Original scientific paper
10.7251/AGSY1404097R

GENOTYPE SPECIFICITY OF THE ORGANOGENESIS OF FRUIT-BEARING PEAR TREE (II THE ANALYSIS OF TWO-YEAR-OLD OUTSPREAD BRANCH)

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Abstract

The two-year-old outspread branch (the last year outspread shoot) is the key for defining pomotechnical operations in a genotypically defined fruit tree pruning. Certain pear cultivars has a distinctive branching pattern of the last year shoot; according to branching pattern, all pear cultivars are classified into 5 ideotypes. Based on the analysis of the two-year-old outspread branch, the cultivars can be classified into the corresponding groups, while the type of the organogenesis of fruit-bearing pear trees can be determined, which represents the cultivar specificity as the base for defining pomotechnical treatments, i.e., we obtain the information how much time it takes lateral vegetative buds form a new growth which bears the generative bud at its top. This paper presents the results of the analysis of the two-year-old outspread branch in three vegetations of 6 pear cultivars as follows: ‘Trevuška’, ‘Santa Maria’, ‘Williams’, ‘Abate Fetel’, ‘Kaluđerka’ and ‘Krasanka’. The interaction effects per cultivars and years have been analyzed, as well.

Key words: *pear, cultivar, organogenesis, fruit-bearing tree*

Introduction

Growing points are a basic prerequisite for determining genotype specificity in the formation, growth and development of all categories of growths, and in this way in the organogenesis of a fruit-bearing tree, as well. (Mićić, 1992). All the growing points of a tree can originate from vegetative cones; then we call them normal growing points. However, they may be formed by the differentiation of parenchyma cells into the meristematic ones; then we call them incidental or adventious growing points (Đurić and Mićić, 1988; Lučić et al., 1996). Depending on how much time it takes to get the lateral vegetative buds form a mixed terminal (generative) bud on the shoot, we may consider the type of organogenesis of fruit-bearing pear tree, i.e., the genotype specificity of this process in pear (Gvozdenović, 2008). The two-year-old outspread branch is the basis of the fruit-bearing potential of the most pome fruit species (Mićić et al., 1998). Nevertheless, as the process of forming fruit-bearing twigs in some varieties of pear fruit trees is more than two years long, while studying the branching pattern, Sansavani (1993) determined 5 fruit-bearing ideotypes in some pear varieties. According to the type of the organogenesis of the fruit bearing tree of pome tree species, Lespinaze (1993) and Lauri et al. (1995) examined the genotypic differences in the axillary bud development as well as fruit-bearing models of fruit-bearing apple twigs during the several years. They also examined the approach to the regulation of fruit-bearing potential. Mićić and Đurić (1997) determined the base for the mathematical modeling of organogenesis cycle, i.e., algorithm basis of organogenesis cycle in pome fruit species. Based on this research, they observed there had been intensively developed computer programs for searching information about the buds, both vegetative and generative ones, that is, fruit-bearing twigs (the type, age, location on the structure of the fruit-bearing tree, etc), the structure of the fruit-bearing tree (the angle towards the parent branch and the ground; the degree of the differentiation of the bud along the fruit-bearing structure, etc) and also the

information about the characteristics of the growths that bear physiologically mature fruits. Based on these information the algorithms of genotype specificity of fruit-bearing potential may be defined; by means of them the main pomotechnical operations are suggested, too. (Lauri et al., 1995; Mićić, 1997).
The ultimate objective of mathematical modeling is the maintaining of relations between growth and fruit-bearing at a certain level as the basis for obtaining the maximum and stable yields.

Material and method

The samples were collected in a orchard in the locality Jurkovica (Gradiška municipality) in the years 1998, 1999 and 2000. The following pear cultivars were selected for the study: 'Trevuška', 'Santa Maria', 'Williams', 'Abate Fetel', 'Kaluđerka', 'Krasanka'. The analysis of the certain growth categories was carried out during a three-year period. In order to determine the fruit-bearing potential of the fruit-bearing trees of the examined pear cultivars, 30 two-year-old outspread branches were taken for the analysis of the following elements:

1. The length of the two-year-old part of the two-year-old outspread branch
2. The structure of the growths on the two-year-old outspread branch
3. The fruit-bearing potential of the two-year-old outspread branch

The obtained results were tested by the analysis of variance with two variables (the cultivar and the year).
The presence of the growth which has generative buds in the two-year-old part is expressed in the percentage from which the coefficient of fruit-bearing potential is calculated according to the formula:
$K = Z \times P$;
Z- % branches which have generative buds on the two-year-old part (in %)
P- Average number of generative buds in 1 meter of two-year-old part of the outspread branch.

