EFFECT OF DIFFERENT TREE TRAINING SYSTEMS ON GROWTH AND YIELDING OF TWO APPLE CULTIVARS

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A B S T R A C T

Experiment with different training systems of apple trees 'Šampion' and 'Topaz' grafted on M.26 rootstock was established in the Experimental Orchard at the Agricultural and Pomicultural Experimental Farm in Przybroda near Poznań, belonging to Department of Pomology, University of Life Sciences in Poznań

Maiden apple trees were planted in the spring 2002 at two densities: 3.5 × 2.0 m (1428 trees ha^{-1}) and 3.5 × 1.0 m (2857 trees ha^{-1}). Depending on the spacing of the trees, nine different tree trainings were applied. Trees of both cultivars planted most densely were trained in the following forms: V from Gűttingen, Hytec, spindle, axis and spindle form from Bodensee Lake. Trees planted at the wider spacing had the following forms: double spindle, Drylling and Mikado. Each training system had 4 replications (five trees in each replication).

Comparison of apple tree training system has shown that the growth and yield of trees depends more on the genetic traits whereas tree form changes the orchard architecture. Observations confirm the high values of the Drylling and Mikado crown forms, which require a moderate labour input for their formation and maintenance during fruiting time.

Key words: cultivar, training system, growth, yield, quality of fruit

INTRODUCTION

Tree trimming belongs to activities which are absolutely necessary in commercial orchards (Mika, 1984; 2003). Density of tree planting, their distribution and span of the canopies decide about the orchard architecture (Gruca, 1998; Mika and Krawiec, 1999; Mika and Krzewińska, 1999; Szewczuk and Gudarowska, 2004) and depend on the tree trimming, which directly or indirectly exerts an influence on the physiological processes of the trees (Taylor and Lenz, 1991). The achievement of an adequate yield and good quality of fruit and the setting of flower buds depend on light conditions, which can be improved through the formation of an adequate tree canopy (Ugolik, 1994; Buler et al., 1999; Gruca, 2001; Buler and Mika, 2004). In intensive orchards one can find different tree canopies. However, the most common is the spindle form (Mika, 1984; Buler and Mika, 2004). When the fruit tree growers introduce changes in the tree density and in the production technology, they have also to decide what canopy form they are going to apply in the orchard.

The objective of the presented work was to determine the effect of nine tree canopies on the growth and yielding of two apple cultivars.

MATERIAL AND METHODS

Studies were carried out in the years 2002-2007 in the experimental orchard of the Department of Pomology, University of Life Sciences in Poznań, located at the area of the Agricultural and Pomicultural Experimental Farm in Przybroda. Experimental material consisted of 'Šampion' and 'Topaz' apple cultivars grafted on M.26 rootstock. In the spring 2002, one-year old maidens were planted at two spacings: 3.5 × 2.0 m (1428 trees/ha) and 3.5 × 1.0 m (2857 trees/ha). The orchard was established on an area which earlier was used for agricultural purposes on a proper grey-brown podsolic soil shallowly overlying light loam, belonging to III b class. The ground water level was at the depth of about 180 cm.

Depending on the tree spacing, nine types of tree canopies were introduced:

In the 3.5 × 2.0 m tree spacing:

1. Near-natural crown shape (Fig. 1),
2. Double spindle form (Y form) (Fig. 2),
3. Drylling form (Fig. 3),
4. Mikado form (Fig. 4).

In the 3.5 × 1.0 m tree spacing:

5. V form from Gűttingen (Fig. 5),
6. Hytec form (Fig. 6),
7. Spindle form (Fig. 7),
8. Axis form (Fig. 8),
9. Spindle form from Bodensee Lake (Fig. 9).

Experiment was established in four replications, ach consisted of 5 trees. Agronomical treatments were carried out according to the recommendations for apple orchards. Tree canopies were formed in the first five years after planting, and since 2007 only corrective trimmings were done.

Estimation of tree vigour was carried out on the basis of stem circumference at the height of 30 cm above the ground and it was recalculated

Figure 1. Near-natural crown shape

Figure 2. Double spindle form (Y form)

Figure 3. Drylling form

Figure 4. Mikado form

Figure 5. V form from Gűttingen

Figure 6. Hytec form

Figure 7. Spindle form

Figure 8. Axis form

Figure 9. Spindle form from Bodensee Lake

into stem trunk cross-section area. Abundance of blooming and individual yield from one tree as well as the fruit quality were estimated on the basis of fruit mass, fruit firmness and extract content.

Obtained results were statistically elaborated by multifactorial analysis of variance using STAT program. Significance of differences between combinations was estimated on the basis of Duncan's t-test at $p \leq 0.05$.

