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SHORT COMMUNICATION

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INFLUENCE OF CULTIVAR AND ROOSTOCK ON FRUIT CRACKING INDEX OF SWEET CHERRY (*Prunus avium* L.)

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ABSTRACT

This study investigated the influence of cultivar and rootstock on the fruit cracking index and harvest date of sweet cherry under the agro-ecological conditions of Trebinje (Bosnia and Herzegovina). Four Italian sweet cherry cultivars (Marysa, Sweet Gabriel, Sweet Valina, and Sweet Stephany) grafted onto two vegetative rootstocks (Gisela 5 and Gisela 6) were evaluated during the 2025 growing season. The results showed statistically significant differences among combinations cultivar/rootstock in both harvest date and fruit cracking index. The lowest cracking index was recorded for Sweet Stephany grafted onto Gisela 6, while the highest susceptibility was observed for Marysa grafted onto the same rootstock. Overall, cultivars grafted onto 'Gisela 6' exhibited higher cracking susceptibility compared to those grafted onto Gisela 5. A strong and highly significant negative correlation (r = –0.91**) was established between harvest date and fruit cracking index, indicating that earlier-ripening cultivars were more prone to cracking. The findings highlight the importance of selecting appropriate cultivars and rootstocks in reducing the risk of fruit cracking. However, in order to provide more valuable information for the introduction of new sweet cherry cultivars and the establishment of sustainable orchards under similar agroecological conditions, it is necessary to extend the study over two or even three years, as only in this way can reliable and relevant data be obtained.

Keywords: sweet cherry, cultivar, rootstock, fruit cracking index, harvest date, correlation

INTRODUCTION

Fruit cracking significantly affects fruit quality and leads to a considerable reduction in the commercial yield of sweet cherry. According to Simon [2006] and Khadivi-Khub [2015], fruit cracking—specifically skin cracking—represents a major source of economic losses in sweet cherry production. A large number of authors have addressed this problem in sweet cherry research [Measham et al. 2009, Balbontín et al. 2014, Koumanov 2015]. Rain-induced fruit cracking is considered one of the main limitations of sweet cherry production and a significant threat to its economic profitability. This physiological disorder manifests as cracks in the fruit skin, which may extend deep into the flesh and occur in different regions of the fruit, including the stem cavity, calyx end, and fruit cheeks (side cracks) [Balbotín et al. 2013]. Cultivar genetics play an important role, as some varieties are naturally more resistant due to skin structure and physiological traits. Also, climate change may further intensify sweet cherry fruit crack-

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ing due to the increased frequency of heavy rainfall events and higher air humidity during the ripening period [Huang et al. 2019]. However, the mechanisms involved in fruit cracking have not yet been fully elucidated.

According to Schuller et al. [2016], the phenotypic characteristics of fruits, such as weight, fruit-to-pit ratio, skin thickness, and fruit firmness, vary significantly among different sweet cherry cultivars. Similar findings are confirmed by Kaya et al. [2026]. Numerous studies have confirmed that fruit cracking is influenced by cultivar and rootstock characteristics [Simon et al. 2004, Granger 2005, Duralija et al. 2007]. In recent years, vegetative (clonal) rootstocks such as Gisela 5, Gisela 6, and Colt have become widely used in intensive sweet cherry production systems, as they enable high-density planting, earlier bearing, and improved orchard management. The most important characteristics of the Gisela 5 rootstock are: low–vigorous, propagated by micropropagation, requires more fertile soils, sensitive to drought, resistant to winter frosts, good compatibility with cultivars, early and regular yield, requires support, fertilization, strong and regular pruning. On the other hand, the Gisela 6 rootstock is characterized by traits such as: moderately vigorous, propagated by micropropagation, tolerates drought, heavy, and clay soils, not suitable for very hot climates, good compatibility with cultivars, early and good yield, and fruit size, suitable for plantings with a density of 800–1200 trees/ha. Late-ripening cultivars exhibit better pomological traits, such as fruit size, color, and flavor, as well as lower susceptibility to fruit cracking [Sansavini and Lugli 2008].

The aim of the research was to determine the ripening dates of different sweet cherry cultivars, as well as the influence of cultivar and rootstock on this trait and on the fruit cracking index. The significance of this study lies in providing recommendations for new Italian sweet cherry cultivars with regard to this economically important trait, as well as recommendations for establishing new orchards by selecting cultivars that are less prone to fruit cracking.