Results and discussion

1. Length of the two-year-old part of the two-year-old outspread branch

The two-year-old outspread branch (the last year outspread shoot) is the key for defining pomotechnical operations in a genotypically defined fruit tree pruning (Mićić, 2008). The results of the analysis of the two-year-old outspread branch in the examined cultivars are in Table 1. According to the data shown in Table 1, the longest length of the two-year-old outspread branch was in 'Trevuška' (91.13 cm) in the year 1998, while the shortest one was in 'Abate Fetel' (21.97) in 2000. The analysis of the variance of the average length of the two-year-old part of the two-year-old outspread branch in the examined pear cultivars shows that the cultivar (as a factor) is highly statistically significant for this feature ($F_{calcul.}$280.84), while the year is also highly statistically significant for the length of the two-year-old part of the two-year-old outspread branch ($F_{calcul.}$18.41). Interaction effect between the cultivar and the year is highly statistically significant, as well ($F_{calcul.}$21.38).
The analysis of the interactive effects performed by the graphical method is presented in Graph 1. Having observed the graph, it can be generally concluded that the cultivars exhibited little variation in the average length of the two-year-old part of the branch. Besides, there are clearly observed genotypic differences between the examined cultivars; in the year 2000 'Trevuška' showed highly significant decrease in the average length of a two-year part of the branch, which is essentially an interactive effect. Taking into account the behavior of the cultivars for the final observation, the determination of this change in 'Trevuška' may be acceptable.

Tab. 1. The length of the two-year-old part of the two-year-old outspread branch

No.	Year / Cultuvar	1998	19991	2000
1	Williams	50.73 ± 3.42	47.00 ± 1.21	50.79 ± 1.03
2	Abate Fetel	24.67 ± 2.19	22.03 ± 1.01	21.97 ± 0.92
3	Krasanka	22.97 ± 1.70	20.00 ± 1.08	23.89 ± 4.55
4	Kaluđerka	25.47 ± 1.93	23.87 ± 1.28	25.73 ± 0.85
5	Santa Maria	41.40 ± 3.28	38.57 ± 1.73	40.17 ± 1.24
6	Trevuška	91.13 ± 3.16	90.03 ± 4.21	48.53 ± 2.84

Based on the above observation, the examined cultivars may be divided into 3 groups as follows:

1. The cultivars with variation occurence; they are the cultivars with the average length of the two-year-old part of the branch (‘Trevuška’)
2. Cultivars with the medium length of the two-year-old part of the branch (‘Williams’ and ‘Santa Maria’).
3. Cultivars with a relatively short two-year-old part of the branch (‘Kaluđerka’, ‘Abate Fetel’ i ‘Krasanka’).

2. Structure of growths on two-year-old outspread branch

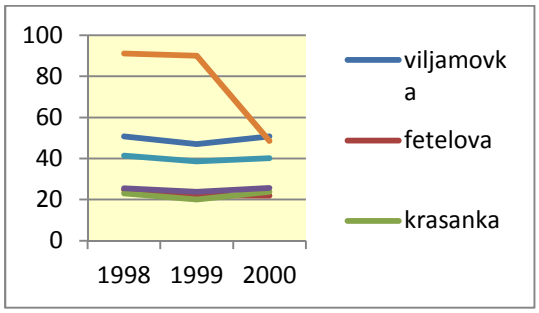
The abundance of the fruit-bearing tree in the evolution on the two-year-old outspread branch can basically be related to the type of organogenesis of fruit-bearing fruit trees. As for pomotechnics, the higher abundance of the fruit-bearing tree in evolution on the two-year-old outspread branch imposes a different approach to pruning, since the formation of generative bud from the lateral vegetative cones is prolonged - postponed in this way. The results of studying the abundance of one-year-old vegetative growths - fruit-bearing tree in evolution in relation to fruit-bearing twigs on a two-year-old part of the outspread branch are shown in Table 2. Based on the data in Table 2, it can be concluded that the smallest abundance of the one-year-old growths, which are by nature a fruit-bearing tree in evolution, was in ‘Williams’ (45.00 %) in 1999, while the highest abundance was in ‘Kaluđerka’ (99,43 %). Otherwise, the abundance of these growths in ‘Kaluđerka’ in all three years of the study was close to 100 %.

