Târnave Vineyard

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Located at the intersection of the geographical coordinates of 46°–47° Northern latitude and 23°–24° Eastern longitude, Târnave vineyards are part of the viticultural zone 1 of Romania. They are situated on the Transylvanian Plateau. The most significant viticultural area of Transylvania, the prestigious Târnave vineyard, named so because most of the vineyards are located on the slopes that delineate the valleys of the rivers Târnava Mare and Târnava Mică, is known and appreciated for its quality wines with a specific flavor and a good sugar/acidity balance.

Keywords: climate change ; Amurg cultivar ; Internet of Things ; precision viticulture

1. Introduction

The evolving overall wine-growing environment represents three facets of the wine world: production, distribution, and wine consumption [1]. The first element of the wine's evolving environment is its biological and chemical origins [1]. The evolving geography of winemaking refers to the dynamics of localization and distribution of viticulture and enology practices for the last ten millennia [1][2][3]. Besides the well-known grapevine growing zones, commercial viticulture is currently also found in the tropics, in higher altitude areas such as Hawaii, Mexico, Brazil, Bolivia, and Peru [4]. To produce enough sugars for fermentation to yield alcohol, the genus Vitis L. (grapevine) requires cycles of colder temperatures (and high diurnal temperature fluctuations) for grapes maturation and ripening [1][5]. Today, the wine industry is full of creativity and change, as new grapevine cultivars are created to expand the limits of wine production beyond its known boundaries [1][6]. The diversification (or rediscovery) of autochthonous grown grapevine cultivars and the consequent global acceleration of wine consumption rates have been balancing the increase of worldwide wine production starting in the 1970s [1][7][8]. This growth in the wine industry has also been enabled by globalization, for better or worse [8][9].

The importance and demand of viticulture and wine industry products are given by their place of origin, plant cultivars, design, and taste, which is undoubtedly different than every other agricultural outcome worldwide [10]. The characteristics of the grape harvest and, by consequence, of the wine production are mostly dictated by the features of the climate and soil in which particular grape cultivars are produced [11]. The growing season affects the qualities of the harvested grapes, whereas the fermentation stage and the bottling period affect the wine that is crafted from them [12]. Terroir is the most often used (and abused) term in the wine vocabulary and is now a touchstone for the promotion of fine wine [13][14].

Thus, the physical environment includes the slope, the soil composition, the depth, the parent materials, mineral quality, texture, humidity content, and the water retention, astronomical, climate, and weather aspects (sun angles and emplacement during the growing period, dawn-day visibility, humidity range and timing, rain, temperature, heating grades, cooling at night, wind speed and direction, the environmental elements that contribute to the seasonal pattern in the atmosphere, timing and intensity of severe weather, such as hail, freezing, and snowfall) during the most biologically active seasons for grapevine [10][15]. In addition, the biological factors of a vineyard environment—biodiversity of flora and fauna that will increase the good microorganisms and predators of insects, thus lowering the risks of grapevine's pests and diseases—are the natural components of terroir [10][15]. While a competent winemaker may claim that good wine is produced irrespective of the geographic location (appellation or denomination) of grape production, modern grapevine growers (usually) agree that "location matters" [16].

Consequently, the objectives of the paper are: To present the existing types of viticulture practices and to highlight the added value that precision viticulture brings to the current practices, To present the background of the Romanian and, more specifically, Transylvanian viticulture and the impact of the climatic changes in Transylvanian viticulture, To reveal the impact of the Internet of Things solutions in viticulture, To present the Amurg grapevine cultivar, as a cultivar whose cultivation can be extended based on the climatic changes context and IoT technologies, To introduce the Climatic Change Precision Viticulture (CCPV) concept to benefit from climatic changes, decision support systems, and IoT technologies to support the extension of the Amurg cultivar and to increase the sustainability of viticulture, by lowering the energetic inputs: fertilizers, herbicides, fungicides, insecticides, and gas, To propose a sustainable CCPV architecture for

a smoother adaption of the Amurg cultivar to Transylvania climate conditions, increased grapevine productivity and income, and lowered costs in terms of the resources used, To reveal the improvements brought by the proposed Internet of Things technologies in viticulture.

2. Precision Viticulture: Impact and IoT Solutions

Our most recent work [17] aimed to assess the relevance and the benefits of using the Smart Agriculture Xtreme platform from Libelium [18] in Romanian vineyards. The vineyard monitoring system follows another approach, which is built upon a layered Internet of Things architecture. In this way, the architecture brings the advantage of being scalable, in comparison with other proposed systems [19][20][21][22]. Moreover, the paper revealed that key parameters such as soil oxygen concentration, soil dielectric permittivity, soil, and air temperature and humidity could be monitored in real-time, with benefits in assessing the quality of the soil, and thus, the status of the vineyard. For example, the values obtained in the experimental results in [17] were compared with reference values of soil quality parameters as found in the literature [23].

In [24], a real-time acquisition and monitoring PV system was proposed, having the advantages of low consumption of energy, a low cost of the hardware implementation and the IoT devices, as well as a straightforward process of monitoring the temperature and moisture of the soil and transmitting this information to a base station. The system can also alert at the occurrence of a disease or pest of the plants in the vineyard when a drone is sent to the specific area and takes pictures that are processed afterward when the drone returns to the base station.

In [22], the SEnviro system was proposed, which is an IoT-based architecture for vineyard monitoring. The system also enables disease prediction, thus leading to an increase in the wine quality and a reduction of the grape losses in the vineyard. The system was implemented in Spain (province Castelló). It consisted of two parts: a node of sensors (SEnviro node) and an IoT software platform capable of managing different sensor nodes (SEnviro connect). Four SEnviro nodes were deployed and installed in the vineyards, and a fifth node was used for tests in a location nearby the laboratory. The collaboration between the SEnviro node and SEnviro connect in the vineyard monitoring enables an autonomous operation and the possibility to send alerts when a disease or another problem is detected in the vineyard.

In [25], the authors evaluated in an experimental setting in a vineyard in Spain the benefits of using IoT technologies that integrate a wireless sensor network (WSN), unmanned aerial vehicles (UAVs), and an engine for the processing and visualization of data. This system can help wine producers to access quickly, with a friendly interface, the data that WSN and UAVs collect from the vineyard.