RESULTS AND DISCUSSION

Experiment was established using a very homogeneous nursery material with 1.1 cm^2 trunk cross-section area for 'Šampion' cultivar and 1.3 cm^2 for 'Topaz'. In the first years after planting 'Topaz' was characterized by more intensive growth and the increment of stem cross-section area was twice greater than in 'Šampion' (Tab. 1). Independently of the training system, trees of both cultivars which were planted an the wider spacing had greater increments than those grown in the narrower spacing. Therefore, one can state that the type of a canopy exerted a smaller effect on the tree growth intensity in both studied cultivars. The obtained results agree with data obtained by Ugolik (1994), Żurawicz (2003) and Kruczyńska (2002).

Trees of both cultivars started fruiting in the second year after planting. Individual yield from one tree in the particular years depended on the cultivar, kind of the tree canopy and spacing. 'Šampion' was more productive and its yields were systematically increasing (Tab. 2). On the other hand, 'Topaz' showed an inclination to alternating fruiting intensity already in the first years (Tab. 2). A kind of the tree canopy, independently of a cultivar, exerted a significant effect on the size of the obtained yield. Trees formed in all the canopies tested gave significantly higher yields when planted at wider spacing. However, the yield recalculated into area unit was proportional to the number of trees per one hectare (Tab. 2).

Interaction of cultivar and canopy form on fruit yield from one 'Šampion' tree was the highest in the trees trained in Mikado and Drylling forms while the lowest yield was obtained from trees trained as Hytec and V form from Gűttingen. On the other hand, 'Topaz' yielded the best with near-natural crown shape while the poorest yield was obtained from trees with Hytec canopy (Tab. 2).

The obtained results confirm the opinion that the number of trees per area unit, in the first years after plantation, exerts greater effect on the yield (Mika, 1996; Gruca, 1998; Mika and Krawiec, 1999) than the type of training.

Index of productivity was closely correlated with the yield and the vigour of tree growth. 'Šampion', which was characterized by poorer growth (Tab. 1) and higher yield (Tab. 2), showed higher productivity index than 'Topaz'. Among the canopy forms, the highest productivity index was found on trees with Drylling and Mikado canopy forms, while the lowest index of productivity had the trees with Axis canopy form (Tab. 3).

Table 1. Effect of tree canopy form on growth vigour of 'Šampion' and 'Topaz' apple trees

Tree canopy form	Cultivar					
	Šampion			Topaz		
	trunk cross section area [cm^2]			trunk cross section area [cm^2]		
	spring 2002	autumn 2007	increment	spring 2002	autumn 2007	increment
	spacing 3.5 × 2.0 m					
1. Near-natural crown shape	0.9 a*	18.5 ab	17.6 ab	1.3 ab	42.3 c	41.0 c
2. Double spindle form (Y form)	1.1 a	17.4 a	16.3 a	1.5 b	38.5 ab	37.0 ab
3. Drylling	1.3 ab	17.5 a	16.2 a	1.1 a	37.4 ab	36.3 a
4. Mikado	1.1 a	19.8 b	18.7 b	1.3 ab	35.9 a	34.6 a
Mean	1.1 a	18.3 b	17.2 b	1.3 a	37.8 b	31.6 a
	spacing 3.5 × 1.0 m					
5. V form from Güttingen	0.9 a	18.1 ab	17.2 ab	1.1 a	32.4 a	31.3 ab
6. Hytec	1.1 ab	15.9 a	14.8 a	1.3 ab	34.4 ab	33.1 bc
7. Spindle	1.1 ab	14.7 a	13.6 a	1.3 ab	32.9 c	31.6 b
8. Axis	0.9 a	14.3 a	13.4 a	1.5 b	32.4 a	30.9 a
9. Spindle form from Bodensee Lake	1.1 ab	17.6 ab	16.5 ab	1.3 ab	32.2 a	30.9 a
Mean	1.1 a	16.4 a	15.1 a	1.3 a	32.8 a	37.2 b

*Means followed by the same letters do not differ at 5% level of significance

Table 2. Effect of training system on yield of 'Šampion' and 'Topaz' apple trees (2003-2007)

