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PHENOLOGICAL CHARACTERISTICS AND GLOBAL TREE ARCHITECTURE OF THE PEAR GERMPLASM FROM BOSNIA AND HERZEGOVINA IN *EX SITU* CONDITIONS

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Abstract
Fruit germplasm plays an important role in the global agrobiodiversity and is a source for both a direct use of fruit genetic resources as well for fruit breeding programme. The *ex-situ* field collection is still the main way to successfully conserve fruit germplasm. Thirty pear accessions from Bosnia and Herzegovina were characterized during three years in the *ex situ* collection maintained by the Institute of Genetic Resources of the University of Banja Luka. The following characteristics were determined: flowering time, harvest maturity time and global tree architecture. The obtained results showed that 53.3% of pear accessions flowered during all three years, 40% of them during two years and 6.7% of them during only one year. The most present tree architecture form was upright. According to the harvest maturity time, extremely early accessions were the most represented, than early, medium and very early pear accessions. Conserved pear germplasm in this *ex situ* collection represents a valuable material for direct use and future breeding programmes.

Keywords: descriptors, accession, flowering, harvesting time.

Introduction
The Balkan Peninsula in general, as well as Bosnia and Herzegovina (BIH), is very rich in pear germplasm, which is confirmed through a few previous expedition missions (Zwet, 1983; Paunović, 1991; Đurić 2009b). Pear genetic resources present in traditional pear cultivars were mostly maintained in home gardening throughout the centuries. In the last few decades, they have been threatened by being replaced with new commercial cultivars. Both, increasing of the climate changes and genetic erosion, negatively affect the fruit germplasm. Activities which can reduce these negative effects are connected to the regular activities of the plant gene banks (Đurić *et al*. 2009a,b). Pear germplasm in gene banks is

conserved in *ex-situ* fruit field collection. Inventarization of fruit germplasm, collecting, characterization and evaluation represent one complete circle, which is necessary to conduct for conservation and sustainable use of fruit germplasm. Conservation activities of the fruit genetic resources in the Republic of Srpska (BIH) have been implemented trough the Working group for fruits and *Vitis* by the Institute of Genetic Resources of the University of Banja Luka. Within the gene bank in the Institute, a fruit field collection was established in 2013. Apple, pear, cherry and plum were collected and conserved in the collection. Determining phenological, pomological and morphological characteristics of accessions in the collection were the main tasks within conservation activities. Determination of the phenological characteristic of pear germplasm is very important primarily for the gene bank, but also for producers and consumers (Đurić, 2014; Espiau and Alonso 2015). Phenological phases, harvest maturity, tree architecture and morpho-pomological characteristic of autochthonous genotypes has a huge variability comparing to the commercial varieties (Đurić *et al*. 2014). Tree architecture evolved as a scientific approach between 1960 and 1970, mostly in tropical forests, but from 1990 the idea was developed at INRA (France) to implement this concept on fruit trees with the aim to analyze genetic diversity and improve breeding and pruning (Lauri, 2015). Sansavini and Musacchi (1994) gave an overview of five models of fruiting wood on pear cultivars in order to explain the necessity of different pruning and fruit setting. The goal of this research was to determine the phenophases of the flowering, harvest maturity and global tree architecture of thirty flowered pear accessions. This is the first step in the characterization process in order to identify accessions with specific characteristics and to direct them for direct use or to the breeding program, but also to eliminate possible duplicates. Previous research conducted on pear accession in order to determine uniqueness and to describe characteristics, which are valuable both for breeding programmes and for direct users, confirmed the importance of such research activities (Espiau and Alonso 2015; Đurić, 2014; Maqsood *et al*., 2017).

Material and Methods

Thirty pear accessions were analysed from *ex situ* fruit field collection located in the Botanical garden of the Institute of Genetic Resources of the University of Banja Luka (Table 1). This *ex-situ* fruit collection was planted in 2013.

