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Features of Growth Processes of Sweet Cherry Trees of Various Ripening Terms in the Conditions of the Right-Bank Forest-Steppe of Ukraine

Lidiia Shubenko*, Svitlana Shokh, Lesia Karpuk, Andriy Pavlichenko, Larysa Philipova

Bila Tserkva National Agrarian University
09117, 8/1 Soborna Sq., Bila Tserkva, Ukraine

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Abstract. One of the main requirements of the new stone fruit varieties recommended for commercial cultivation is a compact crown shape that allows for greater plant density and easier crown maintenance. The aim of the research was to establish the growth processes of the above-ground parts of cherry trees in varieties of different ripening periods. The article presents the results of studies of the features of apical and lateral growth of sweet cherry trees. Biological and varietal features of tree growth strength, growth and total length of annual shoots are determined. The dependence of tree trunk growth on apical growth force is established. According to the results of research, sweet cherry varieties are grouped according to the strength of growth: the vigorous varieties are Amazonka, Dar Mliyeva, Zoryana, Mliyivska zhovta; the semi dwarf are Aboryhenka, Alyonushka, Drohana zhovta, Mirazh; the dwarfing are Biryuza, Donetskyy uholyok, Melitopolska krapchasta, Meotida. The smallest increase in trunk diameter was found for the dwarfing variety Biryuza, and the largest – for the variety Drohana zhovta. The highest yield load per unit cross-sectional area of the trunk was recorded for the variety Donetskyy uholyok, the lowest – for Drohana zhovta. The amount of growth in the trunk diameter was inversely dependent on a load of trees with the crop and the strength of apical growth of sweet cherry trees. The features of shoot-forming ability allow characterising the shape of the crown of cherry trees: round – Donetskyy uholyok, Amazonka; high-round – varieties of Aborigenka, Dar Mliyeva, Zoryana; wide-pyramidal – Alyonushka, Drohana zhovta, Melitopolska krap-chasta; pyramidal – Mliyivska zhovta, Mirazh; low – Meotida, Biryuza. Dar Mliyeva, Zoryana, Mirazh, Melitopolska krapchasta and Drohana zhovta varieties have high shootability; the Mliyivska zhovta, Aboryhenka, Meotida, Amazonka varieties have medium shootability; Alyonushka, Biryuza, Donetskyy uholyok varieties have low shootability

Keywords: sweet cherry varieties, tree growth strength, trunk diameter, trunk girth, growth of annual shoots

*Corresponding author

INTRODUCTION

The basis of intensive gardening is the introduction of new dwarfing varieties into production in order to increase the planting density to 2000 trees per hectare, which reduces the cost of manual labour for harvesting and pruning trees, chemical protection, etc. The size of the tree is taken into account when planning the organisation of plantings, selecting planting schemes and other elements of agricultural technology, although the height of the tree is to a certain extent limited by the design of plantings. The introduction of the latest technologies for growing stone crops is mainly hindered by the lack of low growing clonal rootstocks [1; 2]. Reducing the size of cherry trees is also of great importance when harvesting. Since rootstock combinations of stone breeds are mainly vigorous, therefore harvesting manually is the most time-consuming process, which accounts for 50-80% of all cultivation costs [2].

Young cherry trees show strong growth of the trunk and skeletal branches of the first order and weak – semi-skeletal (semi-basic) branches and overgrown wood. O.A. Kishchak [3] identified a group of varieties in which, without special pruning, many shoots with a length of more than 20 cm are formed during fruiting and growth. They make up more than 50% of the whole crop.

On annual growth shoots, generative buds are placed in the lower part. The ratio of the number of growth and fruit buds on an annual growth depends on its length. On short growth shoots (up to 10 cm), mainly generative buds are formed and only one growth bud is formed at the top. Growths 25-30 cm long have growth buds, from which bouquet twigs are formed. On growths with a length of more than 30 cm, bouquet twigs and lateral growths of the growth type are formed [4]. The growth force of a fruit tree is best regulated by a rootstock [5]. However, currently, there are few vegetatively propagated rootstocks for sweet cherries, although in recent years dwarf rootstocks of Gisela 5 of German and VSL-2 of Russian selection have become widespread [6; 7].

