

Influence of the Crown Shape on the Input of the Fruit and the Productive Potential of Cherry Trees in a High-Density System

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Abstract

The purpose of this study was to practice and improve the use of low volume crowns in a high-density system in order to obtain qualitative cherry production that would be competitive on the market and to make efficient use of the labor force. The research was carried out in the intensive cherry orchard planted in the autumn of 2011 with "Ferrovia", "Kordia", and "Regina" varieties, grafted on Gisela 6 (*Prunus cerasus* × *Prunus canescens*) rootstock interspaced at 4x2.5 m and managed according to the Ameliorated natural crown systems with low volume, Ameliorated Slender Spindle and Vase shaped crown. Harvest, diameter, firmness, dry matter content and fruit weight were determined. The trees started to yield in the third year after planting. The harvest in the second year of yielding was 4-5 kg/tree. The average harvest in the third year of yielding was 9640-13290 kg/ha. For all three varieties the harvested quantity and fruit size were correlated with the crown shape. The Ameliorated Slender Spindle crown provided the highest production per hectare, while the Flattened Vase Shaped crown provided the lowest yield but had the highest values of the fruit size (28.2-28.4 mm) and of the soluble dry matter in the fruit (17.9-18.6 Brix%).

Keywords: cherry, crown shape, yield, quality, variety

Introduction

The cherry culture system is characterized by precocity, productivity per hectare, fruit quality and regularity of production, being determined by the structure of the plantation, including planting distance, crown shape, the spatial positioning of the vegetal macrostructure and the rows in the orchard (Balan, 2015). The technology of cherry tree maintenance in modern orchards requires simplicity in the process of formation, pruning and crown maintenance (Calabro *et al.*, 2009).

Regardless the crown management system, pruning and limiting the growth of the tree top is of high importance to cherry trees, these activities ensure a ventilated and balanced crown formation vertically and laterally, early harvests,

the reduction of the final height of the trees according to the growing system (Balan, 2015, Long *et al.*, 2014). For manual fruit picking, there are recommended relatively natural crown shapes with a height of trees of 3-3.5 m, with a central shaft and cup-shaped. Indifferent the crown form, in trees grafted on reduced vigor rootstocks (Gisela 5, Gisela 6, Gisela 12 Krymsk 5 Krymsk 6) it is important to apply a suitable system in order to form vertical branches of the semi skeleton, which ensures high-quality fruits and easy manual picking (Asanica, 2012, Long, *et al.*, 2014; Stanich *et al.*, 2016).

To solve these problems in modern orchards it is necessary to conduct trees in a low volume shape such as: Fusiform High Axle, Vogel Central

Leader, UFO System, Super Spindle Axis, KGB System, Spanish Bush, etc. associated with small planting distances (4-5 m x 2-3 m) and with vegetative rootstocks (Edabriz, Gisela 5, Gisela 6, Krymsk 5, Krymsk 6, Maxima 14 and others). This fact defines orchard exploitation technology, fruit production level, pruning and productivity (Whiting *et al.*, 2005; Ampatzidis and Whiting, 2013; Long, *et al.*, 2014, Balan, 2015).

The prerogative of the fruit growers from the Republic of Moldova is the use of low-vigour rootstocks in cherry trees in order to exploit natural resources efficiently and to increase fruit yield and quality. They started planting intensive cherry orchards, using low-volume crowns, that make possible all the manual operations when pruning and picking fruits (Balan, 2015). The practical argumentation of using low volume crown forms in high-density systems is to increase the efficiency of labor force, to obtain qualitative fruit yield that would be competitive on the market. This has become an important issue for fruit growers.

Materials and methods

The research has been carried out in the central area of the Republic of Moldova, at Vindex-Agro LLC company, Orhei district. The orchard was established in the autumn of 2011 with "Ferrovia", "Kordia", "Regina" cherry varieties, grafted on the Gisela 6 rootstock, at a planting distance of 4x2.5m. The following low-volume crown forms were used: V1- Ameliorated natural crown with low volume (control); V2- Ameliorated Spindle Slender; V3 - Vase shaped crown.

The experiment was linear and comprised 4 repetitions with 8 trees per repetition. The performances and main characteristics and features were registered in the field and in the laboratory according to the stationary and biological research methods (Moiseicenko, 1994; Balan *et al.*, 2001).

The yield was determined for each individual tree by weighing the fruits of 32 trees in one variant. The average fruit weight was determined by their weighing and counting in a sample of 1 kg of cherries in each repetition.