Tab. 2. The abundance of one-year-old vegetative growths - fruit-bearing tree in evolution in relation to fruit-bearing twigs on the two-year-old part of the outspread branch

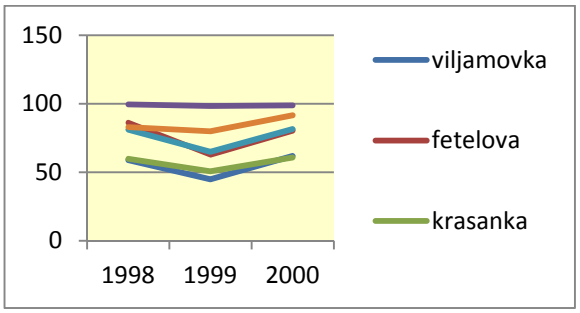
No.	Year / Cultivar	1998	1999	2000
1	Williams	58.87 ± 4.23	45.00 ± 4.01	61.87 ± 4.08
2	Abate Fetel	86.13 ± 3.91	62.79 ± 3.77	80.27 ± 3.89
3	Krasanka	59.87 ± 4.77	50.79 ± 4.19	60.73 ± 12.16
4	Kaluđerka	99.43 ± 0.56	98.30 ± 0.98	98.77 ± 0.73
5	Santa Maria	81.03 ± 3.98	64.90 ± 4.19	81.59 ± 3.85
6	Trevuška	82.93 ± 3.89	79.93 ± 5.37	91.47 ± 2.97

The analysis of variance of the percentage abundance of the one-year-old lateral vegetative growths on the two-year-old outspread branch between the examined cultivars and years shows that the cultivar was highly significant for this feature ($F_{calcul.}$54.40). The exhibited differences between the cultivars per years are highly statistically significant, as well

(F_{calcul}18.04), while the presence of the interaction effect between the cultivar and the year is statistically insignificant (F_{calcul}1.48).
The analysis of the interaction effect done by the graphical method is shown in Graph. 2. Despite the interaction effects which were not statistically significant, the graphical analysis clearly shows genotypic differences, while the cultivar grouping according to this segment of the organogenesis of the fruit-bearing tree is as follows:
1.The smallest abundance of one-year-old vegetative growths-fruit-bearing tree in evolution in relation to fruit-bearing twigs on the two-year-old part of the outspread branch as well as correlated tendency in all the observed years are in ‘Williams’ and ‘Krasanka’. This also suggests that pruning principle in these two cultivars is the least problematic one.
2. ‘Santa Maria’ and ‘Abate Fetel’ had a higher abundance of one-year-old vegetative growths-fruit-bearing tree in evolution per 20 % in relation to fruit-bearing twigs on the two-year-old part of the outspread branch comparing to ‘Williams’ and ‘Krasanka’. The tendency to change is almost identical between ‘Santa Maria’ and ‘Abate in the observed period.
3. ‘Trevuška’ partially varies from ‘Santa Maria’ and ‘Abate Fetel’; in the observed period it exhibits a greater tendency of the abundance of the fruit-bearing tree in evolution on the two-year-old part of the outspread branch.
4. Genotype specificity of ‘Kaluđerka’ is manifested in the fact that all the lateral branching on the two-year-old part of the outspread branch are the growths of the vegetative character in all the observed years.
The structure of the fruit-bearing tree in evolution in relation to the fruit-bearing twigs on the two-years-old part of the outspread branch is basically the aforementioned type of the organogenesis of the fruit-bearing tree; it is essential for defining the pruning (during fruit-bearing) which aims to establish a certain relationship between the growth and fruit-bearing potential. With the increase of the abundance of the fruit-bearing tree in evolution on the two-year-old part of the outspread branch, the possibility for the establishing of pillar pruning system is decreased, while the necessity for growing in the slender spindle training system is imposed, as well.



Graph 1. The length of the part of two-year-old outspread branch



Graph 2. The abundance of one-year-old vegetative growths-fruit-bearing tree in evolution in relation to fruit-bearing twigs on two-year-old part of the outspread branch

3. Fruit-bearing potential of the two-year-old outspread branch

The basic indicator of pomotechnical establishment of the certain relation between growth and fruit-bearing is the type of the organogenesis of the fruit-bearing tree, i.e., the required

number of vegetations for the process of forming the generative bud from the lateral vegetative bud. The indicators presented in Table 3 will be a decisive factor for defining pruning system as well as training system. However, fruit-bearing coefficient as genotype specificity is a significant indicator for the final modeling of growing system and fruit loading of the fruit tree during the full yielding age. The basic calculation parameters and fruit-bearing coefficient are shown in Table 3. The analysis of the abundance of the branches which on their two-year-old part have the growths bearing generative buds in the examined pear cultivars shows as follows:

1. ‘Williams’, ‘Krasanka’ and ‘Santa Maria’ are the cultivars with a high abundance of generative buds on the two-year-old part of the two-year old branch. This suggests a high genetic yield capacity, too.
2. ‘Trevuška’ and ‘Abate Fetel’ are the cultivars with a lower abundance of the branches which on their two-year-old part have the growths bearing generative buds.
3. ‘Kaluđerka’ is the cultivar with a extremely low abundance of the branches which on their two-year-old part have the growths bearing generative buds.