A high effect was obtained from the use of MV+25105 (propyl-3-butyl-phenoxy acetate) on sweet cherry trees [8]. In the plants treated with it, apical dominance decreased due to the synthesis and movement of auxins and changes in hydrocarbon metabolism in the tissues of the central conductor. This contributed to the formation of dwarfing trees with a large number of side shoots, while the yield for the 4th year increased by an average of 1.5 times.

The most effective are gardens with dense planting of dwarfing trees. They enter marketable fruiting early (3-4 years), provide an average yield of 8-10 t/ha and save 5-6 times labour costs for the crown formation and pruning compared to vigorous varieties. Dwarfing trees are more convenient for caring for and harvesting fruits, both manually and mechanically [9-11].

It is established that the environmental conditions, agricultural techniques of growing crops (type of planting, rootstock, crown shape) in which biochemical characteristics were formed and fixed, leave a significant imprint on the taste and chemical composition of fruits [12; 13]. Therefore, one of the main requirements that are set for new varieties of stone crops recommended for industrial cultivation is the compact shape of the crown and convenient placement of the main branches, simultaneous ripening of fruits with a dry separation from the peduncle.

Research purpose – to establish the features and activity of apical and lateral growth of trees of different varieties of sweet cherries. To study the growth processes in the crown of a tree characteristic of each variety. Based on the obtained data, to determine the shape of the crown and the shoot-forming ability of the variety.

MATERIALS AND METHODS

The territory of experimental plantings is located in the central part of the region of the central subzone of the Right-Bank Forest-Steppe, which is characterised by a significant variety of soil cover, which is caused by relatively similar natural conditions.

The soils of the experimental site are gray podzolic. These soils are similar in characteristics and qualities to sod-podzolic and chernozem soils. They have well-defined processes of podzolization, as a result of which the profile is clearly differentiated according to the eluvial-iluvial type and at the same time, there is an accumulation of humus. Its content in various subtypes of gray forest soils varies significantly, but vegetation features cause a significant annual intake of organic residues in the soil and a relatively high content of humus in the soil profile.

The objects of research were 12 varieties of sweet cherries of different ripening periods: Aboryhenka, Biryuza, Dar Mliyeva, Zoryana, Mliyivska zhovta, Mirazh, Melitopolska krapchasta, Meotida, Donetskyy uholyok, Alyonushka, Amazonka, Drohana zhovta. Trees grafted on the rootstock of wild cherries, planted according to the scheme 6x4 m (416 trees/ha) and formed by a sparse-tiered crown.

Records and observations were carried out for three years according to the "Methodology for conducting field studies with fruit crops" by P. V. Kondratenko and M.O. Bublyk [14]. The circumference of the trunk was determined by measuring tape at a height of 10 cm from the soil surface. The increase in the trunk diameter during the growing season was determined by the difference in autumn measurements in the current and past years. The total growth of annual shoots with a length of 5 cm or more was measured with a measuring tape at the end of the growing season. At the same time, the average length of shoots was determined by dividing their total length by the number. Tree habitat was determined by calculating the area of crown projection and tree volume.

For statistical processing of data expressed in points, data conversion was performed according to the method of B.A. Dospekhov [15].

RESULTS AND DISCUSSION

According to the results of the conducted studies, it was found that by the age of 6-7 years, sweet cherry trees reached their maximum size. The maximum tree height was characterised by the varieties Zoryana, Amazonka and Dar Mliyeva (5.1-4.9 m) (Fig. 1). Given the fact that the studied trees are 6-7-8 years old, when the period of growth stops and the plantations begin to bear fruit (according to P.G. Shit), according to the technology of cultivation, the growth of trees was limited to five meters by pruning.

