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FRUIT PROPERTIES OF SWEET CHERRY (*PRUNUS AVIUM* L.) SUITED FOR WOOD PRODUCTION

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Abstract
Sweet cherry *Prunus avium* L. cultivated for wood production is selected and bred mainly based on its growth rate and stem properties to maximize the valuable timber outcome. However, the fruit of sweet cherry has ecological value as food source for animals and can also serve as an income source prior felling. It could be beneficial to consider fruit properties in selection and breeding of cherries for wood production purpose. In this study, we compare the properties, such as volume and moisture content, of fruit collected from cherry orchard and two plantations, where sweet cherry is cultivated for wood production. Based on fruit and trunk properties we select genotypes from cherry orchard, that are promising for further studies and development of locally sourced planting material. Fruit of ten genotypes cultivated for fruit and nine genotypes cultivated for wood was collected in July, 2020. Fruit was then scanned to calculate volume, pitted, weighted and oven dried to obtain dry matter and moisture content. The results show that fruit cultivated in orchard have greater volume and weight, as well as have more pulp compared to genotypes selected for wood production. The relative moisture and dry matter content of the pulp does not follow the same trend, and is not directly associated with morphological properties. Based on fruit size, moisture content and trunk diameter 'Kazdangas', 'Agrais Lielajiem Ķiršiem', 'Brjanskaja Rozovaja' and 'Muiža' are the most promising genotypes for further studies aimed to develop planting material with good fruit yield and timber outcomes.
Key words: cherry plantation, fruit traits, cherry fruit volume, pomology, wild cherry.

Introduction

Sweet or wild cherry *Prunus avium* L. syn. *Cerasus avium* (L.) Moench has gained interest as a fast growing hardwood tree species, that has been studied since the late 80's of the last century (Ducci *et al*., 2013; Russell, 2003; Welk, de Rigo, & Caudullo, 2016). Cherry trees can be cultivated specifically for timber production (Kobliha, 2002; Pryor, 1988); however, historically it has mainly been selected, bred and cultivated for its fruit properties. While the interest in sweet cherry plantation establishment is increasing in Latvia, at the moment sweet cherry wood production happens only on a small scale (Daugaviete *et al*., 2021). Management approaches differ depending on the aims of a plantation. Fruit orchards require regular weed and pest control, trees are heavily pruned, trained and are typically kept at a low height of about 3-4 m (Green, 2005)tall, freestanding trees to much higher planting densities utilizing two approaches to tree training and management. The first system, named the Lenswood tie down system, relies on extensive tying of vigorous branches to a horizontal orientation to induce cropping and manage vigor. This system has often resulted in excessive vigor and shading from the manipulated branches. The second system is a modification of the Spanish bush system. Two versions of this have evolved: the Aussie bush (4 leader bush. Wood producing plantations require less intense management – weed control is crucial in early stage of development (Pryor, 1988) and trees are pruned to reduce competition and promote production of straight and thick trunks. In wood producing plantations, stock material of foreign origin (usually Swedish or Danish) is typically used, as it has shown better growth results compared to locally sourced planting material. On the other hand, selection and breeding of local forms for superior fruit properties, winter hardiness and disease tolerance has been ongoing for decades. There is limited available information on fruit properties of genotypes selected for wood production and vice versa. Some of the genotypes that bear desirable fruit also possess dendrometric qualities that are promising for wood production (Kobliha, 2002). Assessment of the actual growth rate and dendrometric features of these genotypes still needs to be carried out, especially in field conditions. Thus, in this study we focus on fruit properties. Fruit yield may serve as an additional source of income from cherry stands established for wood production (Hasanbegovic, Hadziabulic, & Aliman, 2020). In addition, selection of genotypes that produce high fruit yields can increase the ecological value of sweet cherry as a food source for wild animals (Welk, de Rigo, & Caudullo, 2016). The aim of this study was to evaluate and compare fruit properties of sweet cherry genotypes selected specifically for wood production and genotypes that have been mainly selected for their fruit quality but possess dendrometric properties – thick and straight trunks – potentially suitable for wood production.