MATERIALS AND METHODS

The research was conducted in a sweet cherry orchard located in the area of the city of Trebinje (Bosnia and Herzegovina). The orchard was established in 2024. Four new sweet cherry cultivars of Italian origin were examined: Marysa, Sweet Gabriel, Sweet Valina and Sweet Stephany. Each cultivar was grafted onto two rootstocks, Gisela 5 and Gisela 6. A total of eight cultivar/rootstock combinations were included in the orchard, with each combination represented by nine trees (three trees in three replicates). The training system was slender spindle, and the planting density was 3.0 × 1.2 m. The fruit cracking index was determined using the method described by Christensen [1996]. For each cultivar/rootstock combination, 150 uniform and well-developed fruits were sampled and divided into three replicates (50 fruits per replicate). Fruits were collected from different parts of the tree canopy. The sampled fruits were then immersed in 2 L of distilled water at a temperature of approximately 20 °C. Fruit assessments were performed after 2, 4, and 6 hours of immersion, during which cracked fruits were counted and separated. The fruit cracking index was calculated using the formula:

$$FCI = \frac{(5a + 3b + c) \times 100}{250}$$

Where *a* represents the number of cracked fruits after 2 h, *b* the number of cracked fruits after 4 h, and *c* the number of cracked fruits after 6 h. The fruit cracking index was determined over a one-year period (2025). The ripening date of fruits from the examined sweet cherry cultivar/rootstock combinations was recorded at the beginning of commercial harvest for fresh consumption and expressed as the number of days from 1st January. In addition, the correlation between ripening date and fruit cracking index was analysed in order to examine the relationship between these two important parameters. The obtained data for fruit cracking of fruit are presented as mean values for three replicates ± standard error and were statistically processed using Fisher's model of analysis of variance (ANOVA) for a two-factorial experiment, applying the F-test [Fisher 1953] for P ≤ 0.05 (using the statistical package IBM SPSS Statistics 20 (SPSS Inc, Chicago, IL, USA)). In the two-factorial analysis of variance, the factors used were the cultivar and the rootstock. When the F-test was significant, differences between arithmetic means were tested using Duncan's multiple range test at a significance level of P ≤ 0.05. The results are presented in graphs. Correlation analysis between fruit cracking and time of maturating was performed using IBM SPSS Statistics 20 (SPSS Inc, Chicago, IL, USA).

RESULTS AND DISCUSSION

Ripening time in sweet cherry is a genetically controlled trait primarily determined by the cultivar, while rootstocks may modify the onset of maturity through their effects on tree vigor, assimilate distribution, and fruit development dynamics. Figure 1 shows the number of days from the January 1st to harvest of the studied combinations cultivar/rootstock (red color), sweet cherry cultivars (green color) and rootstocks (yelow color) in the agroecological conditions of Trebinje. Under the conditions of Trebinje, the combinations cultivar/rootstock ripened from the third decade of May to the first decade of June, covering a period of 13 days. In 2025, the earliest onset of fruit ripening was recorded for the cultivar Marysa grafted onto the vegetative rootstock Gisela 6 (May 24), while on the same rootstock the latest ripening was observed for Sweet Stephany (June 6). On average across both rootstocks, fruits of the cultivar Marysa ripened the earliest (May 25), whereas the latest ripening time was recorded for Sweet Stephany (June 6). The mean fruit ripening date for both studied rootstocks was June 1. According to descriptions by the Alma Mater Studiorum – University of Bologna breeding program, Sweet Gabriel and Sweet Valina exhibit intermediate and mid-late ripening windows respectively when compared to the standard cultivar Burlat, while Sweet Stephany is categorized as a late-season cultivar, with ripening occurring approximately 25–27 days after Burlat. Information for Marysa classifies it generally as mid-season based on orchard production data. Previous studies have shown that both cultivar genetics and rootstock choice significantly influence sweet cherry phenology, including the timing of ripening [Duralija et al. 2007, Usenik et al. 2010, Boskov et al. 2022, Filyova 2024].

