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PERFORMANCES EVALUATION OF SOME WINE GRAPE CULTIVARS GROWN IN NORTH-WEST OF ROMANIA

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Abstract

The historic vineyards of Satu Mare County, mentioned since feudal times, were the focus of research in the Bogdand village area from 2021 to 2022. Various wine grape cultivars including 'Fetească regală', 'Sauvignon Blanc', 'Italian Riesling', 'Traminer rose', 'Muscat Ottonel', 'Tămâioasă românească', 'Pinot noir', 'Burgund mare', 'Cabernet Sauvignon', and 'Merlot' were studied. The research encompassed cultivation techniques, soil tillage frequency, pest and disease treatments, and quantitative and qualitative production analyses, including organoleptic evaluations. Despite challenges like droughts and heavy rainfall in 2022, meticulous management yielded balanced sugar-to-acidity ratios and high-quality grapes, notably in the 'Cabernet Sauvignon' and 'Traminer rose' varieties. Recommendations from an initial agrochemical study were implemented in subsequent years to address reported issues. Climatic variations influenced technological applications. National programs aimed at revitalizing Romanian viticulture through European funds have proven successful. The unique terroir and local culinary tradition elevate the profile of these wines, labeled "I.G. Hills of Sătmarului."

Key words: *grape varieties, Satu Mare County, vineyards, wines.*

INTRODUCTION

Vineyards and wine nurseries in Satu Mare County account for roughly 2% of Romania's wine-growing territory (Malaescu et al., 2022). The majority of today's viticultural plantings are based on Satu Mare County's well-documented viticultural history (Bogdan et al., 2021). In 1975, more than 4,300 hectares of vineyards were grown in Satu Mare County (Ștefan et al., 2017). At that time, however, large areas were planted with interspecific hybrids. (Cichi et al., 2022). In recent years, with the assistance of reconversion programmes, over 1,000 hectares of noble vines were planted, and also several vineyards were also established with red varieties, which were not previously common in this area (Heizer et al., 2023). The area of yielding vineyards in Satu Mare County was 3271 ha in 1990, but it decreased by around one-third during the next two decades (Dobrei A.G. et al., 2016). According to data provided by the National Institute of Statistics (NIS), the total number of yielding vineyards was 2990 ha in 2022. Wine tourism has gained popular support in Satu Mare County, with local authorities engaging in the promotion of the "Sătmărean Wine Road" project, which contributes to the rural environment's growth from both a social and economic perspective (Pop et al., 2023).
The objective of the research was to evaluate the performance of ten distinct wine grape cultivars over two consecutive years to account for potential year-to-year variability in weather conditions and growing seasons.

MATERIALS AND METHODS

The study was carried out in Bogdand area (47°25'0" North, 22°56'0" East), Satu Mare County, on ten wine grape cultivars during 2021 and 2022 growing seasons, and monitored the stages of vineyard management, the type and frequency of soil tillage, treatments used to prevent and control diseases and pests, analysis of grape yield, and organoleptic analysis of the wines. The following white grape cultivars: 'Fetească regală', 'Sauvignon Blanc', 'Italian Riesling', 'Traminer roz', 'Muscat Ottonel',

'Tămâioasă românească', some of which are aromatic, are among those cultivated in the vineyards from Bogdand area, Satu Mare County. The grape cultivars for red/rosé wines were 'Pinot Noir', 'Burgund mare', 'Cabernet Sauvignon' and 'Merlot'. The vineyards were 10 years old, with a planting distance of 2.7 m between rows and 0.9 m between vines in the row, with a planting density of 4115 vines/ha. The vines were Double Guyot training. Experimental unit was grouped into blocks based on soil management, herbicide treatments and applied fertilizers. Within each block, treatments were randomly distributed and each treatment was replicated three times within each block.

