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THE PHENOLOGICAL AND POMOLOGICAL TRAITS OF SELECTED GENOTYPES OF WILD PEAR [*Pyrus pyraster* (L.) Du Roi] IMPORTANT FOR THE PRODUCTION OF GENERATIVE ROOTSTOCKS

Šebek T. Gordana✉

University of Montenegro, Biotechnical faculty, Podgorica, Montenegro

ABSTRACT

The aim of this work is to produce the generative rootstocks for the wild pears, which will be of moderate denseness. The initial material is the population of wild pear in the area of Polimlje. The study focused on few segments. Very first one included recording of the phenological traits – first flowering, full flowering, end of flowering and harvest period. The other segment comprised pomological features, i.e. physical [fruit weight (g), fruit size (mm), mass of dry seed (g), and number of seed in 1 kg of the fruit]. Seeds from 9 selected genotypes of wild pears were planted in the nursery and raised seedlings were evaluated for nursery characteristics: germination, seedling vigor, uniformidty and branching. Raised seedlings were used as rootstocks for scion cultivar 'Grand Champion'. The most important benefit of this study is the fact that the parent trees, the seeds of which provide the best morphological and physiological characteristics for the production of generative rootstocks, were found and favored (*in situ*). Results of this research show that the rapid growth and uniformity of scions depend on the genetic characteristics of generative rootstocks of selected genotypes of wild pears, such as: plant height, stem diameter (corpulence), branching and uniformity. The selected genotypes, especially 'Genotype 11', proved to be the best for mountainous areas of the north of Montenegro, higher altitudes and poorer types of soil. The 'Genotype 11' is suggested as the best option for the production of generative rootstocks due to its small vigour level.

Key words: seedling vigor, uniformity, generative rootstock, selected genotypes

INTRODUCTION

Pear, after the apple, represents one of the most important cultivars of pome fruits of the moderate climate zone [Hussain et al. 2013]. Fruits of the most common commercial cultivars of pear are highly valued by consumers due to low amount of calories and high nutritional value, as well as the pleasant taste [Senser et al. 1999]. In addition to fresh consumption, pear fruits are used as raw material for different types of processing. *Pyrus pyraster* is considered an important wild relative of cultivated pear (*Pyrus communis* L.). The tree is considerable in size and diameter and its high quality wood makes this species interesting for reforestation of marginal farmland and for the production of highly valued timber [Kleinschmitt et al. 1998].

In the United States, in the latter half of the nineteenth century, breeders used the wild-type pear (crosses between Asian and European pears) to their crosses, in order to obtain greater resistance to cold and "fire blight" disease caused by the bacterium

✉ sebek@t-com.me

Erwinia amylovora that is widely spread, though causing a large reduction in the quality of the fruit, which was repaired with successive backcrosses. Wild-type pears are used today as a rootstock because of their tolerance to cold and adaptability to different environments [Bell et al. 2011].

The pear (*Pyrus* spp.) genus is variously said to consist of from 20 to over 70 wild or domesticated species [Rehder 1940, Terpo 1985, Oliveira et al. 1999]. It is relatively difficult to give an accurate number of pear species, because they easily cross-pollinate and the obtained crosses have ambiguous taxonomic status. The existence of a very large number of cultivars, species, subspecies, hybrids and clones reinforces the need for genetic characterization and verification. The wild pear is the only species of pear that grows naturally in the region of Central Europe.

The wild pear [*Pyrus pyraster* (L.) Du Roi] belongs to the *Rosaceae* family. There are various descriptions of the species, but some of these include questionable information, possibly because the species can be difficult to identify and distinguish from cultivated pear. Moreover, wild pear trees are relatively rare [Dengler 1992, Grosser 1999, Stephan et al. 2003] and receive little attention in research and forestry practice.

Dendrochronological studies of pear trees are extremely rare. Neri et al. [2005] reported a 69-year chronology for *P. domestica* in central Italy, whereas Antkowiak et al. [2012], a 73-year chronology of *P. pyraster* from north-western Poland.

Despite this, there are efforts made for a more detailed description of the species [Wilhelm 1998] and certain facts can be summarized in general terms. The wild pear [*Pyrus pyraster* (L.) Du Roi] is a light demanding species [Mayer 1992, Hofmann 1993, Stephan et al. 2003], although literature describes a range from semi to high light demand. The species has a deep root system [Mayer 1992, Hofmann 1993] and thrives on or tolerates a wide range of site conditions. Based on the deep root system, wild pear is drought-resistant as well as moisture tolerant [Dengler 1992, Hofmann 1993]. The species has relatively low competitive ability, especially competition with beech (*Fagus sylvatica*) is often fatal for pear [Stephan et al. 2003]. Literature describes wild pear as competitive mainly on dry sites with low water supply, due to the deep-root system that is able to access deep ground water levels [Hofmann 1993]. The growth of wild pear is slow and trees can reach ages of more than 150 years [Dengler 1992]. The shape of trees depend on the location, in favourable growing conditions the trees have a slender form with a rising crown [Stephan et al. 2003], and in less favourable situations one-sided or extremely low crowns frequently occur. The trees rarely reach a height greater than fifteen meters and a diameter at breast height (DBH) of more than 50 cm [Dengler 1992].

The wild pear [*Pyrus pyraster* (L.) Du Roi] population on the Balkan Peninsula consists of different genotypes. It reproduces *via* seeds. Wild pear trees are mostly semi-cultivated trees, growing in home gardens and clearings. Wild pear fruits are rarely suitable for consumption, and are most often dried or processed into brandy. Moreover, wild pear is significant in seedling production, where it is used as a generative rootstock. In case of good pollen germination, wild pear can be used as pollinator in pear tree orchards.

The capacity of *Rosaceae* species for interspecific hybridization, even beyond genus borders, has been exploited in breeding programs to incorporate desirable traits of wild populations into breeding gene pools. Hybridization between fruit crops and their wild relatives has probably also occurred 'spontaneously' and individuals with intermediate phenogenotypes are known to occur throughout the European landscape. The importance of (anthropogenic induced) hybridization processes has been underestimated by conservation biologists until recently [Allendorf et al. 2001]. However, it is becoming more and more apparent that hybridization has led to the extinction of many populations and species and represents a severe threat, especially to rare species that come into contact with other, more abundant species [Rhymer and Simberloff 1996].

