Scientific Papers. Series B, Horticulture. Vol. LXV, No. 1, 2021
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

# THE IMPACT OF THE CROWN MANAGEMENT SYSTEM ON THE GROWTH AND FRUCTIFICATION OF CHERRY TREE VARIETIES IN A HIGH-DENSITY CULTIVATION SYSTEM

**Valerian BALAN, Igor IVANOV, Vasilie ȘARBAN**

State Agricultural University of Moldova, MD 2049, 44 Mircești Street, Republic of Moldova

Corresponding author email: valerianbalan@gmail.com

***Abstract***

*This work examines the growth and fruiting of modern cherry plantations according to the vigour of the variety-rootstock association, crown shape and planting distance. The impact of the crown formation system on the growth and fruiting of 'Ferrovia', 'Kordia', 'Regina', 'Stella', 'Skeena', 'Bigarreau Burlat', 'Lapins', 'Early Star', 'Samba' and 'Black Star' cherry varieties grafted on Gisela-6 and MaxMa 14 rootstocks in various combinations and at diverse planting distances was studied. During the first eight years of fruiting, the trees of 'Skeena' and 'Ferrovia' varieties, which had an improved slender spindle shape of their crowns, yielded the highest harvests. The yield produced by the variety of trees which had been planted at the distance of 5 x 1.5 m (18942-20074 kg/ha) was the highest; the smallest harvest was produced by the varieties planted at the distance of 5 x 2.5 m. During the ninth year of vegetation, the 'Kordia' and 'Regina' varieties grafted on the MaxMa 14 rootstock produced record harvests of 19221-19314 kg/ha. On average over three years, the 'Kordia', 'Regina' and 'Skeena' varieties were more productive as compared with the 'Ferrovia' and 'Stella' varieties.*

***Key words****: Cerasus avium, variety, rootstocks, crown shape, planting distance.*

## INTRODUCTION

Small spindle crowns planted at small distances allow for more efficient use of solar energy in the process of producing large crops of qualitative fruit, the increase in the productivity of manual pruning and fruit harvesting work, and the achievement of a high degree of mechanization of technological work. For orchards of cherry trees the crowns of which are no larger than 3 m prove to be much more productive (Robinson et al., 2013; Cimpoies, 2018).

Numerous researches on tree management systems have been carried out due to the existence of a large variety of biological material (variety-rootstock), numerous planting distances and ecological conditions (Long Lynn et al., 2014). As a result of these studies, it has been revealed that systems of high-density orchards in which the trees have narrow small-volume crowns must be promoted; if there are favourable conditions for the intensification of technological processes, they produce optimal crops from a biological and technical point of view (Gjamovski et al., 2016; Long et al., 2005; Long, 2003; Sumedrea et al., 2014).

The range of low- and average-vigour rootstocks (Gisela, Krymsk, CAB, Weiroot, P-HL and Edabriz Table) allow for the development of high density cherry tree plantations of spindle crown trees, high yield orchards and low product costs (Aglar & Yildiz, 2014; Aglar et al., 2016; Gyeviki et al., 2008; Long, 2003; Usenik et al., 2010; Vercammen, 2002).

The orchards of trees the crowns of which are of (natural) high thin spindle shape are easier to manage as compared to the orchards in which the trees have thick and bulky crowns. In this case, it is easier to do the mechanized pruning, using special platforms to assist the process, in order to reduce labour costs and to improve fruit quality (Babuc, 2012; Long, 2014; Musacchi et al., 2015).

Considering all these facts, the impact of the crown management system on the performance of 'Ferrovia', 'Kordia', 'Regina', 'Stella', 'Skeena', 'Bigarreau Burlat', 'Lapins', 'Early Star', 'Samba' and 'Black Star' cherry tree varieties, which had been grafted on the Gisela 6 and MaxMa 14 rootstocks of average vigour, in different ecological conditions and planted at different distances was studied.

Thus, the purpose of the researches was to increase the productivity of cherry tree plantations in the Republic of Moldova, by identifying highly productive crown shapes.

## MATERIALS AND METHODS

The researches into the formation of highly productive shapes of cherry trees' crowns were carried out in the southern and central orchards of the Republic of Moldova. The crown of the trees was formed in the shape of a Natural Crown Ameliorated with low volume and Slender Spindle Ameliorated.

**Location, planting distance, crown shape**

**Experiment 1.** The orchard was planted by the "ProdCar" Ltd in the village of Negureni, the district of Telenesti, in the spring of 2010. The cherry trees of the 'Adriana', 'Ferrovia' and 'Skeena' varieties had been grafted on the Gisela 6 vegetative rootstock at a planting distance of 4 x 2 m.

