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THE INFLUENCE OF THE PLANT MANAGEMENT SYSTEM OVER CERTAIN PHYSICAL AND PHYSIOLOGICAL PARAMETERS FOR APPLE TREES

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Abstract

Crown shape plays a very important role in ensuring proper lightning conditions for the branches and fruit; it ensures different exposure conditions for the leaves and influences their synthesis capacity, while also permitting the formation of the fruit branches and support of the production. Depending on the plant management system, the planting distances vary for the same vigor of the variety – rootstock combination. The plant management system with five crown shapes determined differences in what regards the biometric parameters of the trees, the quantity of wood removed when pruning, fruit production, degree of illumination of the branches, intensity of the photosynthesis and respiration and fruit quality. Tree crowns which recorded better productivity values were managed as interrupted pyramid and fruit cylinder, while regarding the quality values the vessel bush and interrupted pyramid proved better choices. The best leaf exposure was recorded for the trees managed as vessel bush.

Key words*: crown shapes, physiological indicators, morphological parameters*

INTRODUCTION

Apple culture in Romania is located on the first place considering the weight and area of fruit growing plantations, fact due to which many researchers are interested in modernizing the plantations, increasing the yield per unit of area and increasing the fruit quality. The manner in which plant management systems are applied has direct implications over the planting density, the degree of fruit exposure and quality [4]. By selecting a certain crown shape, a greater or lower illumination degree [1, 8] is ensured for the elements of the crown and for the leaves, with direct influence on their synthesis capacity and on the nutrition of the apple tree as a whole [2, 5, 9]. The chosen crown shape influences the distribution of the branches both vertically and horizontally; as the crown become more voluminous, the percentage of fruit bearing branches decreases [3, 6, 7]. Small sized crowns allow the fruit grower to perform the main manual works from the ground, with greater yield and lower percentage of the manual works in the production costs.

MATERIAL AND METHOD

The objectives of this study were:
- establishing the most economic plant management and maintenance systems for the crown for the trees of Florina variety, in order to obtain colorful, high quality fruit that better resist to storage conditions;
- studying the behavior of Florina apple trees when pruning is applied for fitting within predetermined crown shapes;
- studying the intensity of the processes of photosynthesis and transpiration, correlated with the type of crown;

The experiment was conducted during 2009-2010, at the Fruit Growing Research Center Voineşti, Dâmboviţa, in an apple tree plantation founded in 2000, with a planting distance of 4/3 m, with Florina variety grafted on M 106 rootstock. The trees were initially managed as slender spindle, but in 2004 five crown shapes were established, as follows:
-Variant 1 – control - Voineşti type of crown
- Variant 2 – Slender Spindle
- Variant 3 – Bush-vessel
- Variant 4 – Fruit bearing cylinder
- Variant 5 – Interrupted pyramid

The regular maintenance works, specific to fruit bearing plantations, were applied within the plantation. Measurements and observations were made regarding the dimensions of the trees, amount of wood removed at pruning, intensity of photosynthesis and transpiration, production capacity and fruit quality.

RESULTS AND DISCUSSIONS

The manner in which the trees reacted to the different plant management systems varied, the results regarding the trees' dimensions fitting within the normal limits for the respective age of the trees, but with differences according to the specific characteristics of each crown shape. Thus, the trees were slightly taller in case of crown shapes with axes (V1, V2 and V4) and shorter for the variant with bush-vessel crown (V3). The diameter of the crown after the spring pruning was maintained within the limits of the space ensured by the pruning distance in order to ensure a proper penetration of the light; the diameter recorded values between 235 cm for V3 and 210 cm for V4 (table 1).

The productive crown volume, a very important element the production capacity of the trees depends on, was greater for the trees with crown shapes with ax and lower for the trees without ax. The crown volume per unit of area had values varying between 7173 m^3 for V3 and 9217 m^3 for V1.

