

MULTIDISCIPLINARY CONFERENCE ON SUSTAINABLE DEVELOPMENT KEY RESEARCH IN HORTICULTURE, LANDSCAPING, FORESTRY AND PLANT BIOTECHNOLOGY 35 YEARS OF HORTICULTURAL HIGHER EDUCATION AND RESEARCH IN TIMISOARA MAY 15-16, 2025, IN TIMISOARA, ROMANIA



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Abstract The research was carried out between 2020 and 2022, involving observations and measurements on several local grapevine varieties and biotypes identified in the localities of Săsciori, Loman, Ighiu, Sard, and Alba Iulia in Alba County. The study focused on 12 local grapevine varieties, which were analyzed in comparison with reference varieties representative of the respective areas. Four local varieties were grouped among the white wine grape varieties (Sard I, Ruginiu de Alba, Busuioaca de Ighiu, and Aromat alb) and were compared with the Fetească Regală variety. The other four local varieties were classified in the red wine grape varieties group (Pleoapa, Vechi de Ighiu, Izabela de Ighiu, and Rosu rezistent) and were compared with the Cabernet Sauvignon variety, while four local varieties were classified as table grape varieties (Mare timpuriu, Butuc alb, Precupeasca, and Fraga) and were compared with the Chasselas Doré variety. For this study, data analysis was performed using XLSTAT 2018 software, which provides a comprehensive range of statistical tools for multivariate analysis. The key parameters used for principal component analysis (PCA) included the annual growth of mature wood, the number of inflorescences per vine, yield per vine, bunch weight, berry weight, the number of berries per bunch, and sugar content in the grape must and per vine. A significance level of p < 0.05 was adopted to ensure the statistical significance of the results.

Introduction

Within the vast diversity of grapevine cultivars grown globally, traditional local varieties occupy a distinct and valuable position. These indigenous cultivars, specific to their ancient regions and refined through centuries of adaptation to local environmental conditions [unique sensory profiles, resilience to biolic and abiotic stressors, and deep cultural and historical significance [1]. Local grapevine varieties contribute significantly to the preservation of agricultural biodiversity and the safeguarding of cultural heritage specialized nurseries serve as critical infrastructures for the conservation, propagation, and dissemination of these genetic resources, ensuring their availability for future generations and promoting sustainable viticulture worldwide [13]. Research and d ermplasm are vital for both conservation and sustainable use [23]. Moreover, native varieties and their wild relatives constitute a valuable pool of genetic resources, that is essential both for conservation strategies and for the bre emarkable genetic diversity among grapevine cultivars is primarily driven by sexual reproduction and spontaneous mutations [3]. Despite the existence of over 12,000 documented grapevine cultivars worldwide [18] only a lin conomic importance, leading to a concentration of cultivation efforts around these few [13]. Italy exemplifies the successful conservation and promotion of indigenous grapevine diversity, with over 500 officially recognized cultivars-more than any other country [23]. Many of nally adapted varieties that reflect the interplay between vine, soil, and climate [34]. Similarly, France, renowned as a cradle of fine wine, has preserved and cultivated native grapevine varieties that un empranillo, Albariño, and Garnacha are central to regional wines and well-adapted to the country's diverse climates and soils [8;14]. Greece preserves ancient cultivars such as Assyrtiko, Xinomavro, and Agic ing conditions, including high salinity and drought [30]. Romania, with its rich winemaking history, is home to native varieties like Feteasca Neagra, Feteasca Alba, and Grasa de Cotnari, which reflect the co of Eastern European grape genetic resources [10;17]. These local cultivars not only support sustainable viticulture but also embody centuries of cultural heritage and regional traditionThe objective of the research was to identify, characterize, and evaluate local grapevir

total of twelve local grapevine genotypes were included in the study. Based on morphological traits and organoleptic (flavor) characteristics, four biotypes (Sard I, Ruginiu de Alba, Busuioacă de Ighiu, and Aromat Alb) were classified as white wine grape varieties. Anothe four biotypes (Pleoapa, Vechi de Ighiu, Izabela de Ighiu, and Roşu Rezistent) were assigned to the red wine grape category, while the remaining four (Mare Timpuriu, Butuc Alb, Precupeasca, and Fraga) were categorized as table grape biotypes intended for fresh consumption. Each local biotype was evaluated in comparison with a standard reference cultivar representative of its respective category and growing region: Feteasca Regala for white wine grapes, Cabernet Sauvignon for red wine grapes, and Chasselas Doré for table grapes. The parameters

 All collected data were subjected to statistical analys differentiation among the grapevine varieties across the studied growing seasons. PCA served as a key tool for interpreting the complex relationships between genotypes and the suite of agro-morphological and biochemical traits analyzed

Annual vegetative growth in grapevines is primarily influenced by the intrinsic vigor of the variety, as well as by climatic conditions, vineyard management practices, and yield levels [11, 28].