Spring ploughing was done at 15 cm depth for many years, from the first to the third decade of March. The initial hoeing was typically done each year between the first three days and the last decade of March, depending on weather conditions. The second hoeing was done in June to suppress weeds, followed by the third in August. Only the initial hoeing was completed during the second growing season (2022), as the soil was very hard due to the drought. The first herbicide treatment was applied in April, typically within the first two decades of the month, in 40 cm wide strips, and the second treatment occurred during the latter half of June. During the 2022 growing season, a combination of Chikara (containing flazasulfuron 25%) and Glygold (containing glyphosate) was applied at a dose of 0.07 kg/ha (Chikara + 1.0 liter/ha – Glygold) for the first treatment, while Taifun 360 SL was utilized at a rate of 5 liters per 150 liters of water per hectare for the second treatment. The agrochemical analysis performed during the vineyard establishment suggested multiple options for improving some of the negative items identified, as well as measures to increase the output. During the ten years of grape harvesting, the following recommendations were considered: ammonium nitrate (NH_4NO_3) application was forbidden in this vineyard; $Co(NH_2)$-urea has a residual acidifying effect per kg of N, similar to anhydrous ammonia; to neutralize the acidity, was necessary to apply 1.8 kg of Ca_2CO_3/kg of N. Because the ammonia resulting from hydrolysis has a harmful effect on young vines the urea was not applied at planting. Acidity characterized 87% of the charted surface (pH < 6). Calcareous amendments were not applied to the plots. Limitation of the acidification process was achieved by using nitro-phosphate fertilizers. On vineyards soils, acidification was prevented by using ammonium nitrate (NH_4N0_3) and calcium carbonate ($CaCO_3$) mixture (one part of ammonium nitrate and 0.3-0.7 parts of calcium carbonate). This fertilizer compensates for the base losses caused by ammonium nitrate. The implementation of soil maintenance, pruning, disease and pest control treatments were carried out at different stages, from one year to another, in direct correlation with the climatic conditions. At the spring beginning, after the winter pruning, the remaining canes were not chopped, but were collected from the rows by raking and kept for kindling on fire to avoid frosts in the winter or early spring. The same technology was applied for all cultivars. Yield was determined by weighing the grapes from each plot at harvest. The grape quality was also established at harvest by analyzing the sugar content (g/L) in the juice, by using the refractometer (Portable Digital Refractometer, RFT-PD35F, Infitek Co., Ltd.). The total acidity (g/L H_2SO_4) of grape juice was determined by titration as indicated by a pH meter (HI99111, electrode pH FC10483, Hanna Instruments Ltd.).

Data collected in the first year served as a baseline, while data from the second year provided additional insights into the grape varietals' long-term performance consistency. The sensory characteristics of the wines from the second growing season were determined through sensory analysis. The recorded data were statistically processed and interpreted. Table 1 and Figure 1 provide data about the harvested area as well as the distribution of cultivars in each plot. Plots 12 and 14 were planted with the 'Fetească regală' cultivar on 5.91 hectares area. 'Sauvignon Blanc' was planted in plots 13 and 15, covering 6.87 hectares area. In plot 11, two distinct cultivars were grown: 'Italian Riesling' on 4.80 ha and 'Tămâioasă Românească' on 4.50 ha. Plot no. 10 was divided into 'Muscat Ottonel' (5.17 ha) and 'Traminer rose' (5.00 ha). The 'Burgund Mare' cultivar occupied plot 9, which covered 1.54 ha. 'Cabernet Sauvignon' occupied plots 4, 5, and 6, for a total area of 13.5 ha.

Plots 1, 2, and 3 were planned with the 'Merlot' cultivar, on a total area of 7.07 ha. 'Pinot Noir' was cultivated across plots 7 and 8, with 10.64 ha.

Table 1. The area of grapevine cultivars

Cultivars	The area cultivated with each cultivar (ha)
'Fetească regală'	1.37
	4.54
'Sauvignon Blanc'	3.22
	3.65
'Riesling Italian'	4.80
'Muscat Ottonel'	5.17
'Tămâioasă românească'	4.50
'Traminer roz'	5.00
'Burgund mare'	1.54
'Cabernet Sauvignon'	5.15
	4.95
	3.40
'Merlot'	4.40
	1.31
	1.36
'Pinot noir'	5.04
	5.60

Bogdand area had an average temperature of 10.54°C in 2021 and received 742.8 mm of precipitation (Figure 2). In 2022 growing season, was registered an average temperature of 11.42°C and total precipitation falling to 633.2 mm. The weather data from 2021 and 2022 show both similarities and contrasts in Bogdand's climatic conditions. Despite modest fluctuations, overall temperature patterns remained similar, with slightly higher temperatures reported in 2022. This could show an ongoing progress towards warmer circumstances, possibly affected by larger climatic issues like global warming. However, precipitation levels differed significantly between the two years. During the 2021-2022 growing seasons, various treatments were applied at different stages of grapevine development for controlling diseases and pests, for assuring crop health and quality (Tables 2 and 3) to all cultivars.