3. Viticulture in Romania-General Context

According to the FAO's statistics, in 2019, Romania ranked 10th in the world out of 98 countries for the grapevine cultivated area and harvested 176.340 ha and 18th out of 98 countries concerning the production of the grapes with 973,990 tonnes [26]. The total tonnage of wine produced in Romania in 2018 was 125,743 tonnes, ranking Romania 18th globally [27]. Moreover, the OIV (Organisation Internationale Vitivinicole) statistics [28] in 2020 revealed that Romania kept its position in the grapevine cultivated area ranking with a surface of 190.000 ha. On the other hand, OIV places Romania in 13th place globally from the point of view of wine production with 3.6 million hectolitres. Romania is located between 43°37′–48°15′ N lat and 20°15′–29°44′ E long, in Eastern Europe, having a temperate continental climate, Dfb and Dfa in a Koppen–Geiger climate updated classification [29][30]. The annual average temperature is 8 °C at the northern limit, to 11 °C at the southern boundary, and up to 11.7 °C in the plains [30][31]. The climate is influenced from the east by the steppe climate, from the south-west by the Mediterranean climate, and from the west and north-west oceanic climate [30]. The topography is diverse and distinct and comprises 28% mountains, in the middle of the country, 42% plateaus and hills, and 30% plain land [30]. More than half of Romania, more precisely 62%, is covered by arable land [32], with viticulture mainly concentrated in hilly and plateau areas [30]. Due to the adequate climate for grape production, in Romania, grapevine growing is a traditional practice that has arisen and developed throughout history [30][33]. Eight large grapevine growing regions (**Figure 1**) with specific environmental conditions, as a result of their proximity to the Carpathian mountains (altitude: 2500 m), the Danube river, and the Black Sea, constitute the nationwide viticultural area [30][33]. Furthermore, these regions include 141 plantations or vineyards, the southernmost of these is situated at 43° N, and the northernmost at 48° N [30]. The wine production types are differentiated from south to north depending on the accumulation of heliothermic resources, due to the wide latitude of the Romanian land, as it follows: the southern limit (43° N) is suitable for the table grape production [34], the southern half of Romania (between 43° N and 45° N) is predominantly characterized by red wine production, in the northern half of the country (between 43° N and 45° N), the white wine production is predominant, and at the northern limit (48° N), white table wine and sparkling wine production prevails [30]. **Figure 1** presents the eight important viticultural zones (VZ) of Romania, which are: Transylvanian Plateau (VZ 1),

Moldavian Hills (VZ 2), Muntenia and Oltenia Hills (VZ 3), Banat Hills (VZ 4), Crișana and Maramureș Hills (VZ 5), Dobrogea Hills (VZ 6), Danube Terraces (VZ 7), sands and other suitable terrains from the South (VZ 8) [30][33].

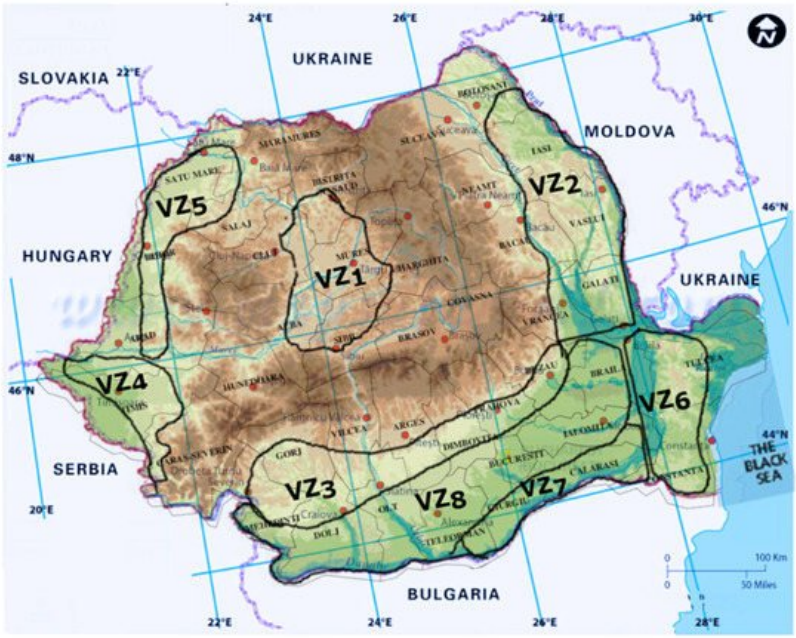


Figure 1. Viticultural zones in Romania.

The map of the Romanian vineyards presented in **Figure 1** was compiled using GIMP editor and four maps: (1) Romania's relief map, (2) Romania's administrative map, (3) the map extracted from the Corine Land Cover Data-base 2006 Europe of the European Environment Agency (EEA 2006) [30] and the Romanian map from Maps of World [35]. Each Romanian viticultural zone, in addition to the popular international grapevine cultivars, have *Vitis vinifera* cultivars that are autochthonous tolerant and resistant to pests [36][37] and weather extremes and offer the local wine production specificity [30]. The specific characteristics of the Romanian vineyards are integrated within the grapevine growing technology adapted to the local cultivars cultivated in these areas [30][36][38].

VZ1 is suitable for obtaining quality and table white wines (QWW and TWW) that are dry, semi-dry and sweet from the cultivars such as Fetească albă, Pinot gris, Traminer roz, Sauvignon, Riesling Italian, Muscat Ottonel, as well as for sparkling white wines (SWW) from the cultivars Fetească regală, Fetească albă, Riesling Italian.

In the VZ2 of the Moldovian Hills, there is a cultivated grapevine for semi-sweet and sweet QWW and TWW from the cultivars Grasă de Cotnari, Fetească albă, Francusa, Tamaioasa romaneasca, Muscat Ottonel, Fetească regală, Aligote, Muscat Ottonel, Zghihara de Husi, Riesling Italian, Galbenă de Odobești, Plavaie, for quality and table red wines (QRW and TRW) from the cultivars Fetească neagră, Pinot noir, Băbească neagră, Merlot, Cabernet Sauvignon, Busuioacă de Bohotin, Oporto and for table grapes (TG) from the cultivars Chasselas doré and Chasselas rose, Muscat Hamburg, Coarnă neagră.

VZ3 is designated for the growing of grapes for QRW and TWW from the cultivars Cabernet Sauvignon, Fetească neagră, Pinot noir, Merlot, Busuioaca de Bohotin, Burgund Mare, for QWW and TWW from the varieties Fetească albă, Riesling Italian, Aligote, Fetească regală, Pinot gris, Sauvignon, Muscat Ottonel, Grasă de Cotnari, Tamaioasa românească, Saint Emilion and for TG from the varieties Chasselas doré and Chasselas rose, Muscat Hamburg, Muscat de Adda, Coarnă neagră, Afuz Ali, Italia, Cardinal.