In order to determine the phenological phases of flowering and fruiting, 30 pear accessions were followed for three years (2016, 2017 and 2018) for the following phases of flowering: beginning of the flowering (about 10% of flower open), full flowering (at least 50% of flowers open, first petals falling) and end of flowering (all petals fallen) according to Meier (2001). Photo documentation of the phenophases was done each five days for the duration of phenophases with Nikon D5300 camera (Nikon Corporation, Japan). The determination of the harvest maturity of 30 pear accessions and global tree architecture were screened according to the IBPGRI descriptors (Thibault *et al*., 1983). Analysis and graphical presentations were conducted with the use of statistical software package IBM SPSS 22.

Table 1. List of pear accessions in the *ex-situ* fruit field collection

Name of the accession	Gene bank number
Litrenjača	PKB-K-3
Ilinjača	PKB-K-6
Batvača	PKB-K-8
Arapka crna	PKB-K-10
Ječmenka	PKB-K-14
Hošija	PKB-K-16
Čađanka	PKB-K-17
Jagodnjača	PKB-K-18
Kantaruša	PKB-K-19
Citronka	PKB-K-20
Kongresovka	PKB-K-21
Čavka	PKB-K-22
Mednica	PKB-K-23
Ljetna kolačuša	PKB-K-24
Nepoznato ime 2	PKB-K-25
Sarajka	PKB-K-29
Sarevka	PKB-K-31
Okrugla bostanka	PKB-K-32
Jesenja kolačuša	PKB-K-34
Glibanjka	PKB-K-35
Bijela takiša	PKB-K-37
Nepoznato ime 2	PKB-K-40
Duplagica	PKB-K-41
Medenka	PKB-K-137
Stambolka	PKB-K-138
Urumenka	PKB-K-139
Avraška	PKB-K-140
Izmirska	PKB-K-141
Batva	PKB-K-142
Duplagica	PKB-K-143

Results and discussion

Flowering of the pear accessions from the *ex-situ* collection was very different during three years of observation (2016, 2017 and 2018). From the total of 30 accessions, 53.3% of them flowered during all tree years, 40% during two years and 6.7% during only one year. The earliest beginning of the flowering was recorded in 2017 on 19th March for accession PKB-K-16 (Hošija), while the earliest full flowering was recorded in same year on 27th March for the accessions Hošija and PKB-K-40 (Nepoznato ime 2). The earliest end of flowering was recorded also in 2017 on 2nd April for accessions PKB-K-40 (Nepoznato ime 2). All three phenophases of flowering (beginning, full, end) were obtained as the earliest timing in 2017. Comparing to the earliest timing, the latest timing of these phenophases was in 2018, as follows: the beginning of flowering on 15th April for accessions PKB-K-137 (Medenka) and PKB-K-142 (Batvača), full flowering on 20th April and end of flowering on 25th April for accession PKB-K-137 (Medenka) (Figure 1). The latest beginning of flowering was observed for the majority of studied cultivars in 2018. The same is related to the dates of full flowering and the end of flowering in this year. The earliest beginning of flowering and earliest full flowering was observed in 2017. The year of 2016 was specific with later beginning and full flowering in comparison to 2017 and earlier in comparison to 2018. According to the flowering time in all three years, some cultivars are indicative as early flowering, such as PKB-K-40 (Nepoznato ime 2) and PKB-K-16 (Hošija). Other cultivars are indicative as late flowering, such as PKB-K-31 (Sarevka) and PKB-K-13 (Litrenjača).