It was found that trees of early-ripening varieties of cherries were characterised by a significant growth force, which on average for three years of research was close to 4.8 m. The trees of the control variety Zoryana reached the optimal size the fastest, but the highest height was observed in the trees of the Dar Mliyeva variety. Mliyivska zhovta trees were characterised by more gradual growth of the conductor. However, by the age of 8, they reached the same level as trees of other early-ripening varieties. So, the studied early ripening varieties of sweet cherries have a tendency to strong apical growth of trees.

Compared to early-ripening varieties, medium-ripening varieties up to 8 years of age were characterised by a lower tree growth force (on average, 3.9 m). The strongest growing varieties were Mirazh and Aboryhenka (4.5 m), lower growth was observed for the variety Melitopolska krapchasta (3.2 m), and especially for the control variety Meotida (3.0 m). The height of trees of these varieties was maintained at the same level by pruning. So, cherry varieties of medium ripening were characterised by moderate growth of trees in height.

The height of trees of late-ripening varieties of sweet cherries averaged 3.4 m, which is 1.4 m lower than the average of early-ripening varieties and 0.5 m lower than the medium-ripening varieties (Fig. 1). The best in this respect was the late-ripening variety Biryuza, in which the height of trees during the study did not exceed 2.6 m and did not require agrotechnical intervention by pruning.

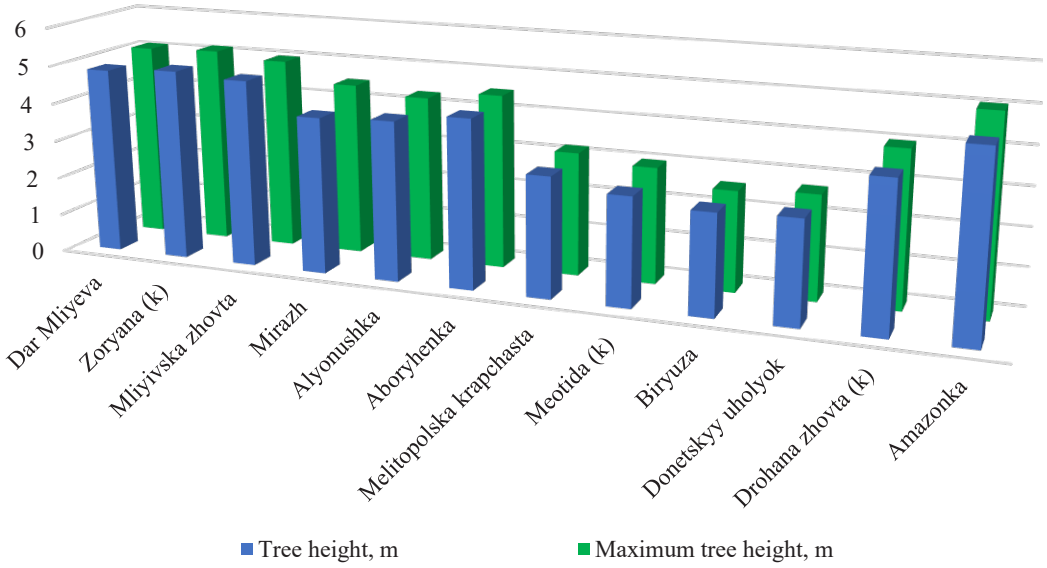

***Figure 1**. Average and maximum height of sweet cherry trees, m*

Late-ripening trees of the late-ripening Donetskyy uholyok variety proved to be weak, but they were slightly higher than the variety Biryuza. Significant heights at the age of 8 reached the Amazonka variety trees and according to this indicator they should be classified as vigorous. Thus, according to the strength of tree growth, the studied sweet cherry varieties can be arranged in the following order (according to the ripening period): vigorous – Dar Mliyeva, Zoryana, Mliyivska zhovta, Amazonka; semi dwarf Mirazh, Alyonushka, Aboryhenka, Drohana zhovta; dwarfing – Melitopolska krapchasta, Meotida, Biryuza, Donetskyy uholyok.

