Bulgarian Journal of Agricultural Science, 22 (No 4) 2016, 600–603
Agricultural Academy

THE EFFECT OF THREE TRAINING SYSTEMS ON THE VEGETATIVE AND REPRODUCTIVE HABITS OF THE APPLE CULTIVAR 'BRAEBURN' GRAFTED ON M9 ROOTSTOCK

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Abstract

GANDEV, S., I. NANEV, P. R SAVOV, E. ISUF, G. KORNOV and D. SERBEZOVA, 2016. The effect of three training systems on the vegetative and reproductive habits of the apple cultivar 'Braeburn' grafted on M9 rootstock. *Bulg. J. Agric. Sci.*, 22: 600–603

There is not a uniform accepted view in the world on the choice of a universal apple tree training system, because the vegetative and reproductive habits of the separate cultivars depend on the soil and climatic conditions of the countries where they are grown. The aim of the experiment was to study the effect of the training systems Slender spindle, Solen and Vertical axis on the growth and fruiting habits of the apple cultivar 'Braeburn' grafted on M9 rootstock and grown under the conditions in Bulgaria. The experimental plantation was established on the territory of the Fruit-Growing Institute in Plovdiv with geographical coordinates of 42°9′ N latitude, 24°45′ E longitude and 160 meters altitude. The study was carried out during the period 2013–2015, i.e. third-fifth vegetation of the trees, covering the first three fruiting seasons. The results obtained show that the largest average and cumulative yields per ha were harvested when Vertical Axis training system was used, which was due to the better reproductive habits of the trees in that variant and the larger number of trees per ha. Under the conditions of our country, tree training to Vertical Axis system is recommended for 'Braeburn' apple cultivar grafted on M9 rootstocks.
Key words: training system, Slender spindle, Solen, Vertical axis

Introduction

According to Hampson et al. (2002) training of fruit trees to a certain system is a method of modelling canopy architecture with the aim of improving light interception and distribution and optimizing yield quantity and quality. Over the past two or three decades many new training systems for intensive apple plantations have been developed in the world (Gandev and Dzhuvinov, 2014). The common thing in all of them is the desire of researchers to develop a training system that is easy and inexpensive to implement; the trees reach quickly the stage of fruit bearing; they provide high yields of good quality; the systems requires easy to perform manual operations; better light interception and absorption in the different parts of the crown and, last but not least, to be cost-effective.

Lauri and Lespinasse (2000) think that training systems do not solve the major problem in apple, i.e. the regular fruit bearing. Chemical thinning of fruit set is recommended to overcome alternate bearing in fruit crops, which is applicable only when the fruit setting is more than the necessary to ensure normal yield (Link, 1998). It is commonly known (Atanasov, 1984) that good flowering and fruit setting is impossible without the favorable effect of light absorption. According to Dallabetta et al. (2014) light absorption in the tree canopy depends on the choice of the training system and on the plantation density. Ozkan et al. (2012) announced that in dense (intensive) apple plantations return of investments is quicker. However, the desire of the farmers for quick return of investments sometimes results in establishing too dense plantations, in which the insufficient inter-row space leads

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to deterioration of the light conditions and hence – to worsening of fruit quality. Shading in the tree canopy reduces apple fruit weight, size and coloration (Jackson, 1968). In a later study Hunter and Proctor (1986) mentioned that the yield per ha increases with the increase of light interception. Pruning for training and fruit-bearing is the major means of improving sunlight interception and distribution within the tree canopy (Petrov, 1979). Campbell et al. (1996) and Miller (1984) think that severe pruning, necessary in some training systems, delays the beginning of fruit-bearing. Obviously, a good balance between the training system and the plantation density should be sought, on the one hand, and light interception, on the other. That could be achieved by choosing the training system with regard to biological characteristics and the soil and climatic conditions in our country.

The aim of the experiment was to study the effect of the training systems Slender spindle, Solen and Vertical axis on growth and fruiting of the apple cultivar 'Braeburn', grafted on M9 rootstock and grown under the soil and climatic conditions in Bulgaria.

