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HORTICULTURE

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**EFFECT OF GROWTH REGULATORS ON THE CROP LOAD
MANAGEMENT, YIELD AND QUALITY OF FRUITS OF CV GALA
DELICIOUS**

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Keywords: *apple; variety; growth regulators; fruit buds; inflorescence; yield.*

ABSTRACT

The study was conducted in the period 2016-2018 in the central area of the Republic of Moldova with the purpose to assess the effect of various crop load management practices on the Cv Gala Delicious, grafted on the rootstock M9, in an intensive system. The trees aged 8-10 years were trained according to improved slender spindle shape and planted at a distance of 3.5 x 1 m. The experiment was organized in 4 repetitions, the spraying was performed on 8 trees in each repetition, using 11 l of solution on 32 trees or 1000 l per hectare, respectively. The used growth regulators ensured a significant increase in the average weight of a fruit (135.4-144.4 g) and a significant increase in the diameter of fruits (over 85% of fruits have been classified in the category I and extra category), but significantly reduced the number of fruits per tree.

INTRODUCTION

In order to obtain high quality and constant yields, modern pomology recommends the use of manual and chemical fruit thinning, but the lack of labour force determined to put an emphasis on the use of growth regulators everywhere (Robinson et al. 1998). At present, the most commonly used chemicals for apple fruit thinning during the flower stage are 2-chloroethylphosphonic acid (ethephon), ammonium thiosulphate (ATS), oil and lime sulfur; Auxins, (NAA and NAD), cytokinins, (6-BA) and, in some cases, the insecticide carbaryl are applied during the fruit stage (Babuc et al. 2013). The efficiency of thinning varies depending on the dose and type of the preparation used, the climatic conditions and the cultivation system of the fruit species (Stopar & Tojnko 2005, Theron 2013, Peșteanu 2018). Obviously, practical argumentation of the crop load management practices in order to obtain sustainable fruit yield, represents a crucial problem for intensive apple orchard growing (Babuc et al. 2013). The purpose and objectives of the paper is to increase the productivity and efficiency of apple plantations by applying various fruit load management practices for Gala Delicious variety, grafted on the M9 rootstock, in an intensive apple orchard system.

MATERIAL AND METHODS

The study was conducted during the period 2016-2018. The influence of

various thinning methods on the cv Gala Delicious was studied: **V1**-Untreated control variant; **V2**-Manual thinning of fruits was performed after the physiological drop, when the fruits reached a diameter of 16-18 mm; **V3**- Spraying with Urea solution 46% N, 6 kg/ha, at a temperature of 12-25°C and air humidity of 65-80%, when 75% of the flowers are open until the petals of the first flowers dropped; **V4**-Spraying with Geramid New solution, 1.5 l/ha, at a temperature of 15-20 °C, when the central fruit reached a diameter of 4-7 mm; **V5**- Spraying with LG Dira Max solution, 2,l/ha at a temperature of 18-25°C, when the central fruit reached a diameter of 10-15 mm.

The intensity of flowering, the stages of fruit development, the time before and after the application of treatment were analyzed. The experiment was organized in 4 repetitions, the spraying was performed on 8 trees in each repetition, using 11 l of solution on 32 trees or 1000 l per hectare, respectively. The authors calculated the number of red dotted buds (NBR), the number of inflorescence set (NIL), the average number of fruits per tree as well as the average weight and diameter of fruits. Based on the number of plants per unit area, the average number of fruits per tree and the average mass of a fruit, the yield was determined for each variant per tree and per hectare. Fruit yield was determined by the gravimetric and calculation method. Based on the number of plants per unit area, the average number of fruits per tree and the average weight of a fruit, it was established the yield on each variant per tree and per hectare. Statistical processing of the research results was performed by the method of monofactorial dispersion analysis, the method of correlation and regression.