The obtained indicators of tree habit make it possible to characterize the shape of the crown of cherry varieties: round – Donetskyy uholyok, Amazonka; high-round – varieties of Aborigenka, Dar Mliyeva, Zoryana; wide-pyramidal – Alyonushka, Drohana zhovta, Melitopolska krapchasta; pyramidal – Mliyivska zhovta, Mirazh; low – Meotida, Biryuza.

One of the main indicators of tree growth processes is an increase in the trunk diameter, which clearly reflects the activity of lateral growth [16; 17]. As a result of three years of observations on the growth of sweet cherry trees in thickness, it can be observed that the increase in trunk diameter was directly dependent on the strength of apical growth of the tree and inverse – on the level of crop load.

In 2019, the largest increase in the diameter of

the trunk of early-ripening varieties was observed for the variety Mliyivska zhovta, and the smallest – for the variety Dar Mliyeva, although the growth of trees of the variety Dar Mlieva in height was stronger (Table 1). The cross-sectional index of the trunk of trees of early-ripening varieties, respectively, was the highest in the vigorous variety Dar Mliyeva, which prevailed over other vigorous varieties of early ripening.

***Table 1**. Apical and lateral growth of sweet cherry trees of different ripening periods*

Pomological variety	Number of shoots, pcs. / trees.	Average length of annual shoots, cm	Total length of annual increments, m	Tree trunk circumference, cm	Increase in tree trunk diameter, cm
Early-ripening varieties					
Dar Mliyeva	49	18.4	10.09	70.6	0.37
Zoryana (k)	46	15.1	6.24	53.9	0.38
Mliyivska zhovta	35	23.4	8.71	42.9	0.84
Medium-ripening varieties					
Mirazh	61	21.8	13.57	32.7	0.49
Alyonushka	12	24.7	2.67	38.7	1.03
Aboryhenka	39	25.7	10.07	47.0	0.14
Melitopolska krapchasta	72	24.5	18.56	35.5	0.59
Meotida (k)	44	22.6	9.55	33.4	0.36
Late-ripening varieties					
Biryuza	34	22.2	7.21	34.8	0.1
Donetskyy uholyok	20	18.2	3.82	32.5	0.13
Drohana zhovta (k)	49	20.2	9.26	40.3	0.85
Amazonka	12	22.5	8.94	54.96	0.35
LSD_{05}	*0.5*	*1.4*	*1.0*	*0.6*	*0.2*

***Note**: – *LSD_{05} – least significant difference at 0.05 significance level*

Fruit plantations in the 2021 season were characterised by a high load of fruits, which in turn affected the decrease in lateral growth of sweet cherry trees. High yields were observed in the varieties Dar Mliyeva and Zoryana (k), in which the increase in trunk diameter was insignificant (0.25 cm). The yield of the Mliyivska zhovta variety was significantly lower, which was accompanied by a more active thickening of the trunk – by 0.76 cm.

In general, on average for three years, the strongest thickening of tree trunks of early-ripening sweet cherry varieties was observed for the Mliyivska zhovta variety, while in other varieties it was much weaker. The largest increase was observed in the trees of the semi dwarf variety Alyonushka, which also had a low level of load on the crop.

Among the varieties of medium ripening, trees of the semi dwarf variety Aboryhenka were characterised by a low stem diameter gain, 0.89 cm less than the highest in this group. As a result of research, the strongest growth of the trunk of trees of medium-ripening sweet cherry varieties in thickness was noted for the Alyonushka variety, and the smallest – for the Aboryhenka variety. In the group of late-ripening varieties, the thickening of the trunk was observed in the vigorous Amazonka variety is more active, and this is natural since the trees of other late-ripening varieties studied are dwarfing. In general, over the years of research, the smallest increase in the trunk diameter was observed in the dwarfing variety Biryuza, and the largest – in the variety Drohana zhovta. The highest yield load per unit cross-sectional area of the trunk was recorded for the variety Donetskyy uholyok, the lowest – for Drohana zhovta. Consequently, the value of the increase in the trunk diameter was inversely related to tree crop loading and the strength of sweet cherry tree apical growth ($r = -0.77 \pm 0.07$).

