

## Geometric Macrostructure Dimensions of the Apple Orchard Regarding the Crown Formation

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**Abstract.** The experimental plot is placed in the orchard “Codru - ST” Ltd. in the central part of Republic of Moldova in Straseni District, village Bucovat and was founded in 2000 with bench-grafting. Apple trees of the varieties Gala Must, Golden Reinders and Idared growth on dwarfing M9 rootstock, the distance of plantation between rows is 4.0 m, and between trees in the row is 1.0 m. During 2001-2005, it was studied the degree of plantation surface coverage under crown projection, the lateral surface of the crown, the crown volume production, the volumetric density and the foliar index based on the formation of improved slender spindle crown. It was established that maximal values of area in valued crown projection, the lateral surface of the crown and the crown volume production was recorded in 2005, when the tree crown formation was completed. In this case, the indicators have been studied, respectively, having the following values: 45-56%, from 14.40 to 16.30 thousand m<sup>2</sup>/ha and 7.63 to 10.50 thousand m<sup>3</sup>/ha. The highest values, the study hints the Gala Must varieties, Idared and Golden Reinders. Volumetric density of the canopy is within the 0.63 to 0.66, being considered a relatively optimal value. Leaf area index in relation to nutrition, at the variants of training variants on the crown due to excessive distance of 4 m between rows of trees is from 1.41 to 1.87 and the crown projection surface is compared to 2.89 to 3.65. These values are within the requirements submitted to super intensive apple plantations.

**Key words:** crown projection, foliar index, lateral surface, orchard, volumetric density

### INTRODUCTION

The increase of fruit growing production in Republic of Moldova can be achieved only establishing new apple tree plantations, with a modern assortment that are grafted on rootstock with under- and small average vigor of growth to obtain an early fruit yield (Pesteanu, 2009).

The structure of the ensemble of orchard's plantation is one of determinant factors of productivity. Main characteristics of the structure of orchard's plantation are: coverage degree of plantation's surface under the crown projection, lateral surface of the crown, the crown production volume, volumetric density, leaf index. The values of these characteristics depend on the size and geometric shape of the canopy, location and distances of planting trees, system management and crown shape (Agafonov, 1983; Babuc, 2000; Balan, 1997; Cimpoies, 2000; Monney and Henriot, 2003).

In superintensive apple orchards, with trees grafted on M9 rootstock, currently the most common geometric macrostructure of all vegetative ensembles, is the continuous canopy system placed on the rows, placed in a vertical plane, with trapezoid-shaped cross section and time management system by slender trees system. Optimal relative size of the macrostructure geometry are considered: line canopy height from 2.4 to 2.6 m, width 1.8 to 2.2 m based on the decrease by 0.7 to 0.8 m top to angle inclination from the vertical side surface 12-13°, angle of the line joining the top and bottom canopy neighboring rows 48-49°. Subject to the

geometric structure of plantation, size deviations occurs depending on the particular biological varieties, increase the vigor of trees (Babuc and Croitoru, 2008; Babuc *et al.*, 2010; Balan *et al.*, 2001; Kudryavets, 1987).

To determine the relatively optimal parameters of plantation structure under study, needs to be analyzed the phytometric characteristics according to the variety and developed a model that would fit in favorable proportions the potential and productive growth of varieties with a higher, medium and lower vigour of growth.

## MATERIALS AND METHODS

The experimental plot is placed in the orchard “Codru-ST” Ltd situated in the central part of the Republic of Moldova near the village Bucovat, Straseni district . There was established in summer of 2000 a plantation with bench grafts. As objects of research served the apple tree varieties Gala Must, Golden Reinders and Idared grafted on rootstock M9. The distance of plantation 4×1 m was established in conformity with present recommendations for apple trees grafted on M9, leaved after the slender spindle system (Pesteanu, 2009). The variants to modify the methods of ameliorated slender spindle crown formation were established in conformity with the main principles of apple tree crown formation in the culture super intensive and intensive system (Matinger and Vigl, 1999; Pesteanu, 2010), being oriented to optimize the report between vegetative and reproductive organs of growth with the aim of having an early fruit production of trees.