Pear is the most important temperate fruit crop and has been cultivated in Europe and Asia since antiquity [Janick 2005]. The pear tree cultivating has a long tradition in Montenegro. According to statisti-

cal data for Montenegro, the number of trees in the year of 2011 was 234,720, out of which 201,724 trees were yielding trees [Monstat 2012]. Pear generative rootstocks are used worldwide due to better adaption of different species of the genus *Pyrus* to various environmental conditions, very often to extremely harsh conditions. Generative rootstocks of pome fruits are in principle less exposed to virus attacks, since they cannot be transmitted during seed reproduction [Misic 1984]. Wild pears of Montenegro have never been a subject of a comprehensive research work, neither a subject of collecting and studying processes. Nowadays, the most important issue is how to preserve it, especially since many local populations have vanished during its development or are reduced to a rather limited number of genotypes. Nevertheless, germplasm of wild pear in less urban areas, such as the area of Polimlje, is rather preserved.

MATERIAL AND METHODS

The researches were conducted continuously in the period from 2013, 2014 to 2015. They involved *in situ* identification, marking and careful observation of selected genotypes of wild pears, accessions, in the area of Polimlje.

During the fall of 2012, from the population of wild pear [*Pyrus pyraster* (L.) Du Roi], eleven genotypes were selected, which were of moderate vigor in comparison to other genotypes existing in this population. The trees of 2 autochthonous pear varieties ('Medunak', 'Ramaganlija') were considered as comparative parameters. The study focused on few segments. Very first one included recording of the phenological traits – first flowering, full flowering, end of flowering and harvest period. Phenological characteristics were determined as below: the beginning of flowering was recorded when at least 5% of the flowers bloomed; full flowering was determined when at least 80% of the flowers bloomed; the end of flowering was determined when 90% of the flowers bloomed and corollas began to fall off, and harvest period was established when the seeds in fruits were sufficiently collared.

The classification of studied genotypes regarding the flowering and ripening time was performed in accordance with IBPGR methodology, based on pear descriptors produced by Thiabault et al. [1983]. For comparison purposes, we approximately determined flowering on the altitude of 600 m (for each 30 m increase in altitude flowering is delayed by one day).

Particular attention was given to the fact that the selected genotypes were to be located on different sites, namely different altitudes and that they needed to be healthy individual trees of full productivity with fruits having more than 8 well developed seeds. The other segment was comprised of pomological, i.e. physical characteristics [fruit weight (g), fruit size (mm), mass of dry seed (g), and number of seed in 1 kg of the fruit]. Fruit mass and mass of 100 pieces of dry seeds were determined by measuring *via* the electric scale METTLER 1200. The results are shown in grams with the accuracy of 0.01 g. Fruit dimensions – length and width were measured by vernier scale. The results are shown in mm. Selection of seeds is conducted according to the method of Stankovic and Jovanovic [1987]. The extraction of seeds was performed manually. The method according to Misic [1984] stipulates for small amounts of seeds to be extracted manually. Drying and storage of seeds were performed in shade with good air circulation. Obtained results were statistically processed by the method of variance analysis and checked by LSD tests.

The seeds from 11 selected genotypes of wild pears [*Pyrus pyraster* (L.) Du Roi], accessions, were planted in the nursery and raised seedlings were evaluated for nursery characteristics: germination, seedling vigour, uniformity and branching. Raised seedlings were used as rootstocks for scion cultivar 'Grand Champion' pear. Uniformity was low (grade 1) when coefficient of variation was less than 15%, medium (grade 2) when it was from 15 to 25% and high (grade 3) when exceeding 25%.

RESULTS AND DISCUSSION

Based on the observed period of three years, Table 1 shows that the beginning (onset) of flowering was recorded in the selected 11 genotypes of wild pear in the average from April 7nd to May 9th.

By annual observation, the latest onset of flowering was recorded in the selected genotypes of wild

pear 'Genotype 7' (May 13th 2014) and the selected genotypes of wild pear 'Genotype 6' and 'Genotype 2' (May 12th 2014 and May 10th 2014). The full flowering stage was recorded on April 10th 2015 ('Genotype 8'), and on May 26th 2014 ('Genotype 2'), and the end of flowering on April 21st 2015 ('Genotype 8') and Jun 5th 2015 ('Genotype 2'). Flowering lasted on average 13 days ('Genotype 6') and 23 days ('Genotype 2'). The earliest end of flowering was recorded on April 21st 2015 in the selected genotypes 'Genotype 8' and the latest end of flowering was recorded on June 5th 2014 in the selected genotypes 'Genotype 2'.

Concerning the autochthonous pear cultivars (control), the earliest onset of flowering was with 'Medunak' (April 21st 2015) and the latest was with 'Ramaganlija' (May 3rd 2014). The earliest end of flowering occurred with the cultivar 'Medunak' (May 9th 2015) and the latest with the cultivar 'Ramaganlija' (May 23rd 2014). During the observed period, the flowering phenophase of autochthonous cultivars lasted on average to 17 days for cultivar 'Medunak', up to 20 days for cultivar 'Ramaganlija'. The observation showed that all selected genotypes of wild pear have adapted their flowering phenophase to the conditions of Polimlje. Flowering phenophase starts at the moment when the late spring frosts are gone or are significantly reduced.

This paper shows, among others, the results of three-year long study of the phenophase of flowering and harvesting of wild pear fruit from the area of Gornje Polimnje, in the north of Montenegro.

Genotype differences had also caused differences in the order of flowering, hence the studied genotypes flourish in the second half of April and early May (when full flowering is reduced to the altitude of 600 m above sea level). The fruits of investigated genotypes ripe in the interval of two months. The great genetic variability of wild pear is the result of centuries-old adaptation of local populations to certain agro-ecological and soil conditions.

Mišić [1984] stated that wild pear flourish in April, while Bulatović [1972] stated that the flowering process occurs in April and May. The quoted authors, however, do not specify the geographical characteristics of the sites, on which the described wild pear trees can be found. Jovančević [1980] found that in the area of Bijelo Polje, at 600 m above sea level, full flowering in 'Viljamovka' cultivar is recorded on April 25th, in 'Krasanka' cultivar on April 23rd, and in 'Društvenka' cultivar on April 22nd.

