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THE PRODUCTIVITY OF APPLE TREES DEPENDING ON THE STRUCTURE OF THE CROWN AND THE BIOLOGICAL CHARACTERISTICS OF THE CULTIVAR

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ABSTRACT

This paper presents the results of a study carried out on new apple cultivars, namely 'Granny Smith', 'Gala Buckeye Simmons', 'Golden Delicious Reinders', 'Red Velox' and 'Fuji Kiku', grafted on 'M9' rootstock, which are intended to create high-density orchards in the central part of the Republic of Moldova. During the growth and fruiting periods of the trees, the number of fruit depends on the variety, the age of the trees and the distance from the ground which increases gradually year in year out. The distribution of fruits along the height of the tree depends on the number of branches and leaves on the tree and on the number of fruiting branches. During the periods of growth and fruiting, the trees of the studied cultivars gave an average yield of 10.9 kg/tree.

INTRODUCTION

The structure of the branches and leaves of the trees in an orchard is one of the determining factors of its productivity. Various activities were carried out in horticulture aimed at increasing the productive potential of orchards. For example, the intensive culture system based on the production capacity of the grafted cultivars, on the clonal rootstocks that limit the vigor of the trees' growth, and on the crown shaping methods which stimulate fruiting has been used to grow apple trees. The main priority of sustainable technologies is to grow a crop (species, variety) on a global scale where the dynamics of natural factors (climate, soil, biocenosis) are best identified with its requirements, so as to achieve a high economic efficiency under conditions of reduced consumption of conventional, polluting energy (Babuc 2012).

MATERIAL AND METHODS

Two groups of trees were used to conduct the research in order to study some apple cultivars.

1) In the orchard established in 2015 of the ElitFruct Ltd in the village of Cosernita, the district of Criuleni, between 2015 and 2020. The 'Granny Smith', 'Gala Buckeye Simmons', 'Red Velox', 'Golden Delicious Reinders' and 'Fuji Kiku' cultivars grafted on the 'M9' rootstock were studied. The 'Granny Smith' variety, which was approved by the Republic of Moldova in 2015 for use in the Southern fruit-growing area, was employed as the control variety. The orchard was laid out with 0.8 m between trees in the row, and 3.2 m between rows.

2) In the experimental orchard of ‘Gala Delicious’, ‘Golden Delicious’ and ‘Granny Smith’ apple cultivars, grafted on the ‘M9’ dwarfing rootstock, which was established in 2009, of the Spica-N Agro Farm Cooperative in the village of Onitcani, the district of Criuleni. The orchard was laid out with 1m between trees in the row, and 3.5 m between rows. In both groups, the trees had an improved slender spindle shape of their crowns. The experiment was carried out using 4 groups of 8 trees each. The researches were carried out according to the generally accepted methodology, both in the field, and in the laboratory, where physiological and biochemical analyses were performed.

RESULTS AND DISCUSSIONS

Given that the fruiting of trees and their productivity are affected by the volume and shape of the tree, all agricultural practices in the first years after planting should be aimed at the fastest increase in crown volume and the optimal number of rationally placed branches. The data on the structure of the 3-year-old apple trees, depending on the variety and the distance from the ground, are presented in table 1. It has been determined that, the apple trees of the ‘Gala Buckeye Simmons’ cultivar has a crown that consists of 45 annual branches and 19 biennial branches, i.e. this variety has a high capacity to form shoots.

It has been also determined that the number of branches of the ‘Granny Smith’, ‘Red Velox’, ‘Golden Delicious Reinders’ and ‘Fuji Kiku’ cultivars decreases from the base to the top of the crown. The balance in the vertical plane is maintained by increasing the branching angle of the branches located towards the top of the crown, and by tilting the branches and shoots during the vegetation period. The trees which have improved slender spindle shaped crowns are characterized by a well-developed vertical axis which has annual branches, subbranches and fruit branches (Balan et al., 2018).

The biennial branches at the base of the crown, located around the radial axis in a spiral pattern, ensure the provision and maintenance of balance in the vertical plane.