**Experiment 2**. The plantation was started at the "Terra-Vitis" Ltd in the village of Burlacu, the district of Cahul, in the southern orcharding area of the Republic of Moldova in the spring of 2010. The cherry trees of the 'Bigarreau Burlat', 'Ferrovia' and 'Lapins' varieties had been grafted on the Gisela 6 vegetative rootstock at a planting distance of 5 x 1.5 m, 5 x 2 m and 5 x 2.5m.

**Experiment 3.** The experiment was organized at the "Vindex-Agro" Ltd in the district of Orhei. The orchard was planted in 2011. The cherry trees of the 'Ferrovia', 'Kordia' and 'Regina' varieties had been grafted on the Gisela 6 rootstock at a planting distance of 4 x 2.5 m.

**Experiments 4 and 5.** The researches were organized in the central orcharding area of the Republic of Moldova, at the "StarAgroGroop" Ltd in the village of Ustia, the district of Criuleni. **Experiment 4** was performed using the 'Kordia', 'Regina', 'Stella', 'Ferrovia' and 'Skeena' varieties which had been grafted on the MaxMa 14 rootstock. The trees had been planted in the autumn of 2012 at a planting distance of 5 x 3 m; the crown of the trees had a Natural Crown Ameliorated with low volume.

**Experiment 5** was conducted in the autumn of 2015 using the 'Early Star', 'Samba' and 'Black Star' cherry varieties planted at a distance of 4 x 2 m which had been grafted on the Gisela 6 rootstock. The crown of the trees had a Slender Spindle Ameliorated.

**Research methodology.** The experiments were conducted according to the multifactorial principle using four randomized groups of 8 representative trees each (Moiseychenko et al., 1994). The interaction between the planting distance and the crown shape, the basic factors that determine the early fruiting, the harvest and the fruit quality, were studied. Morphological descriptions, biometric measurements and the statistical processing of results were made. The difference between the variants had a margin of error of 5% (Dospekhov, 1985).

**Cultural management of the plantation**. The agrotechnical measures in orchards were carried out in accordance with the agrotechnical guidelines in force. In the orchards in the village of Negureni in the district of Telenesti, the village of Burlacu in the district of Cahul and the village of Malaiesti in the district of Orhei, there is a weather station which determines the state of the environment and plants. In the orchards of the "ProdCar" Ltd, the "Vindex Agro" Ltd and the "StarAgroGroop" Ltd drip irrigation is utilized. To monitor soil moisture, Watermark sensors are installed at a depth of 20, 40 and 60 cm on each plot. The water is distributed through mains with drippers fixed at 40 cm from the ground in the direction of the row. In experiment 2 the soil was cultivated; in experiments 1 and 3, during the first two years after the trees had been planted, the soil was cultivated; in the following years the space between the rows was artificially grassed. At the "StarAgroGroop" Ltd the soil in the orchards was artificially grassed. The weeds on the ground between the rows (2-2.5 m wide), which grew naturally and artificially, were mowed when necessary and left as mulch. On the ground along the rows of trees herbicides were applied, or it was twice or three times weeded with a rotary tiller.

## RESULTS AND DISCUSSIONS

As a consequence of the researches into the obtaining of early large and qualitative harvests, trees that have improved crowns which can be planted more densely are grown

in orchards, the growth processes through the utilisation of irrigation and fertilization have been optimized, the pruning has been minimized, and branch inclination to induce early fruiting is applied (Balan, 2015; Ivanov & Balan, V., 2017; Balan et al., 2018; Ivanov, I., Balan et al., 2018).

During the growth and fruiting period, the length and width of the crowns of 'Adriana', 'Ferrovia' and 'Skeena' cherry tree varieties, grafted on Gisela 6 and planted at a distance of 4 x 2 m, were in full development (Table 1).

Table 1. Length and width of the cherry tree crowns according to the variety and crown shape, cm. (Gisela 6 rootstock, planting distance - 4 x 2 m, tree age - 3-5 years old, "ProdCar" Ltd)

| Variety | Length of the crown (cm) | | | Width of the crown (cm) | | |
|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 |
| **Natural Crown Ameliorated with low volume** | | | | | | |
| **'Adriana'** | 132 | 168 | 201 | 110 | 157 | 225 |
| **'Ferrovia'** | 150 | 173 | 215 | 160 | 173 | 224 |
| **'Skeena'** | 120 | 146 | 195 | 124 | 146 | 198 |
| **Slender Spindle Ameliorated** | | | | | | |
| **'Adriana'** | 120 | 168 | 195 | 124 | 157 | 214 |
| **'Ferrovia'** | 172 | 222 | 220 | 190 | 222 | 245 |
| **'Skeena'** | 135 | 165 | 200 | 142 | 164 | 195 |
| **LSD 5%** | - | 27 | 32 | - | 52 | 63 |

Therefore, in the 3rd vegetation year, the trees of the 'Ferrovia' variety, the crowns of which were of improved slim spindle shape, recorded the highest value of the crown length (172 cm). In the 5th year, the cherry trees merged in a row, their crown length being of 195-220 cm. The width of their crowns also increased as they became older, namely from 110-190 cm in the 3rd year to 195-245 cm in the 5th year of vegetation. Over the years, the 'Ferrovia' variety had proven to be more vigorous compared to the 'Adriana' and 'Skeena' varieties, but the growth values were not distinctly significant.