Cultivar	Tree canopy form	Yield [kg tree^{-1}]					Total yield 2003-2004 [kg tree^{-1}]	Mean yield 2003-2007 [t ha^{-1}]
		2003	2004	2005	2006	2007		
		spacing 3.5 × 2.0 m						
Šampion	1. Near-natural crown shape	3.4 c*	5.0 a	12.4 a	21.9 a	25.9 b	68.6 a	19.6 a
	2. Double spindle form (Y form)	2.1 a	6.2 b	12.3 a	24.5 b	21.6 a	66.7 a	19.0 a
	3. Drylling	2.3 a	5.3 a	15.0 c	26.7 b	25.7 b	75.0 b	21.4 ab
	4. Mikado	2.5 ab	6.5 b	13.4 bc	27.7 b	28.1 bc	78.2 c	22.3 b
	Mean	2.6 a	5.7 a	11.1 a	25.2 b	25.3 b	72.1 b	20.6 a
	spacing 3.5 × 1.0 m							
	5. V form from Güttingen	2.2 a	4.4 a	11.9 ab	18.8 b	19.6 d	56.9 bc	32.5 c
	6. Hytec	3.7 c	5.3 ab	10.5 a	14.6 a	14.8 a	48.9 a	27.9 a
	7. Spindle	2.8 b	7.3 c	10.3 a	14.0 a	15.9 a-c	50.3 b	28.7 a
	8. Axis	3.5 c	6.6 b	11.9 ab	14.9 a	15.2 ab	52.1 b	29.8 ab
	9. Spindle form from Bodensee Lake	3.4 c	7.5 c	10.7 a	16.1 ab	16.4 bc	54.1 bc	30.9 b
	Mean	3.1 b	6.2 b	13.3 b	15.7 a	16.4 a	52.5 a	30.0 b
Topaz	spacing 3.5 × 2.0 m							
	1. Near-natural crown shape	3.6 c	9.8 c	15.4 c	34.4 b	14.9 d	78.1 d	22.3 d
	2. Double spindle form (Y form)	1.9 ab	5.3 a	9.2 a	25.9 a	6.9 a	49.2 a	14.1 a
	3. Drylling	1.4 a	8.1 b	10.8 a	30.0 b	10.7 bc	61.0 b	17.4 b
	4. Mikado	2.1 ab	8.5 b	13.3 bc	33.3 b	10.0 bc	67.2 c	19.2 c
	Mean	2.3 a	7.9 b	12.2 a	30.9 b	10.6 b	63.9 b	18.3 a
	spacing 3.5 × 1.0 m							
	5. V form from Güttingen	2.8 ab	8.4 c	25.4 c	19.0 b	7.3 ab	62.9 c	35.9 d
	6. Hytec	2.8 ab	8.1 bc	8.7 a	15.3 a	3.6 a	38.5 a	22.0 a
	7. Spindle	2.5 a	7.6 b	10.7 ab	20.0 b	7.2 ab	48.0 ab	27.4 bc
	8. Axis	2.7 a	5.3 a	10.6 ab	19.2 b	7.3 ab	45.1 ab	25.8 b
	9. Spindle form from Bodensee Lake	3.2 b	7.8 b	11.1 ab	21.1 b	8.6 bc	51.8 b	29.6 bc
	Mean	2.8 b	7.4 a	13.3 b	18.9 a	6.8 a	49.3 a	28.1 b

*Explanations, see Table 1

Table 3. Effect of training system on productivity index of Šampion' and 'Topaz" apple trees

Tree canopy form	Productivity index [kg cm^{-2}]		
	Šampion	Topaz	Mean
	spacing 3.5 × 2.0 m		
1. Near-natural crown shape	3.7 a*	1.6 ab	2.6 a
2. Double spindle form (Y form)	3.8 a	1.3 a	2.6 a
3. Drylling	4.3 b	1.6 ab	2.9 b
4. Mikado	3.9 a	1.9 b	2.9 b
Mean	3.9 b	1.6 b	2.8 b
spacing 3.5 × 1.0 m			
5. V form from Güttingen	3.1 a	1.4 ab	2.2 ab
6. Hytec	3.1 a	1.1 a	2.1 a
7. Spindle	3.4 b	1.4 ab	2.4 cd
8. Axis	3.6 c	1.4 ab	2.5 d
9. Spindle form from Bodensee Lake	3.0 a	1.6 ab	2.3 bc
Mean	3.2 a	1.4 a	2.3 a