Thus, ‘Gala Buckeye Simmons’ trees have 12 branches at a height of 60-160 cm from the ground and 5 branches at a height of 160-240 cm; in the upper part of the crown there are only 2 biennial branches. The number of biennial branches differs insignificantly according to the cultivar: ‘Gala Buckeye Simmons’ has 19 pcs/tree, and ‘Fuji Kiku’ has 24 pcs/tree. This little difference is explained by the fact that all cultivars have the same type of crown.

During the growth and fruiting periods, the number of fruiting branches increased from year to year (tab. 1). In the 3rd year of vegetation, the trees of the studied cultivars, namely ‘Granny Smith’ formed more than 85 fruiting branches, and ‘Gala Buckeye Simmons’ – up to 110 branches. In the 4th and 5th years of vegetation, the number of fruiting branches doubled or even tripled. Thus, in 2017, ‘Granny Smith’ had 85 pcs/tree, in 2018 – 143 pcs/tree, and in 2019 – 234 pcs/tree. On average over 3 years, ‘Gala Buckeye Simmons’ and ‘Golden Delicious’ Reinders’ cultivars had the highest number of fruiting branches, namely 178.3 pcs/tree and 177.3 pcs/tree respectively; ‘Granny Smith’ and ‘Red Velox’ cultivars formed a smaller number of branches, namely 154.0 pcs/tree and 155.6 pcs/tree respectively.

The distribution of fruiting branches in the vertical plane along the axis was relatively uniform, decreasing towards the top of the tree. In the 3rd year of vegetation, the number of fruiting branches in the upper part of the crown was 2-3

times less than at the base of the crown. For example, ‘Red Velox’ of the second type of fruiting had 42 pcs/tree at a height of 60-160 cm above the ground, 34 pcs/tree at a height of 160-240 cm, and only 15 pcs/tree at a height of 240-340 cm. At the beginning of the fruiting period, the number of fruiting branches increased, and their distribution along the height of the tree became more uniform.

Table 1

The location of the apple tree branches and the number of fruiting branches according to the biological characteristics of the cultivar (the planting year 2015, Elit Fruct Ltd, 2017–2019)

Variety	Distance from the ground, cm	Number of branches, the year 2017, pcs/tree		Number of fruiting branches, pcs/tree				
		Annual	two-year-old	year 2017	year 2018	year 2019	average quantity	%
‘Granny Smith’ (control cultivar)	60-160	27	10	38	57	86	60.3	39.1
	160-240	13	5	35	47	78	53.3	34.6
	240-320	3	5	12	39	70	40.3	25.3
Total	-	43	20	85	143	234	154.0	100
‘Gala Buckeye Simmons’	60-160	27	12	45	60	95	66.7	37.5
	160-240	13	5	45	50	89	61.3	34.4
	240-320	5	2	20	43	78	47	28.1
Total	-	45	19	110	153	272	178.3	100
‘Red Velox’	60-160	33	15	42	55	95	64	41.2
	160-240	16	6	34	51	72	52.3	33.7
	240-320	3	2	15	44	71	43.3	25.1
Total	-	52	23	91	148	228	155,6	100
‘Golden Delicious Reinders’	60-160	30	13	48	53	85	62	35.0
	160-240	14	7	33	53	94	60	33.9
	240-320	6	3	17	44	95	52	31.1
Total	-	50	23	98	150	284	177.3	100
‘Fuji Kiku’	60-160	31	15	49	59	73	60.3	35.9
	160-240	12	4	39	46	88	57.7	34.3
	240-320	17	5	12	41	88	47	29.8
Total	-	60	24	100	146	259	168.3	100

In the 4th year after the trees had been established, the number of fruit-bearing branches was different depending on the cultivar. The number of fruiting branches of the ‘Gala Buckeye Simmons’, ‘Granny Smith’ and ‘Red Velox’ cultivars, decreased from bottom to top. The ‘Golden Delicious Reinders’ and ‘Fuji Kiku’ cultivars had the highest number of fruit-bearing branches at a height of 240-320 cm above the ground.

Analysing the number and distribution of fruiting branches of the apple trees of ‘Gala Buckeye Simmons’, ‘Granny Smith’, ‘Red Velox’, ‘Golden Delicious Reinders’ and ‘Fuji Kiku’ cultivars, grafted on the ‘M9’ dwarfing rootstock, it appears reasonable to say that they meet the optimum condition for obtaining high fruit yields in high density orchards.

