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THE LIGHT REGIME AND THE STRUCTURE OF THE CROWN OF THE GOLDEN DELICIOUS REINDERS AND RED VELOX APPLE TREE VARIETIES

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Abstract

The given work relates to the study of the light regime and the structure of the vegetative composition in the Golden Delicious Reinders and Red Velox apple tree varieties. The solar regime in the crown of the apple trees of the studied varieties in the 4th year after their planting differs depending on the position of the sun in the sky, the distance from the ground and the length of the tree rows. The intensity of the solar radiation gradually increases from 9 o'clock till 13-15 o'clock, then decreases. The penetration of the solar energy into the crown increases from the base of the crown to the top of the tree. Based on the data obtained during the study, it can be asserted that the orchards in which trees have a height of 3.5-4.0 m and a crown width at the base of 1.0-1.2 m which decreases towards the top up to 0.8-1.0 m, form well-lit fruit-growing ecosystems, which receive in all areas of the vegetative ensemble more than 0.2 cal/cm^2 x min, i.e. as much as it is necessary for the photosynthesis process. The volume of the crown of the studied varieties depends on the vigour of the variety and the size of the trees. It provides light penetration to all elements of the crown, which allows.

Key words*: apple variety, light intensity, tree crown.*

INTRODUCTION

The apple tree, being a crop adapted to various ecological conditions, occupies over 60% of the total of fruit trees in the orchards of the Republic of Moldova, with a share of over 70% of fruit production; it is profitable and ensures high profits. One of the main functions of the orchard system is the conversion of solar energy into chemical energy bound in fruit. Light interception studies have shown that, in order to obtain high yields, the crown of trees must allow the interception of at least 70% of the available light radiation (Bîlici I., 2018). At the same time, the optimal level of soil coverage by the projection of the tree crown into full productivity turned out to be 65-70% of the nutritional surface. (Babuc V., 2000; Cimpoieș Gh. et al., 2001). However, this cannot be achieved in modern orchards. (Dadu C., 2000) the vegetative growth and the stem development is determined by biological (variety, rootstock, disease and pest resistance) and technological factors (the number of fruit, food and water supply), which condition the development of the physiological processes (Balan V. et al., 2018). The influence of soil factors such as soil structure and fertility, limiting soil factors, and climatic factors such as solar energy, temperature, its maximum and minimum values, but especially the values recorded during the growing season (fruiting phenophases), as well as the amount of precipitation and others should not be overlooked. (Ștefan N., 1993). From the genetic point of view, the variety is the basic factor in determining the crop system and technology.

MATERIALS AND METHODS

The research was carried out at the "Elit Fruct" Ltd in the village of Cosernita, the district of Criuleni, between the years 2015 and 2019. The orchard was founded in 2015. Planting material of 2-year-old trees of the "Certificate" category with a crown base consisting of well-developed branches evenly distributed along the axis was used. The Red Velox and Golden Delicious Reinders grafted on M9 rootstock were studied. The spacing between rows was 3.2 m and between trees – 0.8 m, which corresponded to

3900 trees/ha. The grafting site was placed at a level of 15–20 cm above the ground. Before the orchard was planted, a tree support system was installed – monoplane, simple, made of reinforced concrete poles, with a height of about 4.0 m above the ground, and a metal wire installed at a height of 50 cm above the ground level, which was also used as a support for the irrigation system. In the first year of vegetation, five more metal wires were added. The first two wires were fixed at 80 cm above the ground and at 80 cm between each other, the others - at 160 cm, 240 cm and 320 cm above the ground, respectively. Four groups of trees, 8 trees each, were used in the experiment. The research wa carried out according to the general methodology for conducting experiments with fruit trees.

The distribution of the solar energy in the crown of the Red Velox and Golden Delicious Reinders apple trees was determined by the height of the sun relative to the horizon, the height of the trees, and the density of the crown at the base in the direction between the rows. The rows of trees were in a north-south direction.

RESULTS AND DISCUSSIONS

The light regime in the crown of the Golden Delicious Reinders apple trees, which have an improved spindle-shaped crown type, varies depending on the position of the parts of the crown in relation to the sun and the distance from the ground. Since the crowns of the trees closed along the row, daylight illumination was studied not only in the centre of the crown along the axis, but also in the area of crown closure (Table 1, Figure 1a).

At 9 o'clock, the lowest amount of solar radiation was recorded at the height of 0.5-1.5 m above the ground, in the western part of the crown (0.21- 0.26 cal/cm^2*min) and in the central part (0.24-0.29 cal/cm^2*min) of the tree rows.

