EEET ECOLOGICAL ENGINEERING & ENVIRONMENTAL TECHNOLOGY

Ecological Engineering & Environmental Technology 2022, 23(4), 101–106
https://doi.org/10.12912/27197050/150253
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Received: 2022.05.11
Accepted: 2022.05.24
Published: 2022.06.01

Features of the Assimilation Surface of Sweet Cherry Trees of Different Ripening Terms

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ABSTRACT

The article presents the results of a study of the assimilation surface of sweet cherry trees of different pomological cultivars. The aim of the research was to study the morphological and varietal characteristics of the deciduous cover of sweet cherry trees, depending on the timing of fruit ripening. As a result of observations and analysis, the morphological features of the leaf apparatus of trees, leaf area and total leaf surface were determined as one of the main indicators of the photosynthetic potential of fruit trees. It was established that a characteristic feature of the varieties Turquoise, Drogana yellow and Donetsk coal was an increase in the area of the leaf blade with the age of the trees. Sweet cherry cultivars of late ripening were characterized by a smaller area of the leaf blade compared to cultivars of early and medium maturity. The size of the leaf blade did not depend on the strength of the growth of the fruit tree. A vigorous cultivar Mliyevska yellow and medium-sized Mirage had the maximum area of the leaf blade. The smallest size was found in the undersized variety Turquoise and medium-sized Alionushka.The area of the leaf blade significantly depended on the pomological cultivar of sweet cherry trees, scab damage and freezing of the trees. It was established that with age, the volume of fruit tree crowns of the cultivars of different ripening terms slightly increased. This was most clearly expressed for the Amazon cultivar, where the increase in crown volume was 11.96 m^3, and the smallest increase was for the Donetsk coal cultivar – 1.0 m^3. A high degree of land area development was inherent in trees with more spreading crowns. The varieties Amazonka, Dar Mliyeva and Aborihenka have mastered the feeding area allocated by the planting scheme more effectively. The activity of the passage of photosynthesis processes and the productivity of plantations at the age of 6–8 years were negatively affected by the low area of deciduous cover of sweet cherry plantations – 14–35% of the optimal one.

Keywords: sweet cherry cultivars, leaf area, total leaf surface, crown projection, crown volume, leaf index.

INTRODUCTION

During the last decade the increase in the world gross harvest of sweet cherry trees was due to the expansion of the plantation area which is typical for extensive farm management. According to FAO, in 2020 the share of sweet cherries in the world fruit production (over 755 mln t) was equal to 0.3% or 2.6 mln t. In fact, it can be included in the group of niche fruit crops [Kishchak, 2021].

The area of the sweet cherry plantations amounted to 443.8 th. ha, in the last 10 years it increased by 72.8 th. ha or by16.4%, and gross fruit harvest increased by 13% (327 th. t). Along with this, during the same period average yield capacity in the world did not change very much and it remained at a rather low level – 5.8 t/ha [Bondarenko, 2019].

A radiation mode, i.e., the sun light penetration into different spots of a tree crown, is an important factor for the formation of the yield capacity. However, fruit growers do not always pay proper attention to it. Here is the explanation. The light mode is an abstract concept; its effect on a tree is less obvious, as compared with the effect of fertilizers or plant protection means, also there is the lack of information concerning the modes of crown lighting [Bondarenko, 2019; Kishchak etc., 2020; Kappel et al., 2012].

Sweet cherry, peach and apricot trees belong to a group of light-loving stone crops. According to the conducted research, in the conditions of sufficient lighting net productivity of leaf photosynthesis is higher by 1.5–2 times as compared with the shaded leaves in the central part of a crown. Peripheral spots receive 60–70% of the light (if we take a field as a 100%-lighting). Only 30–50% of sun rays reach the central part of a crown. Thus, to receive one kilo of sweet cherries in the crown center twice as much of a leaf surface is to be used as compared with that of the similar peripheral harvest. In addition, sweet cherries grow bigger and with a better bio-chemical composition in the conditions of sufficient lighting [Shubenko et al., 2021; Balmer et al., 2015; Bujdoso et al., 2016; Meland et al., 2017].

In view of the fact that the ability of sweet cherry trees to form shoots and regenerate is very low (it is more difficult to rejuvenate its tress than apricot or peach ones), bare branches in the sweet cherry orchard is a serious problem and it decreases the yield capacity [Li et al., 2019; Grand etc., 2017]. Hence, one of the main tasks of a fruit producer is to create the plantations the construction of which will ensure proper light mode for all spots of the crown.