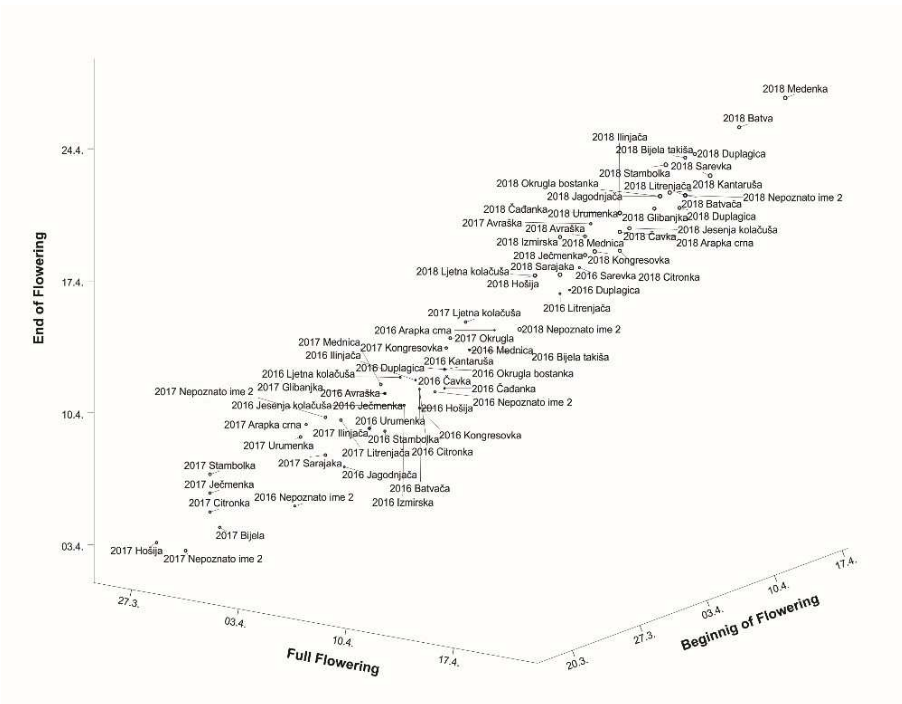

Figure 1. Dynamics of flowering of pear accessions (beginning, full, end) during three years of observation (2016, 2017 and 2018)

According to the length of flowering period, the studied pear accessions are grouped in three groups, i.e. 1) longer flowering period, 2) shorter flowering period and 3) group with mid duration of flowering (Figure 2).