The smallest VZ of Romania, VZ4, is mainly designated for QRW from the cultivars Cabernet Sauvignon, Pinot noir, Merlot, Burgund Mare, Cadarcă, but QRW and TWW from the cultivars Riesling Italian, Fetească regală, Sauvignon, Muscat Ottonel, Creață, Majarca albă, and Steinschiller and TG from the cultivars Chasselas doré and Chasselas rose, Muscat Hamburg, Muscat de Adda are also grown.

The cultivars of the VZ5 are designated for QRW from the cultivars Cabernet Sauvignon, Pinot noir, Merlot, Burgund Mare, Cadarcă, for QRW and TWW from the cultivars Riesling Italian, Fetească regală, Muscat Ottonel, Mustoasă de Măderat, Furmint, Pinot gris, and Traminer roz and TG from the cultivars Chasselas doré and Chasselas rose, Muscat Hamburg. The white cultivars of VZ5 are also used for distillates, and the cultivars Fetească albă, Fetească regală and Iordană for sparkling wines.

The viticultural zone of Dobrogea hills (VZ6) is represented by a large assortment of wines and table grapes and cultivars for raisins (Sultanina). Thus, for QWW and TWW, the cultivars Pinot gris, Chardonnay, Muscat Ottonel, Riesling Italian, Sauvignon, Fetească regală, and Aligote are grown, for QRW and TRW, the cultivars Cabernet Sauvignon, Pinot noir, Merlot, Băbească neagră, Sangiovese, Burgund mare, and for TG, the cultivars Perla de Csaba, Italia, Chasselas doré and Chasselas rose, Cardinal, Muscat Hamburg, Muscat de Adda, Afuz Ali.

The Danube Terraces (VZ7) are mainly cultivated with TG (Perla de Csaba, Italia, Chasselas doré and Chasselas rose, Cardinal, Muscat Hamburg, Muscat de Adda, Afuz Ali) and also the only one in Romania for the seedless raisins. QRW and TRW from the cultivars Cabernet Sauvignon, Pinot noir, Merlot, Burgund mare and QWW and TWW from the cultivars Pinot gris, Riesling Italian, Fetească regală, Sauvignon are also produced here.

On the VZ8, represented by the sands and other suitable terrains from the South of Romania, grapes for TRW and QRW (Rosioara, Sangiovese, Băbească neagră, Cabernet Sauvignon, Merlot, Burgund Mare) for TWW and QWW (St. Emilion, Rkatiteli, Fetească regală, Riesling Italian, Sauvignon, Aligote) and for TG (Muscat Perla de Csaba, Italia, Perla de Csaba, Chasselas doré and Chasselas rose, Cardinal, Muscat Hamburg, Muscat de Adda, Afuz Ali, Coarnă neagră) are cultivated [39].

The presented assortment of wines for all the VZ is completed and extended by newly created cultivars and the acclimatization of other international cultivars. Climate change has generated a dynamic of the cultivar assortment grown [30], and the general trend is the replacement of the white cultivars with the red ones and the increase of altitude for the white types [30].

4. Grapevine Cultivation and Wine Production in Târnave Vineyards

Located at the intersection of the geographical coordinates of 46°–47° Northern latitude and 23°–24° Eastern longitude, Târnave vineyards are part of the viticultural zone 1 of Romania. They are situated on the Transylvanian Plateau [40][41][42][43]. The most significant viticultural area of Transylvania, the prestigious Târnave vineyard, named so because most of the vineyards are located on the slopes that delineate the valleys of the rivers Târnava Mare and Târnava Mica [40][42][43], is known and appreciated for its quality wines with a specific flavor and a good sugar/acidity balance [40][41][43]. From the environmental point of view, grapevine finds good conditions and a good growing season here, with the Târnave vineyard being part of the Țara Vinului [41][44]. Țara Vinului, The Land of Wine or Weinland, is the wine route of Alba County spreading between the rivers Mures, Tarnava Mare, and Tarnava Mica, including the vineyards: Aiud, Alba-Iulia, Sebeș-Apold, and Târnave, and is located on 18 administrative-territorial units (ATU) out of Romania's 78 ATUs [45], with 90 localities out of which five are municipalities and towns with the surrounding villages [45]. In turn, the Târnave vineyard includes five wine centers: Blaj, Jidvei, Mediaș Târnăveni, Zagăr and Valea Nirajului.

SCDVV Blaj, the viticultural and wine research center of the Tarnave vineyard, is one of the main actors of the research and development in the field in Transylvania [45]. In Transylvania, viticulture has been practiced since antiquity, perpetuating and developing ever since the migration of people during the feudal period up to now [40][42][46]. The interest of the inhabitants in this vineyard area has been and is shown by both the grapevine cultivation and the winemaking [42]. The existence of an ancient, well-developed, well-known viticulture in the center of Transylvania imposed the necessity of studying and establishing on a scientific basis the basic assortment specific to this area [42][47]. For this purpose, it was necessary to set up experimental wine-growing stations, which would contribute to the scientific solution of the requirements related to the quantitative increase and the quality of the grape and wine production [41][42][47][48]. In this context, in the territory of the Romanian State Reserve Crăciunelul de Jos, 7 km away from Blaj, in 1946, it was decided to establish the Viticultural Experimental Station Crăciunelu de Jos [47]. The research-development activity initiated by the academician Gheorghe Ionescu Şişeşti was continued. Considering the decision of the Department of Agriculture and State Domains, in 1929, to establish the Institute of Agricultural Research of Romania (ICAR) and being located in the center of one of the oldest vineyards "Tîrnave Vineyard", SCDVV Blaj had an undeniable role in the development and modernization of viticulture in Transylvania [47].

