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# BERRY SIZE AND YIELD INFLUENCE ON GRAPE SHAPE AND WINE QUALITY

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## Abstract:

This study explores the relationship between yield, berry size, and wine quality across five red wine grape varieties: Cabernet Sauvignon, Merlot, Syrah, Pinot Noir, and Feteasca Neagra. Field trials were conducted to assess the impact of berry size, categorized as small (<1.2 g), medium (1.2–1.8 g), and large (>1.8 g), on grape morphology and wine chemical and sensory properties. The results showed significant variability in yield, berry size distribution, and morphological traits among the varieties. For example, Syrah had the highest mean yield (8.7 ± 1.2 kg/vine), with the majority of berries classified as large, while Pinot Noir had the lowest mean yield (5.3 ± 0.5 kg/vine) and a higher proportion of small berries. Morphological analysis revealed that berry shape varied by variety, with Cabernet Sauvignon showing an elongated, compact cluster, while Pinot Noir exhibited a short, cylindrical shape. Micro-vinification parameters were similar across all varieties, with fermentation durations ranging from 10 to 12 days, and no oak aging applied. Wine chemical analyses showed differences in pH, total acidity, and tannin content. Syrah wines exhibited the highest tannin levels (4.7 ± 0.2), while Pinot Noir had the lowest (3.0 ± 0.3). Wines from small berries generally displayed higher phenolic content and deeper colour intensity, with Cabernet Sauvignon showing a colour intensity of 1.28 ± 0.05, compared to Pinot Noir's 0.92 ± 0.03. Sensory evaluations indicated that wines from smaller berries had more intense aromas and better tannin structure. These findings underscore the significant influence of berry size and yield on grape morphology and wine quality, providing valuable insights for vineyard management and wine production optimization.

## • Introduction

Berry size and yield strongly influence wine quality by affecting phenolic content, acidity, and flavour. Smaller berries, with higher skin-to-juice ratios, tend to have more anthocyanins and tannins, improving colour, structure, and aging potential. High yields can dilute key compounds, while moderate yields improve berry composition. Berry shape and size, influenced by yield, also reflect varietal traits and development. Phenolics and acidity are key to wine's style and stability. This study examines five red varieties under similar conditions to explore how berry size and yield affect wine composition, using imaging, chemical, and sensory analysis. It is expected that smaller berries and lower yields enhance wine complexity, while larger berries and high yields may reduce concentration.

## • Material and method

The study took place in a commercial vineyard in western Romania (Timiș County), under temperate-continental climate. Five red grape varieties—Cabernet Sauvignon, Merlot, Syrah, Pinot Noir, and Feteasc Neagră—were grown using standard practices on SO4 rootstock in VSP trellising (4,000 vines/ha). Yield per vine was measured across three categories (low, medium, high), and 300 berries per variety were weighed and classified by size (small, medium, large). Berry shape was analyzed via digital imaging and ImageJ software, calculating aspect ratio. Micro-vinification used 20 kg of grapes per class, fermented in 10 L vessels with EC-1118 yeast at 24–26°C. Chemical analyses included total phenolics (Folin–Ciocalteu), anthocyanins (pH-differential method), acidity (NaOH titration), and pH. A trained panel conducted blind sensory evaluations for colour, tannins, and aroma using structured scales. Data were analyzed using SPSS with ANOVA, correlations, and Tukey's HSD ($p < 0.05$).

## • Results and discussions

Cluster and berry morphology were analyzed using digital image processing (ImageJ) under standard conditions to assess varietal differences. Cluster length, width, and compactness (OIV scale 1–5) were measured, along with berry aspect ratio (length/width). Pinot Noir showed the most spherical berries (1.04) and short, broad clusters (1.68), with moderate compactness (3), suitable for cool climates. Cabernet Sauvignon had elliptical berries (1.10) and elongated, compact clusters (2.50; score 4), ideal for phenolic richness. Merlot showed a rounder berry shape (1.08) and looser clusters (2.11), aiding airflow and ripening. Syrah had the most compact clusters (2.68; score 5) and elliptical berries (1.15), indicating high yield via berry count. Feteasc Neagră showed elongated berries (1.18) and slender clusters (2.20; score 3–4), combining structure and aging potential.

**Grape berry and cluster morphological characteristics**

| Variety | Berry aspect ratio (Mean ± SD) | Cluster length (cm) | Cluster width (cm) | Cluster aspect ratio (L/W) | Compactness (1–5) | Cluster shape |
|---|---|---|---|---|---|---|
| Cabernet Sauvignon | 1.10 ± 0.03 | 17.5 ± 1.2 | 7.0 ± 0.6 | 2.50 ± 0.15 | 4 | Elongated & compact |
| Merlot | 1.08 ± 0.02 | 15.8 ± 1.0 | 7.5 ± 0.7 | 2.11 ± 0.13 | 3 | Moderately loose, conical |
| Syrah | 1.15 ± 0.03 | 18.2 ± 1.5 | 6.8 ± 0.5 | 2.68 ± 0.17 | 5 | Long, narrow, very compact |
| Pinot Noir | 1.04 ± 0.02 | 13.4 ± 0.8 | 8.0 ± 0.6 | 1.68 ± 0.12 | 3 | Short, cylindrical, moderate |
| Feteasc Neagră | 1.18 ± 0.04 | 16.3 ± 1.1 | 7.4 ± 0.7 | 2.20 ± 0.14 | 3–4 | Slender-conical, balanced |