The present results (Figure 1) focus on the annual growth of mature one-year-old wood (canes), number of inflorescences per vine, and grape yield per vine across several local red grape varieties and biotypes.

Principal component analysis (PCA) revealed that the first principal component (F1) accounted for 79.30% of the total variance, making it the most significant factor in distinguishing grapevine varieties based on the analyzed traits. The second component (F2) contributed an additional 14.17% of the variance. A strong positive correlation was identified between the number of inflorescences per vine and grape yield (r = 0.7997, $p = 0.0002^{***}$). Annual wood maturation also correlated significantly with grape yield (r = 0.658, $p = 0.0039^{**}$) and the number of inflorescences (r = 0.6062, $p = 0.0083^{**}$), suggesting an integral role of vegetative vigor in reproductive output. The amount of one-year-old wood was strongly aligned with F1 and showed moderate influence from F2. The reference cultivar Cabernet Sauvignon (C), in both 2021 and 2022, was strongly associated with high levels of wood maturation, indicating robust vegetative development during these years. The local variety Vechi de Ighiu also demonstrated substantial wood maturation, albeit to a slightly lesser extent. The biotype Roşu Rezistent exhibited a strong relationship with both a high number of inflorescences and increased grape yield in 2021 and 2022. Pleoapa showed moderate performance in these parameters, particularly in 2021. In contrast, Izabela de Ighiu showed below-average to average values for wood maturation, yield, and inflorescence count in 2020 and 2021. However, its 2022 performance reflected improved balance in vegetative and reproductive traits, aligning with Vechi de Ighiu (2020, 2022) and Cabernet Sauvignon (2020). The 2020 and 2022 seasons were less favorable for Pleoapa, both in terms of wood maturation and productivity, while 2021 proved significantly more favorable. Cabernet Sauvignon consistently exhibited high wood maturation across all three years, reflecting stable vegetative performance and adaptability under local environmental conditions.

The PCA biplot indicated that Cabernet Sauvignon in 2021 and 2022 was highly associated with mature wood accumulation. Vechi de Ighiu showed balanced traits across all years, suggesting its potential as a versatile local variety. Rosu Rezistent (2021, 2022) was most closely aligned with increased reproductive performance, indicating high yield potential under favorable conditions.

For white grape varieties and biotypes, PCA (Figure 2) revealed that the first principal component (F1) explained 70.71% of total variance, confirming its role as the primary axis of variation based on the assessed traits: mature annual wood, inflorescence number, and grape yield per vine.

In 2021, Aromat Alb and the reference cultivar Fetească Regală (C) exhibited the highest number of inflorescences per vine, resulting in greater grape yields. Busuioacă de Ighiu also displayed strong inflorescence expression in the same season. Grape yield and mature wood growth were moderately correlated (r = 0.6826, $p = 0.0025^{**}$) and both aligned closely with F1. The number of inflorescences was slightly influenced by wood maturation (r = 0.4904, $p = 0.0317^{*}$) and weakly associated with grape yield (r = 0.5014, $p = 0.0284^{*}$), indicating that flowering abundance does not always directly translate to yield (Keller, 2020). In 2021, Aromat Alb and Feteasca Regala (C) demonstrated the most favorable combination of high floral density, significant wood maturation, and high yields, marking this year as particularly advantageous for these cultivars. Although Busuioacă de Ighiu did not achieve high yields or wood maturation in 2020 and 2022, its floral performance was notable in 2021. Ruginiu de Alba and Sard I had consistently lower values for all three parameters across the three years, with particularly poor performance in 2021. The findings suggest that these varieties may require optimized cultivation strategies or alternative site conditions to reach their full potential. While Aromat Alb and Feteasca Regala (C) stood out as the most productive and vigorous white varieties in 2021, Busuloacă de Ighiu showed high floral capacity with weaker correlations to yield and wood development. Conversely, Ruginiu de Alba and Sard I displayed reduced and inconsistent performance, highlighting their sensitivity to environmental or management factors not captured in the current study. In conclusion, PCA identified 2021 as an exceptionally favorable year for white grape varieties such as Aromat Alb and Feteasca Regala (C), with optimal performance across vegetative and reproductive traits. By contrast, the lower and more variable results observed in Ruginiu de Alba and Sard I suggest the influence of additional, unmeasured factors.