Table 1. Average values of the crown dimensions and volume according to the plant management system (Average data 2009-2010)

Variant	Tree height (cm)		Crown diameter (cm)		Productive crown volume after pruning		
	Before pruning	After pruning	Before pruning	After pruning	m^3/tree	Difference from control variant, ±	m^3/ha
V1(control))	399,00	367,50	265,00	220,38	11,07	-	9217,64
V2	404,25	367,50	265,00	215,25	10,41	0,66	8671,86
V3	304,50	273,00	280,90	235,75	8,61	2,45	7173,13
V4	399,00	357,00	275,60	210,13	9,69	1,37	8074,10
V5	378,00	346,50	280,90	225,50	10,67	-0,40	8888,44

Tree vigor and their growth capacity can be expressed through the amount of wood removed at pruning. From this point of view, large differences were recorded among varieties, the values per tree varying between 2,18 kg for V4 and 5,60 kg for V5, an increase of more than 156% (table 2). If a comparison would be done with the values obtained for the first variant, the plant management system specific to the region, the deviations were approximately ± 50%, the control variant being situated at the middle of the variation interval for the recorded values.

The degree of leaf exposure influenced the intensity of the main physiological indicators: photosynthesis and transpiration. By comparing the measurements made for the external, properly illuminated leaves and for the internal leaves with a lower illumination degree, large differences were observed among the recorded values, thus confirming the data from the specialized literature. As a result, the intensity of the photosynthesis for the external leaves was greater for the variants V4 and V2, more than 6,75 mg $CO_2/dm^2/h$, due to slender crowns that expose very well the trees, while the variants V1 and V5 had lower values, less than 4,8 mg $CO_2/dm^2/h$, due to crowns that have a more crowded structure. These values confirmed the data from the specialized literature (Burzo şi colab., 1999). For the internal leaves, the photosynthesis was less intense in case of crowns with a denser structure, the values being less than 4,2 mg $CO_2/dm^2/h$ for V3 – bush-vessel, as maximum value, and only 1,04 mg $CO_2/dm^2/h$ for V4 – fruit bearing cylinder. The intensity of the photosynthesis was directly influenced by the intensity of the light; it was probably influenced also by the structure of the leaves, due to the fact that no good correlation was found between the two parameters (Table 3).

Table 2. The weight of branches removed at pruning, for fitting within the specific types of crown (2009-2010)

Variant	Weight of branches removed at pruning							
	Total				Out of which annual branches			
	per tree (kg)	% compared to the control	Dif. compared to the control	per ha (kg)	per tree (kg)	% compared to the control	Dif. compared to the control	per ha (kg)
V1 (control)	3,94	100,00	-	3282,52	2,55	100,00	-	2126,23
V2	4,98	126,32	1,04	4146,34	3,68	144,00	1,12	3061,77
V3	4,25	107,89	0,31	3541,67	3,27	128,00	0,71	2721,58
V4	2,18	-55,26	-1,76	1814,02	1,74	68,00	-0,82	1445,84
V5	5,60	142,11	1,66	4664,63	3,68	144,00	1,12	3061,77

The intensity of the transpiration was within the normal limits for the exposed leaves (Burzo şi colab., 1999), the recorded values varying between 0,14 $mgH_2O/ dm^2/h$ for V4 and 0,63 $mgH_2O/ dm^2/h$ for V3, with no direct correlation with the intensity of the photosynthesis.

For the leaves with a lower illumination degree, the intensity of the transpiration was lower, the values obtained being between 0,06 $mgH_2O/ dm^2/h$ for V1and 0,31 $mgH_2O/ dm^2/h$ for V2.

