THE VARIABILITY OF FRUIT PRODUCTION, INFLUENCED BY THE ORCHARD SOIL MAINTENANCE SYSTEMS

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Abstract

Presently, there are over 10.000 varieties of apple and the their numbers continues to grow, mainly due to the changes that occur in consumer preferences. It is the duty of pomology specialists to develop the most appropriate crop technologies for these new varieties, to determine the extent to which the new varieties are adapted to natural and technological conditions that are particular to certain areas on Earth.

Key words: production, variety, technology, maintenance system, soil

INTRODUCTION

Apple growing is practiced in our country since ancient times, a fact proven by the impressive number of apple varieties whose origins are lost in the mists of ages. Such varieties, although no longer listed in "The list of crop plant varieties in Romania", can still be found in old orchards near rural households and in the germplasm collections of ICDP Pitesti-Maracineni and pomological stations.

Climatic and soil conditions in most areas of Romania are favorable and very favorable to apple growing, which lead to 48% of 300,000ha of orchards existing in the country in 1990, being occupied by apple plantations (ROPAN et al., 2002).

After 1989, pomology in our country has seen a gradual reduction of the area occupied by commercial orchards, due primarily to the improper application of the provisions of law 18/1991. Only recently, private companies emerged that have set up new pomological plantations, including apple, in order to cover the fruit demand from internal production, which is a lot less expensive compared to imported fruit.

Naturally, the new apple plantations set up in the last 10 years include varieties other than those traditionally grown here. These varieties are mostly of Western European origin and are extensively cultivated in EU countries with a developed pomology.

Transylvania benefits from very diverse climatic and soil conditions, so it is required that new varieties imported in this natural conditions are tested using crop technologies widely used in apple orchards across the country.

It should be noted that such concerns are not new to the Romanian pomology research landscape. On the contrary, since the inception of ICAR, research on crop culture for agricultural and horticultural plants has occupied a prominent place in the research programs of specialized institutes and stations, and many names that are well known in pomology are tied to these research activities (CONSTANTINESCU, BORDEIANU, CIREAŞĂ, GHENA, ŞUTA, MODORAN, DUMITRACHE, PALOCSAYI, IANCU, POPESCU, GODEANU, NEGRILĂ etc.)

MATERIAL AND METHOD

Five apple varieties, less cultivated in Romania but widespread in EU countries, were studied in terms of several features such as tree development, productivity and fruit quality. These varieties are: Rajka, Rubinola, Topaz, Ottawa and Goldstar, all of which exist on the S.C. Delifood S.R.L. plantation in Urvind, Bihor county.

The plantation was established in 1999, with trees grafted on M9 mother plant. Using a planting distance of 4x1.20m, a density of 2083 trees/ha was achieved. The tree crown was formed and headed as a thin shaft with a wider frame on the direction of the tree row, and slimmer perpendicular to the row.

The experience was bifactorial and it included:

Factor A - soil maintenance systems, graded:

a_1 – classic bare fallow, tillage on the entire surface;

a_2 - bare fallow with herbicide on the tree lines;

a_3 - grassy areas between tree lines and tilling on the lines;

a_4 – grass grown on the entire surface of the orchard soil.

Factor B – variety, graded: b_1 Rajka; b_2 Rubinola; b_3 Topaz; b_4 Ottawa and b_5 Goldstar.

This resulted in a total of 20 variants which were positioned using the linear blocks method, with three repetitions, each repetition comprising a total of 10 trees.

The standard crop technology for super-intensive apple orchards was used, with some changes made by the farm's manager depending on the main destination of the fruit production (industrialization).

Observations and measurements

1. The cross-sectional area of the trunk, at 25cm from the point of grafting, annually, by measuring the diameter with a caliper on the direction of

the row and perpendicular to the row and applying the formula πR^2, expressed in cm^2.

2. Crown volume by measuring diameters on the direction of the row and perpendicular to the row, the height of the trees and applying the cone formula $1/3\ \pi R^2 \times h$, expressed in m^3.
3. Average annual growth of shoots by measuring all growth above 5cm and dividing the total to the number of shoots, expressed in cm.
4. Fruit production, by weighing the yield of each tree. The production on the repeat parcel was calculated by summing yield/tree of only 8 of the 10 trees (eliminating neighbor influence) and transforming to t/ha.
5. Determinations on the physic-chemical characteristics of the fruit such as: size of fruit on a samples of 25 fruits, measuring with caliper the large diameter (D), the small diameter (d) and height and then applying the formula (D+d+h)/3, expressed in mm.