Figure 1. Number of days from the January 1st to harvest (2025)

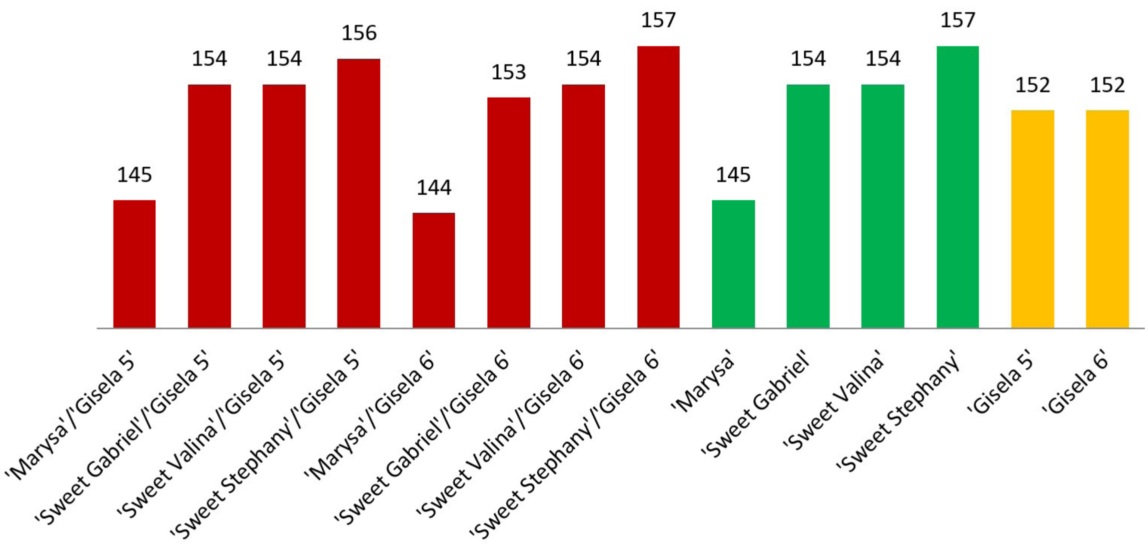
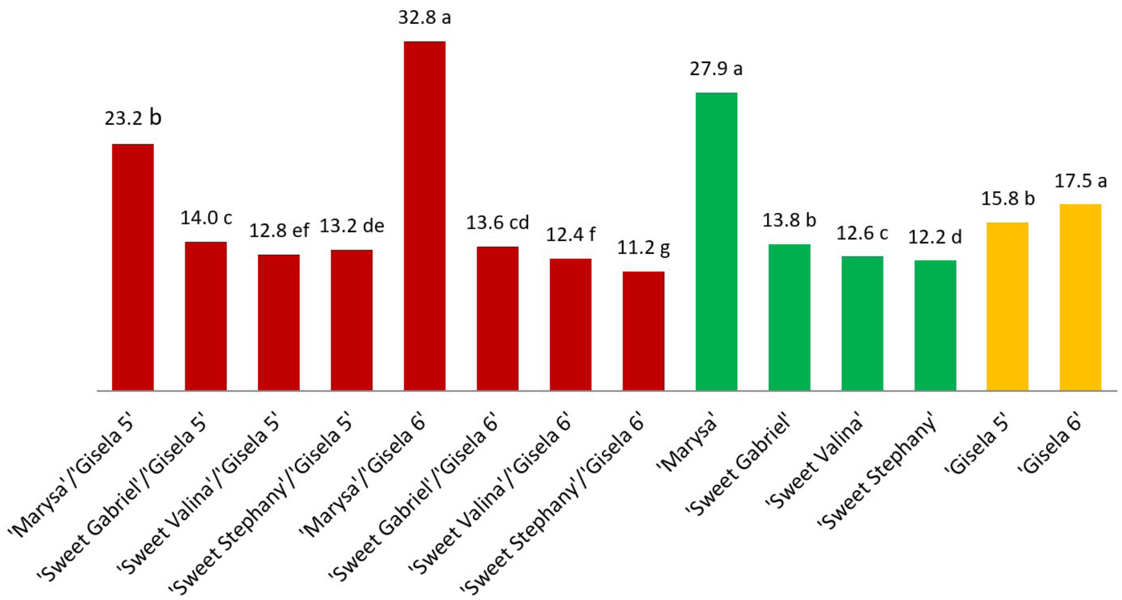