Wild pear seeds can be used in seedling production for producing generative rootstocks. In order to obtain germinated seeds, the moment of harvesting fruits is determined based on the change in the color of the epidermis (skin) of the fruit and the seed. Wild pear generative rootstocks are considered to be more suitable for mountain area of Montenegro, poorer types of soils and greater slopes of the terrain.

Turkin [1954] stated that the wild pear fruit ripes from the end of August till November. Bulatović [1972] found that the wild pear fruit ripes from August to October, and Milovankić [1982] found that the same process happens from the end of August till the beginning of September. At 600 meters above sea level, in Bijelo Polje, the fruit of 'Viljamovka' variety ripes on May 9th, of 'Klapovka' variety on May 25th, and of 'Konferansa' variety on September 1st [Jovančević 1980].

Pomological characteristics of fruit of selected genotypes of wild pears [*Pyrus pyraster* (L.) Du Roi] in the area of Polimlje are given in Table 2. Fruit mass is an inherited genetic characteristics. When comparing selected genotypes and controlled autochthonous varieties ('Medunak' and 'Ramaganlija'), we recorded very significant statistical difference. The analysis of variance for the fruit mass parameter, where the source of variation were genotypes and varieties, showed statistically different results. The highest average fruit mass of selected genotypes of wild pears was recorded with the 'Genotype 3' (31.55 g) and the lowest with the 'Genotype 10' (7.95 g). On the other hand, the average fruit mass for variety 'Ramaganlija' was 76.9 g. Variety 'Medunak' had the average fruit mass of 57.3 g. This means that we can expect such fruit mass with the observed genotypes and varieties in future, with the probability of 99%. The analysis of variance for the fruit mass parameter, where the source of variation was the interaction between genotype and year, did not show statistically significant differences. This means that years of the study, respectively their climate chara-

Table 1. Period of flowering and ripening of fruit in natural places of genotypes of wild pears in Polimlje (year of 2013, 2014, 2015 and total average), convert on sea level of 600 m and classification to period of flowering and ripening time by IBPGR

Genotype /Cultivar	Location			Flowering						Ripening time		
	longitude	latitude	altitude (m)	onset	full	end	duration	full convert 600 m	IBPGR	date	date convert 600 m	IBPGR
'Genotype 1'	19°20'E	42°38'N	579	3.05.2013 5.05.2014 29.04.2015 2.05 b	10.05.2013 13.05.2014 5.05.2015 9.05 de	21.05.2013 21.05.2014 18.05.2015 20.05 b	18 16 20 18 b	8.05 a	9	28.09 23.09 25.09 25.09 b	24.09 a	5
'Genotype 2'	19°59'E	43°02'N	1180	9.05.2013 10.05.2014 8.05.2015 9.05 a	21.05.2013 26.05.2014 20.05.2015 22.05 a	31.05.2013 5.06.2014 30.05.2015 29.05 a	22 26 22 23 a	3.05 b	9	7.10 9.10 11.10 9.10 a	20.09 a	5
'Genotype 3'	19°55'E	42°33'N	940	6.05.2013 9.05.2014 2.05.2015 6.05 a	12.05.2013 16.05.2014 13.05.2015 14.05 c	24.05.2013 27.05.2014 22.05.2015 24.05 ab	18 18 20 19 b	3.05 b	9	2.10 29.09 30.09 31.09 b	20.09 a	5
'Genotype 4'	18°49'E	42°26'N	858	24.04.2013 26.04.2014 22.04.2015 24.04 c	3.05.2013 6.05.2014 3.05.2015 4.05 ef	10.05.2013 12.05.2014 08.05.2015 10.05 d	16 16 16 16 c	27.04 d	8	30.08 26.08 26.08 27.08 d	20.08 e	2
'Genotype 5'	19°55'E	42°33'N	940	4.05.2013 7.05.2014 1.05.2015 4.05 ab	12.05.2013 15.05.2014 8.05.2015 12.05 d	25.05.2013 28.05.2014 21.05.2015 25.05 a	21 21 20 21 a	1.05 c	9	29.09 30.09 28.09 29.09 b	18.09 a	5
'Genotype 6'	19°29'E	42°51'N	984	8.05.2013 12.05.2014 7.05.2015 9.05 a	10.05.2013 14.05.2014 9.05.2015 11.05 d	22.05.2013 30.05.2014 14.05.2015 22.05 b	14 18 7 13 c	28.04 d	8	1.08 1.08 4.08 2.08 h	20.07 h	1
'Genotype 7'	19°20'E	42°38'N	978	10.05.2013 13.05.2014 1.05.2015 8.05 a	18.05.2013 20.05.2014 9.05.2015 16.05 bc	27.05.2013 29.05.2014 13.05.2015 23.05 b	17 16 12 15 c	3.05 b	9	7.09 8.09 8.09 8.09 e	25.08 d	3
'Genotype 8'	19°43'E	42°59'N	601	8.04.2013 11.04.2014 2.04.2015 7.04 ef	16.04.2013 19.04.2014 10.04.2015 15.04 c	25.04.2013 29.04.2014 21.04.2015 25.04 g	17 18 19 18 b	15.04 g	1	16.08 20.08 15.08 17.08 g	17.08 e	2
'Genotype 9'	19°59'E	42°70'N	970	3.05.2013 5.05.2014 30.04.2015 2.05 b	17.05.2013 19.05.2014 12.05.2015 16.05 cb	27.05.2013 30.05.2014 21.05.2015 26.05 a	14 18 21 18 b	4.05 b	9	30. 09 3.10. 2.10 2.10 a	22.09 a	5
'Genotype 10'	19°43'E	42°59'N	601	25.04.2013 27.04.2014 27.04.2015 26.04 c	9.05.2013 12.05.2014 7.05.2015 9.05 de	17.05.2013 20.05.2014 25.05.2015 21.05 b	22 23 28 24 a	9.05 a	9	20.09 25.09 30.09 25.09 b	25.09 a	5
'Genotype 11'	19°41'E	41°01'N	879	28.04.2013 30.04.2014 22.04.2015 30.04 b	8.05.2013 10.05.2014 4.05.2015 7.05 e	15.05.2013 18.05.2014 10.05.2015 14.05 c	17 18 18 18 b	28.04 d	8	3.09 4.09 2.09 3.09 e	24.08 d	3
'Medunak' (control)	19°29'E	42°50'N	974	26.04.2013 30.04.2014 21.04.2015 26.04 c	7.05.2013 10.05.2014 3.05.2015 7.05 e	13.05.2013 16.05.2014 9.05.2015 13.05 c	17 16 18 17 b	25.04 d	5	24.08 23.08 19.08 22.08 g	10.08 f	2
'Ramaganlija' (control)	19°43'E	42°59'N	901	30.04.2013 3.05.2014 24.04.2015 29.04 b	6.05.2013 9.05.2014 3.05.2015 6.05 e	20.05.2013 23.05.2014 13.05.2015 19.05 c	20 20 19 20 a	27.04 d	8	30.08 30.08 27.08 29.08 f	20.08 e	2
LSD 005				4.37	2.24	4.10	2.1	2.25		7.20	6.50	
LSD 001				5.63	3.33	5.08	2.9	2.95		9.65	8.45	