In spring of 2001 to initiate the crown formation of slender spindle type in four variants:

Variant 1 (control) – according to present recommendations (Cimpoies, 2000) , the trees with a trunk of 50-55 cm with a well-developed weak zigzagged vertical axle; at the base of the crown 3-4 first order branches shortened of 40-50 cm with angles on inclination of 60° from the vertical one; on the first order branches and above on the axle at an interval of 20 cm radially uniform placed the semi skeleton branches, oriented to horizontal preponderantly by transfer cuttings to lateral branches.

Variant 2. The crown bio constructive base as a control variant compelled with: rational minimization formation cuttings degree; placement above the crown base of two provisional first order branches alternatively oriented and fixed on espalier in row direction, that after fructification are gradually shortened and being transferred into fructification branches; forced orientation in free space of crown of shoots and branches with a growth to vertical position to transfer them into fructification branches.

Variant 3. The constructive base as in variant 2 with leading the semi skeleton branches to horizontal position by lateral transfer branch cuts.

Variant 4. The bio constructive base as in variant 2 with renovation of semi skeleton branches by with the aim to obtain shoots from dormant buds.

Every variant includes 4 repetitions with 8 trees, intervals between grassy rows, and the strips into the row are loose and herbicides. Drip irrigation.

In the years 2001 - 2005 according to approved methods (Agafonov, 1983), was studied the degree of plantation surface coverage under crown projection, the lateral surface of the crown, the crown volume production, the volumetric density and the foliar index based on the formation of improved slender spindle crown. Maximal geometric indices in all sorts during surveys were recorded in the variant with minimize of pruning's degree at crown formation and design of 2 provisional horizontal branches through fixation on row direction.

## RESULTS AND DISCUSSIONS

Crown projection surface coverage has indicated a satisfactory rate of solar radiation, which space can be used in foliar photosynthetic process and share the sun, and which is the free space between rows of tree canopy and is not used in photosynthetic activity. For superintensive apple orchards relatively optimal values of turning the crown projection area under plantation is considered 50-55% (Babuc, 2000; Balan, 1997; Cimpoieş, 2000; Monney and Evequoz, 2002; Pesteanu, 2005; Szczygiel and Mika, 2003).

At the varieties and variants studied, the valuation of surface under the crown projection have increased with the age of trees, reaching higher values in 2005, differentiated more in terms of variety and less of the mode of crown formation (Tab. 1).

At Gala Must variety, with an under average vigour of trees growth, the valuation of the surface under the crown projection, in the years taken into the study, extends extensively in report to the Golden Reinders and Idared varieties. At the end of 2005 the vegetation of studied varieties in surface recovery is 53-56% under crown projection at Gala Must variety, , at Golden Reinders variety – 47-52% and at Idared variety the index is 45-46%.

Tab. 1

Evaluation of the surface under crown projection according to the mode of crown formation, %

Methods of crown formation	Years				
	2001	2002	2003	2004	2005
Gala Must variety					
Variant 1 (control )	27	46	47	45	54
Variant 2	30	49	48	49	56
Variant 3	27	46	45	47	54
Variant 4	26	44	46	46	53
Golden Reinders variety					
Variant 1 (control)	17	31	37	41	49
Variant 2	23	33	39	42	52
Variant 3	22	32	37	42	47
Variant 4	23	31	36	40	48
Idared variety					
Variant 1 (control)	13	29	30	31	45
Variant 2	16	32	32	32	46
Variant 3	14	30	30	31	45
Variant 4	15	29	29	30	45

It was found that in all varieties and years studied, the maximum indices of valuing the surface under crown projection were registered in the second variant showing signs of recovery projection surface under the crown, and were recorded in the second variant with a minimum degree of cutting training and inclination in the free space of vertical shoots and branches. In this variant the valuation of crown projection area is 56% in 2005 at Gala Must variety, the variety Golden Reinders 52% and 46% at Idared variety. This average values and under average values under the projection surface of crowns, largely confirms that excessive relative distance of 4 m between rows of trees can be reduced to 3.5 m.

Geometric shape and dimensions of the continuous lines of canopy in rows are determinant factors of the absolute value of the lateral and display them in space to capture as full sunlight. Currently, the super intensive apple orchards, a row of trees at distances of 3.5 m, lateral surface is considered relatively optimal within 16.50 to 17.08 thousand m<sup>2</sup>/ha (Agafonov, 1983; Babuc, 2000; Balan, 1997; Cimpoeș, 2000).

