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EFFECTS OF HIGH DENSITY PLANTING AND TWO TRAINING METHODS OF DWARF APPLE TREES GROWN IN SUB-CARPATHIAN REGION

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A B S T R A C T

Apple trees of 'Jonagold' cultivar ('Jonica' strain) grafted on M.9 and P 22 rootstocks were planted in 1994 on medium heavy loam soil at a distance of 3.5 x 1.0 or 1.3 m to be trained as a slender spindle system and at 3.5 x 1.0 or 0.7 m to be trained as vertical axis. Trees on M.9 grew stronger than on P 22 and produced 25% more fruit per tree than on P 22. Those on P 22 were more efficient in cropping and yielded significantly better in the slender spindle system than in vertical axis. The highest yield per ha was obtained from trees on M.9 trained as vertical axis. There was no difference in fruit quality between studied treatments.

Key words: apple trees, rootstocks, planting distances, training

INTRODUCTION

Intensive growing of apple trees, planted at a high density, became possible due to the introduction of dwarf rootstocks and a slender spindle form of trees worked out in Germany. Both events took place as early as the 1930s, but only twenty years later dwarf apple and pear orchards were started to be planted in Holland at a spacing of 4 x 2 m (1250 trees/ha) (Wagenmakers, 1995). Up to 1970 the number of trees planted per hectare increased to 4500 but the duration of orchards decreased to 15 years (Goedegebure, 1986). In the 1990s super-dense planting was started in Germany and the number of trees per hectare reached 18000. Dwarf apple trees were trained as slender spindle, commonly called super-spindle. However, very dense growing apples have not been accepted due to economic reasons.

Numerous experiments showed (Verheij and Verwer, 1972; Jackson et al., 1981; Mika and Piątkowski, 1986; Mika and Krzewińska, 1999) that fruit yield from a surface unit increases proportionally to the number of planted trees, but only to a certain limit, when too high shading by an orchard canopy disables active photosynthesis of leaves (Wertheim et al., 1986). Together with orchard density the light interception increases (particularly in young orchards) and proportionally to that fruit yield from the surface unit also increases (Verheij and Verwer, 1972; Jackson 1980). Sunlight is best utilised by trees when planted in a square pattern. This encouraged fruit growers to grow dwarf trees in multi-row system with 2-5 rows, in which trees were planted at 1 x 1 m or 1.5 x 1.5 m with working alleyways 3.5 m wide. However, excessive shading of trees in multi-row system and the problems of orchard management caused a successive decrease of popularity of that practice (Wertheim, 1985). Also results of the recent experiment at Brzezna (Szczygieł et al., 2001) showed that an excessive planting density (8000 trees/ha) of 'Gloster' and 'Sampion' was not justified.

The aim of the present experiment was to check the effects of training systems and planting densities on the growth and cropping of 'Jonica' apple trees, because cultivars of the 'Jonagold' group have been commonly planted in the last decade in the Sub-Carpathian region.

MATERIAL AND METHODS

Experiment was established in 1994 at the Brzezna Fruit Experimental Station on medium heavy loam of the slight south eastern slope after removing a sour cherry orchard. One-year-old unfeathered maidens of 'Jonica', budded on M.9 and P 22 rootstocks at the height of 10-12 cm, were planted in the spring of 1994 in four rows. Spacing between rows was 3.5 m and in the row for trained slender spindle trees 1.0 and 1.3 m, whereas for vertical axis 0.7 and 1.0 m. Two training systems were introduced for each rootstock: slender spindle and vertical axis. To obtain a slender spindle, tree leaders were pruned at the height of 90 cm after planting and about 50 cm above the highest side shoot in the second year. Side shoots being too strong or growing at a too narrow angle were bent to a horizontal position or cut away. To obtain a vertical axis, tree leaders were not pruned over the first three years after planting and side branches – if grew too vertically – were bounded or – if too strong – removed. Each treatment was replicated three times and the number of trees in each plot varied from 20 to 37 according to the spacing in the rows. Standard renewal pruning was performed up to 1998 after blooming and from 1999 before blooming, except the pruning of leaders, which always was conducted after blooming.