Materials and Methods

Sweet cherry fruit was collected from two plantations and one orchard. In plantation located in Skriveri (56.69 N, 25.14 E), Swedish clone 10 and Swedish clone 13 were planted in 2011. In another plantation, located in Īslīce (56.33 N, 24.11 E), planting material developed in Denmark – Truust F791 provenience – was planted in 2011, fruits of seven trees (genotypes Truust 1, Truust 2, Truust 3, Truust 4, Truust 5, Truust 6 and Truust 7) were collected, as the trees are not genetically identical and fruit differs among individual trees. Ten sweet cherry tree genotypes with straight and thick trunks were selected for fruit collection in cherry orchard located in the Institute of Horticulture in Dobele (56.61 N, 23.30 E) – 'Agrais Lielajiem Ķiršiem', 'Aizkraukles Saldais', 'Brjanskaja Rozovaja', 'Kalniņa Sējenis', 'Kārzdabas', 'Muiža', 'Muiža 2', 'PU 14 498', 'Smiltenes' and 'Smiltenes 9'. In cherry orchard trees were planted in 2006. During fruit collection trunk diameter at 1.3 m height (diameter at breast height) of selected genotypes was measured. Cherry fruits were collected at random heights and face of the crown. There is a small number of individual trees per each genotype in the cherry orchard, thus, only in some cases it was possible to collect fruit from multiple trees of the same genotype. Fully ripe fruits were collected during the period 24.-31. July, 2020.

From each genotype, 50 fruits were scanned using EPSON Expression 12000XL scanner, pitted and 50 cherry pits were scanned. Fruit and pit length, width and volume were calculated based on scanned images WinSEEDLE™ Pro (version 2019a; Regent Instruments Canada Inc.).

Fifty fresh fruits of each genotype were weighted, pits were removed and weighted (with 0.01 g precision). The average weight per fruit and pit and their proportion was calculated. Fifty grams of fresh pulp per genotype was dried at 40 °C until constant weight to evaluate pulps' moisture content. Due to pooled sample approach the statistical analysis for these parameter was not conducted.

All data analysis and visualization was carried out using R version 4.0.5 (R Core Team, 2021). Non-parametric Kruskal-Wallis test and HDS Tukey's post hoc test were used to compare the groups. Clustering dendrogram was created based on fruit volume (mm^3), length (mm), width (mm), fresh weight (g), pits' fresh weight (g), pulps' proportion (%), pits' proportion (%), pulpls' fresh and dry weight (g), moisture content (%) and dry matter content (%).

Results and Discussion

In terms of morphological features, cherries cultivated for fruit production had larger and heavier fruit, with exception of 'Kalniņa Sējenis', that was more similar to genotypes selected for wood production. The mean pit volume followed similar pattern as the whole fruit – larger pits were typical to larger cherry fruits (Figure 1). Fruit of larger mean volume also had higher variance compared to smaller fruits collected from trees that are bred and cultivated