The importance of the wine region from the Transylvanian plateau is reflected in the area, the grapevine cultivars and clones planted here, and also in the quality of dry, semi-dry, semi-sweet, semi-aromatic, aromatic, and sparkling POD and PGI original and noble wines obtained from the established cultivars Fetească albă, Fetească regală, Riesling Italian, Sauvignon blanc, Muscat Ottonel, Neuburger, etc. [40][41][42][49]. As the qualitative assessment results indicate, the grapevine cultivars created at SCDVV Blaj have very good suitability for this area. In terms of quality rating, the clones Fetească Regală 21 Bl, Muscat Ottonel 12 Bl, and Sauvignon Blanc 9 Bl display particularly improved characters compared with the parental cultivars [42]. As a research hub for viticulture and winemaking in Transylvania, new cultivars

and clones are developed and homologated at SCDVV Blaj [50][51][52][53][54][55] (**Table 1**). In 2020, 25 wine-grape cultivars: 11 cultivars, including 8 white cultivars and 3 red cultivars; 13 clones for white wine, homologated at SCDVV Blaj; and 1 red hybrid were grown and used for winemaking at SCDVV Blaj [56]. **Table 1** presents the wine grapevine cultivars and clones homologated and cultivated at SCDVV Blaj. Some of the cultivars and clones homologated at SCDVV Blaj have tolerance to cryptogamic diseases and cold, which are valuable characteristics for sustainable grapevine growing.

Table 1. Grapevine cultivars homologated and cultivated at SCDVV Blaj, Târnave Vineyard, Romania.

Cultivar-Homologation Year	Colour of the Grape's Skin	Usage	Genetic Ortigin	Characteristics
Homologated cultivars developed at SCDVV Blaj				
Roze Blaj-2020	**Rosé**	**Grape cultivar for white wine**	**Sexuate intercrossing of two elites 8-33-44 (Iordană × Traminer roz) × 51-19 (Raisin de Saint Pierre × Perla de Csaba).**	**High richness and yield; suitable for white, dry or semi-dry superior quality wines; high tolerance to drought due to leaf structure; increased tolerance to cryptogamic diseases due to the tight berry skin.**
Rubin-2007	**Red**	**Grape cultivar for red wine**	**Sexuate interspecific hybridization between the Traminer roz cultivar and a hybrid descendant (Seyve Villard 12375 × Regina viilor)**	**High tolerance to diseases and good tolerance to cold; favorable results for economic viticulture, especially for family use and for replacing the direct-producer hybrids; recommended for leisure vineyards.**
Astra-1995	**White**	**Grape cultivar for white wine**	***Vitis vinifera* ssp. sativa L. Fetească regală × Pinot gris**	**High yielding capacity; good potential to accumulate sugars; good tolerance to cold (buds' dead less than 25% at −20), drought and diseases with respect to other cultivars specific to** VZ1 **(Transylvania), preserving its foliar apparatus and grapes in a normal stage. Because of its late bud break, it is more protected against the late spring frosts.**
Homologated cultivars developed at SCDVV Blaj				
Selena-1995	**Rosé**	**Grape cultivar for white wine**	***Vitis vinifera* ssp. sativa L. Sexuate hybridization between Iordană cultivars × Traminer roz**	**High fertility and yieldingness; ensures the production of high quality dry and semi-dry white wines; high to very good tolerance to cold and several cryptogamic diseases.**
Blasius-1994	**White**	**Grape cultivar for white wine**	***Vitis vinifera* ssp. sativa L. (Traminer roz × Iordană) × (Raisin de Saint Piere × Perlă de Csaba)**	**Maturation of the vine ropes is done at a superior level, favoring the cold tolerance increase, while the fertile region is placed at the very base of the cane. The shoot maturation is done at the shoot tip, which favors the tolerance to cold increasing, and the fertile buds are at the base of the cane. Succulent pulp, with a sweet-sour taste, favorable for wine equilibrium sugars/acidity.**
Radames-1993	**Rosé**	**Grape cultivar for white wine**	**Interspecific hybrid Traminer roz × (Seyve Villard 12.375)**	**High tolerance to cold and cryptogamic diseases; high fertility and yieldingness; ensures the production of dry white wines for current consumption or wine-distillates; recommended for leisure farms.**
Amurg-1989	**Dark-red**	**Grape cultivar for red wine**	***Vitis vinifera* ssp. sativa L. Muscat de Hamburg × Cabernet Sauvignon**	**Ensures the production of superior, table and sparkling red wines. Recommended in Târnave and Aiud vineyards and other viticultural zones with favorable conditions for producing red wines; medium tolerance to cryptogamic diseases and cold.**
Brumăriu-1983	**White**	**Grape cultivar for white wine**	**Interspecific hybrid Saint Emilion × Rayon d'Or**	**Good tolerance to cryptogamic diseases and cold; recommended for wine-distillate.**
Homologated clones developed at SCDVV Blaj				

