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Morphological characteristics of Packham's Triumph pear cultivar fruiting wood

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Abstract

Pear as a fruit species forms various categories of fruit-bearing branches during its life cycle. Depending on how many years it takes to form a young fruiting wood of pear cultivar from its meristem, there can be an annual, biennial, or perennial organogenesis cycle, which in the first place depends on cultivar's genotype, the rootstock on which the cultivar is grafted, the applied agricultural techniques in nursery and other conditions. Knowledge of the individual pear cultivars organogenesis cycle is the basis for planning regular and stable yields. In order to determine the structure of a fruiting wood for an individual pear cultivar, it is necessary to make analyses on individual increment categories; what is developing from those increments in the following year. The morphological characteristics of annual increments are analysed (spurs, stems, and long shoots) of Packham's Triumph pear cultivar, as well as the morphological characteristics of each category's annual increment bourse-over-bourse, all with statistically significant difference between studied factors and factorial levels. Peckham's Triumph had higher average length of long shoots in both examining years 2011 (53.63) and 2012 (45.33) and William's cultivar had the shorter ones.

Key words: cultivar, fruit-bearing branch, bourse-over-bourse, organogenesis.

Introduction

All the organs of the fruit tree, vegetative and generative ones, have a common origin from the originally grown meristem, i.e. the undifferentiated meristem of individual growth points (meristem embryos, winter buds, etc.). By dividing cells of meristematic tissue and its growth and differentiation, all the temporary and permanent organs of the fruit are built. Thus, the living organism development involves the growth and differentiation processes. The growth process implies an irreversible increase in size and content, and differentiation is defined as qualitative change in form and function. Organ formation from each individual meristem implies a clearly defined occurrence and development of growth and differentiation processes. This order in organ formation and development is called organogenesis cycle.

The organogenesis cycle of cultivated plants is divided into 12 phases (Kuperman, 1968). Isaeva (1978) retained this division, but because of the specificity of the perennial plants organogenesis phase, certain phases are broken down into a number of subphases. According to this division, the numbering of all characteristic phenophases and micro-phenophases in the life cycle of individual cultivated plant growth and development was performed (Zadox et al., 1974; Tottman and Makepeace, 1979; Tottman et al., 1978) and then the uniform codes for all phenophases and micro-phenophases in the growth and development of dicots, monocots, weeds, and perennials (Lancashire et al., 1991). Studying the Kuperman and Isaeva model, Mićić and Đurić (1994) created a model that basically accepts the 12 Kuperman phases, where they simultaneously redefined the phases X, XI, and XII in accordance with the basic principles of fruit trees growth and development, observed form their biological individuality point of view. Mićić and Đurić state the basis for defining the phases in the fruit tree organogenesis cycle is the determination of characteristic and, in analytical sense, complete processes in organ and tissue differentiation in the annual cycle. This cycle division into 12 phases can basically be accepted by defining a greater number of subphases which are specific for different types of fruit trees (Mićić, 1992; Mićić and Đurić, 1994; Mićić et al., 1997).

Pear yield depends on the age of pear trees and their varieties. The type of pear yield changes with the transition from the initial yield phase to the full yield phase. The first fruits are formed on twigs and short fruiting spurs on a biennial wood. With the fruit wood aging (8-10), most varieties begin to yield on short fruiting spurs (Gvozdenović et al., 1985). Retaining buds expected to produce the best quality fruit and removing weak and poorly positioned buds has been shown to improve fruit set of apples (Tustin et al., 2011). Training branches to the horizontal, to control vegetative growth, could

increase productivity of pears by reducing the proportion of vegetative buds (Du Plooy et al., 2002). Varietal specifics of fruiting, i.e. different ratio in growth and yield, the dominant disposition, type, and age of fruiting spurs in a pear are not as elaborate as in an apple. More precisely, as a forerunner of this research, a little less than 60 years ago, several research papers on apples were published (Sansavini, 1966) in which only the basic individual parameters of this process in a pear were processed.

