VARIABILITY OF FRUIT NUMBER ON THE TREE ACCORDING TO THE INFLUENCE OF SOIL TILLAGE SYSTEMS IN THE ORCHARD

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Abstract

Naturally, new apple plantations established in the last 10 years include other varieties than those that are traditionally grown. These varieties are most of Western European origin and already know a considerable expansion in horticulture developed EU countries.

Key words: fruits, tree, variety, technology, tillage system, soil

INTRODUCTION

Climatic and soil conditions in most areas of Romania are favorable and very favorable for apple, which determined that out of the nearly 300 000 ha of orchards in the country in 1990, 48% to be occupied by apple orchards (ROPAN et al ., 2002).

After 1989, the fruit tree growing in our country has experienced a gradual decrease of the areas of commercial orchards due primarily to improper application of the law 18/1991. Only recently, some private companies that have established new orchards emerged, including apple, in order to cover the demand of the domestic population that is much cheaper than imported fruits.

It should be noted that such concerns are not new in the Romanian fruit tree related research. On the contrary, since the establishment of ICAR, the research on culture technologies dedicated to agricultural and horticultural plants occupied a prominent place in the research institutes and specialized stations, famous names in horticulture being linked to such research over time. (CONSTANTINESCU, BORDEIANU, CIREAŞĂ, GHENA, ŞUTA, MODORAN, DUMITRACHE, PALOCSAYI, IANCU, POPESCU, GODEANU, NEGRILĂ etc.)

MATERIAL AND METHOD

Five apple varieties/cultivars that are less widespread in Romania, but largely widespread in European Community countries were studied in terms of several features of tree development, productivity and fruit quality.

These varieties are: Rajka, Rubinola, Topaz, Otava and Goldstar being cultivated in the plantation SC. Delifood S.R.L. Urvind, Bihor County.

The plantation was established in 1999, with trees grafted on M_9 stock. A density of 2083 trees / ha was achieved at a planting distance of 4 x 1.20 m. The tree crown was formed and led as a thin spindle with two frameworks longer on the tree row direction and two shorter frameworks perpendicular on the row direction.

The experience has been bi-factorial and included:

Factor A- soil tillage systems, with graduations:

a_1 – bare fallow with tilling the entire area of the orchard;

a_2 - bare fallow with herbicide on the row of trees;

a_3 - grass strips between rows and worked among the trees;

a_4 – total turfed/ unreaclaimed of the orchard's soil.

Factor B - variety with the graduations: b_1 Rajka; b_2 Rubinola; b_3 Topaz; b_4 Otava and b_5 Goldstar

A total of 20 variants has resulted that were located by linear block method in three repetitions, each repetition comprising a total of 10 trees.

The culture technology has been the standard one applied to the super-intensive apple orchards, with changes made by the head of the farm according to the main destination of the fruit production (industrialization).

Observations and Measurements

1. Trunk cross-sectional area at 25 cm from the point of grafting annually by measuring the diameter with the calipers in the direction to and perpendicular on the row and applying the formula πR^2 the formula being in cm^2.
2. Crown volume by measuring the two diameters in the direction of the row and perpendicular on the row, the height of trees and applying the formula of the cone $1/3\ \pi R^2 \times h$, formula being expressed in m^3.
3. Average annual growth of shoots by measuring all growth greater than 5 cm and dividing by their number, the formula being expressed in cm.
4. The production of fruit, by weighing them on each tree. Production of replication plot was calculated by summing up the production / tree only at eight of the 10 trees of the plot (eliminating the influence of neighbors) and turning it in t / ha.

5. Determinations on the physico-chemical properties of fruits, such as: size of fruits on samples of 25 fruits, measuring by caliper the large diameter (D), small diameter (d) and height, and then applying the formula (D+d+h)/3, being expressed in mm.

- sugar determined by refractometer, expressed as a percentage%.
- acidity determined by titration with 0.1 N NaOH in the presence of phenolphthalein, expressed as a percentage (%) by multiplying g / kg to 0.067, equivalent to malic acid.

6. Organoleptic fruit quality assessment by taste made by groups of students of the Faculty of Environmental Protection, major in Horticulture, University of Oradea, according to STAS analysis report.

Calculation and Interpretation of Results

Calculation and interpretation of experimental results was done primarily by using the analysis of variance applied to the series of polifactorial experiments of A x B x years type. To establish the significance between the performance of the tested variants, the multiple comparisons test was used (Duncan, Tuckey), $DS_{5\%}$ values being calculated using $s^2_{AxBxyears}$ in order to emphasize the constancy in time of the analysed results. The analysed model was the one presented by Ardelean et al., 2002.