cteristics, did not have statistically significant or relevant impact. Therefore, the mentioned parameter is conditioned by the genotype and years and does not affect the differences between the observed genotypes or controlled varieties. During the research period, the variance coefficient (CV) for the fruit mass parameter, which was calculated on the basis of recorded individual measurement indicators, was at the level of 5.08%. In terms of generative rootstock production, wild pear with generally smaller fruit mass is more commercial in comparison to the autochthonous pear varieties. The most commercial genotypes are: ʻGenotype 10' (7.95 g) and ʻGenotype 5' (9.24 g).

Selimovska et al. [2015] examined the local pear varieties (*Pyrus communis* L.) in West Macedonia, which showed the variation of fruit weight in the range of 13.8 g to 214.1 g, and Đurić et al. [2015] examined the fruit weight of local pear varieties (*Pyrus communis* L.) in north-western part of Bosnia and Herzegovina, and concluded that it ranged from 31.1 to 109.4 g.

Fruit length and width are morphological characteristics that mostly depend on genotypes. The longest average fruit length of selected genotypes of wild pears amounts to 36.21 mm (ʻGenotype 3') and the shortest is 20.12 mm (ʻGenotype 10') (Tab. 2).

Table 3 shows information on fruit width of selected genotypes of wild pears. The largest average fruit width of selected genotypes of wild pears amounts to 33.33 mm (ʻGenotype 3') and the smallest is 12.31 mm (ʻGenotype 10'). According to the research of Paganová [2009], all observed trees of wild pear in the Slovak Republic were with fruits of up to 30 mm in length, which she stated to be typical for this species.

Comparing our data with those of other authors, it can be concluded that dimensions of the fruit are in approximate range [Kleinschmit et al. 1997, Türk 1999] indicating that similar fruit weight causes similar dimensions, because there is positive correlation between these characteristics. This can be explained by the fact that the fruit weight is more influenced by environmental factors than the dimensions [Šebek 2010].

Table 2. Average fruit mass and fruit length of selected genotypes of wild pears

Genotype /Cultivar	Fruit mass (g)				Fruit length (mm)			
	2013	2014	2015	average	2013	2014	2015	average
ʻGenotype 1'	16.03	15.42	15.73	15.69 b	31.72	31.64	31.71	31.68 de
ʻGenotype 2'	11.93	10.16	11.01	10.71 a	27.02	26.81	26.69	26.83 c
ʻGenotype 3'	31.52	31.41	31.72	31.55 d	36.37	35.82	36.45	36.21 f
ʻGenotype 4'	15.15	15.02	15.31	15.12 b	33.72	33.63	33.81	33.72 e
ʻGenotype 5'	9.21	9.02	9.59	9.24 a	26.15	26.13	26.31	26.21 c
ʻGenotype 6'	22.07	24.12	25.04	23.74 c	35.42	35.35	35.69	35.48 f
ʻGenotype 7'	27.41	25.52	28.25	27.06 c	35.91	35.53	37.02	36.15 f
ʻGenotype 8'	11.21	10.72	10.02	10.65 a	27.15	26.82	23.84	25.94 c
ʻGenotype 9'	16.5	16.6	16.1	16.4 b	31.91	31.11	32.01	31.67 de
ʻGenotype 10'	8.05	6.78	9.02	7.95 a	20.15	19.73	20.49	20.12 a
ʻGenotype 11'	11.6	12.1	11.9	11.9 a	25.91	27.11	27.41	26.81 c
ʻMedunak'	57.46	57.19	57.25	57.3 h	56.61	54.51	54.78	55.30 l
ʻRamaganlija'	78.5	76.2	76	76.9 j	58.91	59.25	62.17	60.11 n
LSD	0.05	0.01			LSD	0.05	0.01	
Genotype	2.78	3.69			Genotype	0.85	1.13	
Year	1.34	1.77			Year	0.41	0.54	
Genotype × year	4.82	6.39			Genotype × year	1.47	1.95	

CV fruit mass = 5.08%, CV fruit length = 2.17%

Table 3. Average fruit width of selected genotypes of wild pears (mm)

Genotype /Cultivar	Fruit width (mm)			
	2013	2014	2015	average
'Genotype 1'	27.24	27.17	27.21	27.21 ef
'Genotype 2'	24.07	20.15	24.21	22.81 d
'Genotype 3'	34.02	32.96	33.02	33.33 h
'Genotype 4'	20.19	20.03	20.24	20.15 c
'Genotype 5'	18.61	18.39	18.11	18.69 c
'Genotype 6'	29.85	30.17	30.16	30.06 fg
'Genotype 7'	21.35	21.42	21.39	21.35 d
'Genotype 8'	26.05	25.68	24.81	26.51 ef
'Genotype 9'	20.81	20.25	20.99	20.68 cd
'Genotype 10'	13.51	14.41	9.01	12.31 a
'Genotype 11'	18.61	20.31	19.41	19.43 c
'Medunak'	48.00	47.41	47.99	47.80 l
'Ramaganlija'	51.41	51.85	55.08	52.78 n
LSD	0.05	0.01		
Genotype	0.82	1.09		
Year	0.39	0.52		
Genotype × year	1.42	1.88		

CV fruit width = 1.91 %

In Table 4, there is given information for mass of dry seed and number of seed in 1 kg of the fruit. Mass of dry seed (100 pieces) was 2.659 g with the 'Genotype 1', and up to 3.732 g with the 'Genotype 8'. Regarding the volume of reserve material necessary for germination, the best predispositions are with the 'Genotype 8' (3.732 g) and the 'Genotype 11' (3.612 g). Variation coefficient for the dry seed parameter amounted to 4.31%, which indicates material homogeneity in observed genotypes. Analysis of variance for the seed mass parameter in respect to genotypes and varieties, as to the source of variation, determined a statistically significant difference. This means that we can expect such seed mass with the observed genotypes and varieties in future with the probability of 99%. In respect to the years, as to the source of variations, there were no statistically significant differences.