- The sugar determined by refractometer, expressed as a percentage %.
- Acidity determined by titration with NaOH 0,1 N, in the presence of phenolphthalein, expressed as a percentage (%) by multiplying g/kg with 0,067, malic acid equivalent.

7. Organoleptic assessment of fruit by tasting, carried out by students of the Faculty of Environmental Protection, specializing in Horticulture, University of Oradea, according to STAS Analysis Report.

Calculation and interpretation of results

The calculation and interpretation of the experimental results was done mainly using variation analysis applied to the series of polyfactorial experiments of type A x B x years. To establish the significance between the performances of tested variants, the multiple comparison test was used (Duncan, Tuckey), the $DS_{5\%}$ values calculated using $s^2_{AxBxyears}$ in order to emphasize the constancy of the analyzed results over time. The analyzed model was the one presented by ARDELEAN et al., 2002.

The heritability coefficients of some quantitative traits, of interest to differentiating the studied cultivars with regard to the measurement in which they capitalized on the natural and artificial (orchard soil maintenance systems) environmental conditions, were calculated as the ratio of genetic variance and total phenotypic variance ($H = \frac{s_G^2}{s_P^2}$), data which exists partly as a result of the analysis of variance.

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

RESULTS AND DISSCUSION

With apples, as with most pomological species, the fruit yield per unit of surface remains the main evaluation criterion for the effectiveness of a crop technology or for a hierarchical grouping of cultivars with regard to their suitability for those technologies, in various conditions of the natural environment (NEGRILĂ, 1964; GHENA et al., 1977; COCIU, 1977; MITRE et al., 2007; ROPAN, 2000).

The next table presents fruit production variability per surface unit (t/ha) as illustrated by the data variance analysis for the series of bifactorial experiences in the 2006-2008 period.

The data in this table emphasize the fact that each of the two experimental factors (soil maintenance system and cultivar) and the interaction between them had significant effects on the variability of the results. By far, the strongest effects were exerted by the soil maintenance system that was used, which suggests that, for the apple varieties tested, applying certain maintenance systems can lead to very similar results.

Table 1

Analysis of variance for fruit yield (t/ha) in the series of experiments type A × B × Y (Urvind, 2006 -2008)

Source of variation	SPA *SS*	GL *DF*	s^2	(*F Test*)			
				Versus s^2_E		*Versus* $s^2_{A x B x Y}$	
Total	2491,8	179					
Repetiții (*Replications*)	16,7	6					
Years	25,9	2					
A × Y	35,9	6	5,98204	2,63**	>2,03	2,46	>2,36
B × Y	20,0	8	2,50087	1,10	<2,19	1,03	<2,51
A (*tillage system*)	1800,2	3	600,07	264,12**	>2,68	246,57**	>3,01
B (*cultivar*)	201,2	4	50,31	22,14**	>2,45	20,67**	>2,78
A x B	74,5	12	6,21	2,73*	>1,83	2,55*	>2,18
A × B × Y	58,4	24	2,43	1,07	<1,61		
Error	259,0	114	2,27				

Note that the interaction between cultivar and maintenance system had high enough variance levels to produce calculated F values significantly superior to the theoretical F values for $P_{5\%}$.

The data in Table1 also reveals an important aspect regarding the reaction of the five apple cultivars to the variation of the experimental factors, on one hand, and to the variation in environmental conditions, during the three year period, on the other hand. The F test for the (cultivar x years) interaction produced insignificant values both when calculated based on s^2_E (1,10 < 2,19) and when calculated based on s^2_{AxBxY} (1,03 <2,51). This means that, in terms of total production of fruit, the five cultivars behaved in a steady manner from one year to another. As suitability for apple

growing during the experiment years (2006-2008) was slightly different (2006 – less favorable; 2007 – reasonably favorable; 2008 – very favorable), it can be concluded that the five cultivars show an obvious stability of character, most likely determined by genotype and to a much lesser degree by the (genotype x environment) interaction.

The fact that both experimental factors and their interaction had significant effects on data variability where fruit production per surface unit was concerned, allowed the synthesis of the experimental results to be presented in a table in bilateral form (table 2). The analysis of the data in table 2 points out that both the varieties and the soil maintenance systems had a significant influence on the production levels (t/ha) recorded in our experiments.