Coefficients of heritability of some quantitative traits, of interest to differentiate the cultivars studied on the extent to which they have harnessed the conditions of the natural and artificial environment (soil maintenance systems in the orchard) were computed as a ratio between the genetic variance and the total phenotypic variance ($H = \frac{s^2_G}{s^2_P}$), partial existing data as a result of the variance analysis.

To determine the total variance of the averages of the characters analyzed in the experiment series A x B x years, the following formula was used (ALLARD, 1966):

Results and Discussion

The vast majority of the literature dealing with the apple fruit weight (COCIU, 1977; NEGRILĂ, 1964; MITRE et al., 2007; ROPAN, 2000; CZYNCZYK et al., 2008) considers that, in this species, it is an essential

Variability of trait is large and very large(ARDELEAN, 1986; SESTRAŞ, 2004), being mainly on one hand a result of genotypic differences among cultivars and, on the other hand, a result of the strong influence that the natural and artificial environment conditions (technology culture) exert on the phenotypic manifestation of the respective trait. LUKACS (2009) found that out of the total variability in fruit weight in five apple varieties widespread in Transylvania, only 35% is due to genotype and the remaining 65% is due to the interaction between genotype and environment.

Based on the above mentioned facts, it was considered useful as in the experiences related to the thesis, to quantify the extent to which the soil tillage system in the super-intensive orchard influenced the average fruit weight, in five new varieties of apple, which are less widespread in Transylvania but grown on large areas in the European Union, which is, surely, a sign that these varieties will expand soon, also in our country.

Table 3.1.3.1. presents, in particular, the data on the variability of the average weight of the fruit in a series of bifactorial experiments related to the thesis.

Table 1.

Analysis of variance for fruit weight in the series of bifactorial experiments of A × B× years type (Urvind, 2006 -2008)

Cauza variabilităţii *Source of variation*	SPA *SS*	GL *DF*	s^2	Sample F (*F Test*)			
				Faţă de s^2_E *Versus* s^2_E		Faţă de $s^2_{A \times B \times ani}$ *Versus* $s^2_{A \times B \times years}$	
Totală (*Total*)	61267.8	179					
Repetiţii (*Replications*)	83.4	6					
Ani (*Years*)	663.0	2					
A x ani (*A × Y*)	320.1	6	53.3426	1.34	<2.03	0.70	<2.36
B x ani (*B × Y*)	891.8	8	111.48	2.80*	>2.19	1.46	<2.51
A (sist.intreţ/*tillage system*)	17550.3	3	5850.10	146.86**	>2.68	76.50	>3.01
B (soiul/*cultivar*)	31434.6	4	7858.65	197.28**	>2.45	102.77	>2.78
A x B	3948.1	12	329.01	8.26**	>1.83	4.30	>2.18
A x B x years (*A × B × Y*)	1835.3	24	76.47	1.92*	>1.61		
Eroare/*Error*	4541.2	114	39.83				

Analysis of variance values and F calculated sample versus theoretical F values presented in Table 1., reveals some interesting items related to the variability of the average weight of the fruit apple varieties under study. First, it appears that most of the total variability is due to genotype, the soil tillage system being situated on the second place in this regard. The above statement contradicts, to some extent, the results presented by LUKACS (2009), but this should not be surprising, at least for two reasons:

- the varieties used by the cited author were old, so with a great adaptability to natural and technological environmental conditions from Transylvania, reasons for each G x E interaction had the largest share in the phenotypic expression of the weight of the fruit;
- the varieties of the experiment are much newer, being released after long preliminary tests, making them all react almost in the same manner, at soil tillage systems during the three experimental years.

The F calculated value for the interaction of cultivar x years is lower than the theoretical F suggesting again that the five varieties under study responded quite similarly to the environmental conditions. In contrast, the interaction between environmental and other experimental factor (tillage systems x years) had a calculated F value of 2.80, significantly higher than the theoretical $P_{5\%}$. Note that in the same way, the variability of the data regarding the average weight of the fruit is influenced by the interaction cultivar x tillage system and that from the cultivar x tillage system x years.

When F values were calculated on the basis of s^2_{AxBxY},, things change radically. Of all the sources of the variability of the studied character only the cultivar, tillage system and the combination of these two experimental factors had real significant influence upon the average weight of the fruit. Such a hierarchy of the variability sources made possible to present the summarized results under the form of a bilateral table (Table 2.).

The data of Table 2. also illustrates that, including the new varieties of apple, widespread in the EU, the variability of the average weight of the fruit is quite high (140.7 to 205.2 g), being significantly influenced by each of the two experimental factors in the study and by the interaction among them (data within the table).

Table 2.

