SISTEME NOI DE CONDUCERE A *ARONIEI MELANOCARPA* L. PE VERTICALĂ
NEW VERTICAL TRAINING SYSTEMS FOR *ARONIA MELANOCARPA* L.

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Abstract

A special attention nowadays is paid to small berry fruits due to their high content in valuable biological compounds and nutraceutical richness. *Aronia melanocarpa* L. gets a great recognition among them and become day by day more popular for growers. The present research focuses on innovative vertical training systems for black chokeberry in order to test the plant's capacity to be trained as vertical cordons and to proper address the actual needs of growers and consumers. The experiment was carried out from 2016 to 2017 in the Didactic and Experimental Field of the University of Agronomic Sciences and Veterinary Medicine of Bucharest. The biological material was represented by 3 years old plants of 'Nero' variety, and the variants consist in four types of vertical training systems: the Vertical axe (1 cordon/plant), Bi-Baum (2 cordons/plant), Trident (3 cordons/plant) and Flat multi-cordons (8 cordons/plant). A linear equal spaced of 50 cm between cordons along the plants row was set up, resulting plant distances of 3.5mx0.5m for Vertical axe, 3.5mx1.0m for Bi-Baum and 3.5mx1.5m for Trident and Flat multi-cordon variant. At the end of 2017, the most vigorous plants were remarked at Flat multi-cordon variant. Same higher values in the case of the number of annual growths and growth lengths. The biggest fruits were harvested from Trident plants but the highest yield was recorded by Vertical axe training system. Cordons production efficiency gradually decreased along with the increasing number of cordons/plant. Vertical training systems proved to be also well adapted for convenient manual picking, fruits quality, easy pruning interventions and soil management.

Cuvinte cheie: scoruș negru, ax vertical, Bi Baum, Trident, tufă
Keywords: chokeberry, Vertical axe, Bi Baum

1. Introduction

Chokeberry (*Aronia melanocarpa* L.) has become more and more popular among the berry species due to its content in healthy biological compounds. It is known to be one of the richest natural sources of polyphenols, flavanols and anthocyans (300-600 mg anthocyans/100g of fruits according to Oszmianski S., 1988, 2005; Wu et al., 2004; Jakobek et al., 2007 quote by Pranas V. et al., 2012). Aronia is used for the antioxidant, anti-atherosclerotic, antidiabetic, anti-inflammatory, antiviral and antimutagenic potential (Thi N. D. and Hwang E.S., 2014; Petko N. Denev, 2012). Therefore, many fruit growers worldwide start new investments in chokeberry orchards. Bigger acreages need special machineries to harvest efficient and with low cost per kg. Such harvesters as Victor series are produced by Weremczuk Poland Company that can harvest around 1,5 acre/hour in 5-6 year old *Aronia* field with an accuracy of more than 98%. But these models are very expensive and in their absence, harvesting becomes particularly difficult. So, for small lands and farms, we need to review the planting and training systems used for *Aronia* in order to benefit more from the plants and to make easier the manual harvesting.

In this paper, we focus on developing and testing innovative vertical training systems for black chokeberry, to provide a convenient solution for growers in respect to their requirements considering most of the technological measures applied to the culture.

2. Material and methods

The experiment was set up in the Didactic and Experimental Field of the University of Agronomic Sciences and Veterinary Medicine of Bucharest and carried out between 2016 and 2017.

The biological material of black chokeberry was provided by a Belgian nursery and consists in 3 years old plants of 'Nero' variety grown as multi-stem shrub. The received plants were subject of different pruning interventions in order to transform them in 4 experimental training variants as follows:

- Vertical axe (Fig. 1)
- Bi-Baum training system (Fig. 1)
- Trident system (Fig. 2)
- Flat multi-cordons system (Fig. 2).

