as non-feathered and therefore they were cut down on a height of 60 cm above the budding place. For that reason their yielding was delayed by one growing season. From the fourth year after planting trees were annually pruned soon after petal fall. Trees were not irrigated. Fruitlets were annually only chemically (Pomonit) thinned. From the first year, there was herbicide fallow in the rows and sward between them. Chemical protection was carried out according to the current recommendations of the Orchard Protection Programme.

In the 1994-2003, records of vegetative growth, yield, and fruit quality were taken. The results were statistically elaborated by an analysis of variance. The significance of differences between means was evaluated by Student's multiple range t-test at $P = 0.05$.

RESULTS AND DISCUSSION

Up to the tenth year after planting, vegetative growth, yield and fruit quality were affected by cultivar and rootstock. Although 'Elstar' trees grew stronger than 'Jonagold' often there was no significant difference. Trunk growth was negatively related to plant density, confirming the reports by Callesen (1994) and Mika et. al. (2000), and this effect can be attributed to an enhanced inter-tree competition (Tab. 1). However, the number and total length of annual shoots per leader were the highest for V-system trees. Vegetative growth of Mikado, Drilling and Tatura trees was partitioned into four, three and two elements, respectively, so these trees had less dense crowns. Manual labour on pruning increased significantly depending on decreasing the number of leaders per apple tree (Tab. 2.). This is in agreement with observations by Widmer and Krebs (1997), Buler et al. (1999) and Hampson et al. (2002).

T a b l e 1 . Growth of 'Elstar' and 'Jonagold' depending on tree form

Treatment	Number of shoots leader^{-1} 1996-97	Total length of shoots leader^{-1} 1996-97 [cm]	TCSA autumn 2003 [cm^2]	TCSA increment [cm^2]		
				1994-97	1997-00	2000-03
'Elstar'						
Mikado	38.5	1125	82.7	14.5	33.5	32.8
Drilling	44.1	1328	69.8	13.0	26.5	28.6
Tatura	56.4	1650	58.3	11.2	23.5	22.1
V-Güttingen	96.6	2585	34.8	10.9	11.4	11.1
Mean for cultivar	**58.9**	**1672**	**61.4**	**12.4**	**23.7**	**23.6**
'Jonagold'						
Mikado	42.6	1213	73.0	15.2	25.6	30.0
Drilling	36.1	1174	58.6	11.9	20.1	24.9
Tatura	52.3	1585	44.5	10.3	16.1	16.5
V-Güttingen	81.5	2496	26.1	7.8	9.1	8.7
Mean for cultivar	**53.1**	**1617**	**50.6**	**11.3**	**17.7**	**20.0**
$LSD_{0.05}$ for cultivar	n.s.	n.s.	6.1	n.s.	4.9	n.s.
$LSD_{0.05}$ for tree form within cultivar	16.7	447	6.5	2.1	3.6	3.6

T a b l e 2 . Manual labour on pruning depending on tree form (mean for 1999-2003)

Treatment	Minutes leader^{-1}	Hours hectare^{-1}
Mikado	1.3	100.7
Drilling	1.6	128.2
Tatura	2.2	171.1
V-Güttingen	2.5	196.1
$LSD_{0.05}$	0.26	21.7

Irrespective of tree form, significantly higher cumulative yield both per tree and per ha after nine harvests was obtained for 'Jonagold' (Tab. 3). Results showed that apple trees with 2, 3 and 4 leaders had greater both fruit yields per tree and productivity index values (CEC). Also, fruit yields per hectare from trees with a few leaders were increased, although this effect was observed only for 'Elstar' cultivar. But even for 'Jonagold', yield per hectare did not increase proportionally with the number of trees per hectare – the highest crops per ha were odtained from Tatura trees but the lowest from V-Güttingen system. Trees of both cultivars trained using the Mikado system were the most productive followed by Drilling, Tatura and V-Güttingen. These results are similar to literature data (Buler et al., 1999; Widmer and Krebs, 2001). 'Elstar' trees, especially those trained as Mikado, were characterised by the greatest tendency towards biennial bearing (Tab. 3)

T a b l e 3 . Yielding of 'Elstar' and 'Jonagold' depending on tree form, in 1995-2003