Analysing the values of the gradual crown enlargement of cherry trees grafted on Gisela 6 rootstock and planted at a distance of 4x2 m, it can be stated that they reached the optimal level during the fruiting and growing period of the trees.

The 'Adriana', 'Ferrovia' and 'Skeena' varieties, grafted on Gisela 6, began to bear fruit in the fourth year after their planting, when a harvest of 625-1562 kg/ha was reaped (Table 2). The 'Ferrovia' variety proved to be more productive compared to the 'Adriana' and 'Skeena' varieties. It yielded 1125-1562 kg/ha. In the second fruiting year, the mentioned varieties yielded better harvests, namely 4250-5000 kg/ha. Once the trees got older, viz in 2016, the fruit harvest tripled, namely the 'Adriana' variety yielded 11875-13000 kg/ha, the 'Ferrovia' variety - 13250-14125 kg/ha, and the 'Skeena' variety - 16000 kg/ha. In the seventh year after their planting, the cherry trees yielded twice as many fruits as compared to the previous year, namely the 'Adriana' variety produced 21875-22500 kg/ha and the 'Skeena' variety - 26250-28000 kg/ha.

Table 2. The yield of cherry trees, kg/ha (Gisela 6 rootstock, planting distance – 4 x 2 m, the age of the trees - 4-12 years old, "ProdCar" Ltd)

| Variety | Years | | | | | | | | Average yields (2013-2020) |
|---|---|---|---|---|---|---|---|---|---|
| | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | |
| **Natural Crown Ameliorated with low volume** | | | | | | | | | |
| 'Adriana' | 625 | 4375 | 11875 | 21875 | 10875 | 12958 | 13375 | 9319 | 10659 |
| 'Ferrovia' | 1125 | 4875 | 13250 | 24750 | 15750 | 15222 | 10791 | 14277 | 12505 |
| 'Skeena' | 625 | 4250 | 16000 | 26250 | 16875 | 17583 | 17042 | 16652 | 14409 |
| **Slender Spindle Ameliorated** | | | | | | | | | |
| 'Adriana' | 875 | 4500 | 13000 | 22500 | 10750 | 14820 | 13125 | 10819 | 11298 |
| 'Ferrovia' | 1562 | 5000 | 14125 | 24500 | 12700 | 15388 | 13541 | 16638 | 12931 |
| 'Skeena' | 375 | 4375 | 16000 | 28000 | 14000 | 17500 | 17416 | 18986 | 14581 |
| LSD 5% | - | 435.2 | 971.8 | 1315.2 | 1429.1 | 1423.6 | 2305.7 | 1314.8 | - |

The 'Ferrovia' and 'Skeena' varieties, grown using both tree formation systems, showed a distinctly significant crop increase as compared to the 'Adriana' variety. In the following year (2017) the fruit harvest decreased remarkably, namely the 'Adriana' variety yielded only 10750-10875 kg/ha, the 'Ferrovia' variety - 12700-15750 kg/ha, and the 'Skeena' variety - 14000-16785 kg/ha. In the following years, the fruit harvests were of 9316-18986 kg/ha; the

'Ferrovia' and 'Skeena' varieties yielded higher crops. Analysing the yielding performance during the eighth, ninth and tenth years of the tree vegetation (2017-2020), it can be mentioned that the values are mean for the plantations of cherry trees which are grafted on the rootstock of medium vigour Gisela 6, as compared to the data presented by other authors (Miter et al., 2012; Long et al., 2014).

The cherry trees which had been planted at the distance of 4 x 2.5 m and reached the age of four or five, had a crown length of 129-231 cm; when they reached the age six, their crowns occupied the reserved space in the direction of the row (249- 262 cm). We have to mention that, the distance of 2.5 m between the cherry trees in a row grafted on Gisela 6 was too great, because the trees occupied the space reserved for their crowns only in the 6th vegetation year (Table 3). In the 4th vegetation year the width of the crown was 139-190 cm; in the 6th vegetation year, it was 235-250 cm, but these values are not statistically proved. So, the width of the crown reached the optimal necessary level (250 cm) to assure a high degree of sunlight utilisation and the easy movement of tractors and other agricultural machinery.