Materials and Methods

The experimental plantation was established in the spring of 2011 on the territory of the Fruit-Growing Institute in Plovdiv with geographical coordinates of 42°9′ N latitude, 24° 45′ E longitude and 160 meters altitude. The used planting material was of 'Braeburn' cultivar, grafted on M9 rootstock, without premature shoots. The rows were north-south oriented. The soil is alluvial-meadow, neural in reaction. Drip irrigation installation was constructed for fertilization and irrigation according to tree needs. The soil in the experimental plantation was maintained as black fallow.

The study was carried out in the period 2013–2015, i.e. third-fifth vegetation, covering the first three fruiting seasons of the apple trees. Due to the heavy fruit setting in 2015, chemical thinning was carried out with the product Dirager, the active substance of which is Alfa-Naphtyl-acetic acid (3.3%). The applied rate was 30 ml per da.

Three training systems were studied, forming the separate variants of the experiment. Variants:

- Slender spindle;
- Solen;
- Vertical axis.

Slender spindle

Tree pruning was done following the adopted classical method of training the trees to that system (Wertheim, 1978). At planting the trees were cut to 90 cm above the soil surface. During the first two vegetations shoots were horizontally bended for the formation of the future skeletal branches. The leader was annually changed with its competitor. Pruning practices for fruit-bearing included cutting off the vigorous, growing straight up shoots and retaining those of moderate to weak growth. During the fourth winter pruning the trees were cut to 2.5 m above the soil surface.

Solen

The trees were trained as described by Lespinasse (1989). During the pruning after planting the trees were cut to 1.2 m above the soil surface. At the beginning of vegetation two shoots were selected, which at a later period, in August, were tied horizontally to a wire construction along the row line. Pruning for fruit-bearing was done following the long pruning method.

Vertical axis

Tree pruning was done according to the pruning practices recommended by Lespinasse and Delord (1986). When training the trees, the leader was not cut off or replaced with its competitor. During the third and the forth winter pruning, the shoulders with thickness close to that of the leader were removed. Fruiting shoots were annually cut off at the curve formed after the natural bending under the fruit weight.

The trees of Variant 1 and Variant 2 were planted at a distance of 4 × 2 m (1250 trees per ha) and those of Variant 3 – 4 × 1.5 m (1667 trees per ha). The following characteristics were reported: trunk cross-sectional area /HCC/ in (cm^2); canopy volume (m^3); yield per tree (kg); cumulative yield per tree (kg); mean fruit weight (g); loading with fruits (number of fruits per cm^2/HCC); yield per ha and cumulative yield per ha.

Five trees randomly located in the plantation, were included in each variant and each tree represented a separate replication. Statistical processing was done following Duncan's test (Steele and Torrie, 1980).

Results and Discussion

Data presented in Table 1 show that the studied apple tree training systems have an effect on their growth habits. It should be mentioned that in all the three reporting years, the trunk cross-sectional area was smaller when applying Solen training system (Var. 2) compared to Slender spindle (Var. 1) and Vertical axis (Var. 3). It was also established that the canopy volume of the trees in Var. 2 was also smaller than that of the trees in Var. 1 and Var. 3. The results obtained show that there is a significant difference between the canopy volume of the trees in Var. 1 and Var. 3 in favour of Var. 3. That is due to cutting the trees in Var. 1 to a height of 2.5 m above the soil surface during the fourth winter pruning, which reduces their canopy volume.

Tablle 1

Effect of the training system on trunk cross-sectional area and the canopy volume in the apple cultivar 'Braeburn' grafted on M9 rootstock

Training system	Trunk cross-sectional area (TCA, cm²)			Canopy volume (m³)
	2013	2014	2015	2015
Slender spindle	19.5 a	23.5 a	30.2 a	2.33 b
Solen	13.0 b	15.2 b	24.6 b	1.80 c
Vertical axis	18.4 a	23.4 a	31.6 a	3.81 a