Determinations and classifications of current pear varieties according to the branching method, i.e. the type of habitus is practically non-existent in the available literature. The reasons for the low interest of researchers in studying the pear organogenesis should be sought in the fact that the pear is predominantly grown on a quince rootstock, and in that combination of grafting components, a bigger issue is meristem positioning in pomo-technical approach, than it is the issue of twig and fruiting spur productivity (Mićić et al., 2009). Nowadays, when the wild pear seedling was returned as a rootstock in the cultivation system, the question of pear yield tree organogenesis programming is imposed as a basic issue. The research on lateral and premature branching development in the initial development stages clearly shows that there is a genotypic predisposition to a certain form of habitus (Sansavini and Zocca, 1986).

Based on this research, pear varieties are divided into four groups. It is important to denote that the variety classification according to the premature lateral branching development in the initial development stages does not agree with the pear variety classification according to a type of fruiting that is almost simultaneously performed. According to probably still a unique pear variety classification based on the type of fruiting (Sansavini, 1993), defined for the pear assortment spread in Italy until 1960, pear varieties can be classified into five characteristic groups, i.e., types of fruiting named after the typical representative of that variety: I) William's; II) Doyenne du Comice - Abate Fetel; III) Conference; IV) the Beurre Bosc and V) Passe Crassane. Typical representatives of group II are Doyenne du Comice and Abate Fetel pear cultivars, and they are characterized by the fact that the cultivar fruiting of this group is based on the stem formations that bear biennial branches (partly triennial branches, too) i.e., productive tree carriers. In the second year, a large number of shoots is formed that need to be thinned by pruning the twigs, but then about 60-70% of production stabilizes on branches that are 2-3 years old. Concorde and Packham's Triumph pear varieties have very similar fruiting characteristics. Increasing the leaf to fruit ratio and thus increasing the size of the source relative to the sink is offered as an explanation for the improved fruit size (Lakso et al., 1994; Wünsche and Lakso, 2000).

The morphological properties of the fruiting wood were significantly affected by genotype and environmental factors. The aim of this study was to determine the representation of the most desirable increments on fruit-bearing Packham's Triumph pear cultivars. Williams pear served as a comparative cultivar.

Materials and Methods

The material for morphological analyses was taken from a 12-year-old pear trees located in the Glamočani village, municipality of Laktaši. The researches were performed in 2011 and 2012 on the Packham's Triumph and William's pear cultivars, which were grafted on wild pear seedlings. The analysis included the following growth categories: short wrinkled fruiting twigs or spurs, hard fruiting twigs or shoots, long fruiting shoots, and bourse-over-bourse. The following analyses were performed on each growth category:

1. Spurs – the length of the woody part of the twig in cm (during winter dormancy period), and the number of fruits from a mixed bud.
2. Shoots – the length of a twig (woody part of twigs), the number of increments from lateral buds of the stem, the number of mixed buds on a twig.
3. Long shoots – the length of a twig (woody part of the twig), the number of mixed buds on the twig, the number of increments from the lateral buds of the long fruiting shoots.

Statistical significance was set at $p<0.05$, by Fisher's post-hoc Least Significant Difference (LSD). Biometric processing was performed with the help of the statistics software package SPSS 22 (IBM, 2013).

Results and Discussion

A young, fruiting wood of a pear tree is represented by increments that develop from the lateral vegetative bud on a young tree, and produce fruit for the first time. The length and age of these increments can vary depending on the variety and age of the tree. According to Sansavini (1993), Packham's Triumph cultivar, based on a type of a dominant fruiting wood, belongs to IV group of varieties in which a stem prevails as a dominant fruiting wood, while the cultivar William's belongs to type I cultivars, in which long shoots predominate on young fruiting woods, while with the aging of trees, the share of short shoots increases. The results of the length of different fruiting twig growth categories of the tested pear varieties are presented in Table 1.

Tab. 1. Average length of fruit-bearing branches of the tested pear cultivars (cm)

Cultivar	Year	Growth categories		
		Long shoots	Shoots	Spurs
Packham's Triumph	2011	$53.63^{a} \pm 2.94$	11.6 ± 1.10	1.38 ± 0.12
	2012	$45.33^{b} \pm 5.28$		
William's	2011	$44.52^{b} \pm 3.18$	14.92 ± 1.13	2.76 ± 0.37
	2012	$28.88^{c} \pm 3.22$		

Different letters in a column indicate significant differences (P<0.05), according to the Fisher's LSD test.