Data on the average number of seeds in 1 kg of dry seeds were obtained on the basis of the mass of 100 pieces of dry seeds and weight calculations regarding 1 kg. The average number of seeds in 1 kg of seeds fluctuates from around 24,725 with the 'Genotype 8' to 38,187 with the 'Genotype 1'.

Tables 5 and 6 give some information on the seed germination, plant height, stem diameter or corpulance, branching and uniformity of rootstocks. The results of this research show that the seed germination, plant height, stem diameter, branching and uniformity of rootstocks are genetic characteristics of selected genotypes of wild pear, on which rapid growth and uniformity of scions depend. The results depicted in the Table 5 show that the average seed germination of the selected genotypes of wild pears was in the range from 52% ('Genotype 7') to 72.3% ('Genotype 2'). During our previous experience in the nursery, we found the following: a) the seeds must be kept wet for six days in running water, b) the seeds must then be stratified from 40 to 90 days with wet sand or peat at the temperatures of 0–7°C.

Table 4. Mass of dry seed and number of seeds in 1 kg of the fruit

Genotype /Cultivar	Mass of dry seed (100 piece)				Number of seeds in 1 kg			
	2013	2014	2015	average	2013	2014	2015	average
'Genotype 1'	2.605	2.673	2.701	2.659 b	32,432	31,532	31,174	38,187 d
'Genotype 2'	2.653	2.705	2.715	2.691 b	37,679	36,969	36,832	37,160 d
'Genotype 3'	3.105	3.007	3.117	3.076 b	37,504	39,824	37,235	34,073 c
'Genotype 4'	3.015	3.102	3.125	3.081 b	33,167	32,237	32,000	32,468 c
'Genotype 5'	3.076	3.104	3.117	3.099 b	32,509	32,216	32,082	32,269 c
'Genotype 6'	3.016	3.166	3.352	3.534 a	26,711	25,667	29,023	27,134 a
'Genotype 7'	3.225	3.311	3.378	3.304 b	30,922	30,122	29,527	30,190 b
'Genotype 8'	3.842	3.787	3.567	3.732 a	22,799	25,702	25,674	24,725 a
'Genotype 9'	3.549	3.591	3.672	3.604 a	31,060	30,660	29,917	30,546 b
'Genotype 10'	3.708	3.119	3.124	3.317 b	25,368	25,726	27,271	26,122 a
'Genotype 11'	3.775	3.704	3.358	3.612 a	26,491	26,998	29,779	27,756 a
'Medunak'	2.607	2.629	2.885	2.707 b	25,724	25,556	23,741	25,007 a
'Ramaganlija'	3.358	3.635	3.425	3.472 a	26,485	25,051	26,121	25,886 a
LSD	0.05	0.01			LSD	0.05	0.01	
Genotype	0.26	0.36			Genotype	1913.31	2592.88	
Year	0.13	0.17			Year	919.12	1245.58	
Genotype × year	0.52	0.68			Genotype × year	2420.4	3502.4	

CV dry seed mass = 4.31%, CV number of seed per kg = 3.38%

The results depicted in Table 5 show that the average height of seedlings of the selected genotypes of wild pears was in the range from 50.4 cm ('Genotype 9') to 71.3 cm ('Genotype 4'). The average seedling height at the control autochthonous sort was in the range from 55.2 cm ('Medunak') up to 58.1 cm ('Ramaganlija').

The average stem diameter (corpulence) of selected genotypes of wild pears was in the range from 5.95 mm ('Genotype 9') up to 8.42 mm ('Genotype 1'). The average corpulence of the seedlings at the control autochthonous sort was in the range from 6.32 mm ('Medunak') up to 6.95 mm ('Ramaganlija').

While comparing vigor and uniformity of seedlings (Tab. 6), we can observe that the most voluminous or verdurous seedlings were the ones of the Genotype 1. At the same time, these seedlings were the most ununiformed ones. 'Genotype 1' is situated at the altitude of 579 m above se a level. This height is suitable for growing of autochthonous pear varieties, i.e. this genotype can be pollinated with other genotypes of resident wild pears, as well as and late-flowering autochthonous and standard varieties. This wide variety of pollinators led to the fact that this genotype gives generative rootstocks with high level of heterozygosity, while the vigor level is very high. 'Genotype 3', 'Genotype 6' and 'Genotype 7' have medium variability of seedlings, which can be concluded by the fact that they are late flourishing, hence the selection of pollinators is significantly smaller. All of this caused these genotypes to pollinate with rare genotypes that flourish simultaneously as they do, resulting in their seedlings being of medium variability. 'Genotype 11' has low level of seedling vigour, small variability of produced seedlings, regard-

less of the fact it belongs to the early flourishing genotype of the wild pear. 'Genotype 11' is situated at an altitude of 879 m above sea level, thus the assumption is that its selection of pollinators could be significantly smaller.

Table 7 shows the results of bud setting, growth and uniformity of scions. The best average results of the bud setting process of selected genotypes were recorded in 'Genotype 2' (91.67%) and in 'Genotype 11' (90.67%). The growth of generative rootstocks of selected genotypes had direct influence on the growth of scions of cultivar 'Grand Champion'. Having in mind the producers tend to having medium vigor of their seedlings, the most appropriate result was for the generative rootstock of 'Genotype 11', and it amounted to the average height of 97.6 cm. The result for 'Genotype 11' represents the smallest growth among the selected genotypes, which assures lesser vigor, hence bigger production. The 'Genotype 11' has low level of seedling vigor, small variability of produced seedlings, regardless of the fact it belongs to the early flourishing genotype of the wild pear. 'Genotype 11' is situated at an altitude of 879 m above sea level, thus the assumption is that its selection of pollinators could be significantly smaller.