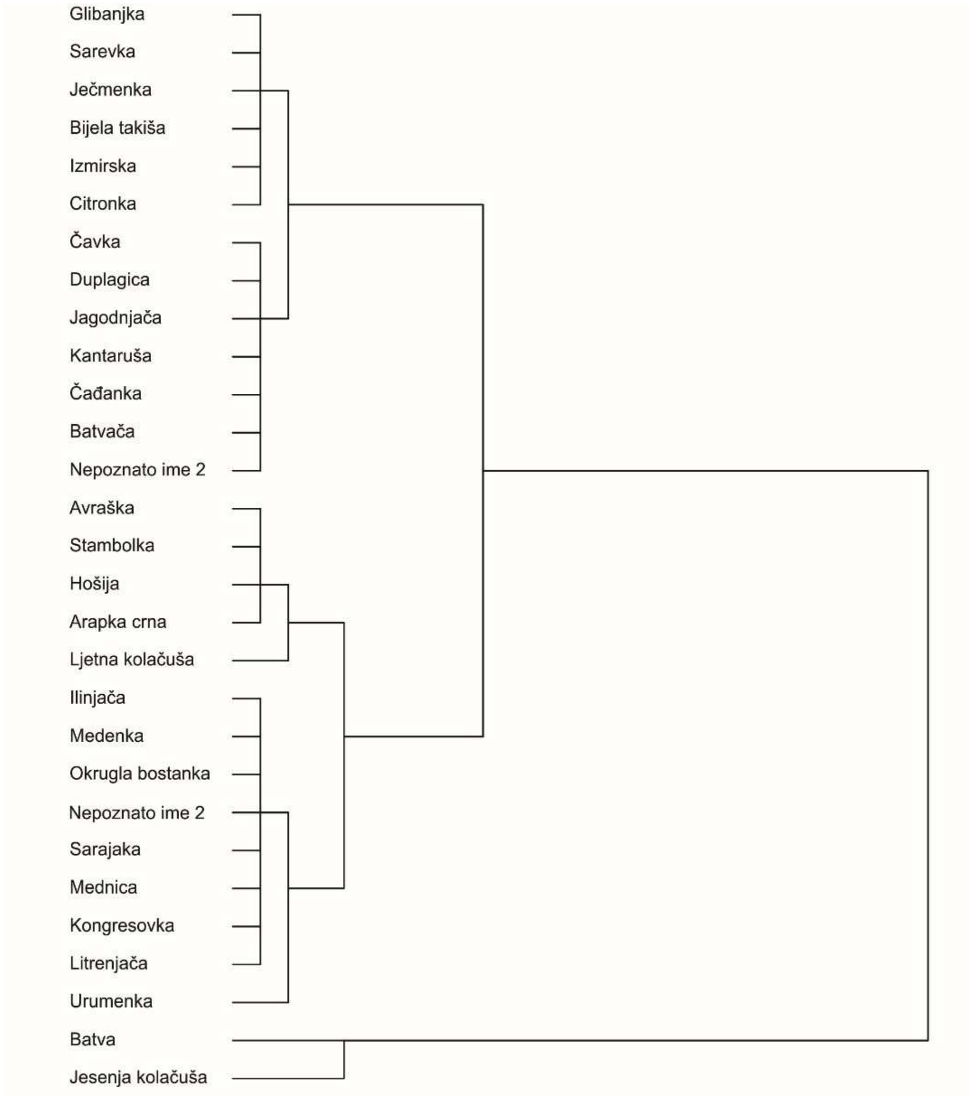

Figure 2. Dendrogram representing studied pear accessions clustered in relation to duration of flowering period measured from the beginning to the end of flowering

The duration of flowering for 30 pear accessions was between 8 and 15 days. Determination of the duration of flowering was reported by Ahmed *et al.* (2017) who reported the duration of flowering between 11 and 24 days, which is higher than in this study. Đurić *et al.* (2014) find that the duration of the flowering of pear germplasm in BIH was in average range of 15 days, which is slightly higher than in this study. A lower duration of flowering, between 6-8 days was reported by

Periera-Lorenzo *et al.* (2012). This indicates that flowering of the pear germplasm in this research was in the range of previous studies.

Table 2. Pear accessions which fruited during observation period and their grouping according to the preliminary harvest maturity time

Extremely early ripening	**Very early ripening**
PKB-K-6 (Ilinjača) PKB-K-8 (Batvača) PKB-K-14 (Ječmenka) PKB-K-16 (Hošija) PKB-K-17 (Čađanka) PKB-K-18 (Jagodnjača) PKB-K-19 (Kantaruša) PKB-K-24 (Ljetnja kolačuša) PKB-K-25 (Nepoznato ime 2) PKB-K-29 (Sarajka) PKB-K-35 (Glibanjka) PKB-K-40 (Nepoznato ime 2) PKB-K-41 (Duplagica) PKB-K-138 (Stambolka) PKB-K-139 (Urumenka) PKB-K-143 (Duplagica)	PKB-K-32 (Okrugla bostanka) PKB-K-141 (Izmirska)
Early ripening	**Medium ripening**
PKB-K-20 (Citronka) PKB-K-23 (Mednica) PKB-K-31 (Sarevka) PKB-K-34 (Jesenja kolačuša) PKB-K-37 (Bijela takiša) PKB-K-137 (Medenka) PKB-K-140 (Avraška) PKB-K-142 (Batva)	PKB-K-3 (Litrenjača) PKB-K-10 (Crna arapka) PKB-K-21 (Kongresovka) PKB-K-22 (Čavka)