Significance at P < 0.05

Table 2 shows that in the first fruit-bearing season (2013) there is not a significant difference in the average yield per tree among the separate variants of the experiment. The results in the next experimental years did not show the same tendency. In 2014, as well as in 2015, the average yield per tree in Var. 2 was lower compared to that of Var. 1 and Var. 3. Obviously pruning practices applied in Solen training system delay the reproductive habits of the trees. Out of that reason, the yield in Var. 2 was only 2.9 kg in 2014. The results presented in Table 2 also show that in 2015 the mean fruit weight in Var. 3 was 178 g and it was significantly lower than that in Var. 1 and Var. 2, which was 200 g and 209 g, respectively. We think that it is due to the heavier loading of the trees with fruits in Var. 3. The results presented in Table 3 prove that statement, as they show that in 2015 the ratio of the number of fruits per cm² of HCC was bigger in Var. 3 – 3.07 fruits/cm² versus 2.39 fruits/cm² in Var. 1 and 2.24 fruits/cm² in Var. 2, respectively. The lower mean fruit weight obtained in Var. 3 (178 g) in 2015 as a result of the heavier tree loading (3.07 fruits/cm²) did not reflect on the quality of the fruit produce, because the value of the mean fruit weight is close to the one, generally adopted for 'Braeburn' cultivar (Milatović and Durović, 2012).

Table 2

Effect of the training system on the average yield per tree, the mean fruit weight and cumulative yield in the apple cultivar 'Braeburn' grafted on M9 rootstock

Training system	Yield and mean fruit weight (kg/tree), (g)						Cumulative yield (kg/tree)
	2013		2014		2015		
	Yield (kg/tree)	Mean fruit weight (g)	Yield (kg/tree)	Mean fruit weight (g)	Yield (kg/tree)	Mean fruit weight (g)	
Slender spindle	1.09 a	203.3 a	5.4 ab	180.0 b	14.4 ab	200.0 a	20.9 a
Solen	0.85 a	182.3 a	2.9 b	197.0 a	11.5 b	209.0 a	15.3 b
Vertical axis	1.19 a	190.0 a	6.5 a	176.1 b	17.1 a	178.0 b	24.8 a

Significance at P < 0.05

Tabl. 3

Effect of the training system on the crop load and yield efficiency in the apple cultivar 'Braeburn' grafted on M9 rootstock

Training system	Crop load (Number of fruit of cm²/TCA)		
	2013	2014	2015
Slender spindle	0.27 a	1.30 a	2.39 b
Solen	0.36 a	1.01 a	2.24 b
Vertical axis	0.34 a	1.59 a	3.07 a

Significance at P<0.05

When reporting the cumulative yield (Table 2), it was established that the yield from the trees in Var. 2 (15.3 kg) was significantly lower than that in Var. 1 (20.9 kg) and Var. 3 (24.8 kg). Obviously Solen training system (Var. 2) leads to obtaining lower cumulative yield per tree compared to Slender spindle (Var. 1) and Vertical axis (Var. 3).

Yield differences between the variants with different training systems are still more marked when calculating the average and the cumulative yield per ha (Table 4). That is due to the fact that in Var. 1 and Var. 2 the number of trees

Tablle 4

Effect of the training system on the yield per ha and the cumulative yield per ha in the apple cultivar 'Braeburn' grafted on M9 rootstock

Training system	Number trees per ha	Yield (t/ha)			Cumulative yield (t/ha)
		2013	2014	2015	
Slender spindle	1250	1.36 b	6.87 b	18.00 b	26.23 b
Solen	1250	1.06 b	3.62 c	14.37 c	19.05 c
Vertical axis	1667	1.98 a	10.83 a	28.50 a	41.31 a

Significance at P < 0.05

per ha is 1250, while in Var. 3 it is 1667, i.e. 33.36% higher. It is known (Robinson, 1992) that the yield is a function of the number of trees per ha and by increasing the density of the plantation the yield also increases. In our experiment the larger number of trees per ha resulted in obtaining a higher cumulative yield in Var. 3 – 41.31 t/ha versus 26. 23 t/ha in Var. 1 and 19.05 t/ha in Var. 2, respectively.

Conclusions

Growth habits of the trees of 'Braeburn' cultivar on M9 rootstock are affected by the choice of the training system. Slender spindle and Vertical axis training systems induce more vigorous growth compared to Solen.

The cumulative yield per tree in Slender spindle and Vertical axis training systems is higher compared to the yield obtained when using Solen training system;

The average and cumulative yields per ha are higher when Vertical axis training is applied, compared to the yields when using Slender spindle and Solen systems of tree training;

In agricultural practice, it is recommended to use Vertical axis training system for 'Braeburn' cultivar on M9 rootstock.

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Received December, 15, 2015; accepted for printing June, 17, 2016