Table 3. Intensity of photosynthesis and transpiration, according to each crown shape

Variant	External leaf (directly exposed to sunlight)			Internal leaf		
	Photo-synthesis *mg CO_2 / dm^2/h*	Transpiration *$mgH_2O/ dm^2/h$*	Intensity of light *$\mu moles/m^2$ /sec*	Photo-synthesis *mg CO_2 / dm^2/h*	Transpiration *$mgH_2O/ dm^2/h$*	Intensity of light *$\mu moles/m^2$ /sec*
V1 (control)	4,83	0,34	1287	2,33	0,06	345
V2	6,75	0,24	1612	3,52	0,31	1190
V3	6,32	0,63	1728	4,22	0,23	1140
V4	6,89	0,14	1387	1,04	0,13	239
V5	4,58	0,21	1520	3,75	0,28	1250
Average	*5,43*	*0,3*	*1621*	*1,6*	*0,09*	*190,5*

The production capacity of the trees was a proper one for this type of plantation (intensive with average density), but with differences among variants. The largest production was obtained for the variants V3 and V4, with more than 28 t/ha, as average production for the two years, while the smallest production was obtained for the control variant (table 4). It was interesting to observe that the third variant, with low crown volume, recorded the second largest production which showed that a better exposure degree of the branches also ensures a better fruit bud differentiation and finally a larger production. The production differences between the variants V2 and V4, both having crowns with ax and being relatively equal in volume, can be justified by a better cylinder structure from the point of view of the support branches for the ax. If it were to analyze the production from a statistical point of view, the variants V3, V4 and V5 were statistically ensured as very significant compared to V1, while V2 was not statistically ensured.

Table 4. The production capacity of Florina variety, grafted on M106, for each crown shape (t/ha)

Variant	2009	2010	Average	Difference	Significance
V1(control)	18,70	19,82	19,26	-	Mt
V2	19,20	20,35	19,78	102,67	N
V3	27,50	29,15	28,33	147,06	***
V4	30,00	31,80	30,90	160,43	***
V5	*25,50*	27,03	26,27	136,36	***

DL 5% - 0,59 t
DL 1% - 0,98 t
DL 0,5% - 1,84 t

From the point of view of fruit quality, small differences were recorded among the analyzed variants. Thus, the total dry substance varied between 13,86% for V4, variant with the largest production, and 15,33% for V3 and V5, variants without ax. The total mineral elements (ash) recorded values between 0,31% for V2 and 0,42% for V3 and were correlated with the content in total dry substance. The soluble dry substance had the lowest recorded value for V4 – 12,0%, variant that produce the most, and a higher value of 14,4% for V5 (table 5).

Table 5. Biochemical composition of fruit for Florina apple-tree variety, grafted on M106 rootstock, according to each crown shape

Variant	Total dry substance (%)	Ash (%)	Soluble dry substance (%)	Vitamin C mg / 100 g	Titrable acidity % malic acid	Total sugar mg/ 100 g
V1(control)	14,51	0,33	12,4	6,25	0,47	9,79
V2	14,72	0,31	12,5	10,38	0,48	8,45
V3	15,33	0,42	13,5	11,01	0,54	10,36
V4	13,86	0,35	12,0	11,07	0,48	9,19
V5	15,34	0,41	14,4	8,62	0,51	9,20
Average	14,75	0,36	12,96	9,47	0,50	9,40

The vitamin C content was greatly influenced by the crown management system; the control variant recorded a content in vitamin C of only 6,25 mg/100, the variants V3 and V4 recorded values of more than 11 mg/100, while the remaining variants had intermediary values. The titrable acidity recorded similar value among the variants, the variation limits being 0,47 for V1 and 53 la V3, while the total sugar content had values between 8,45 mg/100 g for V2 and 10,36 mg/100 g for V3.

CONCLUSIONS

From the present study, the following conclusions can be drawn:

- The growth capacity of the trees had normal values for all variants, according to the age of the trees, the small differences being due to the specific characteristics of each crown shape;
- The amount of wood removed at pruning was greater for the trees with interrupted pyramid shaped crown (5,6 kg/tree) and lower for the trees managed as fruit bearing cylinder (2,18 kg/tree);
- The intensity of the photosynthesis and transpiration was directly influenced by the intensity of the light; the leaves external to the crown recorded higher values, while the leaves from inside the crown had lower values;
- The production capacity was good for the trees managed as fruit bearing cylinder, bush-vessel and interrupted pyramid and not so good for the trees managed as slender spindle and Voineşti type crown;
- The quality of the production was influenced by the production quantity; for the variants with large production, the quality was lower.

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