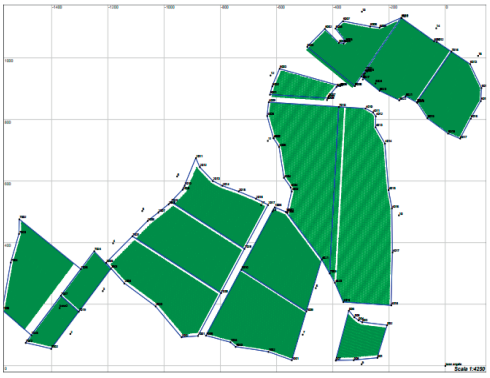

Figure 1. Plots map in Bogdand area

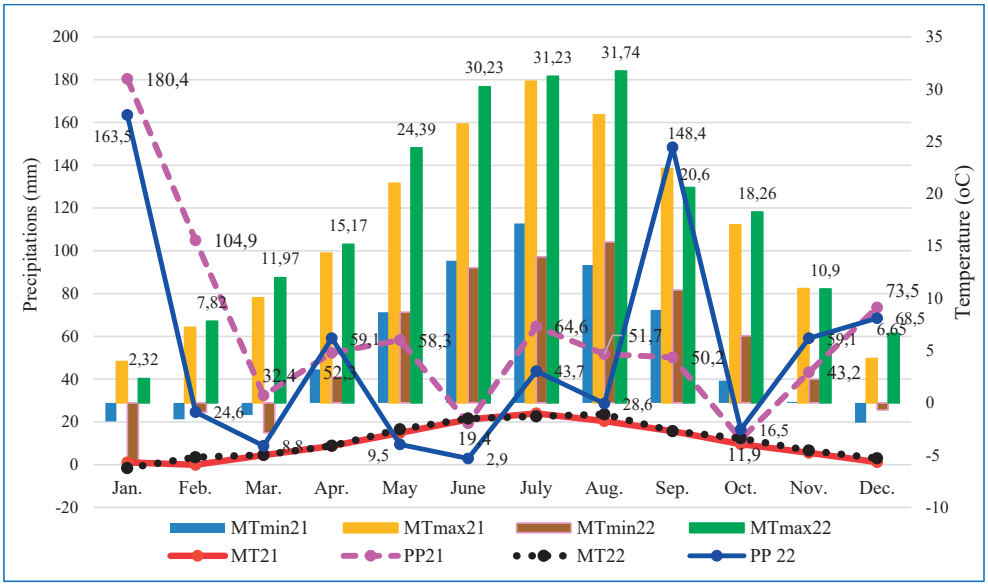

Figure 2. Climate data during 2021-2022 growing seasons in Bogdand area Satu Mare County: MTmin21 - Mean of minimum temperature 2021; MTmax21 - Mean of maximum temperature 2021; MTmin22 - Mean of minimum temperature 2022; MTmax22 - Mean of maximum temperature 2022; MT21 - Mean temperature 2021; MT22 - Mean temperature 2022; PP21 - precipitations 2021; PP22 - precipitations 2022

Table 2. The record of treatments for diseases and pest control during 2021 growing season

No.	Date	Growing stage	Disease or Pest	Treatment and concentration
1	20-30 April	Blooming	Mites Powdery mildew	Nissorun 10 WP, 0.5 kg/ha Thiovit Jet 80 WG (80% sulphur), 3 kg/ha
2	10-25 May	Shoots (10-25 cm)	Downy mildew Powdery mildew	Dithane M45, 0.2% Systhane Forte, 0.01%
3	25 May-10 June	Before flowering	Downy mildew Powdery mildew Moths	Profiler 71 WG, 2.5 kg/ha Talendo® Extra, 0.2 l/ha Sumi Alpha 5EC, 0.2 l/ha
4	10-20 July	After flowering	Downy mildew Powdery mildew, Grape black rot Moths	Profiler 71 WG, 2.5 kg/ha Flint Max 75 WG - 0.16 kg/ha in 1000 l water Sumi Alpha 5EC, 0.2 l/ha
5	20-30 June	Berry development	Downy mildew Powdery mildew Grape black rot Moths	Mikal Flash - 3 kg/ha Flint Max 75 WG - 0.16 kg/ha in 1000 l water Sumi Alpha 5EC, 0.2 l/ha
6	20 July-10 August	Veraison	Downy mildew Powdery mildew gray mold	CopFort, 3 l/ha Thiovit Jet 80WG, 3 kg/ha Pyrus 400 SC, 2.5 l/ha
7	15-30 October	After harvest	Downy mildew	Bordeaux mixture WDG, 0.50%