*Explanations, see Table 1

Table 4. Effect of training system on quality of 'Šampion' and 'Topaz' fruit

Tree canopy form	Mean fruit mass [g]		Fruit firmness [Kg]		Soluble solids [%]	
	Šampion	Topaz	Šampion	Topaz	Šampion	Topaz
	spacing 3.5 × 2.0 m					
1. Near-natural crown shape	161 a*	165 a	6.4 a-e	7.8 a	12.1 a	14.1 a
2. Double spindle form (Y form)	183 a	168 a	6.6 a-g	7.6 a	12.9 ab	14.1 a
3. Drylling	175 a	167 a	6.4 a-d	7.9 a	12.7 a	14.2 a
4. Mikado	165 a	171 a	5.7 a	7.8 a	12.9 ab	14.3 a
Mean	157 a	168 a	6.3 a	7.7 a	12.7 a	14.2 a
spacing 3.5 × 1.0 m						
5. V form from Güttingen	160 a	177 a	6.2 a	7.9 a	12.7 a	14.3 a
6. Hytec	167 a	191 a	6.1 a	7.6 a	12.7 a	13.9 a
7. Spindle	158 a	173 a	6.1 a	7.8 a	12.7 a	14.0 a
8. Axis	153 a	172 a	6.7 a	7.5 a	12.5 a	14.1 a
9. Spindle form from Bodensee Lake	150 a	159 a	6.5 a	7.8 a	12.5 a	13.8 a
Mean	172 a	175 a	6.4 a	7.8 b	12.7 a	14.0 a

*Explanations, see Table 1

There was no significant influence of cultivars and tree canopy forms on the fruit mass (Tab. 4). Kruczyńska (2002) and Gruca et al. (2002) believe that the application of thinning treatments contributes to the equalization of fruit size and fruit mass, hence there is no significant effect exerted by cultivar or tree canopy form. Fruit firmness and the content of extract depended in a higher degree on the cultivar than on the tree canopy form.

Fruit of 'Topaz' had higher firmness and higher content of extract than 'Šampion' and this agrees with the data reported by Żurawicz (2003) and Kruczyńska (2002).

CONCLUSIONS

1. The growth measured by the trunk cross-section area depended on the cultivar and on tree spacing, but in a lesser degree on the tree canopy training. During first years after planting 'Topaz' was characterized by a stronger growth vigour than 'Šampion'.
2. Individual yield from one tree depends on the cultivar, tree canopy form and tree spacing. 'Šampion' produced higher and more equalized yield, while 'Topaz' showed an inclination to alternating yielding intensity already in the first years after planting.
3. Productivity index was closely correlated with the growth vigour, cultivar and yield, hence 'Šampion' showed a higher productivity than 'Topaz'.
4. Fruit quality is a characteristic feature of a cultivar. A higher firmness and higher extract content, independently of tree canopy form, had 'Topaz' fruit.

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FORMY KORON A WZROST I PLONOWANIE DWÓCH ODMIAN JABŁONI

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S T R E S Z C Z E N I E

Gęstość sadzenia drzew, ich rozmieszczenie, wysokość, rozpiętość i kształt koron stanowią architekturę sadu. Obok rozpowszechnionej oceny korony wrzecionowej, ocenia się przydatność do produkcji innych form koron. Doświadczenie ze zróżnicowanymi formami koron drzew owocowych na jabłoniach odmian 'Szampion' i 'Topaz' na podkładce M.26 zostało założone w sadzie doświadczalnym Katedry Sadownictwa Akademii Rolniczej w Poznaniu na terenie Rolniczo-Sadowniczego Gospodarstwa Doświadczalnego w Przybrodzie koło Poznania. Jednoroczne okulanty posadzono wiosną 2002 roku w dwóch rozstawach 3,5 x 2,0 m (1428 drzew na ha) i 3,5 x 1,0 m (2857 drzew na ha). Kombinacje miały cztery powtórzenia po pięć drzew w każdym. Łącznie wykonano obserwacje na 360 drzewach, to jest 9 kombinacji x 4 powtórzenia x 5 drzew. W sadzie w zależności od zastosowanej rozstawy wprowadzono dziewięć form koron. Drzewa obu odmian posadzone w mniejszej rozstawie były prowadzone w następujących formach koron: V z Güttingen,

Hytec, wrzecionowa, osiowa i osiowa znad jeziora Bodeńskiego, natomiast posadzone w większej rozstawie w formach: prawie naturalnej, podwójnego wrzeciona, Drylling i Mikado. W doświadczeniu badano obfitość kwitnienia, wielkość i jakość plonu, wzrost drzew oraz zdolność przechowalniczą owoców. Jakość owoców oceniono na podstawie ich masy, wielkości, wybarwienia, jędrności oraz zawartości ekstraktu, a wzrost drzew na podstawie pomiaru średnicy pni.

Ocena przydatności form koron dla drzew odmian jabłoni wykazała, że wzrost i plon jest bardziej zależny od cech genetycznych odmiany, natomiast forma korony zmienia architekturę sadu i wpływa na poprawę jakości owoców. Obserwacje potwierdzają duże walory korony wrzecionowej, która wymaga umiarkowanego nakładu pracy na jej wyprowadzenie i następnie utrzymanie w sadzie owocującym.

Słowa kluczowe: cięcie, forma korony, plonowanie, odmiana, jakość owoców