Planting distances were designated aiming to even distribute the vertical cordons among the plants in the row, regardless the crown shape. Considering 0.5 m between the cordons in the row, the bushes were planted in three spacing distances:

- 0.5 m for Vertical axis
- 1.0 m for Bi-Baum
- 1.5 m for Trident and Flat multi-cordons system

It results a linear equal spaced cordons along the plants row. All the vertical cordons were tied by bamboo sticks. A trellis system with wood poles and 4 iron wires at 50 cm space between them has been mounted in order to sustain the cordons and the plants in a flat position.

To keep away the weeds around the plants, a strip of 1.0 m width has been mulched with agrotextile material, applied immediately after planting in the spring of 2016. The plot was supplied with a 16 mm drip irrigation pipe, provided with 30 cm between the nozzles and 2l/h water volume release/nozzle.

During the vegetation and winter seasons, plants have been conducted vertically and pruned according to each crown structure parameters. Because of the plants natural resistance to pests and diseases, no sprays were applied during the experimental months.

Several biometrical measurements concerning the vigor of plants and the productivity elements have been also performed. The cordons diameter above 10 cm from the soil has been measured and also the total height of the plant. For each training system it was calculated the number and the length of annual growth, the total annual growth per plant and each cordon. All the inflorescences have been counted and supervised in dynamic through fruits set until the fruits harvest time. The yield was calculated per plant, cordon, crown shape and broad to surface unit.

3. Results and discussions

The new system for conducting chokeberry in the orchard transposes the common and natural way of plant growing into vertical cordons type by choosing at the planting time the most appropriate stems to be raised up and tied in a vertical position. Then, depending on the number of cordons/plant the space between plants has to be adjusted in order to allow enough space for annual growths around the cordons.

One of the major problems encountered when older plants are used for planting in the vertical system is that in most of the cases, first 60-80 cm of the stems are naked. In this case, very good results have been remarked after we applied few incisions above couple of nodes (Fig. 3). Many dormant buds had burst in the next weeks and the basal area of cordons was populated with sprouts that after one year more bore fruits.

Analyzing the way of how plants grew in the next two years after planting demonstrates that *Aronia melanocarpa* behave very well in vertical training systems. The vertical axe shape had increase the plants height only few centimeters but the thickness with more than 3 mm (Table 1). Actually, the biggest value of cordons growth index has been recorded at the plants with only one vertical cordon. As long as the number of cordons/plant increased, the index proportionally decreased. A fast extend in total height was remarked at the flat multi-cordons system (43 cm), the plants surpassing the 2m height. Same total height was observed at Trident (213 cm) which increase the cordons thickness similar to flat multi-cordons plants. Bi-Baum and Trident presented close values for height growth increase and thickness growth index.

Flat multi-cordons plants consistently amplified the crown looking at the increased number of shoots and the average lengths of the annual branches (Table 2). But considering the number of growths/codons, we are surprised to see that Bi-Baum react better comparing to the other vertical training systems. Also the average length of the annual branch of 2 cordons plants exceeded the Vertical axe and Trident variants.

The sum of annual growths increases placed with some similarities the Vertical Axe, Bi-Baum and Trident but, by far it can be seen a clear superiority of the flat multi-cordons crown from this point of view. After one year more, the total annual growths at the plants conducted as flat multi-cordons increased with more than 12 times comparing to vertical axe (5 times more), Bi-Baum and Trident (around 4.5 times more). Interesting is the fact that Bi-Baum training system proved a good efficiency in growth looking at the cordons productivity in this regard. If the Trident system surpasses the total annual growth of Vertical axe with only 59 cm, the Bi-Baum cordons produced with 306 cm more growths than the cordons of Vertical Axis and with 247 cm more than Trident crown.

Concerning the fructification of *Aronia* plants trained as vertical cordons, we evaluated the productivity elements starting from the number of inflorescences/plant, number of flowers/inflorescence, number of fruits harvested/plant and the average fruit weight.

As we can see from the Table 3, the number of inflorescences per plants doubles in case of Vertical axe and Trident, increase with 65% at Bi-Baum shape and develop 3,6 times more inflorescences in case of Flat multi-cordons system. The average number of flowers inside the inflorescences did not

varied too much between 2016 (14 flowers/inflorescence) and 2017 (16 flowers/inflorescence). But the weight of the fruit increased in 2017 with 22 % compared to 2016. The average fruit weight in 2016 was of 0.73 g and in 2017 of 0.89 g. The biggest fruits have been picked from Trident (0.95 g) and the smallest from Vertical axe (0.83 g).