Soil was maintained in a standard way; herbicides in the rows and grassed alleyways cut 6-8 times in the growing season. Trunk thickens was measured upon three trees on each plot at the height of 30 cm at the end of each vegetative season or in early spring of the next season before vegetation started.

Fruit yield per tree was estimated upon the total crop from each plot, replicated 3 times and fruit quality (size, weight and colouring) was estimated on 100 fruits picked at random from whole canopy of the three trees on the plot (the same in which the trunk cross section area was measured). Fruit weight was expressed in g, size in mm of diameter and colouring in % of fruit surface. The data were analysed statistically by using an analysis of variance. Duncan's multiple range t-test at P=0.05 was used to evaluate the differences between the means. Weight and size were averaged together for the most representative four years: 1997, 1998, 2000 and 2001, and the colouration of fruits was shown biennially for 1997-98 and for 2000-01 (Tab. 2).

RESULTS

Growth of trees, expressed as a trunk cross section area, was stronger on M.9 than on P 22. However, growth intensity was not affected significantly by the training system and planting density of trees, although some tendency to stronger growth of slender spindle trees and those planted at a lower density in comparison with vertical axis and planted at a higher density, was noted. It is particularly evident in Table 1.

First yield occurred in 1996, in the third season after planting. During the first cropping period (1996-98) vertical axis trees gave a higher yield than those of slender spindle, although in the case of trees on P 22 the difference was not statistically significant. These differences disappeared in the next two years and in 2001 slender spindle trees yielded better than those of vertical axis in the case of both rootstocks. Final total yield per tree did not show significant differences between the training systems. There was a visible tendency to better cropping of trees planted at a lower density, which was particularly distinct in the vertical axis system. Cropping efficiency index was significantly higher for trees on P 22 than for those on M.9. It was also related to the training system in the first cropping period, being lower for slender spindle trees than for those of vertical axis; this was particularly evident for trees on M.9.

Total countable fruit yield estimated per hectare was related mainly to tree spacing and was greater from plots with higher tree densities in the case of both rootstocks.

Fruit size (Tab. 2) was not affected significantly either by planting density or by the training system. Neither was there any difference between treatments in fruit colouration in both

T a b l e 1. Growth and cropping of ‘Jonica’ apple trees on M.9 and P 22 as related to training system and planting density

Root-stok	Training system	Number of trees per ha	Trunk cross section area [cm^2]		Fruit yield per tree [kg]		Cropping efficiency index		Estimated yield [t/ha]	
			1998	2001	1996-98	1996-01	1996-98	1996-01	1996-98	1996-01
M.9	slender spindle	2700	11.36a*	24.94ab	10.8ab	53.2a	0.95	2.14	29.16a	143.64b
		2050	12.03a	30.21b	10.0a	52.4a	0.83	1.73	20.50a	107.42a
	vertical axis	3834	8.60a	20.29a	13.6bc	41.6a	1.58	2.05	52.14b	159.49b
		2700	8.76a	24.94a	16.5c	51.5ab	1.86	2.06	44.55b	139.05ab
P 22	slender spindle	2700	8.40 b	14.68a	14.9a	41.3bc	1.77	2.81	40.30ab	111.51ab
		2052	7.54ab	15.87a	15.9a	45.5c	2.11	2.87	32.63a	93.37a
	vertical axis	3834	6.06a	10.81a	13.7a	31.9a	2.27	2.95	52.52c	122.30b
		2700	6.89ab	13.38a	17.6a	37.1ab	2.55	2.78	47.52bc	100.30a

*The means followed by the same letter do not differ at P=0.05 according to Duncan’s t-test

T a b l e 2. Fruit quality of ‘Jonica’ apples on two rootstocks as related to training system and planting density

Rootstock	Training system	Number of trees per ha	Mean fruit weight [g] 1997-98 and 2000-01	% of fruits >70 mm in diameter 1997-98 and 2000-01	% of fruits with >50% of coloured surface	
					1997-98	2000-01
M.9	slender spindle	2700	213.5a*	98.7a	97.7a	55.6a
		2050	205.0a	99.0a	93.2a	65.6a
	vertical axis	3834	206.1a	98.6a	92.4a	39.5a
		2700	191.8a	93.0a	95.3a	45.6a
P 22	slender spindle	2700	187.9a	95.0a	92.6a	56.3a
		2052	193.8a	96.5a	97.8a	65.6a
	vertical axis	3834	183.0a	88.6a	86.2a	52.2a
		2700	186.3a	93.1a	91.4a	67.2a

*Explanations see Table 1

cropping periods. However, intensity of fruit colouration was distinctly weaker in the second cropping period than in the first for all treatments.