Table 5. Seed germination and plant height of generative rootstocks

Genotype /Cultivar	Seed germination* (%)				Plant height (cm)				Stem diameter (mm)			
	2013	2014	2015	average	2013	2014	2015	average	2013	2014	2015	average
'Genotype 1'	60	63	71	64.7 b	73.6	63.6	73.3	70.2 b	7.36	9.36	8.53	8.42 b
'Genotype 2'	73	78	76	72.3 a	63.2	62.5	49.1	58.3 a	7.06	6.11	6.95	6.71 a
'Genotype 3'	55	60	65	60 b	53.6	74.3	68.5	65.5 a	5.87	7.80	7.24	6.97 a
'Genotype 4'	64	69	62	68.3 a	71.9	77.2	64.8	71.3 b	8.30	8.78	6.84	7.97 b
'Genotype 5'	63	67	72	67.3 a	66.3	55.6	65.3	62.4 a	6.62	6.75	5.88	6.42 a
'Genotype 6'	63	67	59	63 b	61.5	49.3	51.1	53.9 a	8.09	6.33	6.42	6.95 a
'Genotype 7'	48	51	57	52 c	45.9	62.6	54.7	54.4 a	5.48	7.31	6.39	6.39 a
'Genotype 8'	66	68	62	65 ab	64.7	49.0	71.5	61.7 a	6.92	5.45	7.52	6.63 a
'Genotype 9'	66	64	61	63.7 b	46.6	50.8	53.9	50.4 a	5.51	6.03	6.32	5.95 a
'Genotype 10'	61	64	57	60.7 b	67.8	57.5	62.7	62.7 a	7.09	6.51	6.75	6.78 a
'Genotype 11'	61	66	68	65 ab	46.7	53.5	57.5	52.6 a	5.77	6.65	7.25	6.55 a
'Medunak'	63	67	72	67.3 a	59.5	49.1	56.8	55.2 a	6.71	5.62	6.63	6.32 a
'Ramaganlija'	53	56	63	57.3 bc	57.7	59.9	57.0	58.1 a	6.79	7.23	6.93	6.95 a
LSD	0.05	0.01			LSD	0.05	0.01		LSD	0.05	0.01	
Genotype	4.12	4.21			Genotype	7.62	10.9		Genotype	0.74	0.98	
Year	4.02	4.19			Year	3.53	4.70		Year	0.42	0.50	
Genotype × year	6.24	6.33			Genotype × year	13.0	17.6		Genotype × year	1.28	1.76	

CV seed germination = 4.84%, CV plant height = 26.01%, CV stem diameter = 12.09 %
*Seed was stratified

Table 6. Branching, vigor and uniformity of generative rootstocks

Genotype /Cultivar	Branching	Vigor	Uniformity of generative rootstocks		
			CV (%) plant height	CV (%) stem diameter	level of uniformity
'Genotype 1'	4	very large	29.4	20.4	3
'Genotype 2'	2	very large	24.7	19.95	2
'Genotype 3'	2	medium	14.2	11.5	1
'Genotype 4'	3	very large	25.1	19.9	2
'Genotype 5'	3	large	20.9	16.9	2
'Genotype 6'	2	medium	13.1	10.2	1
'Genotype 7'	3	medium	13.3	11.5	1
'Genotype 8'	1	large	22.1	17.5	2
'Genotype 9'	2	large	19.9	15.6	2
'Genotype 10'	2	large	19.5	17.3	2
'Genotype 11'	2	low	10.1	7.2	1
'Medunak'	1	medium	14.9	11.9	1
'Ramaganlija'	2	medium	12.1	10.2	1

CV – coefficient of variation

Table 7. Bud setting, growth and uniformity of scions

Genotype /Cultivar	Bud settings (%)				Growth of scions (cm)				Uniformity of scions
	2013	2014	2015	average	2013	2014	2015	average	
	88	93	91	90.67 a	132.5	124.3	125.3	127.4 b	3
'Genotype 2'	91	94	90	91.67 a	120.8	121.0	131.3	125.0 b	2
'Genotype 3'	92	89	92	91 a	116	115.2	100.5	110.6 a	1
'Genotype 4'	89	90	93	90.67 a	116.5	101.1	116.5	111.4 a	2
'Genotype 5'	91	90	90	90.33 a	120.9	119.2	108.2	116.1 ab	2
'Genotype 6'	87	79	75	80.33 d	108.5	111.2	106.8	108.8 a	1
'Genotype 7'	77	80	79	78.67 e	100.5	110.6	97.6	102.9 a	1
'Genotype 8'	76	80	84	80 de	125.3	115.9	112.9	118.0 b	2
'Genotype 9'	82	83	81	82 d	98.9	115.6	104.6	106.4 a	2
'Genotype 10'	70	75	78	74.3 fg	121.7	119.5	148.1	129.8 b	2
'Genotype 11'	88	92	92	90.67 a	104.1	96.4	92.2	97.6 a	1
'Medunak'	81	85	80	82 d	89.0	102.0	95.7	95.57 a	1
'Ramaganlija'	68	66	69	67.67 i	111.0	117.1	113.5	113.9 a	1
LSD	0.05	0.01			LSD	0.05	0.01		
Genotype	0.07	0.10			Genotype	8.5	11.0		
Year	0.03	0.04			Year	4.64	5.73		
Genotype × year	0.14	0.18			Genotype × year	14.1	18.3		

CV bud setting = 4.85 %, CV growth of scion = 8.40%

Studies by Šebek [2010] show that fruit height and width are not directly proportional to the fruit mass, while, according to Brown [1966] and Stančević [1980], the shape of fruit and its size indicate a polygenetic mode of inheritance. Rudloff and Schmidt [1953] determined that there is no link between the fruit weight and number of seeds. In our study, fruit mass is an inherited genetic characteristics. The largest fruit mass of selected genotypes of wild pear was recorded with the 'Genotype 3' (31.55 g) and the smallest with the 'Genotype 10' (7.95 g). Fruit length and width are biological characteristics that depend on the genotype. The longest average fruit length of selected genotypes of wild pear amounts to 36.21 mm ('Genotype 3') and the shortest is 20.12 mm ('Genotype 10'). The highest average fruit width of selected genotypes of wild pear amounts to 33.33 mm ('Genotype 3') and the narrowest is 12.31 mm ('Genotype 10'). Regarding the generative rootstock production, wild pear with the least fruit mass is more commercial than the controlled autochthonous pear varieties.