The data in Table 4 show the impact of the crown shape on the yield of 'Ferrovia', 'Kordia' and 'Regina' varieties, which were grafted on Gisela 6 and planted at the distance of 4 x 2.5 m, during the periods of their growth, fruiting and full fruiting. The results of the research into the crown formation system are of interest both in terms of precocity and the yield in the first 7 fruiting years.

Table 3. The length and width of the cherry trees' crowns according to the variety and crown shape, cm (Gisela 6 rootstock, planting distance – 4 x 2.5 m, tree age - 4-6 years old, "Vindex-Agro" Ltd)

| Variety | Length of the crown | | | Width of the crown | | |
|---|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2014 | 2015 | 2016 |
| **Natural Crown Ameliorated with low volume** | | | | | | |
| **'Ferrovia'** | 129 | 192 | 258 | 175 | 234 | 241 |
| **'Kordia'** | 175 | 210 | 255 | 190 | 238 | 243 |
| **'Regina'** | 162 | 215 | 262 | 139 | 252 | 250 |
| **Slender Spindle Ameliorated** | | | | | | |
| **'Ferrovia'** | 136 | 209 | 260 | 154 | 198 | 250 |
| **'Kordia'** | 162 | 231 | 249 | 148 | 229 | 220 |
| **'Regina'** | 170 | 238 | 260 | 132 | 241 | 235 |
| LSD 5% | 27 | 32 | 14 | 30 | 25 | 19 |

The trees started to bear fruit in the 4th vegetation year yielding 400-500 kg/ha. In the 2nd fruiting year, the trees yielded a harvest of 4600-5000 kg/ha, not statistically assured. Starting with the 3rd fruiting year, the 'Ferrovia' and 'Kordia' varieties yielded poorly - 12310-13290 kg/ha and 11270-12830 kg/ha respectively (statistically assured data). In 2017 and 2020, the harvest decreased significantly due to unfavourable climatic conditions during their blossom, namely it was foggy, rainy and cold.

The crops were larger than 10,000 kg/ha only in two years out of seven, namely in 2016 and 2019. During the first 7 years of tree fruiting, the 'Ferrovia' variety yielded 8193-8308 kg/ha, the 'Kordia' variety - 7650-8314 kg/ha, and the 'Regina' variety - 7208-7877 kg/ha.

The trees, the crown of which was formed after the improved thin spindle shape pattern, yielded larger crops not statistically assured.

Table 4. The yield of cherry trees, kg/ha (Gisela 6 rootstock, planting distance – 4 x 2.5 m, tree age - 4-10 years old, "Vindex-Agro" Ltd)

| Variety | Years | | | | | | | Average yields (2014-020) |
|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | |
| **Natural Crown Ameliorated with low volume** | | | | | | | | |
| 'Ferrovia' | 500 | 5000 | 12310 | 7900 | 10875 | 13733 | 7033 | 8193 |
| 'Kordia' | 400 | 4600 | 11270 | 7500 | 7600 | 13811 | 8367 | 7650 |
| 'Regina' | 500 | 4800 | 10380 | 7800 | 7600 | 12366 | 7010 | 7208 |
| **Slender Spindle Ameliorated** | | | | | | | | |
| 'Ferrovia' | 500 | 4900 | 13290 | 7933 | 11778 | 12938 | 6815 | 8308 |
| 'Kordia' | 400 | 4700 | 12830 | 8876 | 8944 | 13321 | 9124 | 8314 |
| 'Regina' | 400 | 5000 | 11890 | 7573 | 11289 | 11997 | 6990 | 7877 |
| LSD 5% | - | 845 | 529 | 824 | 675 | 315 | 783 | - |

The growth and fruiting of the 'Bigarreau Burlat', 'Ferrovia' and 'Lapins' varieties were studied in accordance with the crown management system as well as the planting

distance (Tables 5 and 6). It was found that, regardless of the planting distance, during the period of tree growth, the growth of 'Ferrovia' trees was faster as compared to the 'Bigarreau Burlat' and 'Lapins' varieties. Thus, in the 5th vegetation year, the crowns of the trees of 'Ferrovia' variety reached a length of 172-264 cm. The trees that had been planted at the distance of 5 x 2.5 m reached the highest length of their crowns.

The 4 and 5 year-old trees of 'Bigarreau Burlat', 'Ferrovia' and 'Lapins' varieties, which had been planted at the distance of 5 x 1.5 m, occupied the entire reserved area in a row. Obviously, as the distance between the trees in a row increases from 1.5 m to 2.5 m, the time to occupy the space reserved for the tree crown also increases. The 'Bigarreau Burlat' and 'Ferrovia' varieties joined in the row in the 4th vegetation year, and the 'Lapins' variety - in its 5th year of vegetation.