The first order branches of the ‘Gala Delicious’ variety grown at Spica-N-Agro Company were evenly distributed on the axis with the exception of those which grew at a height of 300-360 cm from the ground (table 2).

The number of fruiting branches, which is an index of tree productivity, decreased from the base of the crown to the top of the tree.

Table 2

The structure of the apple trees of ‘Gala Delicious’ depending on the biological characteristics of the cultivar (the planting year 2015, Spica-N-AgroFarm Cooperative, 2017)

Variety	Distance from the ground, cm	Number of the first-order branches on the axis, pcs	Number of fruiting branches, pcs/tree
‘Golden Delicious’	60-120	10	150
	120-180	10	141
	180-240	10	89
	240-300	11	37
	300-360	5	10
Total		46	427

During the period of tree growth and fruiting, the number of fruits depend on the tree cultivar, the age of the tree and the distance the branches are above the ground (table 3). The apple trees of the studied cultivars began to bear fruit in the 2nd year after their planting (the year 2016), yielding an average output of 5.94 kg/tree (fig.1). In 2017, the number of fruits was relatively evenly distributed along the height of the tree. Thus, ‘Gala Buckeye Simmons’ yielded 34 fruits on the branches which were at a distance of 60-160 cm from the ground, 30 fruit at a distance of 160-240 cm, and 28 fruit at a distance of 240-320 cm from the ground.

The same pattern was observed in ‘Red Velox’ and ‘Golden Delicious Reinders’ cultivars. The vigorous ‘Granny Smith’ and ‘Fuji Kiku’ cultivars produced less fruit in the upper part of their crowns than ‘Gala Buckeye Simmons’, ‘Red Velox’ and ‘Golden Delicious Reinders’ cultivars. ‘Fuji Kiku’ produced 36 fruits in the basal part of the crown, 26 fruit – in the central part of the crown, and only 21 fruit – in the upper part of the crown. In 2018, the fruit crop was much smaller, namely 28-54 fruit/tree, as compared to 2017 – 82-101 fruit/tree.

‘Golden Delicious Reinders’ produced 27 fruits at a height of 60-160 cm from the ground, 16 fruit at 160-240 cm, and only 8 fruits at a height of 240-320 cm above the ground. ‘Gala Buckeye Simmons’, ‘Granny Smith’, ‘Red Velox’ and ‘Fuji Kiku’ cultivars showed the same distribution of fruit, i.e. their number decreased from the base of the crown to its top.

In 2019, the number of fruits increased significantly compared to previous years: ‘Red Velox’ yielded 129 pcs/tree and the ‘Golden Delicious Reinders’ – 170 pcs/tree. The distribution of fruit on a tree depends on the branches and leaves of the tree and the number of fruiting branches. For example, ‘Red Velox’ produced 129 fruits, of which 52 were at a distance of 60-160 cm from the ground, 48 fruit – at 160-240 cm, and only 29 fruits were at a distance of 240-320 cm above the ground. ‘Gala Buckeye Simmons’, ‘Granny Smith’, ‘Golden Delicious Reinders’ and ‘Fuji Kiku’ cultivars showed the same results, i.e. the greater amount of fruit grew in the basal and central part of the crown as compared to the upper part of the tree.

Table 3

The number of fruits according to the biological characteristics of cultivar (the planting year 2015, Elit Fruct Ltd, 2017–2019)

Variety	Distance from the ground, cm	Number of fruit, pcs/tree			Average quantity, pcs/tree	%
		year 2017	year 2018	year 2019		
'Granny Smith' (Control cultivar)	60-160	32	21	45	32.7	35.5
	160-240	31	17	50	32.6	354
	240-320	21	9	49	26.3	29.1
Total	-	84	48	144	92.0	100
'Gala Buckeye Simmons'	60-160	34	26	58	39.3	38.3
	160-240	30	17	65	37.3	36.1
	240-320	28	11	39	26	25.6
Total	-	92	54	162	102.7	100
'Red Velox'	60-160	29	17	52	32.6	39.2
	160-240	28	15	48	30.3	36.4
	240-320	25	7	29	20.3	24.4
Total	-	82	39	129	83.3	100
'Golden Delicious Reinders'	60-160	36	27	56	39.7	37.0
	160-240	35	16	58	36.3	33.8
	240-320	30	8	56	31.3	29.2
Total	-	101	51	170	107.3	100
'Fuji Kiku'	60-160	36	16	68	40	43.0
	160-240	26	9	52	29	31.2
	240-320	21	3	48	24	25.8
Total	-	83	28	168	93.0	100