At the varieties and variants of crown formation in the study (Tab. 2), lateral surface of the canopy line increases consecutively on years, reaching maximum values in 2005. To the end of 2005 vegetation, the lateral surface of the canopy plantation was from 15.00 to 16.30 thousand m<sup>2</sup>/ha Gala Must variety, the variety Golden Reinders 14.80 to 15.00 thousand m<sup>2</sup>/ha and the variety Idared 14.25 to 14.65 thousand m<sup>2</sup>/ha. The maximum values of the lateral surface occurred in the second cutting minimized the formation of crown and forced leveling of shoots and branches to space and it was within the indicated limits. Lower values were recorded in the fourth variant with split branches to stimulate anticipated shoots. To overcome a control variant, especially in the second option (2%), it is not essential for geometric structure contour crown by cutting boundary, which is maintained relatively optimal size depending on growth vigor of tree varieties studied.

Tab. 2

Canopy lateral surface according to the mode of crown formation, thsnds m<sup>2</sup>/ha

Method of crown formation	2003 Year	2004 Year	2005 Year
Variety Gala Must			
Variant1(control)	13.75	15.20	16.00
Variant 2	13.05	14.36	16.30
Variant 3	13.15	13.90	16.25
Variant 4	12.90	13.80	15.00
Golden Reinders Variety			
Variant1(control)	12.80	13.60	15.00
Variant 2	12.95	13.80	15.15
Variant 3	13.10	13.70	14.90
Variant 4	13.20	13.75	14.80
Idared Variety			
Variant1(control)	11.17	13.00	14.60
Variant 2	12.05	13.85	14.65
Variant 3	11.65	12.30	14.40
Variant 4	11.50	12.30	14.25

Base on the results, the lateral surface of the canopy plantation is within the limits considered optimal only for the Gala Must variety, while for the Golden Reinders and Idared varieties, the indicator is 10-12% lower than the optimum level recommended. This is due partly to lower growth vigor of the trees of Gala Must variety and a greater distance between rows of trees.

Volume production of the crown is the outer layer with minimum light level favorable to photosynthesis - 0.2 cal/cm<sup>2</sup> min. Here are placed leaves, fruit bearing shoots and fruit. Therefore, is a productive potential of the tree and full planting (Balan *et al.*, 2001; Kudryavets, 1987; Wertheim *et al.*, 2000).

On vigorous trees with large crowns, the volume production is coating the crown at the periphery of the crown inward, where, as a result of consecutive capture, the intensity of photosynthetic active radiation (FAR) decreases to 0.2 cal/cm<sup>2</sup> min, or with 30% than on open field. In most tree species the thickness of the productive layer of the crown is about 1 to 1.2 m. As a result, for the apple trees in the intensive and superintensive apple orchards, the

crown line formation is located in a vertical plane and 2 to 2.2 m wide at the base and all crown volume is considered productive. Relatively optimal values for super intensive apple orchards is considered 8-11 thousand m<sup>3</sup>/ha (Babuc *et al.*, 2010; Cimpoieș, 2000).

Like other growth characteristics of trees, the productive volume of the crown increases more intensely with the years at the Gala Must variety (Tab. 3). In this variety, in 2005, the production volume of the crown at the variants studied is 10.11 to 10.50 thousand m<sup>3</sup>/ha or 18% higher than the variety Golden Reinders - 8.32 to 9.02 thousand m<sup>3</sup>/ha. Within each variety, the training methods of the crowns did not influence essentially on the volume of production because they relate more to the internal structure of the crown. It was found that the volume of canopy trees sizes in Gala Must variety is relatively optimal; the variety Golden Reinders - minimum allowable and the variety Idared - below the minimum allowable. The main causes are the lower growth vigor of trees and excessive distance between rows of trees.