Analysing the values of the crown length and width of the cherry trees of the 'Bigarreau Burlat', 'Ferrovia' and 'Lapins' varieties, it can be stated that they depend on the age of the trees, the distance between rows and between the trees in a row, and differ insignificantly from one variety to another and from one crown shape to another. Thus, for example, the crown of the 'Bigarreau Burlat' variety which had a naturally improved small volume shaped crown, reached a length of 125-155 cm when planted at a distance of 1.5 m in a row, and 170-258 cm when planted at a distance of 2.5 m in a row.

The same legitimacy was observed in the 'Ferrovia' and 'Lapins' varieties, i.e., regardless of the shape of the crown, as the distance between the trees in a row increased, the length of the crown increased too. The width of the crown of the 'Ferrovia' tree variety planted at a distance of 5 x 2.5 m was 180-182 cm in the 3rd year of vegetation, and 250-264 cm in the 5th year of vegetation. Basically, in the 5th vegetation year, the crowns of cherry trees reached the optimal length, typical for intensive orchards, in order to use the solar energy necessary to produce large yields of qualitative fruit.

Table 5. The length of the crown of cherry trees according to variety, planting distance and crown shape, cm (Gisela 6 rootstock, tree age - 3-5 years old, "Terra-Vitis" Ltd)

| Planting distance, m | 'Bigarreau Burlat' variety | | | 'Ferrovia' variety | | | 'Lapins' variety | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 | 2012 | 2013 | 2014 |
| Natural Crown Ameliorated with low volume | | | | | | | | | |
| 5 x 1.5 | 125 | 145 | 155 | 135 | 165 | 172 | 115 | 145 | 155 |
| 5 x 2 | 162 | 200 | 221 | 160 | 185 | 214 | 135 | 165 | 209 |
| 5 x 2.5 | 170 | 190 | 258 | 182 | 210 | 264 | 160 | 170 | 250 |
| Slender Spindle Ameliorated | | | | | | | | | |
| 5 x 1.5 | 130 | 162 | 155 | 127 | 170 | 170 | 125 | 170 | 170 |
| 5 x 2 | 162 | 190 | 230 | 180 | 195 | 217 | 137 | 162 | 228 |
| 5 x 2.5 | 191 | 210 | 265 | 180 | 190 | 250 | 152 | 190 | 261 |
| LSD 5% | - | 38 | 19 | - | 27 | 16 | - | 42 | 24 |

The varieties 'Bigarreau Burlat', 'Ferrovia' and 'Lapins' began to bear fruit during the 4th vegetation year. The trees which had been planted at a distance of 5 x 2.5 m yielded a crop of 320-400 kg/ha, and 666-1066 kg/ha when planted at a distance of 5 x 1.5 m. During the 2nd year of fruiting, the yield of the orchard increased directly in proportion to the density of the trees, constituting 3720-6822 kg/ha. In the 3rd fruiting year (2014), the trees planted at a distance of 5 x 1.5 m yielded the statistically confirmed largest crop (5478-6822 kg/ha), and the trees planted at a distance of 5 x 2.5 m yielded the smallest crop (3720-4200 kg/ha). During the fruit-bearing period, the yield of the trees doubled or even tripled as compared to the previous period. Thus, in the 6th vegetation year, the cherry trees grafted on Gisela 6 produced a crop of 8000-12864 kg/ha, and in the 7th year they produced 14616-20074 kg/ha of fruit.

The analysis of the yields, produced by the 'Bigarreau Burlat', 'Ferrovia' and 'Lapins' cherry tree varieties grafted on Gisela 6, indicates that the harvest changed depending on the age of the trees, the planting distance and

the shape of their crown. Thus, during the period of full fruiting of trees, the cherry yield did not increase in proportion to the number of trees per hectare. The yield of the trees that had been planted at a shorter distance was higher and statistically confirmed. The trees the crowns of which were formed in the shape of an improved slim spindle achieved higher productivity (15632-20074 kg/ha) as compared to the trees that had a naturally improved small volume shaped crown (14616-18555 kg/ha), but it wasn't always statistically confirmed.

The 'Ferrovia' tree variety yielded the largest crop (20074 kg/ha) in the 7th year of its vegetation. It should be noted that the 'Bigarreau Burlat' and 'Lapins' varieties behaved similarly from the statistical point of view. As expected, the trees planted at a distance of 5 x 1.5 m yielded the largest crops (18942-20074 kg/ha); the smallest quantity of fruit was produced by the trees planted at a distance of 5 x 2.5 m (15632-16904 kg/tree). The cause of that phenomenon lay in the number of trees per hectare in the two planting schemes.