RESULTS AND DISCUSSIONS

The cv Gala Delicious trees selected according to their vigour and uniform development, differentiated a satisfactory quantity of fruit buds and at the emergence of the red dotted buds constituted 179-213 pcs/tree in 2016, 284-312 pcs/tree in 2017 and 213-240 pcs/tree in 2018. The number of red dotted buds (NBR) convincingly shows that trees have a uniform load of reproductive organs and differ from year to year. Regarding the number of inflorescence set (NIL), it was determined that their number is uniform by variants and constitutes don average 90.8 pcs/tree in 2016, 142 in 2017 and 95.8 in 2018, which constitutes an insignificant difference compared to the control variant. Analyzing the NBR and NIL balance, we can conclude that the methods used to adjust the crop load did not influence the number of inflorescences in the tree crown, because the trees are under identical conditions of growth and development

The number of fruits per inflorescence. Data regarding the number of fruits per inflorescence convincingly show that in the untreated V1-Control variant, where the reproductive organs were not thinned, the fruits were more evenly distributed per inflorescences: by one (32.4 - 44.1%), two (36.5 - 46.2%) and three fruits (19.4 – 21.4%). Crop load management increased the number of fruits by one per inflorescence compared to those of two and three fruits per inflorescence. For example, in V2-Manual thinning, 72.6 - 81.2% of fruits were distributed by one and only 18.8 - 27.4% fruits per inflorescence. The number of fruits per inflorescence, when using growth regulators, has increased distinctly their number by one fruit per inflorescence, compared to the untreated control variant. In 2016, the number of fruits by one per inflorescence constituted 71.2% in V3-Urea 46% N, 6 kg/ha, 61.8% in V4-Geramid New, 1.5 l/ha and 67.7% in V5 - Dira Max LG, 2 l/ha, and the

number of fruits by two and three per inflorescence has decreased markedly and constituted 22.5 - 32.3% and 3.6 - 6.3% respectively.

In 2017, the number of fruits was significantly higher compared to 2016, but the distribution of fruits per inflorescence was similar. Thus, as a result of the manual thinning of fruits 72.6% of the fruits were distributed by one per inflorescence, while as a result of using growth regulators this index constituted 64.6% in V3, 70.1% in V4 and 62.9% in V5. When treating the trees with Urea 46% N at the dose of 6 kg/ha, 25.8% formed by one fruit per inflorescence and only 9.6% by three fruits per inflorescence. In 2018, the highest number of fruits distributed per inflorescence was recorded in the variants with manual thinning (V2) and sprinkling with Urea 46% N at 6 kg/ha (V3) and constituted 88.4% and 78.4% respectively.

Number of fruits. Considering the productive potential of the Gala Delicious variety plantations, with trees planted at a distance of 3.5 x 1 m and trained according to the improved slender spindle crown shape, it was determined the quantity of fruits (80-110 pcs/tree), which provides sustainable yields and the highest economic efficiency. The size of fruits represents a very important quality parameter, and the larger fruits also bring greater value on the market and on export. The number of fruits of the Gala Delicious variety varies from year to year. Thus, in 2016 the number of fruits constituted from 73 pcs/tree in variant 5 (Dira Max LG, 2 l/ha) up to 114 pcs/tree in the control variant. This decrease in the number of fruits in V3 is due to the use of the Urea solution 46% in a concentration of 0.6%. The number of fruits at harvest (72 pcs/tree) in V4 is also significantly smaller compared to the control variant.

In 2016, sprinkling with LG Dira Max solution (BA 4.0% + NAA 0.4%) in a concentration of 2 l/ha reduced the number of fruits (64 pcs/tree). The number of fruits (110 pcs/tree) in 2017 was also lower compared to the untreated control (V1) and the use of Urea 46% N, 6 kg/ha (V3). In 2018, the number of fruits per tree was at the level of 2016 and was from 73 pcs/tree in V4 and V5 variants up to 98 pcs/tree in V1 at the time of harvest. The number of fruits in the V2, V3, V4 and V5 is significantly lower compared to untreated control variant V1.

In conclusion, we'd like to mention that in order to obtain a profitable annual yield of cv Gala Delicious, i.e. the adequate number of fruits per tree can be achieved when the number of red dotted buds per tree crown, the number of fruit set per inflorescence as well as the number of fruits after the ovaries drop in June don't record fruit overload per tree.