In the harvest period the physical, chemical and technological characteristics of cherries were studied. The fruit diameter and weight were identified by means of a pattern provided

with holes of 26, 28, 30, 32, 34 and 36 mm, which corresponded to the weight of 8.5, 10; 11.5; 13; 14.5; and 16 g accordingly. The content of the soluble dry matter was determined in the orchard by using the ATAGO N-20E portable refractometer, which expressed values in Brix %. The firmness of the fruit was measured using the AGROSTA 100 dendrometer manufactured by Firm Tech with a measurement index above 250 g/mm² favorable for cherry fruit (Long, *et al.*, 2014).

The statistical processing of the research results was performed by using the method of the monofactorial and polyfactorial dispersion analysis, the correlation and regression method, described by Dospheov (1985), through the Startgraphix and MS Excel 2013 programs. To determine the significance of production differences the Least Significant Differences (LSD) test was used for probability of 5%.

Results and discussion

In modern cherry orchards, the shape of a tree crown must be simple in the process of crown formation as well as in the technique of branches pruning, it should produce many and high quality fruits, allowing renewal of the wood to fructify continuously (Babuc, 2012).

Crown shapes as: Ameliorated natural crown with low volume, Ameliorated Spindle Slender and Vase shaped crown provide only a few of these desired requirements. "Ferrovia", "Kordia" and "Regina" cherry varieties grafted on Gisela 6 produced fruit in the third year after planting. The harvest recorded average values of 300-500 kg/ha for "Ferrovia" variety, 200-400 kg/ha for "Kordia" variety and 400-500 kg/ha for "Regina" variety (Tab. 1).

In the second year of yielding, the studied varieties showed average values of 4700-5000 kg/ha in "Ferrovia", 4200-4600 kg/ha for "Kordia" and 4700-5000 kg/ha for "Regina" variety. The vase-shaped crown provided insignificantly less harvest by 5-6% in "Ferrovia" variety, by 9-11% in "Kordia" variety and by 3-6% in "Regina" variety than the Ameliorated natural crown with low volume and Ameliorated Slender Spindle.

In the third year of yielding, the harvest was three times higher than in the second year. As for the effect of the crown-forming systems on the fruit harvest, the data in Table 1 rank the Ameliorated natural crown with low volume

Table 1. Cherry trees productivity determined by the variety and crown shape (Rootstock Gisela 6, planting distance 4x2.5m, tree age 3-5 years, S.R.L. Vindex-Agro)

Crown Shape	Years, kg/tree			Average (2014-2016)
	2014	2015	2016	
„Ferrovia” variety				
Ameliorated natural crown with low volume (control)	500	5000	12310	5937
Ameliorated Slender Spindle	500	4900	13290	6230
Vase- shaped crown	300	4700	11400	5467
LSD 5%	-	450	665	-
„Kordia” variety				
Ameliorated natural crown with low volume (control)	400	4600	11270	5423
Ameliorated Slender Spindle	400	4700	12830	5976
Vase- shaped crown	200	4200	10570	4990
LSD 5%	-	900	338	-
„Regina” variety				
Ameliorated natural crown with low volume (control)	500	4800	10380	5227
Ameliorated Slender Spindle	400	5000	11890	5763
Vase -shaped crown	400	4700	9640	4913
LSD 5%	-	815	487	-

the first with 13290 kg/ha in “Ferrovia” variety, Ameliorated Slender Spindle with 12830 kg/ha in “Kordia” variety and with 11890 kg/ha in “Regina” variety, with significant differences from the other two crown forming systems.

It has been established that the lowest cherry yield was obtained in the Vase-shaped crown of all tested varieties; that specific type of crown yielded significantly inferior to the Ameliorated natural crown with low volume and Ameliorated Slender Spindle. Obviously, during the growing and yielding period, the formation of cherry trees in the vase form requires more prunings as compared to the forms with the crown with spindle.

The Vase-shaped crown is characterised by lateral open angle branches which require a vase form with oblique walls. That’s why this crown shape requires more interventions in the formation process, instead it assures a more favorable light regime inside the crown, it allows to harvest fruit from the ground level, especially

for the „Kordia” and „Regina” varieties, which fructify mostly on the base of annual shoots and produce quality fruits.

The color of the fruit skin and pulp, the content of soluble dry matter, fruit firmness and the resistance between the fruit and the peduncle determines the optimal harvesting time (Long *et al.*, 2014). The size and uniformity of the cherries are also important indicators when marketing fresh cherries for consumption (Ivanov *et al.*, 2015).

The size of the cherries was influenced by the crown shape and by the biological particularities of the variety (Tab. 2). The fruits of “Ferrovia”, “Kordia” and “Regina” varieties recorded average values ranging from 26.8 to 28.8 mm in equatorial diameter. Bigger size of cherries of 28-28.8 mm in diameter was obtained in “Regina” variety. In “Ferrovia” variety, the highest values insignificantly distinct by 5% belonged to the fruits of the trees with the Vase-shaped crown. The same regularity was recorded in “Kordia” and “Regina” varieties.