The lengths of different fruiting twig types in the examined pear cultivars were compared, and a statistically significant interaction of the variety and type of a fruiting twig was observed (p=0.02). Statistical difference between different types of fruiting twigs examined is highly significant in the examined cultivars (p<0.01) where the long shoots are the longest, followed by the stems and spurs. The tested varieties differ highly significantly in the length of the long shoots, stems, and spurs (p<0.01). The length of long shoots is higher in the Packham's Triumph cultivar, compared with the William's cultivar. By the stem and spur length, the length of William's cultivar stands out significantly in relation to Packham's Triumph. By analyzing the data on the length of the long shoots of the examined cultivars for two examining years, it was established that there is no statistically significant interaction between the two factors (p=0.776).

The influence of the year is statistically highly significant (p=0.005). Significantly greater length was recorded in 2011. The influence of the variety is statistically significant (p=0.019). The Packham's Triumph cultivar is distinguished by a significantly greater twig length in comparison with the William's cultivar (p= 0,004). The number of mixed buds on the fruiting wood of pear tree twigs can be greater than 1, because it often occurs that the lateral buds on the summer shoots are mixed. Their number is different and depends on the variety. In these studies, the results on the number of mixed buds on the fruiting twigs of tested pear cultivars are presented in Table 2.

Tab. 2. Average number of mixed buds on different fruiting wood categories

Cultivar	Year	Growth categories		
		Long shoots	Shoots	Spurs
Packham's Triumph	2011	$1.07^{a} \pm 0.05$	1.1 ± 0.07	1
	2012	$1.22^{a} \pm 0.36$		
William's	2011	$1.50^{b} \pm 0.14$	1.2 ± 0.09	1
	2012	$1.88^{b} \pm 0.29$		

Different letters in a column indicate significant differences (P<0.05), according to the Fisher's LSD test.

Based on the data presented in Table 2, it can be seen that the greater number of mixed buds was present with the William's cultivar on long shoots and stems (1.50 and 1.88), which is in accordance with Radoš's research (2009) and that it was smaller in the Packham's Triumph cultivar (1.22 and 1.07).

Based on the data obtained, the average number of mixed buds on different twig types according to the pear cultivars examined, and it was established that there is no statistically significant difference between the cultivars examined ($p< 0.01$) and between different types of fruiting twigs in number of mixed buds ($p=0.05$). A slightly lower average number of mixed buds is indicative on long shoots in the Packham's Triumph cultivar in comparison with stems, but with no statistically significant influence observed. The number of mixed buds on the long shoots did not depend on the combined influence of the variety and year ($p=0.568$). In 2012, there was, on average, significantly more ($p=0.027$) mixed buds compared with 2011. The variety had highly significant impact ($p<0.001$). Packham's Triumph had a smaller number of mixed buds than the William's cultivar ($p<0.023$). In the pear, reproductive buds are formed almost exclusively terminally on spurs (Tromp, 2000). The pear tree fruiting wood renewal depends on the start of the development of buds that are present on last year's summer shoots. The greater the number of the buds appearing, the greater the possibility for increased fruiting potential. The number of increments which originated from the lateral buds of the examined pear cultivars are presented in Table 3.

Tab. 3. Average number of increments arising from the lateral buds of different pear tree fruiting wood categories on the examined pear cultivars

Cultivar	Year	Growth categories		
		Long shoots	Shoots	Spurs
Packham's Triumph	2011	$14.23^{a} \pm 0.96$	3.20 ± 0.22	0
	2012	$10.22^{b} \pm 1.67$		
William's	2011	$9.40^{b} \pm 1.02$	3.00 ± 0.31	0
	2012	$6.00^{c} \pm 0.63$		

Different letters in a column indicate significant differences ($P<0.05$), according to the Fisher's LSD test.