The average weight of fruits. In 2016, the average weight of a fruit recorded values from 109.5 g in the control variant to 146.5 g in the V4, where the growth regulator Geramid New was applied in the dose of 1.5 l/ha, when the central fruit reached 4-7 mm in diameter. As for the variants V2, V3 and V5, the average weight of a fruit also significantly exceeds the control variant reaching the level of the V4.

In 2017, the average weight of a fruit was lower compared to 2016 and constituted from 102.9 g in the untreated control variant V1 to 142.3 g in V2, where the manual fruit thinning was done after the physiological drop, when the fruits reach in diameter 16-18 mm.

Similar findings result for the year 2018, i.e. the use of manual fruit thinning and growth regulators increase the average weight of a fruit, and the average weight gains of a fruit, in the studied variants, are distinctly significant compared to the fruits from the control variant.

Diameter of fruits. In 2018, the average diameter of a fruit recorded values from 47.5 mm in the control variant up to 74.7 mm in the V3, where Urea 46% N was applied at the dose of 6 kg/ha. In the V2, V4 and V5, where the manual thinning and the growth regulators Geramid New, 1.5 l/ha and Dira Max LG, 2 l/ha were used, the average diameter of a fruit also exceeds the control variant significantly and constitutes 71.7-74.5 mm (table 1).

Table 1.

The influence of the thinning method of the crop load on the fruit distribution of the Cv Gala Delicious according to fruit diameter.

Variant	Average diameter (mm)	Fruit diameter (mm)						
		<55	56-60	61-65	66-70	71-75	76-80	>80
		Fruit share (%)						
V1-	47.5	37.9	35.4	21.0	5.7	-	-	-
V2	74.5	-	-	12.9	10.3	58.2	14.1	4.5
V3	74.7	-	-	11.9	5.4	49.8	26.8	6.1
V4	71.7	-	-	13.6	19.4	56.0	11.0	-
V5	71.9	-	-	11.4	16.5	51.6	20.5	-
DL 5%	4.02							

Analyzing the data related to the average diameter of a fruit of cv Gala Delicious we can conclude that the use of manual thinning after the physiological drop in June, the use of Urea solution 46% N in the concentration of 0.6%, when 75% of flowers dropped and the use of the growth regulators Geramid New, 1.5 l/ha, when the central fruit reaches 4-7 mm in diameter and Dira Max LG, 2 l/ha, when the central fruit reaches 10-15 mm in diameter, ensure a significant increase in fruit diameter.

Fruit diameter of the cv Gala Delicious, when being harvested, is directly influenced by the treatments applied using growth regulators, which determine not only their number and weight but also the distribution of fruits by size. Based on the performed investigations related to the weight of fruits by diameter, it turns out that in the untreated control variant, most fruits (37.9%) have a diameter less than 55 mm and only 5.1% have a diameter of 66-70 mm. Consequently, the fruits from the control variant, because of their size, cannot be assigned to the Extra category and category I. In the case of manual thinning (V2), the number of fruits with a diameter greater than 71 - 75 mm has increased significantly and constituted 68.1%, while the number of fruits with a diameter of 76-80 mm and larger than 80 mm constituted 14.1% and 4.5% respectively. This is because the fruits were evenly distributed in the tree crown and only 12.9% have the diameter of 61-65 mm and 10.3% - 66-70 mm in diameter.

The use of growth regulators favored fruit growth. For example, when using Urea 46% N at the dose of 6 l/ha, when 75% of the flowers dropped, the highest share of 49.8% had fruits with a diameter of 71-75 mm, 26.8% of fruits were 76-80 mm, 6.1% were over 80 mm and only 17.3% of fruits were 61-70 mm. Thus, it appears that the use of Urea 46% N, in the flowering phase, has a double effect, both of flower thinning and for fruit growing. The highest number of fruits (82.7%) is classified in the extra category and category I.

In the V4, as a result of using Geramid New, at a dose of 1.5 l/ha, the fruits recording a diameter of 71-75 mm constituted 56.0% and only 33% had a diameter

of 61-70 mm. A similar distribution of fruits, i.e. an increased number of fruits belonging to the extra category and category I, was also recorded when treating trees with the growth regulator Dira Max LG, at a dose of 2 l/ha, when the central fruit reaches 10-15 mm in diameter and constitutes over 72.1%.