Fruit growers actively introduce/plant sweet cherry orchards on medium- and strong-growing rootstock; there they form tress with round crowns, including KGB type, Spanish bush, round small crown and others [Szpadzik et al., 2019]. The use of leader crown formations (TSA, SSA) in the orchards leads to precocity and better-quality fruit, but it causes some disadvantages, such as higher labor costs for pruning and irregular tree fruiting [Neilsen et al., 2016; Soysal et al., 2019; Long et al., 2015].

The productivity of sweet cherry trees is ensured not only by the intake of nutrition elements from the soil, but also by the synthesis of nutrients in green organs of tree assimilation, namely leaves. Photo-synthesis is a primary source of the formation of organic substances, the most important process of a plant life-cycle are connected with it as well as the development of high yields of the agricultural crops. It is a known fact that the photo-synthesis intensity along with the accumulation of organic substance depend on a size of a leaf surface/blade which is determined with bio-metric parameters of the plants and the duration of the active state of assimilation apparatus [Musacchi et al., 2015]. Leaves on the trees are the main organs which produce organic substance, bio-mass of trees is formed from it as sun light energy assimilated by them. The biological and economic productivity of the trees depends on the intensity of photo-synthesis [Bosa et al., 2016].

The productivity of agro-phyto-cenoses depends directly on the creation of optimal conditions of photo-synthetic activity of a leaf apparatus. The intensity of leaf growth, calculated per area unit, eventually guarantees the proper productivity of fruit plantations. In this respect, foliage, the area of a leaf blade and the gross surface density of the leaves are of great importance [Shubenko et al., 2021; Shubenko et al., 2021; Shubenko, 2020]. It is supposed that an optimal area of a leaf blade is to be 40–50 th m^2/ha for intensive plantations [Yakovenko et al., 2021]. Some data proves that for some grain species the leaf area which is larger than 20–25 th. m^2/ha is not advisable due to the worsening of light mode. Some researchers believe that the optimum of a leaf area is about 1 kg of raw fruit per 1 m^2 of a leaf surface [Havryliuk et al., 2019].

The purpose of the research was to study morphological specific features of leafy covering of sweet cherry trees as a mechanism of photosynthesis depending on varietal features and fruit ripening terms.

RESEARCH CONDITIONS AND METHODS

The soils of the experimental plot are grey opodzolic. This soil type, by its features and properties, is similar to sod-opodzolic and chornozem soils. Opodzolic processes are quite definite, which results in a clear differentiated profile by an elluvial-illuvial type. The process of humus accumulation is rather active and its content changes in different sub-types considerably. A wide variety of vegetation increases the number of organic residues which enter the soil.

The cultivars of sweet cherry trees with different ripening terms were the object of the research: Aboryhenka, Biriuza, Dar Mliyev, Zoriana, Mliivska zhovta, Mirazh, Melitopolska krapchasta, Meotida, Donetskyi uholiok, Alionushka, Amazonka, Drohana zhovta. Trees were grafted on forest sweet cherry rootstock, planted in 6×4 m scheme, formed with a sparse-tiered type of a crown.

During three years the accounting and observation were carried out by the “Methodology of conducting field trials with fruit crops" of P.V. Kondratenko and M.O. Bublyk [Kondratenko etc., 1996].

The area of a leaf blade was determined at the end of September using "cutting" technique, the area of a leaf surface was calculated by multiplying the number of leaves and the area of a leaf blade.

The area of a crown projection was calculated with the formula:

$$S = 0.196 \times (D_1 + D_2)^2 \tag{1}$$

where: S – area of crown projection, m^2;
0.196 – conversion factor;
D_1 – crown diameter along the row, m;
D_2 – crown diameter across the row, m.

The crown volume was calculated with the formula:

$$V = 0.523 \times D^2 \times h \tag{2}$$

where: V – crown volume, m^3;
0.523 – conversion factor;
D – average diameter with mutual-perpendicular crown measurement, m;
h – crown height from the base of skeleton branches to the tree top, m.

The leaf index (LI, m^2/m^2) was identified by the correlation of a total leaf surface to 1 m^2 of a crown projection. The gross density of crown foliage (Sv, m^2/m^3) is a total leaf surface per 1m^3 of a crown volume.

RESEARCH RESULTS AND DISCUSSION

A relatively stable size of the area of a leaf blade for each pomological cultivar was recorded during the years under study. When a group of cultivars with an early ripening term was analyzed, an increase in the leaf blade size was observed when a tree grew older. For instance, the area of a leaf blade of Dar Mliyeva cultivar increased almost by two times on the sixth and up to the 8th year after planting. This was also the case for Mliivska zhovta, but for the early-ripening Zoriana cultivar (the control) a leaf blade increased up to the 7th year, and the following year it decreased slightly (Table 1). Generally, among early cultivars a maximal size of a leaf blade was typical for cultivar Mliivska zhovta, the same can be said about the cultivars of other ripening terms.