The lowest amount of solar radiation was recorded at the height of 0.5-1.5 m above the ground, in the western part of the crown (0.21-0.26 cal/cm^2*min) and in the central part (0.24-0.29 cal/cm^2*min) along the rows of the trees. At the top of the crown, all parts were well lit (0.32-0.36 cal/cm^2*min).

Table 1. The light regime in the crown of the Golden Delicious Reinders variety trees, cal/cm^2*min (the planting year - 2015, "Elit Fruct" Ltd, July 2018)

Time of determination, hour	Solar radiation in open field	Axis side		
		the east side	the centre of the crown	the west side
9^{00}	0.43	0.31	0.28	0.25
11^{00}	0.82	0.72	0.51	0.50
13^{00}	1.07	0.89	0.57	0.72
15^{00}	1.12	0.69	0.69	0.92
17^{00}	0.89	0.58	0.68	0.70
Average	0.87	0.64	0.55	0.62

At 11 o'clock, the solar radiation level in the open field was twice as high (0.82 cal/cm^2*min) compared to the level recorded at 9 o'clock (0.43 cal/cm^2*min). At this time, the eastern part of the crown benefited from more solar energy (0.65-0.82 cal/cm^2*min) compared to the central part of the crown (0.31-0.62 cal/cm^2*min) and its western part (0.38-0.67 cal/cm^2*min).

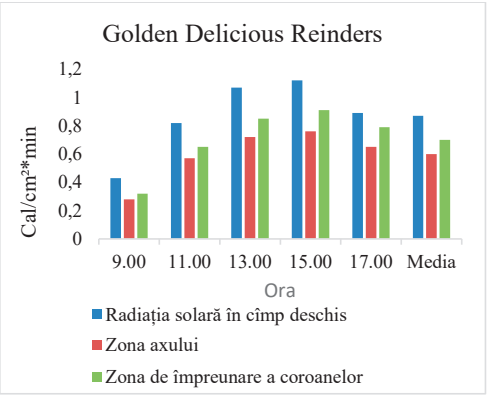

Figure 1a. The light regime in the crown of the Golden Delicious Reinders apple trees, cal/cm^2*min

At 13 o'clock, the sides of the crown were illuminated identically and received a large amount of solar energy (0.78-1.17 cal/cm^2*min) relative to the centre of the crown (0.42-1.13 cal/cm^2*minutes).

While the upper part of the crown received a high amount of direct solar radiation (0.88-0.96 cal/cm^2*min), at 0.5 m above the ground the central part of the crown received only 0.42-.53 cal/cm^2*min, and the western part - 0.62-0.79 cal/cm^2*min.

Thus, at noon, the crown of the Golden Delicious Reinders apple trees was well lit and the light intensity differed slightly in the eastern part compared to the western part, but the inner areas adjacent to the axis and the areas of crown interpenetration were less illuminated (Figure 1b).

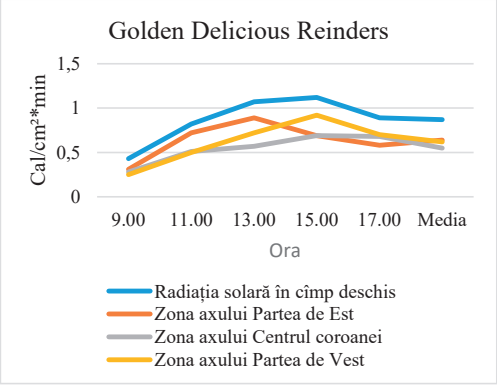

Figure 1b. The light regime in the area of the axis of the Golden Delicious Reinders apple trees, cal/cm^2*min.