The data regarding the fruit harvest presented in figure 1, show that the studied cultivars began to bear fruit in the 2nd year after their planting, namely in 2016 when they yielded an output of 5.1-6.6 kg/tree. 'Gala Buckeye Simmons' and the 'Red Velox' cultivars produced the largest crop – 6.6 kg/tree and 6.4 kg/tree respectively.

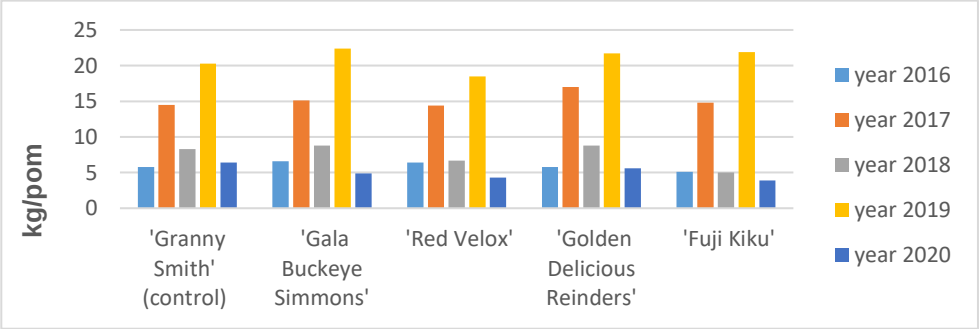

Figure 1. Fruit crop according to the biological characteristics of the variety, kg/tree (the planting year 2015, Elit Fruct Ltd, 2016–2020)

In 2017, the three-year-old trees produced a crop which was three times larger as compared to the previous years: 'Red Velox' produced 14.4 kg/tree and 'Golden Delicious

Reinders' – 17.0 kg/tree. 'Golden Delicious Reinders' produced the largest crop in comparison with the 'Gala Buckeye Simmons', 'Granny Smith', 'Red Velox' and 'Fuji Kiku' cultivars.

In 2018, the fruit harvest decreased considerably and amounted to only 5.0-8.8 kg/tree. This decrease is explained by the fact that the trees produced too many fruit the previous year. In the 5th year after their planting (2019), the fruit harvest increased as compared to the previous years. In 2020, yields dropped significantly, with 'Fuji Kiku' producing 3.9 kg/tree and 'Granny Smith' 6.4 kg/tree, also due to the very high yield they had the previous year. During the growth and fruiting periods, the trees of the studied cultivars produced an average crop of 10.9 kg/tree. The trees of 'Gala Buckeye Simmons', 'Granny Smith' and 'Golden Delicious Reinders' cultivars yielded the highest crop, but the values were not always statistically proved.

CONCLUSIONS

In conclusion, it appears reasonable to say that the number of one-year- and two-year-old vegetative branches of the studied cultivars depends on the shape of the crown and the hereditary character of the variety, which is able to form shoots.

On average over 3 years of fruiting, 37-43% of the fruit grew on the branches that were at a distance of 60-160 cm from the ground, 31.2-36.4% – at 160-240 cm from the ground, and 24.4-29.2% – on the branches that were in the upper part of the crown. High density orchards make it possible to increase the efficiency of agrotechnical work, as well as to obtain products that are excellent in quantity and quality. According to the data on the distribution of fruits in the crown of an apple tree during the period of growth and fruiting, it cannot be said with certainty that trees with the same crown shape will show the same results, but it is quite obvious that when using an improved spindle-shaped crown type, the illumination of the crown will improve and, as a result, a more uniform distribution of fruit along the height of the tree.

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