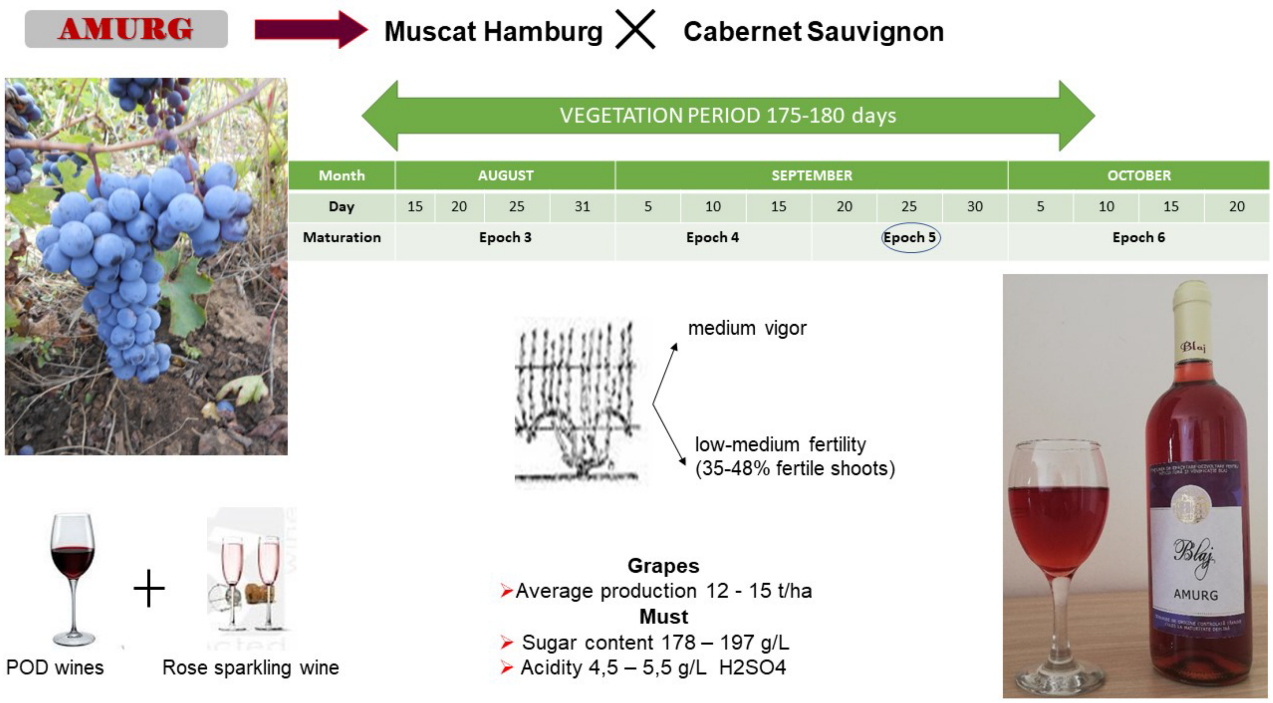
Cultivar-Homologation Year	Colour of the Grape's Skin	Usage	Genetic Ortigin	Characteristics
Pinot gris 11 Bl. 2020	White	Grape cultivar for white wine	*Vitis vinifera* ssp. sativa L. Pinot gris	
Fetească albă 29 Bl. 2006	White	Grape cultivar for white wine	*Vitis vinifera* ssp. sativa L. Population of the Fetească albă cultivar	
Iordană 9-1 Bl. 2006	White	Grape cultivar for white wine	*Vitis vinifera* ssp. sativa L. Population of the Iordană cultivar	Superior qualities compared to the parental cultivar population. Better fertility; it does not show millerandage (or shot berries, hens, and chicks and pumpkins and peas) phenomena has resistance to diseases. Ensures the production of high-quality white wines with POD potential.
Riesling de Rhin 7-2 Bl. 2006	White	Grape cultivars for white wine	*Vitis vinifera* ssp. sativa L. Population Riesling de Rhin cultivar	
Muscat Ottonel 12 Bl. 1995	White	Grape cultivar for white wine	*Vitis vinifera* ssp. sativa L. Population of the Muscat Ottonel cultivar	
Neuburger-10 Bl. 1993	White	Grape cultivar for white wine	*Vitis vinifera* ssp. sativa L. Population of the Neuburger cultivar	
Homologated clones developed at SCDVV Blaj				
Riesling Italian-3 Bl. 1983	White	Grape cultivar for white wine	*Vitis vinifera* ssp. sativa L. Population of the Riesling Italian cultivar	
Fetească regală-21 Bl. 1979	White	Grape cultivar for white wine	*Vitis vinifera* ssp. sativa L. Population of the Fetească regală cultivar	
Traminer roz-60 Bl. 1975	Pink	Grape cultivar for white wine	*Vitis vinifera* ssp. sativa L. Population of the Traminer roz cultivar	Superior qualities compared to the parental cultivar population. Better fertility; does not show millerandage (or shot berries, hens and chicks and pumpkins and peas) phenomena has resistance to diseases. It ensures the production of high-quality white wines with POD potential.
Pinot gris-34 Bl. 1975	White	Grape cultivar for white wine	Vitis vinifera ssp. sativa L. Population of the Pinot gris cultivar	
Sauvignon gris-9 Bl. 1975	White	Grape cultivar for white wine	*Vitis vinifera* ssp. sativa L. Population of the Sauvignon blanc cultivar	

5. Grapevine Amurg Cultivar

Amurg cultivar was obtained through the efforts of Csavossy Gheorghe, a researcher at the Research Station for Viticulture and Enology Blaj by intraspecific sexual hybridization between the acclimatized genitors Muscat de Hamburg and Cabernet Sauvignon cultivars with a unique Transylvanian terroir and was homologated in 1989 [49][57].

Amurg grapevine cultivar has a white-green, fluffy rosette (vegetative shoots), and its flower is a normal hermaphrodite. The adult leaf is round, large, with 3–5 lobes, and slightly hairy on the underside [49]. The lateral sinuses of the leaf are circularly closed, the petiole sinus is lyre-shaped and the petiole point is reddish [49]. The leaf edge has large, sharp teeth [49]. The grape is medium in size, cylindrical-conical, winged, compact [49]. The berry is ovoid, slightly elongated, red-blue, and has a juicy core [49].

Figure 2. Agrobiological and technological characteristics of the Amurg grapevine cultivar. Adapted from [58].



Amurg is a cultivar of medium to great vigor, with the maturation of the grapes in the 5th epoch [49] (**Figure 2**). It shows tolerance to low winter temperatures, up to minus 22 °C and is resistant to both downy mildew and Botrytis [49].

The fertility of the cultivar is low-medium, it forms only 35–48% fertile shoots (**Figure 2**), and the fertility coefficients have average values of 0.8 for the relative one and 1.7 for the absolute one [49]. The average weight of a grape is 260 g, the weight of 100 berries is 261 g, and the potential for sugar accumulation is 178–197 g/L, accompanied by a must acidity of 4.5–5.5 g/L H 2SO 4 [58]. We highlighted in **Table 2** that Amurg wine has an acidity of 5.92 g/L H 2SO 4 (**Table 2**) and is characterized by a content of 12.38% alcohol volume and 21.18 g/L non-reducing dry extract. The grape production obtained is on average 12–15 t/ha, from which a POD wine is obtained that can be used as a raw material for rosé sparkling wines (**Figure 2**) [58].

Table 2. Physicochemical analyses of Amurg wine.

Alcohol (% vol.)	Inverted Total Sugars (g/L)	Total Acidity (g/L H_2SO_4)	Volatile Acidity (g/L Acetic Acid)	SO_2 Free (mg/L)	SO_2 Total (mg/L)	Total Dry Extract (g/L)	Non-Reducing Dry Extract (g/L)	Glucose + Fructose (g/L)
12.38	1.52	5.92	0.35	22.50	110.00	22.70	21.18	0.35

In **Table 6**, we present the sensorial characteristics of the Amurg wine.

Table 6. Sensorial description of the Amurg wine.