Among the varieties, Topaz and Rubinola stand out as very productive, averaging over three years on the four different types on soil maintenance systems a total of fruit production of 26.2 t/ha (Topaz) and 25.7 t/ha (Rubinola). The least productive proved to be the Goldstar (21.5 t/ha) and Ottawa (21.6 t/ha) varieties, while the Rajka variety can be considered average in terms of productivity in the conditions present at Urvind, Bihor county.

Table 2

Effect of cultivar and tillage system on fruit yield (t/ha) in the series of experiments type A × B × Y(Urvind, 2006 -2008)

Cultivar / *Tillage system*	Rajka	Rubinola	Topaz	Otava	Goldstar	*Average of tillage system*
Bare fallow	27,4 a	26,1 c	27,0 a	24,9 d	24,6 d	26,0 A
Bare fallow+herbicides	25,7 c	26,2 b	26,2 b	24,3 d	22,8 ef	25,0 A
Turf strips	22,6 f	24,4 d	23,5 e	21,3 g	20,6 g	22,5 B
Turf	18,8 i	17,5 j	19,0 h	15,9 k	18,0 ij	17,8 C
Mean of cultivar	23,6 N	25,7 M	26,2 M	21,6 P	21,5 P	

$DS/SD_{5\%}$ *for two means of A* = 2,4 – 2,6 t/ha

$DS/SD_{5\%}$ *for two means of B* = 1,5 – 1,7 t/ha

$DS/SD_{5\%}$ *for two means A × B* = 0,8 – 0,9 t/ha

It should be noted that the differential response of the apple genotypes tested to their artificial growing medium (soil maintenance systems) and the natural growing medium (the climatic conditions during the experimental years at Urvind) was expected. In older work and, obviously, older varieties (Jonathan, Golden Delicious, Starkrimson), DUMITRACHE et al., 1990 get the same high variability in average fruit production per year and per soil maintenance system.

With regard to the effect of maintenance systems on fruit production, the data in the last column of table 2 ranks bare fallow first (25,0-26,0 t/ha), followed by turf strips (22,5 t/ha). Note the significant difference between the two systems, showing the high economic efficiency of bare fallow, regardless whether it is „classic" or with herbicides.

The analysis of (genotype x maintenance system) (G x S) reveals that it has highly visible consequences on the differentiation of the 20 experimental variants. The largest fruit production was recorded for the Topaz (27.0 t/ha) and Rajka (27.4 t/ha) varieties, in bare fallow soil maintenance system, at a significant distance from all other variants. At small, but significant distance are the Topaz and Rubinola varieties, both in bare fallow and turf strips (27,0 – 26,2 t/ha). The lowest fruit production was obtained on turf soil, for all varieties and especially Ottawa for which the fruit production was significantly inferior to the rest of the experimental variants tested, which seriously questions the suitability of that variety to turf maintenance systems.

It should be mentioned that our results at Urvind are consistent, broadly, with those of other authors that have worked with these varieties (SOSNA, 2005; CZYNCZYK et al., 2005) noting that, in their experiences, Topaz was the most productive and Rajka came in second. Only CZYNCZYK (2008) found the same classification for production performance of these new varieties (Rajka, most productive, followed by Topaz), but testing those varieties in conditions specific to organic farming.

In can be concluded that, based on the data discussed, the new varieties, in widespread cultivation in the EU, obviously react to soil maintenance systems. They all favor bare fallow, on which Rajka and Topaz have yielded on average, over three years, fruit productions close to 30 t/ha. Obviously, the Ottawa variety, with very low production levels in turf systems, is not recommended in the Urvind area for orchards that use that type of soil system.

CONCLUSIONS

1. Analysis of the production data presented here shows that both variety and soil maintenance system had a significant influence on the production levels (t/ha) recorded in our experiments.

2. Among the varieties, Topaz and Rubinola stand out as very productive, with an average over three years and for types of soil maintenance systems, yielded total fruit productions of 26.2 t/ha (Topaz) and 25.7 t/ha (Rubinola). The least productive proved to be Goldstar (21.5 t/ha) and Ottawa (21.6 t/ha) while Rajka can be considered of average productivity (23.6 t/ha) in the conditions present at Urvind, Bihor county.

3. The study of the effects of soil maintenance systems on total fruit production place bare fallow first, in both variants (25.0-26.0 t/ha), followed by turf strips (22.5 t/ha) and turf (17.8 t/ha).

4. Because the difference between the two groups of orchard soil maintenance systems (classic bare fallow and with herbicides, versus turf strips and turf) is very significant, it highlights the high economic efficiency of bare fallow over other systems.

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