At 15 o'clock, the level of the solar radiation in the open field was the highest (1.12 cal/cm^2*min), and the distribution of light in the orchard depended on the area of the crown.
Thus, the highest intensity of the solar energy was recorded in the area of the axis, in the western part of the crown (0.84-0.99 cal/cm^2*min), followed by the central area (0.63-0.93 cal/ cm^2*min) and the eastern part of the crown (0.45-0.95 cal/cm^2*min). In the area of the crown closure, the same pattern of crown illumination was recorded, in the sense that the western part was better illuminated than the central part and, to a lesser extent, the eastern part of the crown.
At 17 o'clock, in the region of the central axis, the western part of the trees in the orchard received the greatest amount of sunlight (0.69-0.79 cal/cm^2*min). The central and eastern parts of the tree rows were less illuminated - 0.62-0.75 cal/cm^2*min and 0.47-0.73 cal/cm^2*min, respectively.
The light regime in the crown of the Red Velox (Table 2.). apple trees proved that the variety had a decisive influence on the illumination of the crown.
The obtained experimental data show that a smaller amount of light penetrates into the lower part of the crown along the row of trees during the day compared to other parts of the crown. The illumination in the tree crown increases during the day as the height of the crown above the ground increases. At the same time, the illumination increases from morning to 13:00, when the eastern part of the crown is better lit, and the western and central parts of the crown are less lit. The intensity of the light the trees receive is slightly different at 13:00, In the afternoon, the western part of the crown receives more solar energy, and the central and eastern parts of the crown receives less energy.
The Red Velox variety forms much smaller leaves compared to the Golden Delicious Reinders variety which forms much larger leaves. Therefore, the light penetrates more easily into the crowns of the Red Velox apple trees, compared to the Golden Delicious Reinders variety, ensuring a rational lighting of the tree rows (Figure 2).
The light regime in the crowns of trees of the Red Velox variety indicates that the variety has a decisive influence on the illumination of the crown. Thus, the penetration of solar energy into the eastern and western parts of the crown in this variety is relatively identical to the Golden Delicious Reinders variety, but the centre of the crown is much better lit.

Table 2. The light regime in the crown of the Red Velox apple trees, cal/cm^2*min (the planting year 2015, "Elit Fruct" Ltd, July 2018)

Time of determination, hour	Solar radiation in the open field	Crown joining area		
		the east side	the centre of the crown	the west side
9^{00}	0.40	0.34	0.32	0.28
11^{00}	0.81	0.67	0.67	0.61
13^{00}	1.05	0.89	0.81	0.85
15^{00}	1.10	0.82	1.00	1.00
17^{00}	0.87	0.69	0.84	0.84
Average	0.85	0.68	0.73	0.72

At 9 o'clock, the Red Velox variety, both in the area of the central axis and in the crown closure, received 0.32-0.38 cal/cm^2*min or 80-95% of radiation, and at 11 o'clock - 0.60-0.67 cal/cm^2*min or 74-83%. At 13 o'clock, when the sun was at its zenith, the central part of the crown received 0.76-0.81 cal/cm^2*min or 72-77% of the total radiation. In the afternoon, the light intensity was quite high (0.87-1.10

cal/cm^2*min) and the central part of the crown was lit very well. Thus, at 15 o'clock, the illumination in the central part of the crown was 0.71-1.0 cal/cm^2*min or 65-91%, and at 17 o'clock, the centrl part of the crown received 0.68-0.84 cal/cm^2*min or 78-96% of the total radiation.

Therefore, the light penetrated more easily into the crowns of the Red Velox apple trees, compared to the Golden Delicious Reinders variety, and ensured a rational lighting of the tree row (Figure 2).

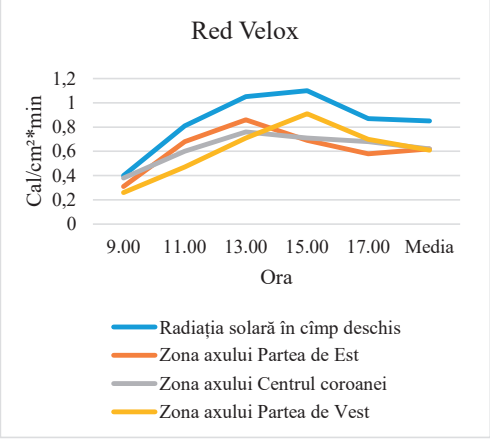

Figure 2. The light regime in the axis area of the Red Velox apple tree, cal/cm^2*min

Analysing the lighting regime in the apple tree orchards of the Golden Delicious Reinders and Red Velox varieties, it can be argued that in continuous rows oriented from north to south, the crown height of which at the base does not exceed 120 cm, the problem of self-shading does not persist, even if the height of the trees reaches 3.5-4.0 m. The intensity of the solar radiation received by the crown of the apple trees in the 4th year after their planting changes during the day depending on the height of the crown from the ground, as well as the solar radiation on open ground. The conducted studies aimed at establishing the level of illumination in the new varieties introduced into intensive horticulture in the Republic of Moldova will become the basis for establishing solar energy reserves to increase the photosynthesis yield in modern gardens.