Figure 2 shows data related to the susceptibility of sweet cherry cultivars and rootstocks to fruit cracking. The lowest fruit cracking index was recorded for the cultivar Sweet Stephany grafted onto the rootstock Gisela 6 (11.2), while the highest value was observed for the cultivar Marysa grafted onto the same rootstock (Gisela 6) (32.8), which was statistically significantly higher compared to the other combinations. The examined cultivars, rootstocks and cultivar/rootstock combinations differed significantly with respect to the fruit cracking index (Figure 2). When comparing cultivars, fruits of Marysa showed the highest susceptibility to cracking, which was statistically significant in relation to the other cultivars. The trend of the fruit cracking index among cultivars was as follows: Marysa (27.9) > Sweet Gabriel (13.8) > Sweet Valina (12.6) > Sweet Stephany (12.2). Conversely, fruits sampled from trees grafted onto the vegetative rootstock Gisela 6 showed a statistically significantly higher susceptibility to fruit cracking (17.5) compared to fruits sampled from trees grafted onto the rootstock Gisela 5 (15.8). According to the values of the fruit skin cracking index, all cultivars can be classified into four groups: slightly susceptible (cracking index <10.0), moderately susceptible (cracking index 10.1–30.0), susceptible (cracking index 30.1–50.0), and highly susceptible (cracking index >50) [Milatović and Đurović 2010]. The studied cultivar/rootstock combinations could be divided into two groups: moderately susceptible (Sweet Gabriel/Gisela 5; Sweet Valina/Gisela 5; Marysa/Gisela 5; Sweet Stephany/Gisela 5; Sweet Gabriel/Gisela 6; Sweet Valina/Gisela 6; Sweet Stephany/Gisela 6) and susceptible (Marysa/Gisela 6). The results indicate that cracking susceptibility is strongly dependent on cultivar characteristics and may be modified by rootstock choice, emphasizing the importance of selecting appropriate combinations for specific agro-ecological conditions. Although the susceptibility of sweet cherry cultivars to fruit cracking has been studied extensively in a wide range of genotypes using standardized cracking indices, no scientific publications to date have reported cracking susceptibility measurements specifically for the cultivars Sweet Gabriel, Sweet Valina, Sweet Stephany, or Marysa. This highlights a gap in the literature regarding cracking behavior in newly introduced cherry cultivars from the Bologna breeding program. A correlation was established between the fruit cracking index and the ripening time. This correlation was negative and highly significant (–0.91**). Specifically, cultivars with earlier ripening dates exhibited higher fruit cracking index values, indicating they were significantly more susceptible to cracking. From an economic perspective, this information is particularly important when selecting sweet cherry cultivars.

Figure 2. The fruit cracking index value depending on cultivar/rootstock combination



Mean values following the same letter within a column for each cultivar are not significantly different according to the Duncan multiple range test (P ≤ 0.05)

CONCLUSION

The results revealed significant differences in fruit cracking susceptibility among the examined cultivar/rootstock combinations, confirming the strong influence of both genetic and agronomic factors. Higher susceptibility observed in certain combinations, particularly on Gisela 6, may be associated with differences in fruit skin structure, water uptake dynamics, and osmotic pressure within the fruit during ripening. The strong negative correlation between harvest date and cracking index indicates that earlier-ripening cultivars are more exposed to environmental stress, especially rainfall, which can intensify cracking.

However, it should be emphasized that the results obtained in this study are based on a one-year investigation (2025), which represents a limitation when drawing broader conclusions. Therefore, in order to obtain more reliable and comprehensive results, it is necessary to conduct multi-year research under similar agroecological conditions. Only on the basis of such studies can more precise recommendations be made regarding the selection of sweet cherry cultivars and rootstocks for cultivation in environments similar to those of Trebinje. Generally, these are preliminary one-year studies and that in order to provide clear guidance to growers and nursery producers, they need to be repeated.

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DECLARATION OF THE USE OF GENERATIVE AI IN THE PROCESS OF PREPARING THE PAPER

No generative AI tools were used in the preparation, writing, editing, analysis, or revision of this manuscript. All ideas, research, analysis, and written content were produced solely by the author.

AUTHORS' CONTRIBUTIONS

M.R. – working on a conception and assumptions, developing the methods, conducting research, supervision, writing-review and editing; M.L. – working on a conception and assumptions, conducting research; S.J.Š. – developing the methods, supervision, writing-review and editing; J.A. – conducting research; A.D. – conducting research; J.H.S. – supervision, writing-review and editing; N.B. – supervision, writing-review and editing.

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