Tab. 3

Productive volume of canopy according to the mode of crown formation, thsnds m<sup>3</sup>/ha

Method of crown formation	2003 Year	2004 Year	2005 Year
Gala Must Variety			
Variant1(control)	7.57	8.32	10.12
Variant 2	7.20	8.39	10.50
Variant 3	7.07	7.79	10.50
Variant 4	7.00	7.65	10.11
Golden Reinders Variety			
Variant1(control)	6.17	6.72	8.47
Variant 2	6.40	6.97	9.02
Variant 3	6.20	6.95	8.32
Variant 4	6.20	6.62	8.52
Idared Variety			
Variant1(control)	4.52	5.30	7.60
Variant 2	4.80	5.35	7.63
Variant 3	4.40	4.77	7.75
Variant 4	4.22	4.72	7.77

Volumetric density is the ratio of the crown volume at the lateral surface and, by this indirectly, the illumination level in the crown. For the super intensive apple orchards the canopy is placed in a vertical trapezoid-shaped cross section and the base width of about 2 m, volumetric density values are considered relatively optimal within 0.6 to 0.8 units (Babuc, 2000). Values below 0.6 indicate the excessive lighting in the crown and, therefore, the energy use of the photosynthetic active radiation, and values above 0.8 - the poor lighting and reduce photosynthetic activity.

At Gala Must variety (Tab. 4), in all variants of crown formation, volumetric density in 2005 is within the 0.63 to 0.66, falling relatively optimal values.

At the variety Golden Reinders only variant 2, by minimizing the training and forced inclination in the open space of some vertical shoots and branches, the volumetric density reaches 0.60 and lower limit within the optimum. Other variants of formation of the crown have lower volumetric density.

The variety Idared, in all variants studied, volumetric density of the crowns in 2005 was between 0.52 and 0.54.

In conclusion, results show a need to increase the size of crown dimensions in relatively small proportion of the variety Golden Reinders and proportions considerable for

the variety Idared to comply with the optimal dimensions of volumetric density and volume of production as production potential.

Tab. 4

Volumetric density of row canopy according to the mode of crown formation,  
m<sup>3</sup> volume/m<sup>2</sup> lateral surface

Method of crown formation	2003 Year	2004 Year	2005 Year
Gala Must Variety			
Variant1(control)	0.55	0.56	0.63
Variant 2	0.55	0.58	0.65
Variant 3	0.54	0.56	0.65
Variant 4	0.54	0.56	0.66
Golden Reinders Variety			
Variant1(control)	0.48	0.49	0.56
Variant 2	0.49	0.50	0.60
Variant 3	0.47	0.51	0.59
Variant 4	0.47	0.49	0.58
Idared Variety			
Variant1(control)	0.47	0.48	0.52
Variant 2	0.48	0.50	0.53
Variant 3	0.46	0.48	0.54
Variant 4	0.45	0.46	0.54

Foliar leaf area index is a ratio of the area of nutrition given tree, crown projection, crown volume, indicating leaf area density above the surface of nutrition or crown projection surface in a unit volume of the crown or photosynthetic area.

For high productivity agrocoenosis, the relatively optimal values of the index leaf is considered equal to 4 (Cimpoieș, 2000). The super intensive apple orchards in Moldova, foliar index values, adjusted to the plantation area is considered satisfactory from 1.5 to 2.5 (Babuc, 2000; Monney and Henriot, 2003).

Foliar index, reported in the area of nutrition in varieties and variations of the crown (Tab. 5) included in the study, falling to the bottom of the satisfaction level. This is due to excessive distance (4 m) between rows of trees.

Higher values of leaf index, reported in the area of nutrition, in all the years of formation of versions of the crown, in the study were registered with Gala Must variety most vigorous trees. In this variety, by the end of crown formation in 2005, the version control foliar index reached 1.56, and the second option to minimize cutting formation and inclination of shoots and branches with vertical guidance (1.87), being 20% higher than controls. In variants 3 and 4, leveling was done by cutting branches semischelet transfer or horizontal shoots from dormant buds induction issue exhausted by division branches, leaf index values exceeding version control about 15%.

The variety Golden Reinders has the same dynamic index leaf growth by year and variants studied, but with absolute values lower than Gala Must variety. In version control in 2005, foliar index is 1.63 and the second variant with minimizing the formation cuts (1.84), exceeding the 13% version control. In variants 3 and 4 leaf index value exceeds witness 7-8%.

The lowest values of leaf index, reported in the area of nutrition, was the variety Idared - 1.41 to 1.66, being 11-12% lower than the varieties Gala Must and Golden Reinders. In this variety, the upper leaf index was in the second option to minimize training cuts (1.66).