Pear seeds can be: small, medium, and large [Adamic *et al*. 1936]. Stankovic [1955] states that seed quality is resembled in its morphological and biological characteristics, where the seed size is the most important morphological characteristic, but equal development of seedlings and their resistance depend on biological characteristics (potentials). Seed germination, growing of seedlings and their normal development are also influenced by the seed size, since cotyledons of larger seeds contain more reserve organic materials [Stankovic and Jovanovic 1987]. Our research showed that 1 kg of seeds contains 24,725–38,187 pieces of seeds. Slovic [1953] states that the number of seeds in 1 kg is 30,000–35,000. According to Misic [1984], 100 kg of medium-sized wild pear fruits give around 1.1 kg of seeds. 1 kg of seeds contains 20,000–40,000, or on average, 30,000 seeds.

Having in mind the production of generative rootstocks in Western European countries, Misic [1984] concludes that increasing attention is being paid to fruit trees – pollinators, since only certain hybrid combinations can give at the same time the seeds and seedlings of the high quality. In our study, 'Genotype 11' has low level of seedling vigor, small variability of produced seedlings, regardless of the fact it belongs to the early flourishing varieties of the wild pear. 'Genotype 11' is situated at an altitude of 879 m above sea level, thus the assumption is that its selection of pollinators could be significantly smaller.

The borders of growth, the start, the course and duration of seedling phenophase and their variability have been primarily conditioned by genotype characteristics, which are influenced by external factors [Stampar 1966].

Results of the research conducted by Šebek and Kovačević [2014] indicate that the mutual relation between the cultivar and the rootstock influence some vegetative parameters.

Previously, several reports have been documented the relationships between various physiological parameters of pear cultivar/various rootstocks combinations [Mišić 1984, Stanković and Jovanović 1987, Janik 2005]. These relationships are important from a horticultural point of view, because they provide a basis for selecting the best graft combination for particular environmental conditions and high fruit quality. Selection of an appropriate graft combination is crucial for the production of deciduous orchard species, because the scion–rootstock interaction influences the water relations, leaf gas exchange, plant size, blossoming, timing of fruit set, fruit quality and yield efficiency. The results of our research also show that the rootstock influences the characteristics of produced scions, i.e. the height of the scion and its branching directly depend on the genetic characteristics of the rootstocks used.

CONCLUSIONS

The research was conducted on 11 different wild pear [*Pyrus pyraster* (L.) Du Roi] genotypes, which allows to obtain important phonological and morphological traits.

1. The most important benefit of this study is the fact that the parent trees, the seeds of which provide the best morphological and physiological characteristics for the production of generative rootstocks, were found and favored (*in situ*). The great genetic variability of wild pear is the result of centuries-old adap-

tation of local populations to certain agro-ecological and soil conditions.

2. The highest average fruit mass of selected genotypes of wild pears was recorded with the ʻGenotype 3' (31.55 g) and the lowest with the ʻGenotype 10' (7.95 g). Mass of dry seed (100 pieces) was 2.659 g with the ʻGenotype 1' up to 3.732 g with the ʻGenotype 8'. Regarding the volume of reserve material necessary for germination, the best predispositions are with the ʻGenotype 8' (3.732 g) and the ʻGenotype 11' (3.612 g). The average number of seeds in 1 kg of seeds fluctuates from around 24,725 with the 'Genotype 8' to 38,187 with the 'Genotype 1'. The average seed germination of selected genotypes of wild pears was in the range from 52% (ʻGenotype 7') to 72.3% (ʻGenotype 2'). The average height of seedlings of selected genotypes of wild pears was in the range from 50.4 cm (ʻGenotype 9') to 71.3 cm (ʻGenotype 4'). The average stem diameter (corpulence) of seedlings of the selected genotypes of wild pears was in the range from 5.95 mm (ʻGenotype 9') up to 8.42 mm (ʻGenotype 1').

3. Selected genotypes, especially 'Genotype 11', proved to be the best for mountainous areas of the north Montenegro, higher altitudes and poorer types of soil. The 'Genotype 11' has low level of seedling vigor, small variability of produced seedlings, regardless of the fact it belongs to the early flourishing genotype of the wild pear. 'Genotype 11' is situated at an altitude of 879 m above sea level, hence the assumption is that its selection of pollinators could be significantly smaller. We recommend 'Genotype 11' as potential pear generative rootstock due to the following characteristics:

a) considering the aspect of generative rootstocks production, the mass of the fruit is at the satisfactory level (11.9 g); when it comes to this small fruits, we can obtain out of their relatively small total fruit mass the largest quantity of seeds needed for the production of generative rootstocks;

b) high mass of 100 pieces of dry seeds (3.612 g), as well as very good seed germination; the average germination of seeds for this genotype of wild pear was 65%;

c) low vigor and variability of seedlings;

d) the lowest average growth of annual scions in 'Grand Champion' cultivar (97.6 cm) in comparison to the average growth of scions produced by grafting the generative rootstocks obtained out of other wild pear genotypes used in this elaboration and production process;

e) the level of grafting reception with the cultivar 'Grand Champion' (90.67%) is satisfactory.

4. Autochthonous varieties of pears cannot be used for the generative rootstock production due to the large size of fruit (from 57.3 g to 76.9 g), despite the fact they have good germination of seeds (from 57.3% to 67.3%).

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REFERENCES

Adamic, F. (1936). Pomology of Yugoslavia. Zadruzna knjiga, Beograd.

Allendorf, F.W., Leary, R.F., Spruell, P., Wenburg, J.K. (2001). The problems with hybrids: setting conservation guidelines. Trends Ecol. Evol., 16, 613–622.

Antkowiack, W., Cedro, A., Prajs, B., Wolko, Ł., Michalak, M. (2012). Success of wild pear *Pyrus pyraster* (L.) Burgsd. in colonization of steep sunny slopes: an interdisciplinary study in the Bielinek Reserve (NW Poland). Pol. J. Ecol., 60(1), 57–78.

Bell, R.L., Itai, A. (2011). *Pyrus*. In: Wild Crop Relatives. Genomic and Breeding Resources. Temperate Fruits, Kole, C. (ed.), Springer Verlag, Berlin–Heidelberg, 147–178.

Brown, A.G. (1966). New Fruit from Old. Fruit Present and Future. Royal Hort. Soc., London, 10–24.

Bulatović, S. (1972). Rod *Pyrus* L. In: Flora SR Srbije, vol. 4. Srpska Akademija Nauka i Umetnosti, Beograd, 133–134.