Influenţa soiului şi a sistemului de lucrare a solului asupra greutăţii fructului (g) în seria de experienţe bifactoriale de tip A x B x ani (Urvind, 2006 -2008)

Influence of cultivar and tillage system on the fruit weight (g) in the series of bifactorial experiments of A × B × Y type (Urvind, 2006 -2008)

Soiul/Cultivar / Sistem de lucrare a solului *Tillage system*	Rajka		Rubinola		Topaz		Otava		Goldstar		Media sistem cultură *Mean of tillage system*	
Ogor negru/*Bare fallow*	205.2	A	192.9	B	164.1	de	162.7	De	187.5	b	182.5	A
Ogor negru+erbicidat /*Bare fallow + herbicides*	185.0	B	186.4	B	157.1	cd	147.5	Gh	175.6	bc	170.3	B
Benzi înierbate/*Turf strips*	168.4	de	162.3	de	140.7	h	150.7	Fg	173.2	c	159.1	C
Inţelenit/*Turf*	167.9	cd	164.3	de	141.5	gh	147.8	Gh	169.6	cd	158.2	C
Media soi/*Mean of cultivar*	181.6	MN	185.0	M	186.4	M	152.2	P	176.5	N		

$DS/SD_{5\%}$ pentru două medii A/*for two means of A* = 7.1 – 7.7 g

$DS/SD_{5\%}$ pentru două medii B/*for two means of B* = 10.3 – 11.4 g

$DS/SD_{5\%}$ pentru două medii AxB/*for two means A × B* = 7.3 – 8.7 g

N.B. *The differrence between any of two values, followed by at least a common letter, is not significant*

The studied cultivars behaved fairly evenly on the four soil tillage systems, among the varieties Rajka, Rubinola, Topaz and Goldstar there were no practically significant differences with respect to the average fruit weight (176.5 to 186.4 g). The exception is Otava variety whose average fruit weight (152.2 g) is significantly lower than the other four varieties, irrespective of the soil tillage system in the orchard.

The last column of Table 2. shows that the differences between the various soil tillage systems as regards the average fruit weight for the five varieties under study, are significant and highly significant. The bare fallow provides for all five varieties, fruit weights close to 190 g, followed by significant differences in the case of bare follow and herbicides on the fruit rows (170.3 g). Turf strips and total turf of the orchard, even if they lead to a slower water loss from the soil due to the mulch represented by the grass mowed regularly, does not favour the development of some average fruit weights in the case of bare follow, the differences between these two options and the first two options being statistically ensured.

The data presented in Table 2. emphasize that the interaction cultivar x tillage system caused the greatest variability in the average weight of the fruit. Clearly, the variety Rajka has the largest fruits when grown in bare fallow (205.2 g), with significant differences compared to all other combinations of the experimental factors. At the opposite pole there are situated Otava and Topaz varieties grown in grass strips and the total turf system (140.7 to 147.8 g).

A special mention must be made for the variety Otava that even in the case of the bare fallow with herbicide on the row achieved average weights of the small fruits equal to those achieved in the case of the total turf system. This is a further evidence that, at least in this variety, the average weight of the fruit is strongly linked to heredity and less influenced by the its interaction with the natural and technological environmental conditions. In terms of this trait, variety Otava is less adapted to the conditions of Urvind.

We also mention that the results regarding the average fruit weight in apple under the influence of genotype and culture system are very similar to those published by SOSNA (2005) which, in the view of this productivity element, mentions as very valuable the varieties Rubinola and Rajka and ranks lowest the variety Topaz. This is a confirmation of our results demonstrating that new varieties of apple, widely grown in the EU, present nevertheless obvious differences in the level of phenotypic expression of some very important elements of productivity, such as the average weight of the fruit.

Conclusions

1. Analysis of production data highlights that in the case of the number of fruits / tree, the contribution of the natural environment is quite similar to that of the genotype while in the case of the other elements of productivity, the artificial environmental effects are larger and equally important as those of the genotype (cultivar).

2. Among the varieties, varieties Topaz and Rubinola are highligted with respect to the number of fruits per tree. The least productive varieties in this regard proved to be Goldstar and Otava, while Rajka variety may be considered averagely productive in terms of Urvind conditions, Bihor County.

3. The study of the soil tillage systems'effects on the number of fruits per tree, ranks first the bare fallow for both versions, followed by tillage system only on the rows and by the total turf system of the orchard.

4. The difference between the two groups of soil tillage systems in the orchard (bare fallow, bare fallow with herbicides with respect to/versus grass strips between trees and total turf) being significant, enables highlighting the high economic efficiency of the bare fallow in comparison with the other system.

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