Table 6. The width of the cherry trees' crown according to variety, planting distance and the shape of the crown, cm (Gisela 6 rootstock, tree age - 3-5 years old, "Terra- Vitis" Ltd)

| Variety | Planting distance, m | Natural Crown Ameliorated with low volume | | | Slender Spindle Ameliorated | | |
|---|---|---|---|---|---|---|---|
| | | Year 2012 | Year 2013 | Year 2014 | Year 2012 | Year 2013 | Year 2014 |
| 'Bigarreau Burlat' | 5 x 1.5 | 120 | 147 | 258 | 116 | 140 | 245 |
| | 5 x 2 | 120 | 159 | 250 | 125 | 158 | 262 |
| 'Ferrovia' | 5 x 1.5 | 132 | 150 | 254 | 128 | 162 | 261 |
| | 5 x 2 | 110 | 140 | 262 | 140 | 160 | 250 |
| 'Lapins' | 5 x 1.5 | 130 | 165 | 254 | 140 | 169 | 260 |
| | 5 x 2 | 120 | 172 | 262 | 140 | 180 | 271 |

As regarding the optimization of the area under trees, it can be said with certainty that the maximum width between rows is equal to the sum of the planting distance between trees per row plus two meters required for the movement of the tractors (Balan V., 2015; Babuc V., 2012). Therefore, the crown parameters of the cherry trees varieties grafted on the medium vigour Gisela 6 rootstock show that the distance of 2.5 m between trees in a row is large, and if the trees are planted at 2 m apart in the row, the distance between rows is optimal, i.e. 4 m (2 m + 2 m).

Table 7. The yield of cherry trees according to variety, planting distance and crown shape, kg/ha (Gisela rootstock 6, tree age - 4-7 years old, "Terra- Vitis" Ltd)

| Variety | Planting distance, m | Natural Crown Ameliorated with low volume | | | | Slender Spindle Ameliorated | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Year 2013 | Year 2014 | Year 2015 | Year 2016 | Year 2013 | Year 2014 | Year 2015 | Year 2016 |
| 'Bigarreau Burlat' | 5 x 1.5 | 799 | 5962 | 11410 | 17982 | 711 | 6339 | 12209 | 18942 |
| | 5 x 2 | 400 | 4893 | 9150 | 15160 | 500 | 5120 | 11820 | 16160 |
| 'Ferrovia' | 5 x 1.5 | 931 | 6397 | 12716 | 18155 | 1066 | 6822 | 13823 | 20074 |
| | 5 x 2 | 700 | 5260 | 12350 | 15920 | 800 | 5580 | 13130 | 17810 |
| 'Lapins' | 5 x 1.5 | 666 | 5478 | 12277 | 18555 | 666 | 5799 | 11864 | 19382 |
| | 5 x 2 | 500 | 4580 | 9400 | 17240 | 500 | 5010 | 9900 | 18210 |
| LSD 5% | | 275 | 647 | 1375 | 1284 | 275 | 647 | 1375 | 1284 |

Analysing the fruit harvest data presented in Table 7, it is evident that the grafting of cherry trees on the Gisela 6 rootstock and their planting at shorter distances, allow for the obtaining of medium-sized trees, the stimulation the early fruiting, the caring for the trees from ground level, thus reducing the pruning and harvesting costs by increasing the pruning and harvesting productivity.

In the 8th vegetation year, the 'Ferrovia', 'Kordia', 'Regina', 'Skeena' and 'Stella' cherry varieties grafted on the MaxMa 14 rootstock produced a yield ranging from 4181 kg/ha in the 'Ferrovia' variety up to 15702 kg/ha in the 'Skeena' variety (Table 8).

The 'Kordia' (10944 kg/ha), 'Skeena' (15702 kg/ha) and 'Stella' (912861 kg/ha) varieties yielded the largest crops. In the 9th year of vegetation, the 'Kordia' and 'Regina' varieties yielded record crops of 19221-19314 kg/ha; the 'Ferrovia' (4113 kg/ha) and 'Stella' (7992 kg/ha) varieties yielded the smallest crops. In the 10th year of vegetation, the 'Regina' variety produced the highest yield (12055

kg/ha); the ‘Ferrovia’ (2731 kg/ha) and ‘Kordia’ (2910 kg/ha) varieties produced the lowest yield.