Fruit yield. Analyzing the data on fruit yield (table 2) of the Gala Delicious apple tree variety we can mention that the highest yield, distinctly significant, was obtained in the control variant, compared to the manual thinning (V2) and the treatment with growth regulators (V3, V4, V5). In 2016, the fruit harvest in the control variant constituted 35.7 t/ha, while in the case of V2, where fruit thinning was performed after the drop in June, the yield constituted 29.8 t/ha. The variants treated with Urea 46% N, at a dose of 6 kg/ha (V3), Geramid New, 1.5 l/ha (V4) and Dira Max LG, 2 l/ha (V5) ensured a fruit yield of 28.7 – 32.3 t/ha.

In 2017, the average fruit yield increased significantly (40.9 t/ha) compared to 2016 when it reached only 31.2 t/ha. Regardless of the active substance of growth regulators, in all the treated variants, the fruit yield was significantly lower compared to the untreated trees. This is due to the fact that the number of fruits in the treated variants has decreased because of the manual fruit thinning, when the fruit reached 16-18 mm in diameter (V2), the thinning of the flowers when 75% of the flowers were open (V3) and the chemical fruit thinning, when the central fruit reached 4-7 mm (V4) and 10-15 mm (V5) in diameter.

Table 2.

Productivity of Gala Delicious apple plantations depending on how the thinning method of the reproductive organs

Variant	Average fruit weight (g)			Fruit production (t/ha)			Average (t/ha)
	Year 2016	Year 2017	Year 2018	Year 2016	Year 2017	Year 2018	
V1	109.5	102.9	105.7	35.7	46.8	39.5	40.7
V2	145.7	142.3	141.9	29.8	45.6	32.4	35.9
V3	146.5	144.2	139.3	32.3	47.2	34.3	37.9
V4	138.3	141.9	137.8	28.7	44.6	32.6	35.3
V5	137.9	142.1	138.1	29.1	45.1	33.9	36.0
LD 5%	4.7	16.8	7.9	3.1	1.2	2,6	-

Similar findings also result for the year 2018, when the use of manual fruit thinning and growth regulators determined the decrease of the fruit yield significantly by 13.2 – 17.0%. Thus, the yield in the untreated control V1 was of 35.4 t/ha and in the treated variants (V2, V3, V4, V5) it constituted 32.4 – 34.3 t/ha.

Analyzing the fruit yield over three years, it was found out that the Gala Delicious variety trees, grafted on the rootstock M9, of 8-10 years old, are constantly fruitful reaching the average yield of 37.1 t/ha. Manual fruit thinning reduced fruit yield by 10.2%, the use of growth regulators also reduced the fruit production by 5.2% using Urea 46% N, 6 kg/ha, by 11.8%, when treated with Geramid New, 1.5 l/ha and 9.9% at sprinkling with Dira Max LG solution, 2 l / ha., but the quality of fruits (87.1 – 88.6%), category I and extra category.

CONCLUSIONS

During the fruiting and growing period of trees (8-10 years), the use of Urea 46% N, 6 kg/ha has the effect of both fruit flower thinning and fruit growth, it is not a pollutant

and can be used without taking into account fruit diameter and climatic conditions when performing the treatment and after it.

Gala Delicious apple trees, grafted on the rootstock M9, aged 8-10 years, bear fruit constantly (average yield 37.1 t/ha). Manual thinning of fruits reduced the yield by 10.2%, and the use of growth regulators also reduced fruit yield by 5.2 – 11.8%, but increased the share of fruits (72.1-82.7%) falling into the category I and extra category.

Urea 46% N, is an effective fertilizer for flower thinning, can be easily used in all types of orchards at a dose of 6 kg/ha, using 1000 l of water, allows the selection of fruit sets, which turn out into uniform fruits. It is applied when 75% of the flowers are open until the petals of the first flowers drop, destroying the stigma and pollen of the open flowers, crumbling the petals to the unopened ones.