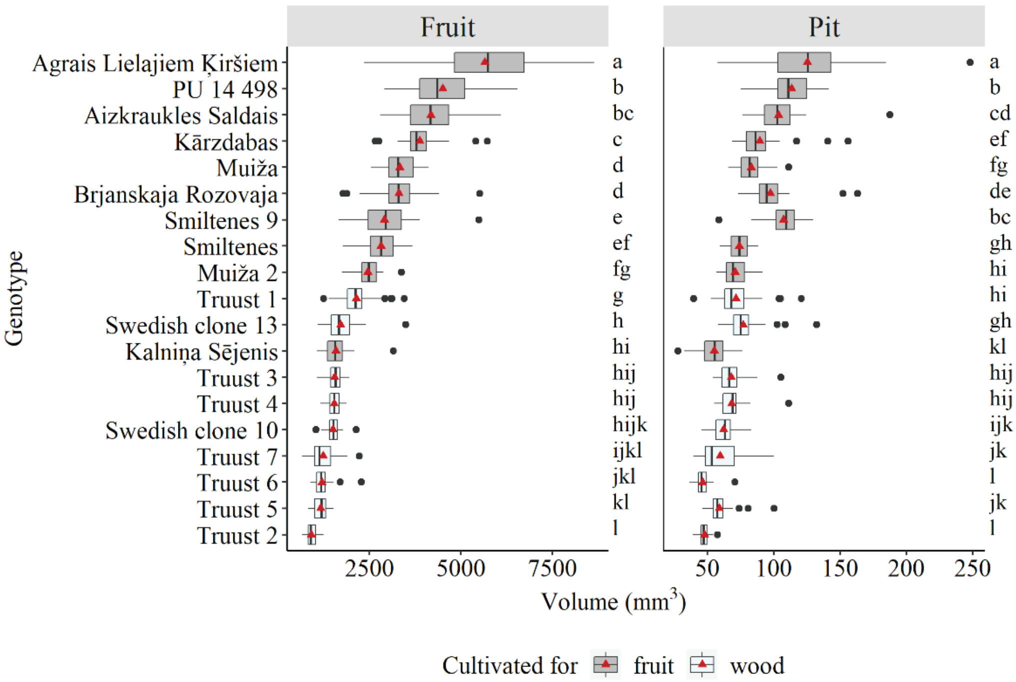

Figure 1. Volume of sweet cherry fruits and their pits depending on genotype and cultivation purpose. Different letters on the right side represent significant (p <0.05) differences between genotypes. Box shows interquartile range (25-75%), vertical line in the box represents median, red triangle shows the mean, whiskers represent maximum and minimum values and black dots show outliers.

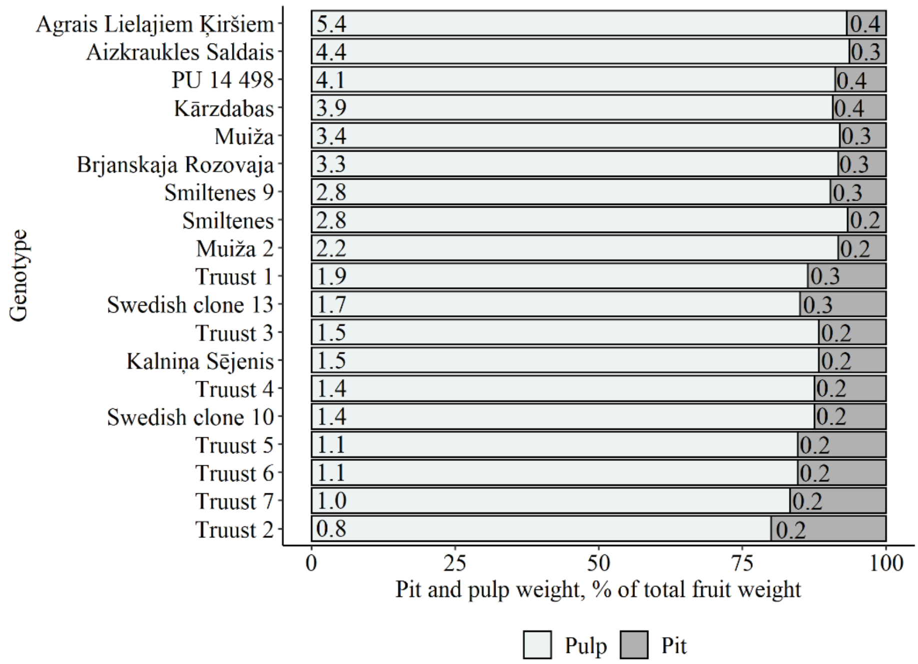

Figure 2. Relative weight of sweet cherry fruit pulp and pit depending on genotype.
Values inside bars represent average pulp and pit weight in grams.

for wood production. There were significant fruit and pit volume differences amongst fruit produced by Truust F791 provenience originated planting material. Truust genotypes have been selected and bred for rapid growth and straight trunks, but some, such as Truust 1, can also produce desirable fruit. It should be noted that fruit analysed in this study was collected from different areas under different managements, thus, the local microclimate as well as management practices may affect the results.