Table 8. The yield of cherry trees, kg/ha (MaxMa 14 rootstock, planting distance - 5 x 3 m, the shape of a Natural Crown Ameliorated with low volume, tree age - 8-10 years old, "StarAgroGroop" Ltd)

| Variety | Years | | | Average yields (2018-2020) |
|---|---|---|---|---|
| | 2018 | 2019 | 2020 | |
| ‘Ferrovia’ | 4181 | 4113 | 2731 | 3675 |
| ‘Kordia’ | 10944 | 19314 | 2910 | 11056 |
| ‘Regina’ | 5766 | 19221 | 12055 | 12347 |
| ‘Skeena’ | 15702 | 9168 | 9058 | 11309 |
| ‘Stella’ | 12861 | 7992 | 5574 | 8809 |
| LSD 5% | 1238 | 1835 | 934 | |

During the fruiting period of the trees, the ‘Skeena’ variety produced a more constant yield compared to the ‘Ferrovia’, ‘Kordia’, ‘Regina’ and ‘Stella’ varieties. On average over the 3 years, the ‘Kordia’ (11056 kg/ha), ‘Regina’ (12347 kg/ha) and ‘Skeena’ (11309 kg/ha) varieties were more productive as compared to the ‘Ferrovia’ (3675 kg/ha) and ‘Stella’ (8809 kg/ha) varieties.

‘Early Star’ and ‘Black Star’ varieties, grafted on the Gisela 6 rootstock, began to bear fruit in the 4th vegetation year, and the ‘Samba’ variety - in the 5th year of vegetation. In 2019, the ‘Early Star’ variety yielded a crop of 7012 kg/ha, and the ‘Samba’ variety - 16820 kg/ha. The ‘Black Star’ variety produced an intermediate quantity of fruit, namely 10750 kg/ha. In 2020, the fruit harvest decreased considerably, namely the ‘Early Star’ and ‘Samba’ varieties produced only 3625-4463 kg/ha. The ‘Black Star’ variety proved to be more resistant to late spring frosts and produced a crop of 9875 kg/ha. On average over 3 years, the ‘Samba’ variety proved to be the most productive, namely 8037 kg/ha.

Table 9. The yield of cherry trees, kg/ha (Gisela 6 rootstock, planting distance - 4 x 2 m, the shape of a Slender Spindle Ameliorated, tree age - 4-6 years, "StarAgroGroop" Ltd)

| Variety | Years | | | Average yields (2018-2020) |
|---|---|---|---|---|
| | 2018 | 2019 | 2020 | |
| ‘Early Star’ | 2945 | 7012 | 4463 | 4807 |
| ‘Samba’ | 3667 | 16820 | 3625 | 8037 |
| ‘Black Star’ | 0 | 10750 | 9875 | 6875 |
| LSD 5% | 992 | 874 | 1013 | |

## CONCLUSIONS

The relatively long period of time for the researches, the rootstock associations, the crown shapes and the planting distances used to study the growth and fruiting of the cherry trees, as well as the analysis of the research material allow for the following conclusions:

The crown size of the cherry trees grafted on the Gisela 6 rootstock and planted at a distance of 4 x 2 m, reached the optimal level once the trees entered the period of growth and fruiting. In the first 8 fruiting years, the ‘Skeena’ (14581 kg/ha) and ‘Ferrovia’ (12931 kg/ha) varieties, the trees of which had an improved slim spindle shaped crowns, produced the highest yield.

At the age of 6, the crown of the cherry trees planted at a distance of 4 x 2.5 m occupied the reserved space in the direction of the row (249-262 cm). During the first 7 fruiting years, the ‘Ferrovia’ variety yielded 8193-8308 kg/ha, the ‘Kordia’ variety - 7650-8314 kg/ha, and the ‘Regina’ variety - 7208-7877 kg/ha. The trees which had an improved slim spindle shaped crown produced larger quantities of fruit, but these data were not statistically confirmed.

The ‘Bigarreau Burlat’ and ‘Ferrovia’ trees varieties planted at a distance of 5 x 1.5 m, 5 x 2 m and 5 x 2.5 m, fused in the direction of the row in the 4th vegetation year, and the ‘Lapins’ variety - in the 5th year of vegetation. The trees planted at a distance of 5 x 1.5 m produced better yields (18942-20074 kg/ha), and the trees planted at a distance of 5 x 2.5 m produced the poorest yields (15632-16904 kg/ha).

In the 9th year of vegetation the ‘Ferrovia’, ‘Kordia’, ‘Regina’, ‘Skeena’ and ‘Stella’ cherry tree varieties grafted on the MaxMa 14 rootstock, and ‘Kordia’ and ‘Regina’ varieties grafted on the MaxMa 14 rootstock yielded a crop of 19221-19314 kg/ha. On average over 3 years, the ‘Kordia’ (11056 kg/ha), ‘Regina’ (12347 kg/ha) and ‘Skeena’ (11309 kg/ha) varieties were more productive as compared to the ‘Ferrovia’ (3675 kg/ha) and ‘Stella’ (8809 kg/ha) varieties.