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**LEAF AREA FORMATION IN THE NEW APPLE VARIETIES
CULTIVATED IN THE REPUBLIC OF MOLDOVA**

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Keywords: *apple; variety; leaf area; shoots; fruiting branches.*

ABSTRACT

This paper presents the leaf area was studied in the Gala Buckeye Simmons, Granny Smith, Red Velox, and Golden Delicious Reinders apple varieties, grafted on the M9 rootstock and aged 2-5 years. The inter-row spacing was 3,2 m and the intra-row spacing – 0,8 m. The experiments were installed in the central area of the Republic of Moldova, in 4 random repetitions of 8 trees each one. The dynamics of leaf area formation in trees over time and during the vegetation period is correlated with the total length of shoots and the number of rosettes of leaves on the tree. During the growth stage of the trees, most of the leaf area (68.9-76.1%) is formed on shoots and only 23.9-31.1% - on spurs and bourse shoots. During the growth and fruiting stages of the trees, the leaf area on the tree registered identical values on the shoots and on the fruiting branches. The Granny Smith and Golden Delicious Reinders varieties registered a larger leaf area (8.85-8.34 m²/tree), compared to the Gala Buckeye Simmons and Red Velox varieties.

INTRODUCTION

The subject regarding the foliar apparatus is quite controversial both in the specialized literature and in the fruit production practice (Babuc 2012, Cimpoieș 2012). Therefore, based on various studies, it is necessary to establish a direct connection between the cultivation system and the biological material used with the purpose to optimize the expression of the biological production potential. This kind research highlighted the fact that the coefficient of solar energy use depends on the foliar apparatus at the unit of land area. In many cases, the leaf area in fruit varieties registered values of 20-30 thousand m²/ha (Balan 1997, 2009, Peșteanu 2008), and the further increase of the leaf area leads to shading inside the tree canopy and, respectively, to the decrease of the photosynthesis efficiency (Balan 2009a, Vămășescu 2018). By introducing new high yielding varieties and economically advanced technologies, we will raise the interest of fruit producers in the cultivation of apples. Sustainable fruits can be obtained under favorable conditions for the development of photosynthetic processes. Therefore, the dynamic formation of the leaf area determines to a significant extent the performance of an orchard. The research undertaken in this field by Jackson (1980), Агафонов (1983), Cimpoieș (2000), Balan (2009) has shown that fruit plantations are imperfect biological systems for the efficient use of solar energy. A large amount of light energy (19%) is lost until the emergence of leaves on the

trees. About 50-54% of the active light is not intercepted by the foliage, 20% is reflected back by the leaves, 10% is photosynthetically inactive, and 20% pass through the vegetative system of tree rows due to the inappropriate parameters of the plantation (Budan & Amzar 1992). Thus, the solution of these problems largely depends on planting trees at optimal distances and shaping simple, natural canopies, which allow the formation of a well-lit leaf surface, greatly reducing the effect of mutual shading, while increasing the fruit yield (Balan 2009).