Dengler, A. (1992). Die einheimischen Laubbaumarten Mitteleuropas. In: Waldbau auf ökologischer Grundlage. Paul Parey, Hamburg, 189–190.

Đurić, G., Žabić, M., Rodić, M., Stanivuković, S., Bosančić, B., Pašalić, B. (2015). Biochemical and pomological assesment of European pear accessions from Bosnia and Herzegovina. Hortic. Sci., 42(4), 176–184.

Grosser, D. (1999). Das Holz des Birnbaums – Seine Eigenschaften und Verwendung. Beiträge zur Wildbirne. Bayrische Landesanstalt für Wald und Forstwirtschaft, Freising, 34–39.

Hofmann, H. (1993). Zur Verbreitung und Ökologie der Wildbirne (*Pyrus communis* L.) in Süd-Niedersachsen und Nordhessen sowie ihrer Abgrenzung von verwilderten Kulturbirnen (*P. domestica* Med.). Mitt. Dtsch Dendrol. Ges., 81, 27–69.

Hussain, S., Masud, T., Ali, S., Bano, R., Ali, A. (2013). Some physico-chemical attributes of pear (*Pyrus communis* L.) cultivars grown in Pakistan. Int. J. Biosci., 3(12), 206–215.

Janick, J. (2005). The origins of fruits, fruits growing and fruit breeding. Plant Breed. Rev., 25, 255–321.

Jovančević, R. (1980). Dinamika cvetanja sorti krušaka u uslovima Polimlja. Jugosl. voćar., 53/54(3–4), 191–198.

Kleinschmit, J., Stephan, R. (1997). Wild fruit trees (*Prunus avium*, *Malus sylvestris* and *Pyrus pyraster*). Report of the second meeting of Noble Hardwoods Network, 51–57.

Kleinschmit, J., Stephan, R., Wagner, I. (1998). Wild fruit trees (*Prunus avium*, *Malus sylvestris* and *Pyrus pyraster*) genetic resources conservation strategy. In: Noble Hardwoods EUFORGEN. Available at: www.bioversityinternation-al.org

Mayer, H. (1992). Baumarten des kollinen Eichenmischwaldes. In: Waldbau auf soziologisch-ökologischer Grundlage. Gustav Fischer Verlag, Stuttgart, 120–121.

Milovankić, M. (1980). Pomologija. Poljoprivredni fakultet, Novi Sad.

Milošević, T. (1997). Specijalno voćarstvo. Agronomski fakultet Čačak.

Mišić, P.D. (1984). Fruit rootstocks. Nolit, Beograd, YU.

Monstat. (2012). Statistical Yearbook of Montenegro. Statistical Office, Montenegro.

Neri, D., Urbinati, C., Savini, G., Sanchioni, A. (2005). Age determination and tree-ring growth dynamic in old tree of *Pyrus communis* 'Angelica'. Acta Hortic. 671, 9th Inter. Pear Symp., 623–629.

Oliveira, C.M., Mota, M., Monte-Corvo, L., Goulao, L., Silva, D.M. (1999). Molecular typing of *Pyrus* based on RAPD markers. Sci. Hortic., 79, 163–174.

Paganová, V. (2009). The occurrence and morphological characteristics of the wild pear lower taxa in Slovakia. Hortic. Sci., 36(1), 1–13.

Rehder, A. (1940). Manual of cultivated trees and shrubs. Mac Millan, New York, 389–399.

Rhymer, J.M., Simberloff, D. (1996). Extinction by hybridization and introgression. Annu. Rev. Ecol. Syst. 27, 83–109.

Rudloff, C.F., Schmidt, M. (1953). Investigations on number of seeds and fruit weight and their mutual relations in certain apple varieties. Züchter, 23, 44–61. From Plant Breed. Abstr., 23, 459–460.

Šebek, G. (2010). Mogućnost korišćenja autohtonih sorti za organske krušike. Zbornik radova Prve međuna rodne konferencija zdrave, ekološke i organske proizvodnje hrane Bio Planet BOOK, Zlatibor (Srbija), 131–140.

Šebek, G., Kovačević, V. (2014). Compatibility and vigour of seedling for autochtonous peer in the region of north Montenegro. Genetika, 46(1), 277–286.

Selimovska, A., Miskoska-Milevska, E., Najdenovska, O., Canev, I. (2015). Fruit characteristics of some traditi onal pear varietes in the Prespa region. Acta Agric. Serb., 20(40), 107–115.

Senser, F., Scherzo, H., Munchen, G. (1999). Tablas de composicion de alimentos, 2nd ed. Editorial Acribia, Zaragosa.

Slovic, D. (1953). Organization of nurseries and fruit seedling production. Zadruzna knjiga, Beograd.

Stampar, K. (1966). Opce vocarstvo. I deo, Zagreb.

Stančević, A. (1980). Kruška. Nolit, Beograd.

Stanković, D. (1955). General fruit growing, part I, Biological and ecological characteristics of fruit production. Naučna knjiga, Beograd.

Stanković, D., Jovanović, M. (1987). General fruit growing. IRO Gradjevinska knjiga, Beograd, YU.

Stephan, B.R., Wagner, I., Kleinschmit, J. (2003). EUROFORGEN Technical Guidelines for genetic conservation and use for wild apple and pear (*Mauls sylvestris* and *Pyrus pyraster*). International Plant GeneticResources Institute, Rome, Italy, 6 pp.

Terpo, A. (1985), Studies on taxonomy and grouping of *Pyrus* species. Feddes Repert., 96, 73–87.

Turkin, A.V. (1954). Ispoljzovanje dikorastućih plodovojabolćnih i orehoplodnih rastenj. Selhozgiz, Moscow.

Türk, W. (1999). Wildbirne (*P. pyraster*) und Wildapfel (*M. sylvestris*) als Bestandteil einheimischer Gehölzgesellschaften. Beiträge zur Wildbirne. Bayrische Landesanstalt für Wald und Forstwirtschaft, Freising, 9–15.

Thibault, B., Watkins, R., Smith, R.A. (1983). Pear descriptors. CEC, Brussels, International Board of Plant Genetic Resources, Rome.

Wilhelm, G.J. (1998). Beobachtungen zur Wildbirne. AFZ Wald, 53(16), 856–859.