The total increase in the length of annual shoots in some way affects the formation of the crop [18]. According to the results of research, the difference between the total growth of annual shoots in different years is quite significant. In the seventh year of tree vegetation, growth processes were quite intense, possibly due to the low level of load on the trees. In terms of the total length of annual shoots of the studied varieties, the highest level of the indicator was achieved

in trees of the variety Melitopolska krapchasta, and the lowest in the variety Alyonushka.

Analysing the obtained data separately for the growing seasons, it was found that the largest total length of growth was observed in 2020, when the productivity of plantations was the lowest. It is likely that the nutrients absorbed from the soil were used by the trees for wood growth. However, this statement is not correct in all cases: in the varieties Mliyivska zhovta, Melitopolska krapchasta, Biryuza, Drohana zhovta and Amazonka, the largest total length of annual shoots was observed in the previous year 2019 simultaneously with the maximum yield of trees of these varieties. High yields in 2021 negatively affected the total length of annual shoots, causing it to decrease. Despite this, the growth trend for varieties continued over the years. Thus, the indicator of the total length of annual increments is determined by the biological characteristics of the studied sweet cherry varieties.

This is confirmed by the fact that among the group of early-ripening varieties, the Dar Mlieva variety, which also has the largest crown volume, had the greatest total length of one-year shoots on average over the three years of the study. Also, in stands of medium-ripening varieties, according to the results of three-year observations, the dwarfing variety Melitopolska krapchasta, although the crown volume of the trees was the smallest compared to other medium-ripening varieties, had a high total length of annual growth. A significant total length of annual growths in trees of late-ripening sweet cherry varieties was obtained in semi dwarf, with a fairly small crown volume of the Drohana zhovta variety. It is believed that the structure of the crown of trees with a mixed type of fruiting should be dominated by shoots up to 10 ... 20 cm long [18; 19], this contributes to the formation of fruit-bearing formations and generative buds.

Having considered the length of annual shoots of sweet cherry trees by years of research, it can be assumed that the change in this indicator was most influenced by the level of tree productivity and weather conditions during the growing season. It is possible that the high air temperature in 2019 during the first wave of shoot growth slowed down apical growth and caused premature formation of apical buds.

The total growth of annual shoots also depends on the number of shoots on the tree, that is, the shoot-forming ability of sweet cherry trees. As is known from literature sources, sweet cherry trees by their biological characteristics are mainly vigorous and have a weak shoot-forming ability [19; 20]. Analysing the data obtained, it should be noted that the number of shoots on the tree changed significantly in some years.

If the rate of early-ripening varieties in 2019 ranged from 39-73, in the following years, respectively – 32-67 and 30-41. A sharp decrease in the shoot-forming ability of sweet cherry trees in 2020 can be explained by a significant load on their yield, while in 2021 its practical absence contributed to the activation of vegetative growth. A significant number of shoots on trees of the varieties Zoryana (k) and Mliyivska zhovta in 2019 may be due to less favourable overwintering conditions for the trees and damage to the generative buds, which resulted in increased growth processes. A similar situation was observed in sweet cherry trees of medium-ripening periods, in 2020, when there was an increase in the number of shoots with a high level of yield of plantings. High shoot-forming ability in this group was observed for the variety Melitopolska krapchasta, which formed about 72 shoots per tree. Low shoot-forming ability is characteristic of the variety Alyonushka – from 9 to 16 shoots per tree.

In the group of late varieties, an average of 12-49 shoots per tree were formed during the research period. The highest rate was recorded in 2020 for the Drohana zhovta variety, which can also be attributed to the group with high bud excitability. The lowest number of shoots was observed for the variety Donetskyy uholyok – no more than 24 shoots per tree.

Thus, according to the obtained data, it is advisable to divide cherry varieties into groups according to their ability to shoot: with a high degree – Dar Mliyeva, Zoryana, Mirazh, Melitopolska krapchasta and Drohana zhovta; medium – Mliyivska zhovta, Aboryhenka, Meotida, Amazonka and low degree of shoot formation – varieties Alyonushka, Biryuza, Donetskyy uholyok.