**Wine chemical and sensory properties**

| Variety | pH (±SD) | Titratable Acidity (g/L ±SD) | Alcohol (% v/v ±SD) | Colour intensity (520 nm ±SD) | Aroma intensity (±SD) | Tannins (±SD) |
|---|---|---|---|---|---|---|
| Cabernet Sauvignon | 3.55 ± 0.02 | 5.6 ± 0.1 | 13.2 ± 0.1 | 1.28 ± 0.05 | 4.2 ± 0.3 | 4.2 ± 0.3 |
| Merlot | 3.52 ± 0.01 | 5.4 ± 0.1 | 13.4 ± 0.1 | 1.10 ± 0.04 | 4.5 ± 0.2 | 3.8 ± 0.3 |
| Syrah | 3.58 ± 0.02 | 5.5 ± 0.1 | 13.6 ± 0.2 | 1.45 ± 0.06 | 4.3 ± 0.2 | 4.7 ± 0.2 |
| Pinot Noir | 3.48 ± 0.01 | 5.7 ± 0.1 | 12.9 ± 0.1 | 0.92 ± 0.03 | 4.6 ± 0.2 | 3.0 ± 0.3 |
| Feteasc Neagră | 3.50 ± 0.02 | 5.8 ± 0.1 | 13.1 ± 0.1 | 1.20 ± 0.05 | 4.4 ± 0.3 | 3.9 ± 0.2 |

Key chemical parameters (pH, acidity, alcohol, colour) were measured using OIV methods, alongside a blind sensory evaluation by 10 trained tasters rating aroma, fruit, and tannins on a 5-point scale. Cabernet Sauvignon showed high colour (1.28), firm tannins (4.2), and moderate alcohol (13.2%), reflecting its small berries and phenolic richness. Merlot had softer tannins (3.8), higher alcohol (13.4%), and strong fruit expression (4.5), consistent with its larger berry size. Syrah had the highest colour (1.45) and tannins (4.7), linked to its dense clusters. Pinot Noir showed lightest colour (0.92), softest tannins (3.0), and top aroma score (4.6), typical for the variety. Feteasc Neagră balanced acidity (5.8 g/L), moderate tannins (3.9), and rich aroma (4.4), confirming its aging potential. Results confirm that varietal traits persist under controlled vinification, highlighting genotype and berry traits as key to wine quality.

Principal Component Analysis (PCA) of cluster and berry morphological traits (Figure 1) revealed clear varietal differentiation, with the first two principal components (F1 and F2) explaining a cumulative 96.84% of the total variance (86.75% by F1 and 10.09% by F2).

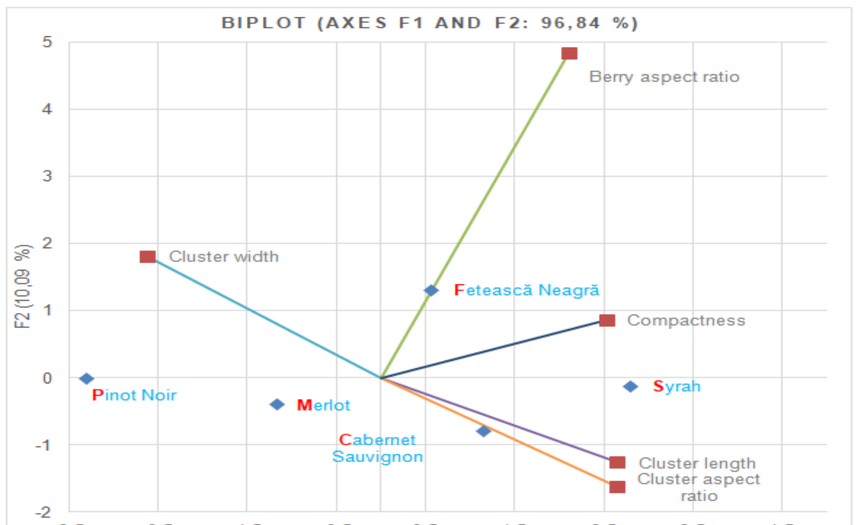


**Figure 1. Principal Component Analysis (PCA) of cluster architecture and berry morphology in five *Vitis Vinifera L.* cultivars**

The F1 axis primarily captured variability associated with cluster architecture, as indicated by strong positive loadings for cluster length and cluster aspect ratio, as well as compactness, while showing a strong negative correlation with cluster width. These findings align with prior studies emphasizing the role of cluster morphology in varietal discrimination. Along this axis, Syrah was clearly separated due to its elongated and compact clusters, characterized by high aspect ratio and compactness scores—traits previously linked to increased phenolic concentration and structural complexity

Conversely, Pinot Noir and Merlot were positioned on the negative side of F1, reflecting their shorter, wider clusters with looser architecture, consistent with reports of their open bunch structure that promotes airflow and reduces disease pressure. The F2 axis, though contributing less to the total variance, distinguished varieties based on berry shape, with high positive loading for berry aspect ratio. Feteasc Neagră and Syrah showed strong associations with elongated berry morphology, while Pinot Noir, Merlot, and Cabernet Sauvignon were more closely associated with rounder berries. Notably, Feteasc Neagră occupied a central position in the biplot, suggesting a balanced morphology combining moderate compactness and berry elongation, supporting its reported adaptability and structural equilibrium. These multivariate relationships reinforce the morphometric differences among cultivars and highlight the capacity of image-based phenotyping and PCA to discriminate grapevine varieties based on structural traits relevant to viticulture and oenology .

## • Conclusions

The study found clear varietal differences in yield, berry size, and morphology affecting wine quality. Syrah yielded most through high fruit set, while Merlot and Feteasc Neagră had larger berries and balanced yields. Pinot Noir retained its aromatic character with small berries and loose clusters. Morphology aligned with wine traits—Syrah and Cabernet Sauvignon had stronger tannins and colour; Merlot and Feteasc Neagră were softer and fruitier. Results highlight the role of genotype and value of image-based phenotyping.