The number of fruits/plant steadily increased as the number of cordons/plant increased. Although this seems logical, the productivity of each individual cordon shows us that the most efficient ones are cordons from Vertical axe (more than 1,100 fruits/plant in the second year). In fact, the cordon efficiency decreased from one single cordon per plant to 2 cordons/plant, 3 cordons/plant and 8 cordons/plant.

The same trend was seized in the plant and cordon yield (Table 4), where the vertical axe proved to be very fruitful compared to the other systems (Fig. 4). But looking at the production estimated per 1 ha, the flat multi-cordons plants performed better. This means that a space distribution less than 0.5 m between the cordons is much productive. Future plant distances between cordons per linear meter along the row need to be tested in order to gain the maximum yield efficiency for vertical training systems.

Some cultural advantages of vertical training system experimented for chokeberry worth to be mentioned. As a general remark, technological operations such as pruning, sprays and harvest are much easier to be made because of a better exposure of all crown elements and easy access to them. The fruits get more color and the ripening moment of the fruits inside the inflorescence have place in a shorter period of time. Comparing to bush training system, the vertical cordons favor easy soil management around the plants.

4. Conclusions

- Most vigorous plants considering training system, proved to be the flat multi-cordons type. Tallest plants correspond to Trident and flat multi-cordons and the highest increase of cordon thickness to Vertical axe.
- The highest number and length of annual growths was remarked for flat multi-cordons plants. Bi-Baum system reacts better than Vertical axe or Trident considering the total annual growths/cordon.
- Bigger fruits in size were picked up from Trident, followed by Flat multi-cordon training system.
- Vertical axe deliver the highest yield per plant, per cordon and per hectare. The cordons production efficiency gradually decreased from Vertical axe to Bi-Baum, Trident and Flat multi-cordons type.
- Less than 0.5 m space distribution between the cordons in case of Flat multi-cordons training system indicate to be still very productive/surface unit in the second year after planting. Yield was very close to Vertical axe that use more space for that.
- In non-mechanical harvest purpose chokeberry orchard, the vertical cordon systems are very suited for convenient manual picking, fruits quality, easy pruning interventions and soil management.

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Tables and figures

Fig. 1. *Aronia* trained as vertical axe with single cordon/plant and Bi-Baum with two vertical cordons/plant (2016)

Fig. 2. *Aronia* trained as Trident with three cordons/plant and Flat multi-cordons variant with more vertical cordons/plant (2016)

Table 1. The growth vigor of chokeberry plants depending on training system applied

Training system	No of cordons / plant	Height of the plant (cm)		Height increasement (cm)	Average diameter of cordons (mm)		Thickness increasement (mm)	Cordons thickness growth index*
		2016	2017		2016	2017		
Vertical axe	1	183	185.4	2.4	20.25	23.63	3.38	3.38
Bi-Baum	2	183	205	22	21.69	23.43	1.74	0.87
Trident	3	188	213.8	25.8	22.53	24.91	2.38	0.79
Flat multi-cordon	8	170	213	43	17.45	20.03	2.58	0.32

*Index is calculated as ratio between thickness increasement and the number of cordons/plant

Table 2. Growth characteristics of black chokeberry plants in relation to the training system

Training system	No of cordons / plant	Average number of annual branches/plant		Average length of annual branches (cm)		Total annual growths				Annual increase of growth (%)
						Per plant (cm)		Per cordon (cm)		
		2016	2017	2016	2017	2016		2017		
Vertical axe	1	26.0	44.6	7.29	20,74	183	183	925	925	506
Bi-Baum	2	85.6	101.5	6.69	24,25	550	275	2461	1230	447
Trident	3	93.6	125.5	6.92	23,53	643	214	2953	984	459
Flat multi-cordon	8	132.8	372.4	6.71	30,71	884	110	11437	1430	1294