CONCLUSIONS

Analysis of the data obtained showed that the growth vigour of the cherry trees depended on the biological characteristics of the variety, while no effect on fruit ripening time was detected. According to the strength of tree growth, cherry varieties were vigorous – Amazonka, Dar Mliyeva, Zoryana, Mliyivska zhovta; semidwarf – Aboryhenka, Alyonushka, Drohana zhovta, Mirazh; dwarf – Biryuza, Donetskyy uholyok, Melitopolska krapchasta, Meotida. The maximum height (within 5 m) was observed in trees of the varieties Zoryana, Dar Mliyeva, Amazonka.

As a result of observations, the largest increase in the diameter of the trunk was found in trees of the varieties Alyonushka, Mliyivska zhovta and Drohana zhovta. The ripening period of the variety did not affect the lateral growth of trees. The increase in trunk diameter was in direct correlation with the strength of the tree's apical growth and inversely with the level of crop loading.

The shape of the crown, and therefore the formation of the future crop, was significantly influenced by the indicators of shoot-forming ability: the number of shoots, the average and total length of annual shoots. High ability to shoot was noted in the varieties Melitopolska krapchasta, Mirazh, Dar Mliyeva, Zoryana. The smallest number of shoots and their annual growth was obtained in the varieties Alyonushka, Biryuza, Donetskyy uholyok.

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Особливості ростових процесів дерев черешні різних строків достигання в умовах Правобережного Лісостепу України

Лідія Анатоліївна Шубенко, Світлана Сергіївна Шох, Леся Михайлівна Карпук, Андрій Андрійович Павліченко, Лариса Миколаївна Філіпова

Білоцерківський національний аграрний університет
09117, Соборна площа, 8/1, м. Біла Церква, Україна

Анотація. Однією з основних вимог, які ставлять до нових сортів кісточкових культур, рекомендованих для промислового вирощування є компактна форма крони, яка дозволяє збільшити щільність насаджень та спростити догляд за кроною. Метою досліджень було встановити ростові процеси надземної частини дерев черешні сортів різних строків достигання. В статті наведено результати досліджень особливостей апікального і латерального росту дерев черешні. Визначено біологічні та сортові особливості сили росту дерев, приріст і загальну довжину однорічних пагонів. Встановлено залежність приросту штамбу дерев від сили апікального росту. За результатами досліджень сорти черешні згруповано за силою росту: сильнорослими були сорти черешні – Амазонка, Дар Млієва, Зоряна, Мліївська жовта, середньорослими – Аборигенка, Альонушка, Дрогана жовта, Міраж; слаборослими – Бірюза, Донецький угольок, Мелітопольська крапчаста, Меотіда. Найменший приріст діаметра штамбу встановлений для слаборослого сорту Бірюза, а найбільший – для сорту Дрогана жовта. Найбільше навантаження врожаєм на одиницю площі поперечного перерізу штамбу зафіксовано для сорту Донецький угольок, найменше – для сорту Дрогана жовта. Величина приросту діаметра штамбу знаходилася в оберненій залежності від навантаження дерев урожаєм і сили апікального росту дерев черешні. Особливості пагоноутворювальної здатності дають змогу охарактеризувати форму крони дерев черешні: округла – Донецький угольок, Амазонка; високо-округла – сорти Аборигенка, Дар Млієва, Зоряна; широко-пірамідальна – Альонушка, Дрогана жовта, Мелітопольська крапчаста; пірамідальна – Мліївська жовта, Міраж; поникла – Меотіда, Бірюза. Високою пагоноутворювальною здатністю володіють сорти – Дар Млієва, Зоряна, Міраж, Мелітопольська крапчаста і Дрогана жовта; середньою – Мліївська жовта, Аборигенка, Меотіда, Амазонка; низькою – Альонушка, Бірюза, Донецький угольок

Ключові слова: сорти черешні, сила росту дерев, діаметр штамбу, обхват штамбу, приріст однорічних пагонів