Based on the data presented in Table 3, it can be seen that a greater number of increments on long shoots was present with the Packham's Triumph cultivar (14.23) and smaller number (6.00) was present in William's cultivar in 2012. The same trend was also observed with the stem, which is not in accordance with the cited literature (Radoš, 2009). Based on the obtained results, the average number of increments from lateral buds on long shoots and stems was analyzed and a statistically significant interaction

between the variety and the type of a fruit-bearing branch was found ($p<0.01$). Packham's Triumph stands out from the William's cultivar statistically significantly highly, by the greater number of lateral increments on long shoots. Long shoots have a consistently higher number of increments than the stems have on both varieties tested ($p<0.01$). The number of increments on long shoots was not affected by the examined factors in combination ($p = 0.848$). In 2011, there was a statistically significantly higher increase ($p<0.001$) in comparison with 2012. The varieties also differed significantly ($p<0.001$). The Packham's Triumph cultivar had highly significantly more increments than William's ($p< 0.001$).

Fruit leaves represent temporary organs whose main function is photosynthetic activity. Their function begins with their very first appearance on a tree, and ends in October. In order to supply the fruit with photosynthetic assimilates, a certain number of leaves per fruit is necessary. This number is different for different varieties. Number of leaves on all lateral increments of the examined pear cultivar fruiting twig type is presented in Table 4.

Tab. 4. Average number of leaves on lateral increments of fruiting twigs in the young pear cultivars examined

Cultivar	Year	Growth categories		
		Long shoots	Shoots	Spurs
Packham's Triumph	2011	$62.60^{a} \pm 5.02$	12.97 ± 0.98	0
	2012	$37.00^{c} \pm 6.87$		
William's	2011	$46.73^{b} \pm 4.60$	3.00 ± 0.31	0
	2012	$26.13^{d} \pm 2.86$		

Different letters in a column indicate significant differences ($P<0.05$), according to the Fisher's LSD test.

Based on the data presented in Table 4, it can be concluded that the photosynthetic activity, which was expressed through the number of leaves in 2011, was more enhanced in comparison with 2012. Greater number of leaves on the increments of long shoots was in the Peckham's Triumph cultivar (62.60) and the smaller number of leaves was in the William's cultivar (26.13). Also, a larger number of leaves was recorded on the stems of Packham's Triumph (12.97) in comparison with the William's cultivar (3.00). Analysing the average number of leaves from lateral buds on long shoots and stems, a consistent significant difference was found between the examined cultivars by the number of leaves ($p=0.02$) and between different twig types examined ($p<0.01$). Packham's Triumph stands out statistically significantly ($p<0.01$) by a larger number of leaves on fruiting William's pear twigs. The examined cultivars reacted consistently in both examining years ($p=0.883$). In

2011, the number of leaves was significantly higher than in 2012 ($p<0.001$). The varieties differed significantly ($p<0.041$), too. Packham's Triumph had a significantly larger number of leaves (0.013) in comparison with William's.

The fruit is the target organ of fruit production; the fruit yield per area unit depends on the number of fruits and the average fruit weight, which implies the success of certain production. Number of fruits per different types of examined pear cultivar fruiting twigs is presented in Table 5. Based on the data presented in Table 5, it can be seen that the larger number of fruits per mixed bud was in the William's cultivar (1.76) on a long shoot, and the smaller number of fruits on a stem was in the Packham's Triumph cultivar (1.03).

Tab. 5. Average number of fruits on the examined pear cultivar's fruiting twigs

Cultivar	Year	Growth categories		
		Long shoots	Shoots	Spurs
Packham's Triumph	2011	$1.23^{d} \pm 0.09$	1.13 ± 0.08	1.03 ± 0.03
	2012	$1.33^{c} \pm 0.18$		
William's	2011	$1.57^{b} \pm 0.09$	1.53 ± 0.11	1.30 ± 0.10
	2012	$1.76^{a} \pm 0.25$		

Different letters in a column indicate significant differences ($P<0.05$), according to the Fisher's LSD test.