The crown shapes tested on cherry trees did not have a significant impact on the yield formation of the studied varieties, since the naturally improved small volume crown and the improved slim spindle crown were suitable for the formation of cherry trees grafted on

medium vigour Gisela 6 and MaxMa 14 rootstocks in a high-density fruit tree cultivation system.

## ACKNOWLEDGMENTS

This study was supported by the National Agency for Research and Development (NARD), project 18.817.05.29A "*The improvement of the maintenance technologies of super-intensive cherry and apple orchards; the development of fruit quality formation techniques in Europe*." Project director - Valerian BALAN, Habilitated Doctor of Agriculture, professor.

## REFERENCES

Aglar E, Yildiz K (2014). Influence of rootstocks (Gisela 5, Gisela 6, MaxMa SL 64) on performance of '0900 Ziraat' sweet cherry. *Journal of Basic and Applied Science*, 10:60.

Aglar E., Yildizand K, Long LE (2016). The effects of rootstocks and training systems on the early performance of '0900 Ziraat' sweet cherry. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 44(2):573-578.

Babuc, V. (2012). *Pomicultura. Chişinău*. 662 p. ISBN 978-9975-53-067-5.

Balan V., Ivanov, I, Balan, P. (2018). Influence of the crown shape on the input of the fruit and the productive potential of cherry trees in a high-density system. *Bulletin UASVM Horticulture* 75(2)/Cluj-Napoca, Print ISSN 1843-5262, Electronic ISSN 1843-536X, p. 118-122

Balan, V. (2015). *Tehnologii în intensificarea culturii mărului şi cireşulu*i. Academos 2, pp. 74-79

Cimpoieş, Gh. (2018). *Pomicultura specială*. Chişinău: Print Caro, p.65-94. ISBN 978-9975-56-572-1.

Gjamovski V, Kiptijanovski M, Arsov T (2016). Evaluation of some cherry varieties grafted on Gisela 5 rootstock. *Turkish Journal of Agriculture and Forestry* 40(5):737-745.

Gyeviki M, Bujdosó G and Hrotkó K (2008). Results of cherry rootstock evaluations in Hungary. *International Journal of Horticultural Science*, 14(4):11-14.

Ivanov I, Balan V. (2017). Efectul sistemului de formare a coroanei la cireș asupra intrării pomilor pe rod, productivității și calității fructelor. *Știința agricolă nr.* 1, p. 28-32.

Ivanov, I., Balan V., Pește anu A., Vamasescu S., Balan P., Sarban V. (2018). Influence of the planting distance and the shape on the fruit harvest and the productive potential of cherry trees in a high-density system. *Bulletin UASVM Horticulture* 75(2)/Cluj-Napoca Print ISSN 1843-5262, Electronic ISSN 1843-536X, p. 163-167.

Long L.E., Facteau T., Nuñez-Elisea R. and Cahn H. (2005). Developments in High Density Cherries in the USA. *Acta Hort*. 667, ISHS pp303-309

Long, L.E. (2003). Cherry *Training Systems: Selection and Development*. PNW 543. Oregon State University, Corvallis, OR. 26 pp.

Long, Lynn E., Long, Marlene, Peșteanu, A, Gudumac, E. (2014). *Producerea cireşelor. Manual tehnologic. Chişinău,* p. 119-126

Musacchi S, Gagliardi F, Serra S (2015). New training systems for highdensity planting of sweet cherry. *HortScience*, 50(1):59-67.

Sumedrea D., Isac Il., Iancu M. (2014*). Pomi, arbuşti fructiferi, căpşun. Ghid tehnic şi economic*. Otopeni: Invel Multimedia, ISBN 978-973-1886-82-4, 546 p.

Usenik V, Fajt N, Mikulic-Petkovsek M, Slatnar A, Stampar F, Veberic R (2010). Sweet cherry pomological and biochemical characteristics influenced by rootstock. *Journal of Agricultural and Food Chemistry*, 58(8):4928-4933.

Vercammen J (2002). Dwarfing rootstocks for sweet cherries. *Acta Horticulturae*, 658:307-311.

Доспехов, Б. А. (1985). Методика полевого опыта (с основами статистической обработки результатов исследования). *Москва: Агропромиздат*. 351 с.

Мойсейченко В. Ф., Заверюха, А. Х., Трифанова, М. Ф. (1994). Основы научных исследований в плодоводстве, *овощеводстве и виноградарстве. Колос, Москва,* 365p