Fruit weight followed the same pattern as the volume, where 'Agrais Lielajiem Ķiršiem' had the heaviest fruit with mean weight of 5.8 grams, followed by 'Aizkraukles Saldais', 'PU 14 498' and 'Kārzdabas'. The fruit of these genotypes had bigger volume, total weight and more absolute as well as relative pulp compared to most other studied genotypes. In addition, these genotypes had heavier and bigger pits, making them better suited for propagation via seeds. Cherries cultivated for wood had smaller fruit, they had less relative pulp (82.5-88.5%), whereas cherries cultivated for fruit production had more absolute (1.5-5.4 g) as well as relative pulp (89.5-94.0%) (Figure 2). Overall, pits comprised from 6.0 to 17.5% of the total fruit (11.5-17.5% of fruit from trees cultivated for wood and 6.0-10.5% of fruit from trees cultivated for fruit).

In terms of marketing, fruit physical properties, such as the density of the pulp, water content, skin thickness as well as morphological and visual features and taste quality are of great importance (Bujdosó *et al.*, 2020). Water content of cherry fruit (Figure 3) did not follow the same trend as size properties (Figure 1). Water content has to do with fruit firmness as well as their ripeness stage during harvest. While 'Kārzdabas', 'PU 14 498' and 'Aizkraukles Saldais' had some of the biggest and heaviest fruit, their relative moisture content was also high compared to other genotypes. Based on the relatively small size and non-uniform shape, as well as high moisture content, thus, reduced transportability and possibly lower resilience to long term storage, all of the studied fruit are better suited for processing market rather than fresh market. In other studies the preferred weight of a cherry fruit has been found to vary between 11 and 13 g (Kappel, Fisher-Fleming, & Hogue, 1996)based on average fruit weight, for sweet cherries was ll to 12 g. A nine- row or 29- to 30-mm-diameter sweet cherry would be the equivalent industry standard. When two separate panels were conducted with overlapping samples, panelists had similar results for optimum fruit size. The optimum color is represented by the 6 color chip of the prototype of the Centre Technique lnterprofessionnel des Fruits et Legumes (CTIFL, which is at least twice as much as the heaviest cherries – 'Agrais Lielajiem Ķiršiem' (Figure 2) – in this study. Consumer and producer aim for fruit size from 21 mm up to more than 29 mm in diameter (Bujdosó *et al.*, 2020; Ladner *et al.*, 2008; Turner *et al.*, 2008), and only three genotypes – 'Agrais Lielajiem Ķiršiem', 'Aizkraukles Saldais' and 'PU 14 498' – had the average size above 21 mm. However, the taste is still