DISCUSSION

Contrary to some earlier observations (Mika and Piątkowski, 1986; Szczygieł et al., 2001) growth intensity of trees, expressed as a trunk cross section area, was slightly and not significantly affected by the planting density. This results may be explained by relatively small differences in tree number planted per hectare in each training system.

The results concerning training systems are in agreement with previous findings (Szczygieł et al., 2001) and confirm a commonly accepted opinion that trees having leader not headed after planting come into cropping earlier and crop better during the first years than those with headed leader. However, this result can change in later years to the benefit of slender spindle trees, having leaders headed at least twice after planting. This is particularly evident when one-year-old unfeathered maidens are planted, as was the case in the present experiment. Pruning the leader of such trees stimulates them to produce sooner a required number of branches and thus to increase their cropping potential in later years.

According to the earlier observations (Mika et al., 1981) fruit yield per tree is decreasing with an increasing planting density due to the reciprocal competition of trees for light and water. In the present trial this was evident only on plots with vertical axis trained trees. Lack of such effect on slender spindle trees may be due to the fact that only 2700 of such trees/ha were planted at the highest density applied.

Decreasing fruit colouration with the age of trees can be explained by an increasing shading in tree canopies and thus decreasing light penetration, which become a limiting factor in fruit colouration when it falls to about half of normal sunrise radiation.

In spite of some decrease of yield per tree with an increasing planting density, the cropping efficiency per hectare enhanced. Earlier results (Mika et al., 1981; Szczygieł et al., 2001) show that, in spite of yield decrease per tree with an increasing planting density, the productivity of orchard hectare increases. In this trial slender spindle trees planted at a density of 2700 per hectare produced 36 tons more apples than 2050 trees per hectare during 6 years. Similarly, the difference in yield between 3834 and 2700 vertical axis trees per hectare was 20 tons.

CONCLUSSIONS

1. Unfeathered apple maidens, trained as vertical axis (without pruning the leader) showed a weaker growth and an earlier and higher yield than trees trained as slender spindle, but only during the first few years after planting.
2. When the number of dwarf apple trees planted per hectare is below a certain value (e.g. 3000), the effect of planting density on tree

growth and yield is usually small or none, in the early years of orchard management.

3. Training system and planting density of dwarf apple trees may not influence fruit size and colouring in the early years. However, fruit colouring may be significantly reduced during later years with the growth of tree canopies. Therefore, attention should be paid to satisfactory summer pruning.
4. Increasing planting density, within some limits, results in a higher total yield per hectare. However, increasing tree density above a certain limit requires more trees to obtain an additional yield and may not be justified from the economic point of view.

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REZULTATY GĘSTEGO SADZENIA JABŁONI KARŁOWYCH I DWÓCH METOD PROWADZENIA DRZEW UPRAWIANYCH W REJONIE PODKARPACIA

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

Jabłonie 'Jonagold' (mutacja 'Jonica') szczepione na podkładkach M.9 i P 22 posadzono w 1994 roku na ciężkiej glebie gliniastej w rozstawie 3,5 x 1,0 m i 3,5 x 1,3 m dla formowania wysmukłych koron wrzecionowych oraz 3,5 x 1,0 m i 3,5 x 0,7 m dla prowadzenia koron osiowych. Jabłonie szczepione na M.9 rosły istotnie silniej niż szczepione na P 22 i wydały około 25% wyższy plon w przeliczeniu na drzewo. Jabłonie na P 22 były produktywniejsze i owocowały obficiej prowadzone w formie wysmukłego wrzeciona niż w formie osiowej. Najwyższy przeliczeniowy plon z hektara osiągnięto z jabłoni szczepionych na M.9 i prowadzonych w formie osiowej. Nie stwierdzono żadnych różnic w jakości owoców między kombinacjami.

Słowa kluczowe: jabłonie, podkładki, rozstawy, formowanie