Overcoming the witness variant is 18%. Slightly lower values of the index leaf were recorded in variants 3 and 4, but the prevalence of 6-17% compared to the control.

Tab. 5

Leaf index, reported to the nutrition surface of trees, according to the mode of crown formation

Method of crown formation	Leaf index				
	2001 Year	2002 Year	2003 Year	2004 Year	2005 Year
Gala Must Variety					
Variant1(control)	0.40	0.90	1.08	1.45	1.56
Variant 2	0.49	1.09	1.28	1.58	1.87
Variant 3	0.45	1.04	1.21	1.53	1.78
Variant 4	0.42	0.99	1.16	1.51	1.76
Golden Reinders Variety					
Variant1(control)	0.34	0.75	0.94	1.13	1.63
Variant 2	0.44	0.90	1.05	1.33	1.84
Variant 3	0.39	0.86	1.04	1.30	1.76
Variant 4	0.38	0.83	1.02	1.24	1.74
Idared Variety					
Variant1(control)	0.31	0.51	0.73	0.96	1.41
Variant 2	0.39	0.63	0.87	1.15	1.66
Variant 3	0.36	0.59	0.84	1.11	1.65
Variant 4	0.34	0.56	0.78	1.10	1.49

Another indicator is the index leaf relative to the projection of the crown, which is 2.89 to 3.39 in Gala Must variety, 3.38 to 3.65 in variety Golden Reinders and 3.32 to 3.34 in variety Idared, higher than values reported in the area of nutrition varieties respectively 1.83, 2.01 and 2.2 times (Tab. 6). Higher values indicated - 3.34 to 3.35 are close to index 4, characteristic agrocoenosis high productivity. This confirms the high productivity potential of spindly crowns. Varieties Idared and Golden Reinders have smaller crowns and higher degree of leaf, leaf index, reported to crown projection and is 15-17% higher than Gala Must variety.

Tab. 6

Leaf index, reported to the surface of canopy projection, according to the mode of formation

Method of crown formation	2001 Year	2002 Year	2003 Year	2004 Year	2005 Year
Gala Must Variety					
Variant1(control)	1.36	1.73	2.32	3.23	2.89
Variant 2	1.51	2.22	2.72	3.37	3.39
Variant 3	1.58	2.15	2.70	3.30	3.32
Variant 4	1.51	2.13	2.53	3.23	3.14
Golden Reinders Variety					
Variant1(control)	1.37	2.15	2.69	3.07	3,36
Variant 2	1.81	2.48	2.96	3.60	3.65
Variant 3	1.82	2.48	3.03	3.65	3.53
Variant 4	1.66	2.35	2.96	3.60	3.50
Idared Variety					
Variant1(control)	1.38	1.76	1.76	2.36	3.32
Variant 2	1.39	2.10	2.08	2.68	3.64
Variant 3	1.12	1.99	2.10	2.71	3.44
Variant 4	1.14	1.93	2.01	2.69	3.32

In 2005, in Gala Must variety, the upper leaf index (3.39) was recorded in the second option to minimize training cuts, tilt forced shoots and branches with vertical guidance beyond space and witnessed by 18%.

At the varieties Idared and Golden Reinders the higher values of index leaf were recorded throughout the second variant, 3.65 and 3.64 units respectively, being 10.9% higher than controls. In variants 3 and 4, the leveling branches by cutting transfer and split the branches of fruit exhausted, foliar index values, adjusted to crown projection area, are smaller than the second option.

## CONCLUSIONS

For all varieties and training methods of the crown studied, all growth processes that are characteristic age of apple trees grafted on M9, led by slender spindle system. Formation on the shaft, above the crown, the provisional additional branches and leveling of the space orientation of the vertical structure is improving all the vegetative ensemble of orchard.

Maximal indices of recovery in the projection of the crown surface, lateral surface of the plantation canopy and canopy volume in all sorts during surveys were recorded in the variant with minimize of pruning's degree at crown formation and design of 2 provisional horizontal branches through fixation on row direction.

Upper leaf index values relative to crown projection area were recorded version cuts minimize training and inclination of branches, shoots with vertical guidance, being close to those characteristic agrocoenosis high productivity.

Find the need to increase the size of crowns in relatively small proportion of the variety Golden Reinders and considerable proportions to employment in Idared variety of optimal size and volumetric density that the potential production volume production.

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