Table 3.The record of treatments for diseases and pest control during 2022 growing season

No.	Date	Growing stage	Disease or Pest	Treatment and concentration
1	20-30 April	Blooming	Mites Powdery mildew	Nissorun 10 WP, 0.5 kg/ha Thiovit Jet 80 WG (80% sulphur), 3 kg/ha
2	10-25 May	Shoots (10-25 cm)	Downy mildew Powdery mildew	Curzate® F, 0.4 l/ha Talendo®, 0.225 l/ha
3	25 May-10 June	Before flowering	Downy mildew Powdery mildew Moths	Orondis Ultra pack, 0.5 l/ha Dinaly, 0.65 l/ha Wizard - 0.2 l/ha
4	10-20 June	After flowering	Downy mildew Powdery mildew, Grape black rot Moths	Profiler 71 WG, 2.5 kg/ha Flint Max 75 WG - 0.16 kg/ha in 1000 l water Sumi Alpha 5EC, 0.2 l/ha
5	20-30 July	Berry development	Downy mildew Powdery mildew Grape black rot Moths	Zorvec™ Zelavin® Bria 0.2 l/ha+1.25 kg/ha Flint Max 75 WG - 0.16 kg/ha in 1000 l water Wizard - 0.2 l/ha
6	20 July-10 August	Veraison	Downy mildew Powdery mildew gray mold	Cabrio Top, 2 kg/ha Thiovit Jet 80WG, 3 kg/ha Pyrus 400 SC, 2.5 l/ha
7	10-25 October	After harvest	Downy mildew	Bordeaux mixture WDG, 0.50%

Sensory analysis in wines typically follows a standardized protocol to ensure consistency and reliability in evaluations. A group of nine experienced and trained panellists were selected to participate in a sensory analysis of wines. Carefully selected wines were stored appropriately to preserve their integrity. The tasting room was meticulously prepared to eliminate strong odours and distractions, with neutral lighting and controlled temperature ensuring an optimal environment for tasting. Panellists were provided with evaluation sheets containing standardized criteria for assessing various sensory attributes, including colour/clarity, aroma, taste, and overall impression. They swirled the wine in their glasses to release aromas and evaluated the intensity, complexity, and character of the aroma, noting descriptors such as fruity, floral or herbal. Factors such as sweetness, acidity, tannin levels, and flavour intensity were evaluated, with descriptors including fruity, savoury, citrus, or mineral notes. Panellists provided an overall assessment of the wine,

considering its balance, complexity, harmony, and potential for aging.

Statistical analysis

Statistical analysis was conducted using XLSTAT (version 2020.1.3; Addinsoft; Paris; France) software for conducting correlation analysis, principal component analysis (PCA), analysis of variance (ANOVA) and t-test to explore the relationships among the variables (sugars content, acidity, maturation index, and alcohol concentration).

Pearson correlation coefficients to assess the linear relationships between variables were calculated. The relationships among the variables were examined at a significance level of $p < 0.05$, providing valuable insights into the interplay between sugars content, acidity, maturation index, and alcohol concentration in winemaking processes.