Parameters	Characteristics
Appearance	clear, glossy
Colour	cherry
Aroma/ Bouquet	floral notes aromas and fresh fruit aromas
Taste	pleasant, dry, light raspberry aroma, soft wine, balanced
Acidity	low

6. Amurg's Diseases Tolerance and Resistance

Although much of the climate change debate has been centered on temperature effects, other concerns impacting the production of grapes, wines, and their quality include shifting viticulture due to elevated levels of CO 2 in the environment, additional moisture pressures in water-limited areas, as well as changes in the presence or severity of pests and grapevine diseases [59]. Some of the essential qualities of the Amurg cultivar are the resistance to low winter temperatures

and the tolerance or even resistance to some diseases like black rot. The resistance or tolerance of grapevine to such diseases represents a critical feature that reflects the sustainability of their cultivation because, in this way, the fungicides treatments are lowered.

Guignardia bidwellii (Ellis) Viala and Ravaz, the pathogen of the grapevine's black rot, is at the present time one of the most important fungal pathogens found in the vineyards worldwide [37]. The loss of harvest associated with this disease can vary from 5 to 100%, depending on climate, the reserve of pathogen's inoculum, and sensitivity of cultivated cultivars [37][60][61]. Romania's vineyards had sporadic and economically minor black rot outbreaks by the year 2006 [37]. In recent years, the incidence and severity of the disease in particular in the vineyards of Central Transylvania have been steadily increasing due to climate change, leading to substantial declines in productivity, with direct repercussions for wine quality and grapevine growers' incomes in the region, [37][62][63]. Genetic stamina is the most rational and economical way of controlling this disease, particularly for plantations cultivated in a sustainable system [64][65]; although, at present, there are various methods and means of preventing and countering the attack of black rot and other diseases, e.g., smart viticulture [37].

In this framework, the results of the susceptibility/tolerance at the attack of black rot of cultivars homologated at SCDVV Blaj (for the period 2016–2018) revealed the tolerance of Amurg (Attack Degree = 0.25%) compared with other autochthonous cultivars [37]. A correlation between high rainfall, above 10 mm, high temperatures above 15 °C and infection pressure, incidence and severity of the Guignardia bidwellii attack was noticed in all three years [37]. For example, in June and July of 2016–2018, the attack frequency (F) on the clones Fetească regală-21 Bl. (F = 90%), Fetească albă-29 Bl. (F = 95%), Muscat Ottonel-12 Bl. (F = 90%) and Pinot gris-34 Bl. (F = 85%) increased by average values of 85–90% due to a few weeks with intense daily precipitation combined with high temperatures [37]. The frequency of the attack was below 5% for the cultivars Rubin (F = 2.80%) and Amurg (F = 4.50%) for the same climatic conditions [37]. For the Fetească albă-29 Bl. (I = 37%) and Muscat Ottonel-12 Bl. (I = 43%) clones, the intensity (I) of the black rot attack was especially high, while for the Rubin and Amurg cultivars, the intensity was much lower with an average of 4.80%, and 5.60%, respectively [37].

Table 3 reviews the results concerning attack frequency and intensity for each of the cultivars involved in the study.

Table 3. *Guignardia bidwellii* attack frequency and intensity on grape cultivars at SCCDV Blaj. Adapted from [37].

Cultivar	Attack Frequency (F) (%)	Intensity (I) (%)	Climatic Conditions
Fetească regală 21 Bl	**90**	**35**	
Fetească albă 29 Bl	**95**	**37**	
Muscat Ottonel 12 Bl	**90**	**43**	**few weeks with intense daily precipitation combined with high temperatures**
Pinot gris 34 Bl	**85**	**36**	
Rubin	**2.8**	**4.8**	
Amurg	**4.5**	**5.6**	

References

1. Tiefenbacher, J.P.; Townsend, C. The Semiofoodscape of Wine: The Changing Global Landscape of Wine Culture and the Language of Making, Selling, and Drinking Wine. In Handbook of the Changing World Language Map; Springer International Publishing: Basel, Switzerland, 2019; pp. 1–44.
2. Mullins, M. Biology of the Grapevine; Cambridge University Press: Cambridge, NY, USA, 1992.
3. Gramaje, D.; Úrbez-Torres, J.R.; Sosnowski, M.R. Managing Grapevine Trunk Diseases with Respect to Etiology and Epidemiology: Current Strategies and Future Prospects. Plant Dis. 2018, 102, 12–39.
4. Possingham, J. On the growing of grapevines in the tropics. Acta Hortic. 2004, 39–44.