Table 2. Cherry fruit quality determined by the variety and crown forming system (Rootstock Gisela 6, planting distance 4x2.5m, tree age 3-5 years, S.R.L. Vindex-Agro)

Crown shape	Fruit diameter, mm	Cherry weight, g	Soluble dry substance, Brix %	Fruit acidity, malic acid/100 g of fresh fruit	Fruit firmness, kg/cm ²
„Ferrovia” variety					
Ameliorated natural crown with low volume (control)	26,8	8,64	17,7	0,75	2,55
Ameliorated Slender Spindle	26,8	8,61	17,5	0,78	2,53
Vase- shaped crown	28,2	8,70	17,9	0,78	2,55
Average	27,3	8,65	17,7	0,77	2,54
„Kordia” variety					
Ameliorated natural crown with low volume (control)	26,6	8,77	18,5	0,69	2,91
Ameliorated Slender Spindle	26,8	8,93	18,2	0,64	3,10
Vase- shaped crown	28,3	9,13	18,6	0,65	3,15
Media Average	27.2	8,94	18,4	0,66	3,05
„Regina” variety					
Ameliorated natural crown with low volume (control)	28,0	8,89	17,0	0,59	3,08
Ameliorated Slender Spindle	28,3	8,90	17,0	0,55	3,17
Vase- shaped crown	28,8	9,26	17,9	0,58	3,20
Average	28,4	9,02	17,3	0,57	3,15
LSD 5%	2,23	0,32	0,85	0,28	0,43

In this context, it can be stated that the shape of the crown in the growing and yielding period of cherry trees does not significantly affect the size of the fruit, because the growth of the vegetative organs predominates over yielding.

The fruit weight is a character directly proportional to the diameter, which is also influenced by the crown shape and by the biological particularities of the variety. In the third year of yielding the fruit weight was 8.61-8.70 g in “Ferrovia” variety, 8.77-9.13 g in “Kordia” variety and 8.89-9.26 g in “Regina” variety. As for the average values, the Vase- shaped crown, where the cherries mean weight is higher, compared with the Ameliorated natural crown with low volume and the Ameliorated Slender Spindle, but it is significantly distinct only in “Kordia” and “Regina” varieties.

Soluble dry matter in the fruits recorded different values in the tested varieties, it ranged from 17.5-17.9 Brix % in “Ferrovia” variety, 18.2-18.6 Brix% in “Kordia” variety and 19-17.9 Brix % in “Regina” variety. The difference is significantly distinct between “Ferrovia” and „Regina” varieties with “Kordia” variety.

The level of titratable acidity was higher in “Ferrovia” variety, it constituted 0.75-0.78 g malic acid/100 g fresh fruit, and the lowest values were recorded in “Regina” variety with 0.55-0.58 malic acid /100 g fresh fruit.

The taste of the fruit was influenced by the ratio between soluble dry matter content and titratable acidity, with the mean value of 22.9 in “Ferrovia” variety, 27.8 in “Kordia” variety and 30.4 in “Regina” variety and it was not influenced by the crown formation.

The fruit firmness, being a closely related index of the variety, fruit size, maturation stage, temperature and growth technology, determines cherry deformation resistance, showing the degree of tissue elasticity. The firmness index was 2.53-2.55 kg/cm² in “Ferrovia” variety, 2.91-3.15 kg/cm² in “Kordia” variety and 3.08-3.20 kg/cm² in “Regina” variety. If we compare within varieties, it can be specified that “Kordia” and “Regina” varieties are the most resistant to deformation, recording significant differences in comparison with “Ferrovia” variety.

Conclusion

The cherry trees of “Ferrovia”, “Kordia” and “Regina” varieties, grafted on vegetative rootstock Gisela 6, began yielding in the third year after planting. The harvest in the second year of yielding ranged values from 4700-5000 kg/ha in “Ferrovia” variety, 4200-4600 kg/ha in “Kordia” variety and 4700-5000 kg/ha in “Regina” variety. In the third year of yielding, the harvested quantity tripled, being higher in “Ferrovia” variety, in the case of the Ameliorated natural crown with low volume and in “Kordia” and “Regina” varieties, when trees were formed according to the Ameliorated Slender Spindle.

For all the cherry varieties studied, the Vase-shaped crown decreased the general tree productivity but enhanced the fruit size and dry matter.

The crown formation system didn't influence the fruit weight, firmness and dry matter content.

Though the results are preliminary, it seems that the Vase-shaped crown formation system in “Ferrovia”, “Kordia” and “Regina” varieties, grafted on Gisela 6, will produce qualitative fruits and permits manual harvesting from the ground level.

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