RESULTS AND DISCUSSIONS

The evaluation of grape quality was done after the analysis of some parameters important for winemaking (e.g. sugars, acidity, ripeness and the alcohol potential of the juice) which indicate the level of ripeness, determining the optimal time of harvesting (Rotaru et al., 2010). The evaluation of the quality parameters is necessary to guide the winemakers in making decisions during the harvest and the winemaking process, for the production of high-quality wines (Dejeu et al., 2008). During 2021 growing season, the most productive varieties were 'Feteasca regală' (10 tons/ha), followed by 'Italian Riesling', 'Burgund mare', 'Merlot' (9 tons/ha), 'Cabernet Sauvignon' (8 tons/ha), 'Sauvignon blanc' (7 tons/ha), and 'Pinot noir' (7 tons/ha). 'Traminer rose', 'Muscat Ottonel', and 'Tămâioasă Românească' cultivars yielded less, at around 6 tons per ha. Qualitatively, in 2021, the cultivars of 'Muscat Ottonel', 'Traminer rose', 'Cabernet Sauvignon', and 'Merlot' had an optimal maturity index, while the other cultivars had a small imbalance in the sugar-to-acidity ratio. In 2021, the cultivars of 'Cabernet Sauvignon' (225 g/L sugars) and 'Traminer rose' (220 g/L sugars) accumulated the highest sugars in the berries, while 'Sauvignon blanc' (190 g/L sugar) and 'Muscat Ottonel' (192 g/L sugars) accumulated the least amounts of sugars. Nistor et al. (2021) found in 'Traminer rose', an amount of sugars between 20.1 and 23.3 °Brix. The alcoholic potential in 2021, between 11.17 and 13.23% alcohol by volume offer the possibility of producing higher-quality wines for all ten cultivars (Table 4). According to the statistical analysis for the mean of the control varieties, the 'Traminer rose' cultivar had significant positive results, while the 'Cabernet Sauvignon' cultivar is very significant positive.

Table 4. Grape quality in the 2021 growing season

Cultivar	Sugars (g/L)	Total acidity (g/L H_2SO_4)	Maturity indices	Potential alcohol (vol. alc. %)
'Fetească regală '	200	5.8	34.48	11.76
'Sauvignon Blanc'	190	5.3	35.84	11.17
'Italian Riesling'	205	5.2	39.42	12.05
'Muscat Ottonel'	192	4.8	40.00	11.29
'Tămâioasă românească'	198	5.0	39.60	11.64
'Traminer rose'	220	4.7	46.80	12.94
'Burgund mare'	195	5.6	34.82	11.47
'Cabernet Sauvignon'	225	5.1	44.11	13.23
'Merlot'	200	5.0	40.00	11.76
'Pinot noir'	205	5.2	39.42	12.05
T	t=56.11	t=48.54	t=32.15	t=56.06
P value (two tailed)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Significant (alpha≤ 0.05)	Yes	Yes	Yes	Yes

In the 2022 growing season, there was a severe drought in the vineyards from Bogdand, area, especially from March 1st to September 4th, 2022, when the recorded precipitation was only 47 mm/m^2. Abundant rainfall for two weeks, with measurements indicating a volume over 100 mm/m^2 fell between September 4th and September 18th. As a result of a challenging

climatic year, the grape production in 2022 was low, ranging between 4-5 tons/ha for most varieties, with the exception of the 'Cabernet Sauvignon', with 7 tons/ha recorded. The grape harvest for winemaking was left to overripe, with maturity indices averaging 46.13, ensuring that all cultivars had a balanced sugar-to-acidity ratio.

All ten grape varieties investigated in 2022 for grape quality had high levels of sugar in the berries, with at least 210 g/L in the 'Sauvignon Blanc' and 'Muscat Ottonel' cultivars and up to 250 g/L in the 'Traminer rose' and 'Cabernet Sauvignon' (Table 5).

The alcoholic potential, with an average of 11.93% alcohol by volume, for all cultivars, suggests the possibility of producing higher-quality wines. Water availability is crucial for grapevine growth, especially during critical stages like blooming and fruit set (Martínez-Lüscher et al., 2016).

Growing season 2021 had more precipitations, and offered adequate moisture for grapevine growth, given the overall amounts recorded. However, severe rainfall raised the danger of fungal diseases including mildew and botrytis, and affected grape quality and yield.

The slightly decreased precipitation in 2022 reduced disease pressure, resulting in healthier grapevines and better fruit quality.

Table 5. Grape quality for the 2022 growing season

Cultivar	Sugars (g/L)	Total acidity (g/L H_2SO_4)	Maturity index	Potential alcohol (vol. alc. %)
'Fetească regală'	230	5.5	41.81	13.52
'Sauvignon Blanc'	210	5.1	41.17	12.35
'Italian Riesling'	230	4.9	46.93	13.52
'Muscat Ottonel'	210	4.5	46.66	12.35
'Tămâioasă românească'	230	4.8	47.91	13.52
'Traminer rose'	250	4.5	55.55	14.70
'Burgund mare'	220	5.4	40.74	12.94
'Cabernet Sauvignon'	250	4.9	51.02	14.70
'Merlot'	220	4.7	46.80	12.94
'Pinot noir'	220	4.9	44.89	12.94
t	t=50.62	t=46.31	t=31.85	t=50.71
P value (two tailed)	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Significant (alpha≤ 0.05)	Yes	Yes	Yes	Yes

The correlation analysis among the variables (sugars, acidity, maturation index, and alcohol volume) provides valuable insights into their relationships and potential impacts on wine characteristics (Table 6).