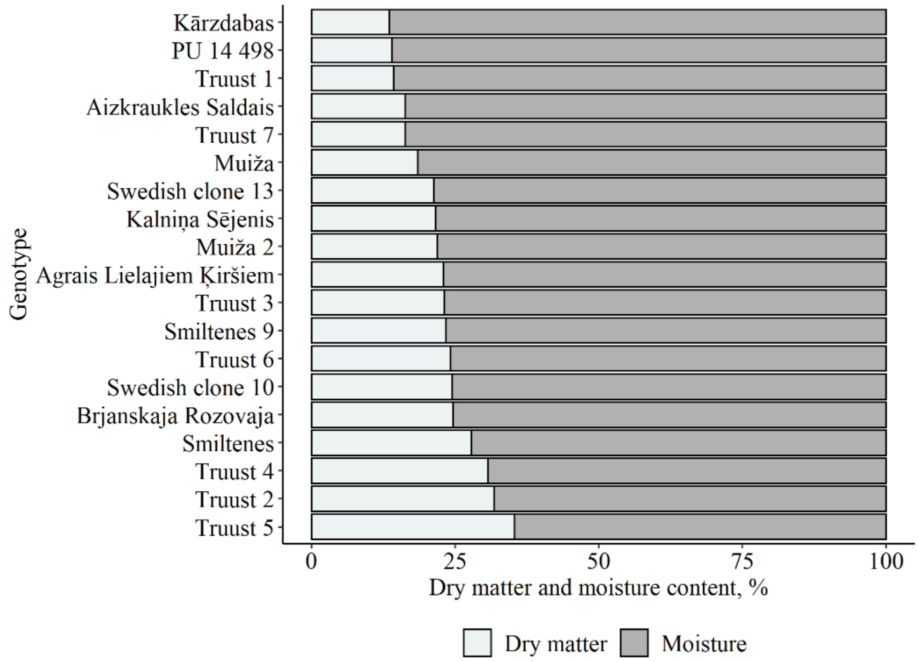

Figure 3. Dry matter and moisture content of sweet cherry fruit pulps depending on genotype.

the main determining factor of consumers' preference (Turner *et al.*, 2008).

Based on the properties studied, genotypes were grouped in four clusters (Figure 4). 'Agrais Lielajiem Ķiršiem' is the most different of the genotypes in terms of fruit (Figure 1 and 2), having the biggest fruit size. 'Aizkraukles Saldais', 'Kārzdabas' and 'PU 14 498' also have desirable fruit; however, 'Aizkraukles Saldais' and 'PU 14 498' had the smallest trunk diameter at breast height (13.9 and 13.4 cm respectively), whereas 'Kārzdabas' was the thickest (23.6 cm) of trees selected from cherry orchard. The replicate number in orchard is too low to evaluate if these stem properties are typical to the genotype. Thus, further growth studies must be carried out, to accurately assess the wood producing potential of selected genotypes. 'Smiltenes 9', 'Smiltenes', 'Muiža', 'Brjanskaja Rozovaja' and 'Muiža 2' have medium fruit. Of this cluster, 'Smiltenes' was the thickest – 23.2 cm – followed by 'Brjanskaja Rozovaja' – 19.8 cm. 'Kalniņa sējenis' is more similar to genotypes grown in plantations –

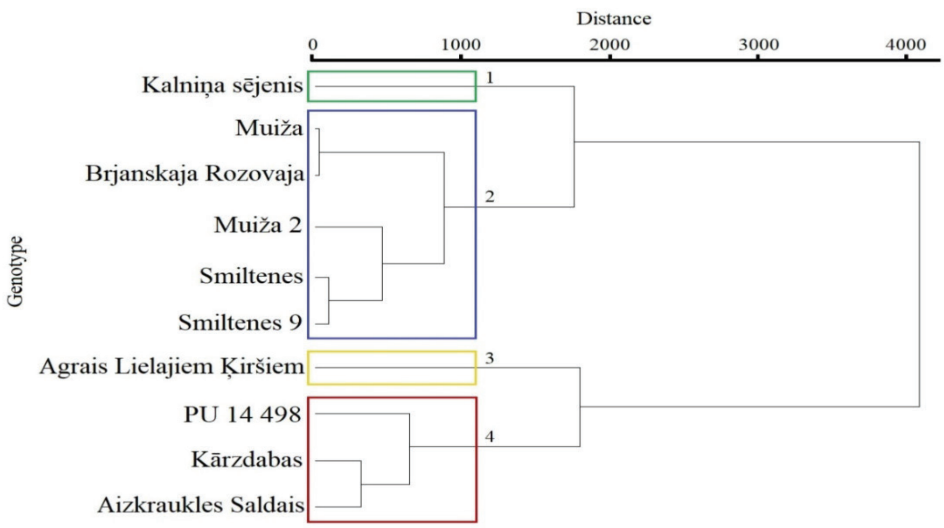

Figure 4. Dendrogram showing results of hierarchical cluster analysis conducted on seven fruit traits and tree diameter at breast height of ten sweet cherry genotypes (based on Euclidian distance). Numbers on the dendrogram branches represent four clusters.