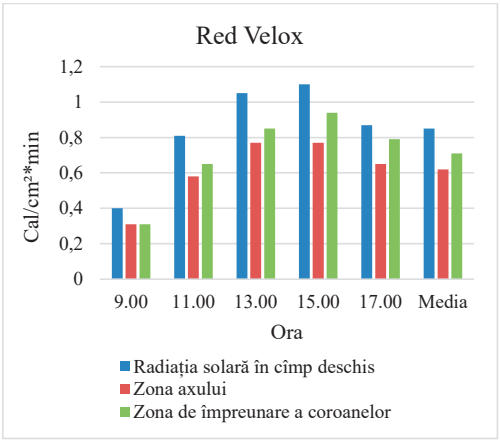

Figure 3. The light regime in the crown of the Red Velox apple trees, cal/cm^2*min

The vegetative growth of the studied varieties is expressed quantitatively in the amount of accumulated annual vegetative growth, crown height and width, crown surface and volume, as well as the degree of soil coverage by the shadow of the tree crowns (Figure 3.). The height of the crown of the studied varieties was 256-265 cm in the 3rd year after their planting. The dwarf variety Red Velox recorded the lowest value of the crown height, namely 256 cm.

The width of the crown at the base recorded maximum values (105-125 cm) admissible in relation to the planting distance of the trees in a row (80 cm). The width of the crown at the top depends on the growth vigour of the variety and varied between 25 cm in the Red Velox variety, and 50 cm in the high-vigour Golden Delicious Reinders variety.

In conclusion it must be said that the volume of the crown in the studied varieties depends on the vigour of the variety and the size of the trees (Table 3.). It provides light penetration to all elements of the crown, thereby creating the necessary conditions for the growth of fruit branches in order to obtain the highest possible yield.

Table 3. The structure of the crown of apple trees according to age and the biological characteristics of the variety (the planting year – 2015, "Elit Fruct" Ltd, 2017–2019)

Variety	Crown hight, cm	Crown width, cm		Degree of soil coverage by the shadow of the tree crowns, %	The lateral surface of the crown, thousand m^2/ha	Crown volume, m^3	
		at the basis	at the top			tree	ha
the year 2017, 3-year-old trees							
Red Velox	256	105	25	32.8	20975	1.6	6249
Golden Delicious Reinders	265	115	50	35.9	22654	2.2	8593
the year 2019, 5-year-old trees							
Red Velox	285	130	45	40.6	24021	2.5	9765
Golden Delicious Reinders	333	130	70	40.6	28748	3.3	12889

The degree of soil coverage by the shadow of the tree crowns which received solar energy reached the values of 32.8-35.9%. The difference in the use of the nutrition surface of the trees was insignificant, since the distance between the rows and within the row were optimal for the apple varieties grafted on the M9 rootstock in high density orchards.

Using the data on the tree vigour, the crown volume was calculated and related to the surface unit. The lateral crown surface of the 3-year-old apple trees was 20975-22654 m^2/ha, and the crown volume was 1.6-2.2 m^3/tree and 6249-8593 m^3/ha, respectively.

Along with the growth and development of the trees, the parameters of the crown also increased. In 5-year-old trees, the height of the crown was 285-333 cm, depending on the variety, and the width of 130 cm stayed constant in both varieties studied (the distance of 3.2 m between rows does not allow wider crowns). The width of the crown at the top varied from 45 cm in the trees of the Red Velox variety, to 70 cm in the trees of the Golden Delicious Reinders variety. The degree of soil coverage by the shadow of the tree crowns reached the optimum level possible for a row spacing of 3.2 m and was 40.6% for both varieties.

In 2019. the lateral surface of the crown (24021-28748 m^2/ha) increased significantly compared to 2017 achieving optimal values for such orchards. The crown volume, which depends on the crown area, also increased significantly, reaching 2.5-3.3 m^3/tree and 9765-12889 m^3/ha, respectively. In 2019, the crown area and volume were greater in the Golden Delicious Reinders variety compared to the Red Velox variety. Thus, in the 5th year of vegetation, the trees of the studied varieties reached the optimal surface and crown volume, which characterizes the productive potential of the orchard.

CONCLUSIONS

The intensity of the solar radiation gradually increased from 900 to 1300-1500 and then decreased; the penetration of the solar energy into the tree crown increased from the base of the crown to the top of the tree. In the first half of the day, the leaves in the eastern part of the continuous rows were better illuminated; in the second half of the day, the western part of the rows were better illuminated. The apple trees of the studied varieties grafted on the low vigour M9 rootstock, planted at a distance of 3.2 x 0.8 m and the crown of which are of improved slender-spindle shape, of a height of 3.5-4.0 m and a width of 1.0-1.2 m at the base and 0.8-1.0 m at the top, form well-lit orchards, which receive in all areas of the crown more than 0.2 cal/cm^2*min, i.e. the necessary amount for the photosynthesis process. The light intensity in the crown of the Red Velox variety is higher because these trees form much smaller leaves compared to the other varieties.

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