By analyzing the number of fruits from mixed buds in the examined cultivars, a statistically significant combined influence of variety and type of a fruiting twig on the average number of fruits from a mixed bud was observed ($p=0.02$). In the examined Packham's Triumph and William's pear cultivars, the year did not have a significant effect on the number of fruits per mixed bud, which completely agrees with the results obtained by Radoš (2009). The number of young trees which are formed from vegetative growth points of bourse-over-bourse is important, because the leaves are formed on them, and in the following seasons they can be fruiting wood or fruiting wood carriers. Their number depends on many factors, and is often a varietal characteristic. Number of young shoots on bourse-over-bourse of the examined pear cultivars is presented in Table 6. As can be seen in Table 6, the largest number of formed young shoots was recorded with the William's pear cultivar (1.75) on long shoots, and the smallest number was recorded with the Packham's Triumph pear cultivar on stems (1.1).

Tab. 6. Average number of young shoots developed from a bourse-over-bourse of the examined pear cultivars

Cultivar	Year	Growth categories		
		Long shoots	Shoots	Spurs
Packham's Triumph	2011	1.59[a] ± 0.09	1.10 ± 0.06	1.30 ± 0.09
	2012	1.67[a] ± 0.18		
William's	2011	1.59[a] ± 0.12	1.30 ± 0.09	1.31 ± 0.10
	2012	1.75 [a] ± 0.25		

Different letters in a column indicate significant differences (P<0.05), according to the Fisher's LSD test.

By analysing the obtained data, no consistent difference was observed in the average number of young shoots from a mixed bud in the examined Packham's Triumph and William's pear cultivars (p=0.347). Long shoots consistently had a higher number of young shoots (p<0.01) in comparison with the stems and spurs, between which there was no statistically significant difference (p=0.43).

Conclusion

Based on the results presented, it can be concluded that Peckham's Triumph had higher average length of long shoots in both examining years, and that the William's cultivar had the shorter ones. There are statistically significant differences in the length of long shoots between the cultivars examined and their examining years. The highest average shoot length was in the William's pear cultivar (14.92) and it represents a statistically significant difference in comparison with the Packham's Triumph pear cultivar. The number of mixed buds on long shoots was not statistically different between the cultivars examined. The differences in the number of mixed buds on stems and spurs were not statistically significant. On the summer shoots from the previous vegetation, the larger number of developed increments from lateral buds was recorded in the Packham's Triumph pear cultivar (14.23) in 2011, and the smaller number was recorded in the William's pear cultivar (6.00) in 2012, on long shoots. The variety and the year had a statistically significant influence on the number of lateral increments of long shoots. Compared with the average number of leaves on young shoots formed from lateral buds, the examined cultivars reacted consistently over the years, but by the number of leaves, the Packham's Triumph pear cultivar stands out statistically significantly. The number of young shoots on mixed pear bud ranged from 1.1 on the Packham's Triumph cultivar stem up to 1.75 on the

William's pear cultivar long shoot. Differences in the number of young shoots for individual fruiting wood categories of the examined pear cultivars did not show statistically significant differences. From the aspect of fruiting twig productivity, it can be denoted that the most productive fruiting twig type, in all cultivars examined, was a long shoot, then spur and stem.

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Морфолошке карактеристике родног дрвета крушке сорте Pakams triumf

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Сажетак

Крушка као воћна врста у току животног циклуса формира разне категорије родних гранчица. У зависности од тога колико година је потребно да се од бочне вегетационе купе формира младо родно дрво говоримо о једно дво или вишегодишњем циклусу органогенезе, што у првом реду зависи од генотипа сорте, подлоге на којима је сорта укалемљена, примијењене агротехнике у засаду и других услова. Познавање циклуса органогенезе појединих сорти крушака је основа планирања редовних и стабилних приноса. Да бисмо утврдили структуру родног дрвета за појединu сорту крушке неопходно је да се ураде анализе појединачних категорија прираста, шта се развија из тих прираста у наредној години. У раду су анализиране морфолошке карактеристике једногодишњих прираста (стапчица, стапка и дуга вита) крушке сорте Pakams triumf, као и морфолошке карактерисистике родног колача од сваке категорије једногодишњег прираста, са статистички значајном разликом између проучаваних фактора и нивоом фактора. Pakams triumf имао је већу просјечну дужину дуге вите и у испитиваној 2011. години (53,63) и у 2012. (45,33), а сорта Вилијамовка је имала мању.

Кључне ријечи: сорта, родна грана, родни колач, органогенеза.

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