with relatively small fruit, but good trunk properties (diameter at breast height – 19.8 cm). If the diameter at breast height is considered in combination with fruit properties, 'Kārzdabas', 'Agrais Lielajiem Ķiršiem', 'Brjanskaja Rozovaja' and 'Muiža' are the most promising genotypes for propagation with intent to obtain a good compromise between fruit and timber production.

The results of this study show, that cherries bred and cultivated for wood production have small fruit that can compete with fruit from orchards only in terms of dry matter and moisture content (thus, the potential juice yield). Greater biomass accumulation occurs when more resources can be allocated into growth rather than other processes (including reproductive processes and fruit bearing) (Castro-Díez, Montserrat-Martí, & Cornelissen, 2003; Martín *et al*., 2015). Thus, there will always be some trade-offs between wood and fruit production. However, some compromise could be achieved through selective breeding and also by adapting management practices accordingly. To obtain some financial benefit from fruit in plantations established with purpose of wood production, fruit harvesting could be carried out simultaneously with pruning operations. While intensive pruning can decrease tree growth rate (Springmann, Rogers, & Spiecker, 2011)pruning artificially is the only practical option. The study analysed the effect of conventional whorl-wise pruning and selective pruning, on height growth, diameter growth and secondary shoot development of wild cherry. Four pruning treatments were applied on cherry trees in summer 2007, one group of cherries was left unpruned to serve as a control: treatment C1 (upper 5 whorls left, summer pruning effect on fruit productivity is either positive or neutral (Measham *et al.*, 2017; Roversi, Ughini, & Monteforte, 2008)various combinations of winter and summer pruning treatments were imposed on eight-year-old trees of four sweet cherry varieties. For each variety, 5 different types of pruning strategies were imposed, combining winter pruning (made with 2 levels of pruning intensity. However, in pruning the lower portion of branches that bear relatively smaller fruit (Davidson & George, 1959) is typically removed. It has been found, that younger branches bear fruit of higher quality (San Martino, Hochmaier, & Manavella, 2014) and shoots up to 20 cm in length produce larger number of flower and leaf buds (Thurzó *et al*., 2008). Thus, specific pruning approaches and training systems need to be developed to maximize harvest without compromising stem growth in plantations where wood production is the main goal.

To increase the ecological resilience of tree stands, it is recommended to use multiple species and genotypes instead of strictly monoculture or clonal material (Liu, Kuchma, & Krutovsky 2018). In mixed genotype stands with different fruit set timing, but similar stem properties, the period of fruit harvest could be prolonged and, thus, benefit from fruit exploitation increased.

Conclusions

Overall, there was a clear difference between the size of cherry fruit collected from trees growing in orchard and from trees specifically cultivated for production of wood. In case of cherry trees cultivated for wood production, it is not clear, if the small size of fruit is a result of biological trade-offs between wood and fruit production, or if the fruit properties have simply been neglected during the breeding and selection processes. Combining the results of this study with further germination and growth assessment of referred genotypes will help evaluate if fruit harvesting can be feasibly incorporated into systems where wood and timber production is the main goal. Further studies should focus on 'Kārzdabas', 'Agrais Lielajiem Ķiršiem', 'Brjanskaja Rozovaja' and 'Muiža', as we found these genotypes to have the most promising equilibrium between fruit and trunk properties.

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