Table 6. Pearson correlations between berry quality parameters

Variables	Sugars	Acidity	Maturation Index	Vol. alc. %
Sugars	**1**	-0.317	0.795	1.000
Acidity	-0.317	**1**	-0.824	-0.317
Maturation Index	0.795	-0.824	**1**	0.795
Vol. alc. %	1.000	-0.317	0.795	**1**

The strong positive correlation between sugars and berries maturity indicates that wine can achieve higher complexity, taste and flavours. Lower acidity resulted in rounder and smoother wine but with too much sugar which influenced wine balance. The high negative correlation (0.824) between total acidity and maturation index in grape berries for cultivars studied is a natural consequence of the physiological changes explained by acidity decreasing and increase in sugar content; one of the changes is the breakdown of organic acids which contribute to the total acidity of the berries. Usually, acidity adds structure and brightness to wine, because an excessive acidity overshadow wine flavours and alcohol perception; the balanced correlation (-0.317) between sugar and acidity ensured the tasting harmony of wine. In the PCA diagram (Figure 3), F1 accounted for 76.78% and F2, 23.16% of

the variation, which is evident that these components play a significant role in modelling the observations. 'Cabernet Sauvignon' stood out with the highest volume of alcohol and sugar concentrations, indicating the potential for full-bodied and robust wines. Instead, 'Burgund Mare' and 'Feteasca Regală' presented a high level of acidity, highlighting the potential for refreshing wines. Grapes from the 'Traminer rose' variety presented the best ripeness index, suggesting the development of more intense aromas. Besides from its alcohol content, wine is a sophisticated blend of organoleptic characteristics (such as colour, taste, flavour, and aroma (Liang et al., 2021; Dobrei, 2016), Table 7.

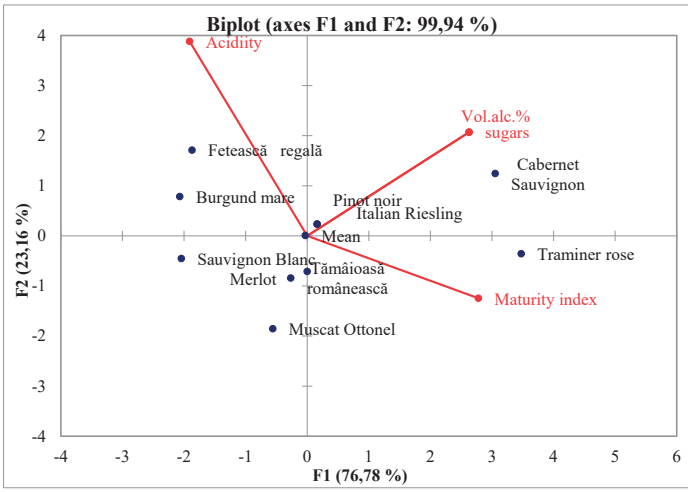

Figure 3. PCA diagram for the quality parameters in the grape varieties

Table 7. The organoleptic items description of the wines from 2022 growing season