5. Jordão, A.; Vilela, A.; Cosme, F. From Sugar of Grape to Alcohol of Wine: Sensorial Impact of Alcohol in Wine. Beverages 2015, 1, 292–310.
6. Guguchkina, T.; Antonenko, M.; Yakimenko, Y. New grape varieties for production of high-quality wines, and assessment methodology for varietal characteristics of the product. BIO Web Conf. 2020, 25, 02016.
7. Santos, J.A.; Fraga, H.; Malheiro, A.C.; Moutinho-Pereira, J.; Dinis, L.T.; Correia, C.; Moriondo, M.; Leolini, L.; Dibari, C.; Costafreda-Aumedes, S.; et al. A Review of the Potential Climate Change Impacts and Adaptation Options for European Viticulture. Appl. Sci. 2020, 10, 3092.
8. Gokcekus, O.; Fargnoli, A. Is Globalization Good for Wine Drinkers in the United States? J. Wine Econ. 2007, 2, 187–195.
9. Anderson, K. Wine's Gradual Globalization. In Handbook of Eating and Drinking; Springer International Publishing: Basel, Switzerland, 2019; pp. 1–17.
10. Leeuwen, C.V.; Seguin, G. The concept of terroir in viticulture. J. Wine Res. 2006, 17, 1–10.
11. Vaudour, E. The Quality of Grapes and Wine in Relation to Geography: Notions of Terroir at Various Scales. J. Wine Res. 2002, 13, 117–141.
12. Meinert, L.D. 8. WINE AND TERROIR. Geochem. Perspect. 2020, 9, 99–112.
13. Charters, S.; Spielmann, N.; Babin, B.J. The nature and value of terroir products. Eur. J. Mark. 2017, 51, 748–771.
14. Schaller, K. Terroir—Myth and/or Reality—Outstanding Marketing Idea? A Review. Not. Bot. Horti Agrobot. Cluj-Napoca 2017, 45, 332–342.
15. Reiss, M.; Bernard, B.; Jedicke, E. Climate Change Resilience in Viticulture: Knowledge transfer and ecosystem services of adaptation strategies. In Proceedings of the EGU General Assembly 2020, Vienna, Austria, 3–8 May 2020; p. 37.
16. Drumonde-Neves, J.; Franco-Duarte, R.; Lima, T.; Schuller, D.; Pais, C. Association between Grape Yeast Communities and the Vineyard Ecosystems. PLoS ONE 2017, 12, e0169883.
17. Bălăceanu, C.; Negoiţă, A.; Drăgulinescu, A.M.; Roşcăneanu, R.; Chedea, V.S.; Suciu, G., Jr. The use of IoT technology in Smart Viticulture. In Proceedings of the 23rd Conference on Control Systems and Computer Science, Intelligence, Systems and Applications (IISA), Online, 12–14 July 2021; pp. 362–369.
18. Libelium. Libelium Smart Agriculture Xtreme IoT Vertical Kit. 2020. Available online: https://www.the-iot-marketplace.com/libelium-smart-agriculture-xtreme-iot-vertical-kit (accessed on 10 June 2021).
19. Pérez-Expósito, J.P.; Fernández-Caramés, T.M.; Fraga-Lamas, P.; Castedo, L. An IoT Monitoring System for Precision Viticulture. In Proceedings of the 2017 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData), Exeter, UK, 21–23 June 2017; pp. 662–669.
20. Maraš, V.; Popović, T.; Gajinov, S.; Mugoša, M.; Popović, V.; Savović, A.; Pavićević, K.; Mirović, V. Precision Viticulture Using Wireless Sensor Network. In Proceedings of the 2020 9th Mediterranean Conference on Embedded Computing (MECO), Budva, Montenegro, 8–11 June 2020; pp. 1–6.
21. Mouakher, A.; Belkaroui, R.; Bertaux, A.; Labbani, O.; Hugol-Gential, C.; Nicolle, C. An Ontology-Based Monitoring System in Vineyards of the Burgundy Region. In Proceedings of the 2019 IEEE 28th International Conference on Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE), Naples, Italy, 12–14 June 2019; pp. 307–312.
22. Oliver, S.T.; González-Pérez, A.; Guijarro, J.H. An IoT Proposal for Monitoring Vineyards Called SEnviro for Agriculture. In Proceedings of the 8th International Conference on the Internet of Things—IOT'18, Santa Barbara, CA, USA, 15–18 October 2018; Association for Computing Machinery: New York, NY, USA, 2018.
23. Pepper, I.; Brusseau, M. Chapter 2—Physical-Chemical Characteristics of Soils and the Subsurface. In Environmental and Pollution Science, 3rd ed.; Brusseau, M.L., Pepper, I.L., Gerba, C.P., Eds.; Academic Press: Cambridge, MA, USA, 2019; pp. 9–22.
24. Spachos, P. Towards a Low-Cost Precision Viticulture System Using Internet of Things Devices. IoT 2020, 1, 5–20.
25. Orozco-Barbosa, L.; García, F.M.; Ramos, A.B.; Riquelme, F.M. An Experimental Evaluation of IoT Technologies in Precision Viticulture. In Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering; Springer International Publishing: Basel, Switzerland, 2016; pp. 51–62.
26. FAOSTAT. 2021 Food and Agriculture Organization of the United Nations. Available online: www.fao.org/faostat/en/#data/QC (accessed on 12 April 2021).

27. FAOSTAT. 2021 Food and Agriculture Organization of the United Nations. Available online: www.fao.org/faostat/en/#data/QD (accessed on 12 April 2021).
28. Organisation Internationale Vitivinicole Note de Conjoncture Vitivinicole Mondiale 2020. 2020. Available online: https://www.oiv.int/public/medias/7899/oiv-note-de-conjoncture-vitivinicole-mondiale-2020.pdf (accessed on 2 July 2021).
29. Kottek, M.; Grieser, J.; Beck, C.; Rudolf, B.; Rubel, F. World Map of the Köppen-Geiger climate classification updated. Meteorol. Z. 2006, 15, 259–263.
30. Irimia, L.M.; Patriche, C.V.; Roșca, B. Climate change impact on climate suitability for wine production in Romania. Theor. Appl. Climatol. 2017, 133, 1–14.
31. Dumitrescu, A.; Bojariu, R.; Birsan, M.V.; Marin, L.; Manea, A. Recent climatic changes in Romania from observational data (1961–2013). Theor. Appl. Climatol. 2014, 122, 111–119.
32. Bălteanu, D.; Chendeş, V.; Sima, M.; Enciu, P. A country-wide spatial assessment of landslide susceptibility in Romania. Geomorphology 2010, 124, 102–112.
33. Chirciu, I.A.; Zaharia, I.; Soare, E. Production Of Wine Grapes And Cultural Traditions Related To Vine In Romania. Sci. Pap. Ser. Manag. Econ. Eng. Agric. Rural Dev. 2020, 20, 133–144.
34. Cichi, D.D.; Stoica, F.; Muntean, C.; Cichi, M.; Cîmpeanu, C.B. Table Grapes Production Sector In Romania-Evaluation, The Current State And Perspectives. Sci. Pap. Ser. Hortic. 2019, 63, 217–226.
35. Romania Map. Available online: https://www.mapsofworld.com/romania/ (accessed on 7 March 2021).
36. Rotaru, L.; Colibaba, L.C.; Aelenei, S.I. The agrobiological and technological value of ancient Romanian grape varieties cultivated in Iaşi vineyard. Lucr. Ştiinţifice, Univ. Ştiinţe Agric. Med. Vet. Ion Ionescu Brad Iaşi Ser. Hortic. 2018, 61, 135–138.
37. Tomoiagă, L.L.; Chedea, V.S. Grapevine Trunk Diseases Management in Vineyards from Central Transylvania. Bull. Univ. Agric. Sci. Vet. Med. Cluj-Napoca Hortic. 2020, 77, 117.
38. Iliescu, M.; Tomoiaga, L.; Chedea, V.S.; Pop, E.A.; Sirbu, A.; Popa, M.; Calugar, A.; Babes, A. Evaluation Of Climate Changes On The Vine Agrosystem In Tarnave Vineyard. J. Environ. Prot. Ecol. 2019, 20, 1754–1760.
39. Oşlobeanu, M. Zonarea Soiurilor de viţă de vie în România; Ceres: Bucharest, Romania, 1991.
40. Iliescu, M.; Tomoiaga, L.; Farago, M.; Comsa, M. The Nutrition of Vine in Tarnave; Academic Press: Cambridge, MA, USA, 2010.
41. Cudur, F.; Iliescu, M.; Comsa, M.; Popescu, D.; Cristea, C. Soil Type Influence On Yield Quantity And Quality At Grape Varieties for White Wines Obtained In The Viticultural Centre Blaj. Bull. Univ. Agric. Sci. Vet. Med. Cluj-Napoca Hortic. 2014, 71, 21–28.
42. Călugăr, A.; Babeş, A.C.; Bunea, C.I.; Pop, T.I.; Tomoiagă, L.; Iliescu, M. Oenological characterization of wines from grape clones created at Research Station for Viticulture and Enology Blaj, Romania. Stiinta Agric. 2018, 2018, 50–56.
43. Donici, A.; Bunea, C.I.; Călugăr, A.; Harsan, E.; Bora, F.D. Investigation of the copper content in vineyard soil, grape, must and wine in the main vineyards of Romania: A preliminary study. Bull. UASVM Hortic 2019, 76, 31–46.
44. Valeriu, C. Podgoriile şi Vinurile României; Ed. Acad. Române: Bucurest, Romania, 2003.
45. Coroș, M.M.; Pop, A.M.; Popa, A.I. Vineyards and Wineries in Alba County, Romania towards Sustainable Business Development. Sustainability 2019, 11, 4036.
46. Macici, M. Romania's Wines; Alcor Edimpex SRL: Bucharest, Romania, 1996.
47. SCDVV. Brief History of SCDVV Blaj. 2021. Available online: https://www.scvblaj.ro/articole/scurt-istoric-al-scdvv-blaj (accessed on 28 January 2021).
48. Popescu, D.; Iliescu, M.; Cristea, C.; Comşa, M. Researches Regarding the Agrotehnic Behaviour of Perspective Elites Obtained at Research Station for Viticulture and Enology Blaj. Bull. Univ. Agric. Sci. Vet. Med. Cluj-Napoca Hortic. 2014, 71, 293–298.
49. Stroe, M. Ampelografie; Ceres Publishing House: Bucharest, Romania, 2012.
50. Comșa, A.; Cristea, C.; Cudur, F. Behaviour In The Production Of New Varieties For White Wines Created at SCDVV Blaj. In Proceedings of the Simpozionul Ştiinţific Anual Cu Participare Internaţională "Horticultura—Ştiinţă, Calitate, Diversitate Şi Armonie", Iași, Romania, 26–28 May 2011.
51. Comșa, A.; Cristea, C.; Cudur, F. Perspective clone elites from the Italian Riesling variety, Scientifical papers. USAMV Bucur. Ser. Hortic. 2011, LV, 501–504.