Table 3. Fructification particularities of black chokeberry plants in relation to the training system

Training system	No of plants/ ha	Average no of inflorescences /plant		Average no. of flowers/ inflorescence		Average fruit number				Average weight of the fruit (g)	
						Per plant		Per cordon			
		2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
Vertical axe	5714	32.68	64.8	14	16	455	1206	455	1126	0.73	0.83
Bi-Baum	2857	70.51	116.8			981	1823	491	911		0.88
Trident	1905	69.75	155.2			970	2123	323	708		0.95
Flat multi-cordon	1905	53.52	193.6			744	3099	93	387		0.90

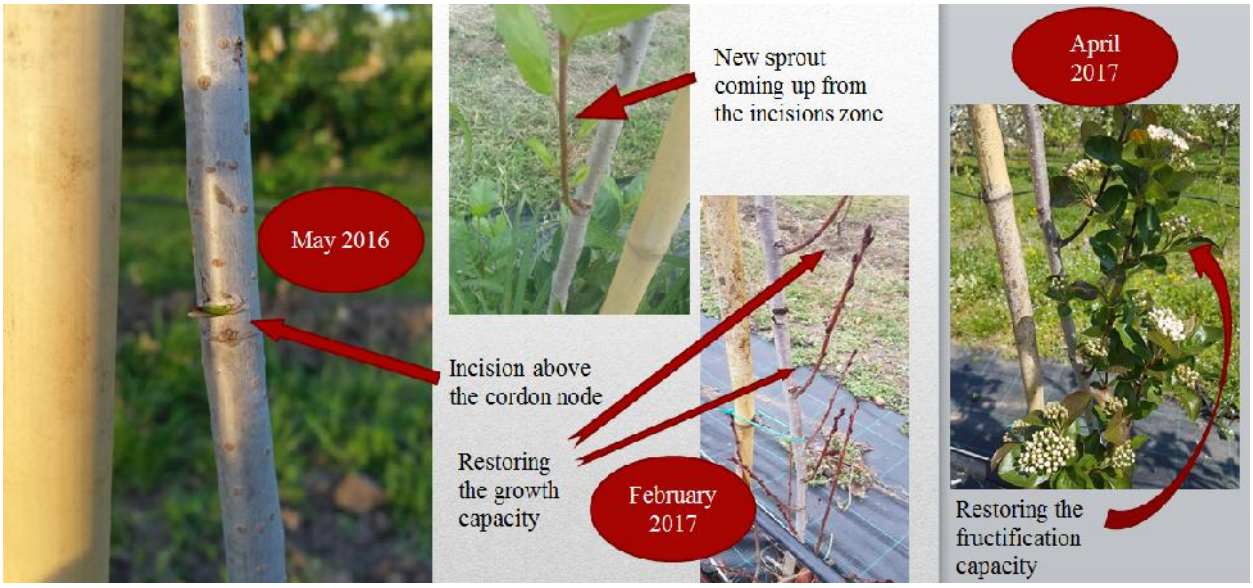

Fig. 3. Restoring the growing and fruiting capacity of the basal part of black chokeberry plants

Table 4. Productivity of black chokeberry plants in different vertical training systems

Training system	No of cordons / plant	Planting distances (m)	Cordons spacing in the row (cm)	No of plants/ ha	Yield				Estimated yield for 1 ha (t/ha)	
					Per plant (g)		Per cordon (g)			
					2016	2017	2016	2017	2016	2017
Vertical axe	1	3.5x0.5	0.5	5714	332	1001	332	1001	1,897	5.719
Bi-Baum	2	3.5x1.0	0.5	2857	716	1604	358	802	2,045	4.582
Trident	3	3.5x1.5	0.5	1905	708	2017	354	672	1,349	3.842
Flat multi-cordon	8	3.5x1.5	0.19	1905	543	2789	271	349	1,035	5.313

Fig. 4. The productivity of Vertical Axe training system at *Aronia melanocarpa*