The largest area of a leaf blade for the cultivars of a medium ripening term was recorded for Mirazh cultivar; it was closer to the similar indicators of an early ripening Mliivska zhovta cultivar. The indicator which was lower by two times was recorded for Alionushka cultivar. No correlation between the change of a leaf blade and a tree age for medium ripening cultivars was observed. For example, the area of a leaf blade of Alionushka cultivar increased evenly during the research; the area of a leaf blade for 7-year-old

Table 1. Characteristics of leafy covering of sweet cherry trees

Pomological cultivar	Tree foliage, pcs./tree	Area of leaf blade cm^2	Total leaf surface, m^2	Area of leaf covering, th.m^2/ha
Early ripening cultivars				
Dar Mliyeva	18787	50.67	95.4	39.67
Zoriana (control)	8451	44.13	44	18.3
Mliivska zhovta	3862	69.85	27.2	11.3
Medium ripening cultivars				
Mirazh	23129	61.39	141.4	58.84
Alionushka	4665	36.64	17.1	7.09
Aboryhenka	4384	44.79	19.6	8.17
Melitopolska krapchasta	14627	57.92	84.70	35.24
Meotida (control)	15887	55.73	87.10	36.23
Late ripening cultivars				
Biriuza	5528	32.44	17.90	7.47
Donetskyi uholiok	4995	49.23	24.7	10.26
Drohana zhovta (control)	8927	48.6	43.20	17.98
Amazonka	14845	52.51	77.90	32.43
SSD_{05}	575	6.63	5.21	2.75

cultivars Mirazh and Meotida was smaller than in other years; this indicator increased for cultivars Aboryhenka and Melitopolska krapchasta of the same age as compared with that of the previous years. As compared with the control (Meotida cultivar), on the average in the years under study, cultivars Mirazh and Melitopolska krapchasta were characterized with a larger size of a leaf blade (by 2.19–5.66 cm^2, respectively).

Sweet cherry cultivars of a late ripening term were characterized with a smaller area of a leaf blade as compare with the cultivars of early and medium terms.

A maximal area of a leaf blade was typical for 8 year-old trees of cultivar Donetskyi uholiok. On the average in the years under study, the largest area of a leaf blade was recorded for cultivar Amazonka. The smallest leaf blade among late ripening cultivars as well as the cultivars of other ripening groups was observed for Biriuza cultivar.

The increase of the area of a leaf blade when a tree grew older was characteristic for such cultivars as Biriuza, Drohana zhovta and Donetskyi uholiok, however there was no such tendency for Amazonka cultivar, and 7 year-old trees had the largest area of a leaf blade.

A photo-synthetic potential of a fruit tree depends on both the area of a leaf blade and the total area of leaf covering of a tree, various factors, e.g. a proper number of leaves in the tree, having an impact on it. The area of a leaf surface is one of the main indicators of a photo-synthetic potential of fruit trees. It is supposed [Havryliuk et al., 2020] that the optimal area of leaf covering is to range within 40–50 th. m^2/ha for the plantations of an intensive type.

During the research it was found out that weather conditions and phyto-sanitary state of the orchards had a significant effect on the size of the assimilation surface. Due to the non-traditional winter conditions of the years of 1019/2020, in particular temperature fluctuations and moisture, the area of leaf covering of sweet cherry trees was smaller than that in the following years of the research. In 2020 a serious negative effect on the formation of a leaf surface of the trees (particularly for cultivars Alionushka, Biriuza and Dorhana zhovta) was caused by infection cocomicosis which resulted in damaged leaf fall and inhibited photo-synthetic activity. However, it had a slight effect on the size of a total leaf surface of the trees because new leaves were growing fast.

The conducted research confirmed that the trees in the treatments with a large area of a leaf blade were not always characterized with a larger total area of leaf covering. This tendency was seen for cultivar Mliivska zhovta, it was not the case for Mirazh cultivar though.

When trees grew older, the area of a leaf surface increased which could be explained by the increase of a crown volume, the area of a leaf blade and tree foliage.

For fruit trees to reach their potential productivity, a crown of each tree should fill up the space, meant for it, in the shortest possible terms.

As the research results prove (Table 2), the crowns of the trees of different pomological cultivars of sweet cherry trees use the space and the nutrition area, meant by a planting scheme for them, in a different way.

Naturally, the trees with more spreading crowns used their nutrition area more efficiently. The highest level of the use of the land area was recorded for such cultivars as Amazonka, Dar Mliyeva and Aboryhenka; it has to be stated that as to the vigor, Amazonka and Dar Mliyeva belong to vigorous cultivars and Aboryhenka is a weak-grown cultivar; as to the crown form, they belong to high-round and drooping types, respectively [Shubenko et al., 2021].