52. Iliescu, M.; Tomoiagă, L.; Babeș, A.C.; Călugăr, A. New Grapevine Variety Created And Approved: Roze Blaj. In Proceedings of the 2020 19th International Conference Life Sciences for Sustainable Development, Cluj-Napoca, Romania, 25 September 2020.
53. Sîrbu, A.; Tomoiagă, L.; Vasiu, I.; Chedea, V.S.; Iliescu, M. New Wines from Târnave vineyard: SELENA and Blasius. In Proceedings of the 2020 19th International Conference Life Sciences for Sustainable Development, Cluj-Napoca, Romania, 25 September 2020.
54. Iliescu, M.; Tomoiagă, L.; Elena, A.P.; Sîrbu, A. Soiuri noi de struguri, create la SCDVV Blaj SELENA—Soi pentru vinuri albe, DOC BLASIUS—Soi recomandat pentru vinuri albe de calitate superioara. InfoAMSEM J. 2020, 3, 20.
55. Iliescu, M.; Tomoiagă, L.; Bărbuleţiu, A.; Pop, A.; Sîrbu, A.; Şerbu, F. Clona de viţă de vie pentru vinuri albe Pinot Gris 11BL. In Oferta Cercetării; ASAS: București, Romania, 2020.
56. Tomoiagă, L.L.; Iliescu, M.L.; Răcoare, H.S.; Botea, V.; Sîrbu, A.D.; Puşcă, G.; Chedea, V.S. Grape pomance generation from grape cultivars cultivated in Târnave vineyards in the framework of the climate change. Rom. J. Hortic. 2020, 1, 81–88.
57. Comșa, A.; Cristea, C.; Cudur, F. Soiul de viţă de vie pentru vinuri roşii Amurg. In Oferta Cercetării; ASAS: Champaign, IL, USA, 2011.
58. Chedea, V.S.; Bălăceanu, C.M.; Tomoiagă, L.L.; Zătreanu, I.; Iliescu, M.L. Climate change-the ground for improving the cultivated assortment of grapevine varieties with new autochthonous disease tolerant grapevine varieties. In Proceedings of the 8th World Sustainability Forum, Geneva, Switzerland, 14–19 September 2020.
59. Jones, G.V.; Reid, R.; Vilks, A. Climate, Grapes, andWine: Structure and Suitability in a Variable and Changing Climate. In The Geography of Wine; Springer: Cham, The Netherlands, 2011; pp. 109–133.
60. Janex-Favre, M.; Parguey-Leduc, A.; Jailloux, F. The ontogeny of pycnidia of Guignardia bidwellii in culture. Mycol. Res. 1993, 97, 1333–1339.
61. Tomoiaga, L.; Criveanu, H.; Micle, S. Monitoring of climatic parameters an effective solution of fighting against the black rot of the vine (Black-Rot). In Proceedings of the UTC–N Symposium Modern Science and Energy, Cluj-Napoca, Romania, 15–17 May 2002; pp. 337–341.
62. Tomoiaga, L.; Chedea, V.S. The Behaviour of Some Grapevine Varieties to the Guignardia bidwellii Fungus Attack. Bull. Univ. Agric. Sci. Vet. Med. Cluj-Napoca Hortic. 2020, 77, 122.
63. Tomoiaga, L.; Comsa, M. The strategy of optimization for combat the Black Rot of vine (Guignardia bidwellii), in the ecoclimatic conditions from vineyard Tarnave. Bull. Univ. Agric. Sci. Vet. Med. Cluj-Napoca Hortic. 2010, 67, 500.
64. Alves, A.; Phillips, A.J.; Henriques, I.; Correia, A. Rapid differentiation of species of Botryosphaeriaceae by PCR fingerprinting. Res. Microbiol. 2007, 158, 112–121.
65. Wilcox, W.F. Black Rot Guignardia Bidwellii (Ellis) Viala and Ravaz; Disease Identification Sheet No. 102GFSG-D4; Cornell Cooperative: Ithaca, NY, USA, 2003.