Tab. 3. The abundance of branches which on their two-year-old part have generative buds

No.	Cultivar	Year	A	B	C
1	Williams	1998	96.67	12.94	1,251.00
		1999	83.02	13.56	1,125.75
		2000	94.18	18.32	1,725.38
2	Abate Fetel	1998	30.00	13.01	390.30
		1999	42.13	12.24	514.08
		2000	65.27	20.15	1,315.19
3	Krasanka	1998	83.33	16.94	1,411.61
		1999	74.54	18.33	1,315.19
		2000	68.32	19.97	1,364.35
4	Kaluđerka	1998	3.33	5.26	17.52
		1999	1.84	3.98	7.32
		2000	2.73	4.38	11.96
5	Santa Maria	1998	63.33	13.02	824.56
		1999	64.54	16.24	840.31
		2000	72.32	39.03	2,822.65
6	Trevuška	1998	43.33	4.74	205.38
		1999	40.13	3.29	142.56
		2000	45.08	5.44	235.71

A - The abundance of branches which on their two-year-old part have generative buds (%)
B - The average number of generative buds in 1m of the two-year-old part of the outspread branch
C - Coefficient of potential fruit-bearing

When the percentage of the abundance of the branches which on their two-year-old part have generative buds is multiplied with the average number of generative buds in 1 m of the two-year-old part of the outspread branch, coefficient of potential fruit-bearing is gained.

The analysis of this coefficient is completely in accordance with the observation given in the analysis of the abundance of branches which on their two-year-old part have generative buds. However, the coefficient of potential fruit-bearing in ‘Santa Maria’ is 3.5 times bigger than it is usual, which clearly indicates a strong tendency toward alternation. The same tendency is in

’Abate Fetel’. Based on the obtained coefficients, it can be concluded that apart from doing differentiation of cultivars according to fruit-bearing potential, the coefficient of potential fruit-bearing can also be a good indicator of alternative preferences.

Conclusion

Based on the average length of the two-year-old part of the two-year-old outspread branch, the observed cultivars can be divided into 3 following groups:

• The cultivars with the average length of the two-year-old part of the branch but with variations such as ‘Trevuška’;

• The cultivars with the medium length of the two-year-old part of the branch such as ‘Williams’ and ‘Santa Maria’;

• The cultivars with a relativelly short length of the two-year-old part of the branch such as ‘Kaluđerka’, ‘Abate Fetel’ and ‘Krasanka’.

The structure of the growths on the two-year-old outspread branch observed through the relation of the fruit-bearing tree in evolution and fruit-bearing twigs ranged from 99.43% of the abundance of vegetative growths in ‘Kaluđerka’ to 45.00% in ‘Williams’. These data enable the grouping of cultivars according to genotypic differences as follows:

• Williams’ and ‘Krasanka’ have the least abundance of the one-yeat old vegetative growths – fruit-bearing tree in evolution in relation to fruit-bearing twigs on the two-year old outspread branch. They also have a correlated tendency in all three observed years.

• ‘Santa Maria’ and ‘Abate Fetelova’, comparing to ‘Williams’ i ‘Krasanka’, had a higher abundance of one-year-old vegetative growths-fruit-bearing tree in evolution per 20 % in relation to fruit-bearing twigs on the two-year-old part of the outspread branch

• ‘Trevuška’ partially varies from ‘Santa Maria’ and ‘Abate Fetel’; in the observed period it exhibits a greater tendency of the abundance of the fruit-bearing tree in evolution on the two-year-old part of the outspread branch.

• Genotype specificity of ‘Kaluđerka’ is manifested in the fact that all the lateral branching on the two-year-old part of the outspread branch are the growths of the vegetative character in all the observed years.

Based on the abundance of branching on the two-year-old part of the two-year-old branch which has generative buds and coefficient of potential fruit-bearing, the examined cultivars were divided into following 3 groups:

• ‘Williams’, ‘Krasanka’ and ‘Santa Maria’ are the cultivars with a high abundance of generative buds on the two-year-old part of the two-year old branch, which also proves a high genetic yield capacity.

• ‘Trevuška’ and ‘Abate Fetel’ are the cultivars with a lower abundance of the branches which on their two-year-old part have the growths bearing generative buds.

• ‘Kaluđerka’ is the cultivar with a n extremely low abundance of the branches which on their two-year-old part have the growths bearing generative buds.

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