Among the local table grape varieties and biotypes, one-year-old wood (canes), number of inflorescences, and grape yield per vine showed significant variation across the studied years. This variability was largely captured by the first principal component (F1), which accounted for 68.85% of the total variance (Figure 3).

The varieties Fragă and Butuc Alb exhibited a higher number of inflorescences per vine in 2021 compared to other varieties, which is often a precursor to potentially higher yields. The variety Precupească excelled in inflorescence count, indicating exceptional fertility during the 2021 season. These observations align with findings that environmental factors, such as temperature and light, significantly influence bud fruitfulness and inflorescence primordia formation in grapevines [32].

Mare Timpuriu and the reference variety Chasselas Doré (C) produced higher vields per vine in 2021. Notably, the reference variety not only had high productivity but also exhibited a substantial amount of mature wood, suggesting robust vegetative development. Throughout the same year, Chasselas Doré (C) performed particularly well in terms of both productivity and wood maturation, indicating a positive response to the favorable climatic and vineyard management conditions of 2021. This is consistent with studies showing that optimal vegetative growth, influenced by factors like soil management and irrigation timing, can enhance grape yield and quality [27]. A significant positive correlation was observed between mature annual wood growth and grape yield per vine (r = 0.7113; p = 0.0015), suggesting that higher wood maturation was associated with increased grape production. In contrast, annual wood growth had a significant but negative correlation with the number of inflorescences per vine (r = -0.504; p = 0.0277), indicating a potential trade-off between vegetative vigor and floral initiation. Moreover, the number of inflorescences per vine did not positively influence grape yield across the 2020–2022 period (r = -0.362; p = -0.0277).





Mare Timpuriu and Chasselas Doré (C) were strongly associated with higher levels of mature wood in 2021 compared to 2020. The year 2021 also proved particularly favorable for Precupească, Fragă, and Butuc Alb in terms of inflorescence number. In contrast, these three varieties exhibited significantly lower values for all three parameters in the previous year. The analysis highlighted the performance variability of table grape varieties across growing seasons, with 2021 standing out as the most favorable year for yield per vine, inflorescence count, and wood maturation. In 2022, most varieties demonstrated balanced values across all parameters. However, the reference variety Chasselas Doré (C) showed consistently lower performance in these traits, especially during the 2020 growing season. Additional results concerning grape yield per vine, cluster weight, berry number per cluster, and berry weight in local red grape varieties and biotypes revealed further interesting trends. The principal components F1 and F2 together explained a significant portion of the total variance (88.13%), contributing to the understanding and differentiation of red grape varieties based on the key traits that influence their performance (Figure 4).

Statistical analysis revealed a significant positive correlation between cluster weight and grape yield per vine (r = 0.7021; p = 0.0018**), indicating the critical contribution of cluster mass to total vine productivity. Moreover, grape yield per vine was strongly influenced by both the number of berries per cluster (r = 0.8660; p < 0.0001***) and berry weight (r = 0.5905; p = 0.0102*), confirming the combined impact of fruit number and size on yield outcomes. These findings are consistent with previous studies in grapevine physiology, which emphasize the balance between berry number and size as a key determinant of yield and fruit quality [20; 25]. The PCA analysis highlights Precupească as the most productive variety in 2021, while Mare timpuriu and Chasselas doré (C) were most effective at producing larger and heavier berries in 2020. These insights are valuable for guiding vineyard management and variety selection strategies, depending on the production goal-either to maximize yield per vine or to cultivate high-guality table grapes with superior berry attributes.

Conclusions

In viticulture, identifying local grapevine varieties resilient to climatic and technological challenges is key to ensuring consistent, high-quality production. These varieties can be used in blends or as breeding stock to improve resilience. Multi-year research confirmed that all studied cultivars maintained a good balance between growth and fruiting, with stable productivity. The local red variety Pleoapă showed over 80% mature wood—higher than the control—while the white variety Sard 1 recorded the highest wood maturation overall, highlighting their adaptability. The results indicated that a higher number of berries per cluster increased yield but slightly reduced individual berry weight, highlighting a trade-off between quantity and quality.

Sard 1 was the most productive in 2021, whereas Ruginiu de Alba produced heavier clusters and berries, suggesting differing strengths by variety. Principal component analysis of table grape biotypes confirmed the dominant role of F1 (81.92%) in varietal differentiation, supporting the importance of selecting cultivars with high fertility and inflorescence numbers for sustained productivity. In conclusion, local varieties like Pleoapă and Șard 1 show strong potential for use in sustainable viticulture, particularly in regions facing frequent environmental stress.

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