The lowest level of the use of the land area was recorded for the weak-grown cultivars with a round crown form, namely Donetskyi uholiok and Biriuza. The cultivars with a pyramidal crown showed better results: vigorous cultivar Mliivska zhovta and medium-grown cultivar Mirazh as well as weak-grown cultivars Melitopolska krapchasta (a wide pyramidal crown) and Meotida (a drooping crown).

Kishchak et al. [2020], Yakovenko et al. [2021]; Havryliuk et al. [2019] and other researchers state that the optimal level of the use of the land area by fruit trees is 70%. So, only some sweet cherry cultivars, which were studied, used the nutrition area, meant by a planting scheme for them, to its full capacity.

The conclusion can be made that the applied tree planting scheme (6 × 4 m) does not correspond properly to the growth features of the studied sweet cherry cultivars.

The use of the air space by the fruit trees is an important indicator of the characteristics of their growth processes. The trees of sweet cherry cultivars can form crowns of different sizes and volumes which has a direct impact on the productivity of the plantations.

Table 2. Total assimilation surface of sweet cherry trees

Pomological cultivar	Crown diameter, м	Area of crown projection, m^2	Crown volume, m^3	Use of land area by crown projection, %	Leaf index, m^2/m^2	Specific density of crown foliage, m^2/m^3
Early ripening cultivars						
Dar Mliyeva	4.50	3.79	50.8	67.9	25.17	1.87
Zoriana (control)	4.10	3.29	40.3	52.4	13.37	10.09
Mliivska zhovta	2.90	1.65	20.5	27.4	16.48	1.32
Medium ripening cultivars						
Mirazh	3.00	1.76	16.9	26.8	80.34	8.36
Alionushka	4.20	3.46	31.3	48.7	4.9	0.54
Aboryhenka	4.50	3.97	44.9	66.9	4.93	0.43
Melitopolska krapchasta	3.10	1.88	13.5	28.1	4.62	6.27
Meotida (control)	3.00	1.76	11.6	26.8	49.48	7.51
Late ripening cultivars						
Biriuza	2.60	1.32	8.9	21.8	13.50	2.01
Donetskyi uholiok	2.50	1.23	8.3	20.1	20.08	2.97
Drohana zhovta (control)	3.60	2.54	24.5	41.7	17.0	1.76
Amazonka	4.90	4.71	57.6	7.5	16.53	1.35
SSD_{05}	0.4	0.17	5.2	1.5	12.4	0.8

According to the research results (Table 2), one can state that the crown sizes of the early-ripening cultivars exceeded those of medium- and late-ripening sweet cherry trees by two times.

At the age of 8 the trees of cultivar Dar Mliyeva reached a large crown volume among the cultivars of early ripening terms; it exceeded that of other cultivars of the same group by 10.55–30.33 m^3. Among the cultivars of early ripening terms the smallest crown volume was recorded for Mliivska zhovta.

Aboryhenka had the largest crown volume among medium-ripening cultivars. It is due to the fact that the trees of this cultivar are vigorous. A weak-grown control cultivar Meotida was characterized with the smallest crown volume.

As compared with early- and medium-ripening cultivars, those in a late-ripening group were characterized with a smaller crown volume. The trees of cultivar Donetskyi uholiok had their crowns of a smaller volume; this indicator was a bit higher for cultivar Biriuza. The trees of cultivar Amazonka were the exception: the size of their crowns exceeded that of late-ripening cultivars by 33.1–49.29 m^3. Besides, cultivar Amazonka had the largest crown volume among the cultivars of all other ripening terms.

CONCLUSIONS

The size of a leaf blade did not depend on the vigor of a fruit tree. A leaf blade had a maximal area for vigorous cultivar Mliivska zhovta and medium-grown cultivar Mirazh; its smallest size was recorded for weak-grown cultivar Biriuza and medium-grown cultivar Alionushka. The area of a leaf blade depended considerably on a pomological cultivar of a sweet cherry tree, scab damage and tree freezing. No correlation between tree vigor and the size of leaves was recorded.

The results of the research proved that the area of leaf covering was not large in 6–8 year-old plantations – not more than 14–35% from the optimal one; and it had a negative effect on the photo-synthesis processes of and the orchard productivity.

The analysis of the data received during the three-year research confirmed that the crown volume of the cultivars of various ripening terms slightly increased as the trees grew older. It was clearly seen for cultivar Amazonka: the increase of the crown volume amounted to 11.96 m^3, the smallest indicator (1.0 m^3) was recorded for cultivar Donetskyi uholiok.

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