Treatment	Cumulative yield 1995-2003		CEC [kg cm^{-2}] 1995-2003	Biennial bearing index 0-1
	kg tree^{-1}	t ha^{-1}		
'Elstar'				
Mikado	188.1	223.8	2.27	0.70
Drilling	140.2	222.5	2.01	0.56
Tatura	90.0	214.3	1.54	0.51
V-Güttingen	42.1	200.5	1.21	0.53
Mean for cultivar	**115.1**	**215.3**	**1.76**	**0.57**
'Jonagold'				
Mikado	257.1	305.9	3.52	0.47
Drilling	203.2	322.5	3.47	0.46
Tatura	145.0	345.2	3.26	0.41
V-Güttingen	63.8	303.8	2.44	0.52
Mean for cultivar	**167.3**	**319.4**	**3.17**	**0.46**
$LSD_{0.05}$ for cultivar	5.0	6.3	0.36	0.06
$LSD_{0.05}$ for tree form within cultivar	15.3	28.3	0.38	0.15

Dense planting of 'Jonagold' trees in V-system caused a significant decrease in the mean fruit weight during 1996-2003 in comparison to the Mikado from (Tab. 4). Significant differences in mean fruit weight between tree forms for 'Elstar' were not observed. According to Widmer and Krebs (2001), and Robinson et al. (1991), the open tree forms have a good influence on fruit size and colouring because of optimum light interception. Similar results were obtained in this experiment. The best fruit quality was recorded in the first years after planting, then, with an increasing tree age it declined. Due to a stronger shading of crowns, the colouring of apples from the most densely planted trees in V-Güttingen system was the worst. Tree forms did not significantly affect the size of fruit.

Table 4. Effect of tree form on 'Elstar' and 'Jonagold' apple quality

Treatment	Mean fruit weight [g]				% of apples with diameter >7.5 cm 1997-2003*	% of apples with blush over ½ 1997-2003*
	1996-97	1998-00	2001-03	1996-03		
'Elstar'						
Mikado	177	152	135	147	27.1	75.3
Drilling	173	154	138	150	28.6	76.8
Tatura	177	157	145	154	33.0	69.6
V-Güttingen	176	148	148	152	28.2	57.9
Mean for cultivar	**176**	**153**	**142**	**151**	**29.2**	**69.9**
'Jonagold'						
Mikado	217	234	210	221	65.5	69.2
Drilling	207	236	210	221	66.9	70.0
Tatura	217	230	206	218	66.8	64.3
V-Güttingen	215	223	201	213	66.0	52.5
Mean for cultivar	**214**	**231**	**207**	**218**	**66.3**	**64.0**
$LSD_{0.05}$ for cultivar	10	9	12	9	15.8	n.s.
$LSD_{0.05}$ for tree form within cultivar	n.s.	10	12	7	n.s.	8.3

*Means transformed according to Bliss's function

This experiment showed that planting of trees with 2, 3 or 4 leaders may be an efficient way to reduce costs of both orchard establishment and tree training.

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OCENA KILKU SYSTEMÓW PROWADZENIA DRZEW JABŁONI

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STRESZCZENIE

W doświadczeniu prowadzonym w latach 1994-2003 w Stacji Badawczo-Dydaktycznej w okolicach Wrocławia badano wpływ kilku systemów prowadzenia drzew jabłoni na wzrost, owocowanie i jakość owoców. Jednoroczne okulanty odmian 'Elstar' i 'Jonagold' na podkładce M.9 posadzono metodą losowanych podbloków w czterech powtórzeniach po 3 (Mikado – 4 przewodniki), 4 (Drilling – 3 przewodniki), 6 (Tatura – 2 przewodniki) oraz 12 (V-Güttingen) drzew na poletku. Drzewa posadzono w rozstawie 3,5 m między rzędami przy zróżnicowanej rozstawie jabłoni w rzędzie: 2,4 m (Mikado), 1,8 m (Drilling), 1,2 m (Tatura) oraz 0,6 m (V-Güttingen). W ten sposób wszystkie formy koron miały zbliżoną liczbę elementów, czyli przewodników w przeliczeniu na 1 hektar. Badania wykazały, że drzewa z 2, 3 i 4 przewodnikami plonowały lepiej i miały wyższe współczynniki plenności. U odmiany 'Elstar' również plony w przeliczeniu na 1 hektar były wyższe dla drzew z koronami kilkuprzewodnikowymi. Wraz z wiekiem drzew jakość jabłek się pogarszała. Sadzenie drzew z kilkoma przewodnikami może być dobrym sposobem na obniżenie nie tylko kosztów założenia (potrzeba mniej drzew), ale również prowadzenia sadu (niższe nakłady na cięcie).

Słowa kluczowe: jabłoń, Mikado, Drilling, Tatura, V-system, wzrost, plonowanie, jakość owoców