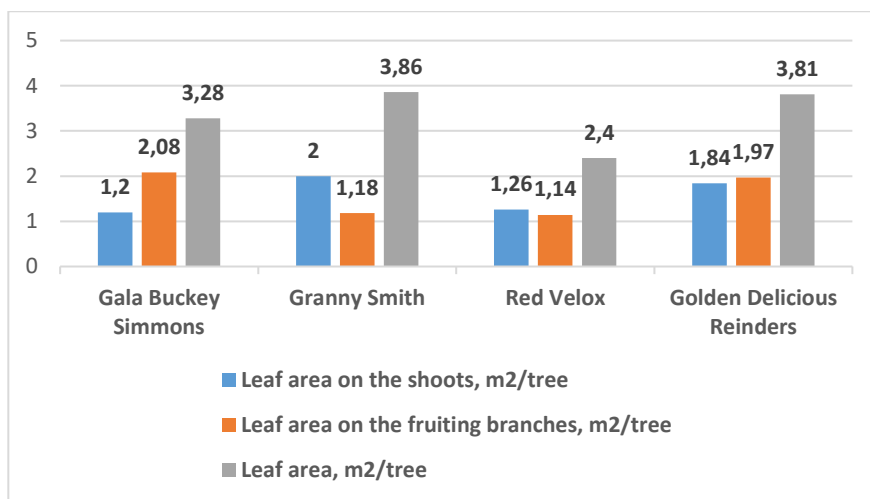
MATERIAL AND METHODS

The researches were carried out in the apple plantations established in 2014 at „Prodcar” Ltd. from Telenești district. The apple varieties Gala Buckeye Simmons, Granny Smith, Red Velox and Golden Delicious Reinders, grafted on the rootstock M9, were studied. The inter-row spacing was of 3.2 m and the intra-row spacing – 0.8 m. At planting, the grafting site was located 20 cm above the ground level. Until the planting of the orchard, it was installed a simple monoplane tree support system made of reinforced concrete pillars with a height of about 4 m above the ground and a metal wire installed at a height of 50 cm from the ground, which is also used as a support for the irrigation system. 5 more metal wires were installed in the first year of vegetation. The first 2 wires were fixed at the height of 80 cm from the ground at a distance of 40 cm from each other, the following wires were installed at 80 cm from each other.

The experiment was performed in 4 random repetitions of 8 trees each one. The counting of fruiting branches and their measurements were carried out both in open field conditions at 4 recorded trees of each variety and in lab conditions according to approved research methods in fruit growing (Мойсейченко 1988). The photosynthetic and growth potential of the trees was determined based on the number of fruits and emerging fruit buds and the measurements of the average and total length of the annual branches. Statistical processing of research results was carried out using the method of mono-factorial dispersion analysis (Доснехов 1985).

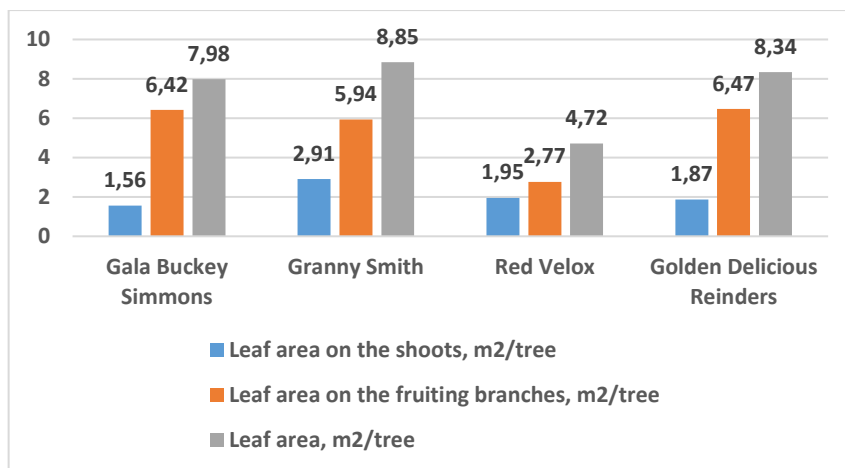
RESULTS AND DISCUSSIONS

The leaf area of the 3-year-old apple trees (fig.1), ranged from 2.40 m²/tree for the Red Velox variety up to 3.86 m²/tree for the Granny Smith variety. Gala Buckeye Simmons, Granny Smith and Golden Delicious Reinders varieties formed a distinctly larger leaf area compared to the Red Velox variety. We'd like to mention that the Granny Smith and Golden Delicious Reinders varieties formed a larger leaf area compared to the Gala Buckeye Simmons and Red Velox varieties, and they also recorded higher annual growths. As for the leaf area on the fruiting branches, it is established that the Gala Buckeye Simmons and Golden Delicious Reinders varieties formed more fruiting branches and leaves respectively (1.97-2.08 m²/tree), compared to the Granny Smith and Red Velox varieties (1.14-1.18 m²/tree). The foliar apparatus, relative to the field unit, is larger for the Gala Buckeye Simmons, Granny Smith and Golden Delicious Reinders varieties (31122-34515 m²/ha), compared to the Red Velox variety (18408 m²/ha). The latter situation can be explained by the fact that the Red Velox variety is weak in vigor and has lower growths.