Fruiting of thirty pear accessions during three years was uneven. In 2017, the lowest number of fruiting accessions was recorded, only four of them. The highest number of fruiting accessions was recorded in 2018, in total 20 accessions. In 2016, fruiting was recorded on 9 accessions. Only 2 accessions were fruited in all three years, 8 of them during two years and 20 were fruited just in one year of observation (Table 2). In accordance with IBGRI descriptor for pear (Thibault *et al*., 1983), pear accessions can be preliminary separated by harvest maturity time in the following groups: extremely early (16 accessions), very early (2 accessions), early (8 accessions) and medium (4 accessions). The accession PKB-K-14 (Ječmenka), had the earliest ripening, whereas accession PKB-K-10 (Arapka crna) had the latest ripening. More than 50% of the analyzed accessions are grouped as early summer cultivars which is in the accordance with the previous research conducted by Đurić *et al.* (2014). Ozturk and Demirsoy (2013) in their study also

reported that the highest number of analysed pear accessions were in the group of the very early harvest maturity.
Screening of the 30 pear accessions for tree architecture was done in order to characterize their habitus. This is a very important step in the determination process of the accession uniqueness in the *ex-situ* collection. According to the tree architecture, the analysed pear accessions can be divided in four groups. In first group there are accessions with upright tree form (53.3%), in second group there are accessions with spreading tree form (30%), then upright "Fastigiate" (10%) and drooping (6.7%). The most present tree form was upright and the least present tree form was dropping.

Table 3. Grouping of BIH pear accessions according to global tree architecture

Upright	**Spreading**
PKB-K-8 (Batvača)	PKB-K-3 (Litrenjača)
PKB-K-10 (Arapka crna)	PKB-K-6 (Ilinjača)
PKB-K-18 (Jagodnjača)	PKB-K-14 (Ječemnka)
PKB-K-19 (Kantaruša)	PKB-K-16 (Hošija)
PKB-K-22 (Čavka)	PKB-K-21 (Kongresovka)
PKB-K-23 (Mednica)	PKB-K-31 (Sarevka)
PKB-K-24 (Ljetnja kolačuša)	PKB-K-37 (Bijela takiša)
PKB-K-32 (Okrugla bostanka)	PKB-K-138 (Stambolka)
PKB-K-34 (Jesenja kolačuša)	PKB-K-142 (Batva)
PKB-K-35 (Glibanjka)	
PKB-K-41 (Duplagica)	
PKB-K-137 (Medenka)	
PKB-K-139 (Urumenka)	
PKB-K-140 (Avraška)	
PKB-K-141 (Izmirska)	
PKB-K-143 (Duplagica)	
Very upright "Fastigiate"	**Drooping**
PKB-K-20 (Citronka)	PKB-K-17 (Čađanka)
PKB-K-25 (Nepoznato ime 2)	PKB-K-29 (Sarajka)
PKB-K-40 (Nepoznato ime 2)	

The analysed pear accessions fruited differently in the examined period. Accessions which fruited during three years had upright and spreading tree form while accessions which fruited during two years had upright, spreading and dropping tree form. The most represented tree form for accessions which fruited in one year was upright and very upright.
The obtained results showed differences between analysed pear accessions and also represent an overview of the important characteristics for characterization and growing. Similar findings were reported for Czech pear germplasm collection

which is also marked as interesting for breeding programmes (Paprstein *et al.* 2017).

Conclusions

During the examination period of three years, the flowering of 30 accessions was uneven. In 2018, all phenophases of flowering were observed as the latest, while in 2017, the earliest beginning of each phenophase was observed. Regardless of the length of flowering, three groups of accessions were identified: 1) accessions with longer flowering period, 2) accessions with shorter flowering period and 3) accessions with mid duration of flowering period. The majority of accessions belonged to the extremely early ripening accessions, more than 50% of analysed accessions belong to the early summer cultivars. Only 13.3 % of accessions belong to the late summer cultivars. The most present tree form of the pear accessions was upright. Two pear accessions gave fruits during three years and they had upright (PKB-K-138 Duplagica) and spreading tree forms (PKB-K-140 Avraška). Eight pear accessions gave fruits during two years and they mostly had upright, then spreading and dropping tree form. Accessions, which fruited in just one year, had mostly upright and very upright form. All these results showed that the pear germplasm from the *ex-situ* fruit field collection of the Institute of Genetic Resources of the University of Banja Luka (BIH) represent an interesting material for gene banks, but also for producers and as a starting material for breeding programmes.