Wines	Organoleptic characteristics of wines		
	Colour/Clarity	Aroma	Taste
'Feteasca regală'	Yellow-green/ Clear	subtle floral aroma, yellow melon scent, quince, citrus notes	semi-dry, light, fruity, fresh, high acidity perfectly balanced by sweetness, long aftertaste
'Sauvignon Blanc'	yellow straw with green hues/Clear	elderflower and summer fruits, peaches, green apples, figs	semi-dry, lively acidity, pleasant, elderflower notes
'Italian Riesling'	pale greenish-white / Clear	grassy and mineral notes, citrus aromas	dry, fresh, mineral, long aftertaste finish with watermelon notes
'Muscat Ottonel'	pale yellowish-green/Clear	floral and fruity fragrance, with hints of rose, muscat, and honeysuckle, notes of green apricots	semi-sweet, fresh, discreet, lemongrass notes, sweet-bitter aftertaste
'Tămâioasă românească'	yellowish-green with golden reflections/Clear	muscat, basil, and honey	semi-sweet, long aftertaste, acacia flower aromas
'Traminer rose'	golden-yellow / Clear	expressive, delicate, aromas of rose petals, strawberries, grapefruit	semi-dry, aromatic, fruity, full-bodied, moderate acidity, citrus aromas, and rose sweetness
'Burgund mare'	ruby-red with lilac reflections/Clear	forest red fruits - blueberries and fresh raspberries, hints of violets	semi-dry, balanced, with fruitiness, medium-bodied, persistent aftertaste
'Cabernet Sauvignon'	dark red colour/ Clear	blackberries, blueberries, black currants, and sour cherries	dry, intense, blackcurrants, slightly astringent, hints of tobacco
'Cabernet Sauvignon rose'	intense salmon pink/Clear	summer red fruits and dried herbs	semi-dry, fresh, with well-integrated alcohol, balanced acidity, sweetish aftertaste.
'Merlot'	ruby red/Clear	vibrant aromas of red fruits, very ripe cherries, blackberries, and blueberries	semi-dry, harmonious, fruity, with aromas of plums, cranberries, and ripe cherries
'Pinot noir'	pale ruby-red/Clear	aromas of cherries and sour cherries, strawberries, and red currants	dry, elegant, fresh, pleasant tannins, lasting aftertaste
'Pinot noir rose'	rose, strawberry shade/Clear	raspberry and strawberry.	semi-dry, versatile, full-bodied, hints of cranberries and blackcurrants
Blending of 'Riesling Italian' + 'Tămâioasă românească'	golden-yellow/ Clear	rustic aroma, notes of wildflowers, hay, and green apples.	semi-dry, fresh, balanced, fruity, with hints of honey and muscat, lasting aftertaste

Understanding these characteristics is critical to enjoying the complexities and variability found in each glass (Lick et al., 2017). By comparing the colours, certain common traits between the different varieties were found. Every variety shared the same quality of clarity, giving each one a transparent, clear look that amplifies its visual attractiveness. Every wine shared the same quality of clarity, giving each one a transparent, clear look that amplifies its visual attractiveness.

The colours, however, differ greatly, ranging from the rich ruby-reds of Burgund Mare and Cabernet Sauvignon wines to the vivid yellows and greens of Fetească Regală and Muscat Ottonel wines.

The terroir and winemaking technique of each grape variety are reflected in the distinct character and character that each colour expresses. Considering these variations, the wines all have a similar level of elegance and purity. When analysing the aroma profiles of the wines, several patterns emerge. Many wines contain floral notes, which offer refinement and delicacy to the bouquet. The aromatic spectrum of fruits, which range from citrus and stone fruit, to berries and tropical fruits, provide a feeling of freshness and vitality. Herbal and mineral notes offer complexity and depth, improving the whole sensory experience. While each grape variety has its own distinct aroma profile, they all share a thread of complexity, balance, and attractiveness. Many of the analysed wines have flavours that range from fruity and flowery to mineral and savoury, and they all show a good balance between sweetness and acidity. Certain wines, like Muscat Ottonel, offer a more delicate and nuanced flavour profile, while others, like 'Cabernet Sauvignon', offer strong and intense flavours. Despite these differences, all the wines share a common thread of complexity and balance.

CONCLUSIONS

The comparative analysis of Bogdand weather data for 2021 and 2022 demonstrates the strong impact of weather fluctuation on grapevine quality and productivity. While growing season 2021 provided more favourable conditions for grape growing than 2022, minor variations in temperature and precipitation have altered grape ripening processes and overall fruit quality.

Understanding the complex interplay between climatic conditions and grapevine physiology is critical for vineyard management strategies designed to improving grape quality and output in Bogdand and other viticultural regions. The 2022 growing season in the Bogdand area brought substantial challenges due to a prolonged drought followed by plentiful rains, which impacted grape production and harvesting. Despite low yields, accurate management produced balanced sugar-to-acidity ratios and high-quality grapes, particularly in 'Traminer rose' and 'Cabernet Sauvignon'. While water supply remained critical for grapevine growth, the balance of precipitation and disease pressure finally contributed to stronger vines and better fruit quality. This demonstrates vineyards' resilience and adaptation in circumstances of significant climatic conditions. Each variety's flavour profile ranges from fruity and flowery to mineral and savoury, with a balance of sweetness and acidity. While some wines have delicate nuances, some have strong flavours, yet they all share an identifiable characteristic of complexity and balance. Overall, this exploration emphasises the variety and diversity of wines.

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