LD, 5 %, 0.42 m²/tree

Figure 1. Leaf area in the apple varieties depending on the biological peculiarities of the variety



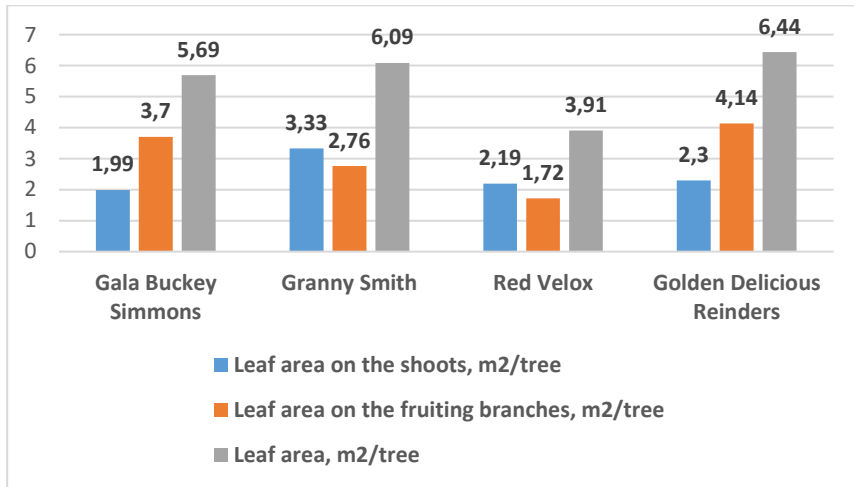
LD, 5 %, 1.15

Figure 2. Leaf area in the apple varieties depending on the biological peculiarities of the variety

The leaf area of 4-year-old trees (fig.2) ranged from 4.72 for the Red Velox variety to 8.85 m²/tree for the Granny Smith variety. The foliar apparatus was formed mainly on the fruiting branches (2.77 - 6.47 m²/tree) and only 1.56 - 2.91 m²/tree was formed on the annual branches. This is due to the fact that once the trees bear fruits, the length of the annual growths decreases and the number of fruiting branches increases. If we refer to the variety, then the varieties Granny Smith and Golden Delicious Reinders registered a larger leaf area (8.85 - 8.34 m²/tree and 34515 - 32526 m²/ha respectively), compared to the varieties Gala Buckeye Simmons and Red Velox. Obtained data show that the varieties Gala Buckeye Simmons, Granny Smith and Golden Delicious Reinders

form a larger leaf area, significantly secured, compared to the Red Velox variety, which also has a more pronounced fruiting alternation.

In 2018 (fig.3), the leaf area on the shoots, at the end of vegetation stage was 1.99-3.33 m²/tree. A higher increase of the leaf area on the shoots was recorded by the Granny Smith variety (3.33 m²/tree), and a smaller one by the Gala Buckeye Simmons variety. On the other hand, the leaf area on the fruiting branches was the largest for the Gala Buckeye Simmons variety and the smallest for the Red Velox variety (1.72 m²/tree).



DL, 5 %, 0.42

Figure 3. Leaf area in the apple varieties depending on the biological peculiarities of the variety

The leaf apparatus of a tree (3.91 - 6.44 m²/tree) differs from one variety to another and depends on the leaf area on the shoots (1.99 - 3.3 m²/tree) and on the fruiting branches (1.72 – 4.14 m²/tree). The Golden Delicious Reinders variety recorded the largest leaf area (6.44 m²/tree), and the Red Velox variety the smallest (3.91 m²/tree) compared to the Gala Buckeye Simmons and Granny Smith varieties. A similar distribution of the leaf area by variety was recorded per unit area. Although the leaf area of trees in the studied varieties is optimal (Cimpoieş & Boţan 2005, Babuc & Croitoru 2008, Balan 2009), an important role is played by the dynamics of leaf area formation on the shoots and mainly on the rosettes (Palmer 1988). As a result, the photosynthetic potential of the canopy is correlated over time with the dynamics of leaf area formation on trees, including the intensity of shoot and rosette growth.

Analyzing the data on the leaf area of the studied varieties during the stages of growth and fruiting, we can conclude that the highest values were registered by the Golden Delicious Reinders and Granny Smith. Apple trees, aged 3 years, formed a leaf area of 9360 - 15054 m²/ha (tab.1).