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References

Ahmed, M., Anjum, M.A., Hussain, S., Ejaz, S., Ahmad, A. & Ercisli, S. (2017): Biodiversity in Indigenous Germplasm of Pyrus from Pakistan Based on Phenotypical and Morphological Traits. *Erwerbs-Obstbau*, 59: 19-27.

Đurić, G., Tomić, L., Radun, M. & Pećanac, D. (2009a): *Očuvanje i održivo korišćenje biljnih genetičkih resursa u Republici Srpskoj*. Naučno stručni skup sa međunarodnim učešćem «Zaštita i zdravlje na radu i zaštita životne sredine», Banjaluka. Zbornik radova: 81-94.

Đurić, G., Tomić, L., Mićić, N., Cvetković, M., Radoš, Lj. & Pašalić, B. (2009b): Fruit genetic resources in Republika Srpska. *Acta Agriculturae Serbica*, 15(28): 31-40.

Đurić, G., Mićić, N. & Salkić, B. (2014) Evaluation of pear (*Pyrus communis* L.) germplasm collected in Bosina and Herzegovina using some pomological and ecophysiological characteristics. *Acta Horticulturae* 1032: 105-115.

Espiau, M.T. and Alonso, J.M. (2015): Phenotypical characterization of landraces and local germplasm in the Spanish pear germplasm bank in Zaragoza. *Acta Horticulturae* 1094, 139-144.

Lauri, P. (2015): *Apple and pear tree architecture a way to improve orchard management*. WSU Fruit School – Apple and pear horticulture. WSU Tree Fruit Extension (available at https://docplayer.net/48095078-Apple-and-pear-tree-architecture-a-way-to-improve-orchard-management.html)

Meier, U. (2001). Growth stages of mono-and dicotyledonous plants. BBCH Monograph 12, 141–147.

Maqsood, A., Anjum, M. A., Sajjad, H. Ejaz, S. & Ahmad, S. (2015): Biodiversity in indigenous germplasm of *Pyrus* from Pakistan based on phenotypical and morphological traits. *Erwerbsobstbau*, 59(1): 19-27.

Ozturk, A. & Demirsoy, L. (2013): Promising Pear Genotypes from North Anatolia, Turkey: Preliminary Observations. *Journal of the American Pomological Society*, 67(4): 217-227.

Paprstein, F., Sedlak, J. & Holubec, V. (2017): Pear genetic resources in the Czech Republic. *Acta Horticulturae* 1172, 245-248.

Paunović, S. (1991): Banka gena voćaka Jugoslavije, Izveštaj. Agronomski fakultet Univerziteta u Kragujevcu, 19-33.

Pereira-Lorenzo, S., Ferreira dos Santos, A.R., Ramos-Cabrer, A. M., Saub, F. & Díaz-Hernández, M.B. (2012). Morphological variation in local pears from north-western Spain. *Scientia Horticulturae*, 138:176-182.

Sansavini, S. & Musacchi, S. (1994). Canopy architecture, training and pruning in the modern european pear orchards: an overview. *Acta Horticulturae* 367: 152-172.

Thibault, B., Watkins, R. & Smith, R.A. (1983). Descriptor list for pear (*Pyrus*). CEC Secretariat, Brussels, IBPGR Secretariat, Rome.

Zwet, V. D. T., Stankovic, D. & Cociu, V. (1983): Collecting *Pyrus* germplasm in Eastern Europe and its significance to the USDA pear breeding program. *Acta Horticulturae*, 140: 43-45.

IBM SPSS 22: *IBM SPSS Statistics Base* (available at https://ibm-spss-statistics-base.en.uptodown.com/windows)