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The behavior of the 'Columna' and 'Mamaia' varieties, cultivated in ecological and conventional system at Murfatlar, in the specific climatic conditions of the wine year 2019-2020

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Abstract The cultivation of vines in a conventional, but also ecological system requires a favorable climate for the growth, development and maturation of grapes. The abiotic factors favorable to the cultivation of grapevine varieties for wine are: temperature, precipitation, relative humidity and insolation. Thus, climatic conditions must limit the development of diseases and pests as much as possible. The study carried out in the vineyards from the Research Station for Viticulture and Oenology Murfatlar showed that the wine year 2019 - 2020 was a year with an excessive heliothermal balance, especially during the vegetation period, but was extremely dry, with a pronounced water deficit during the phenophases of grape growth and maturation. These conditions had a positive influence on the quality of the harvest, but a negative one on the quantity of grape production/ha. The study included two varieties created at the Research Station for Viticulture and Oenology Murfatlar: Columna and Mamaia, cultivated in both of the ecological and conventional systems, on which the evolution of phenological stages was noted, together with the quality and quantity of production per hectare. The results obtained in the climatic conditions of 2020 highlight the fact that the cultivation system had an influence on the duration of phenological stages, the lack of moisture and nebulosity limited infection and the development and spread of pathogens, being a favorable year for growing grapes organically.

Key words

cultivation system, wine year, harvest, quality, production

Climate is a major factor dividing the spatio-temporal distribution for most agricultural systems, due to the climate changes that occur during the year [6]. Presently, viticulture faces new challenges and threats, among the most important being those related to climate change. Climate variations contribute to fluctuations in propagation yield, and in terms of spring temperatures, it is believed that they influence the formation of grapevine flowers, as well as fruiting.

It is known that the most famous wines are produced in regions with a beneficial climate, specific to growing different grape varieties. Recently, several studies based on data processing between different disciplines have been conducted in order to determine the suitability of the grapevine for cultivation in various growing areas. These studies present the different impact that environmental characteristics have, such as the hydrological and geological regimes, climate and environment ecology, those being the defining factors for zoning the suitability of grape production [5].

The quality of the grapes varies, depending on the daily temperatures during the ripening period, because this parameter affects the sugar concentration, the composition of the grapes, anthocyanin, as well as the aroma [12]. Meteorological parameters have a crucial importance on the production of grapes (Vitis Vinifera L.) in terms of quantity and quality, but also on the growth and development of the plant. Climate change in recent decades, described by an uneven distribution of rainfall during the year and high temperatures, lead to disturbances of vegetation phenophases, the processes of growth and maturation of grapes. The choice of varieties resistant to thermal and water stress plays an important role in the fight against this phenomenon. Air temperature is considered the most important factor in the growth and productivity of wine grapes [7]. The physiology of the vine and the metabolism, along with the composition of the grapes are strongly influenced by the average temperature during the vegetation period.

According to Carbonneau's research [2], the microclimatic and mesoclimatic characteristics of a wine region are key factors in adapting grapevine varieties. These climatic aspects have been capitalized and taken into account in all ancestral wine-making regions, for being best suited to regional or local environmental conditions [9]. Solar radiation is also a key factor affecting viticulture. Adequate radiant energy is required, especially during maturation [11]. During this period, sugar and phenolic content are favored by sunny days [13].

The phenology of the grapevine and the ripening of the grapes depend on the conditions of water assimilation. Moderate water deficiency reduces shoot growth, berry size and yield, but increases fruit ripening and the synthesis of phenolic products in berries. The final weight of the berry, a determining factor of quality in wine production, is determined by the cumulated effect of biotic and abiotic factors, that can influence the composition of the berries [14]. Annual rainfall and its seasonal distribution is also a critical factor influencing viticulture, as water stress can lead to a wide range of effects, largely dependent on the stage of development [1]. The optimal climate for a certain variety leads to constant yields, balanced grape composition and acceptable variations from one year to another [8]. A key factor in adapting to climate change may include growing varieties with different thermal requirements and greater resistance to stress.

Three main phenological stages can be used to describe the development cycle of the vine: budding, flowering and veraison. Budding marks the start of vegetative growth, flowering takes place between budding and the fall of the last corolla in the inflorescence, and the veraison is the beginning of the ripening process, which ends at full maturity, followed by harvesting when sugar and acidity reach the optimum level required [4] . The change in phenological evolution is the most remarkable biological effect of climate change in vineyards around the world. Associated with the accentuation of maturity, there is a shortening of the harvesting period, which puts a significant pressure on the infrastructure of the vineyards and wineries. Estimating phenological stages using models has important implications for wine technology planning, in the context of the impact of climate change on phenology.

Eco-pedoclimatic conditions affect the quality of grapes and wine, thus the relationship between soil and grape quality is the basis of the definition of the "terroir"[3]. Climatic conditions have an important impact on the crop, and temperature is one of the main factors controlling the development of the plant. Temperature-based thermal models are applied to estimate the development of many varieties. To implement these models, a base temperature (BT) is required to characterize the differences during the stages of variety development [15].

Material and Method

Two varieties, creations of the Research Station for Viticulture and Oenology Murfatlar, were chosen, namely Columna (white variety) and Mamaia (red variety) . The varieties studied were grafted on the same rootstock, Opperheim Selection 4 clone 4, the adopted training system was semi-trunk Guyot, with 2-3 fruiting canes, with a load of 38 eyes per trunk, a planting distance of 2,2 / 1,2 m. The plots where these varieties are grown are located on a land with E-V exposure, with a slope of 2-3%, on a calcareous chernozem soil, with a grainy structure, a loamy texture and with a humus content of 2,3%. The suitability of the vineyard regarding the cultivation of vines in ecological and conventional system was studied, analyzing the climatic data (temperature, precipitation, insolation) between November 2019 and October 2020. The monitoring and recording of weather data was performed by the automatic station owned by the institution. For each climatic factor, the data from the analyzed wine year is compared with the normal average values. Regarding the temperature, the two types of thermal sums (global and active), average, minimum and maximum monthly temperature were analyzed. Regarding precipitation, the values of each month and the number of days with precipitation of each month on three levels were analyzed: over 0,1, 5 and 10 mm. The brightness was determined by the number of hours of sunshine during the growing season (April 1-September 30). We followed the phenological stages for the 2 varieties mentioned above in the Murfatlar wine-growing area during the growing period, in both of the ecological and conventional cultivation systems. Viticulture and winemaking are important practices, which are a key economic activity in this region. For each variety we followed all the phenological stages, from the weeping stage of the vine to full maturity, and we calculated the duration of the growing period from the moment of budding, until full maturity, and the quality of grapes at harvest: the mechanical composition of grapes, meaning the weight and the volume of one kilogram of grapes, the weight of 100 berries, the number of berries in 100 grams of grapes.

Results and Discussions

The data regarding the thermal regime characteristic of the wine year 2019-2020 (Table 1) reveal that this year was rich in heliothermal resources, with an average temperature of 15,05°C, 3,55°C above the normal average temperature (11,5°C). Also, all of the twelve months of the year were warmer, compared to the normal average values for those months. The global sum of thermal degrees represents the sum of the average daily temperatures. The normal average of this climatic indicator is 4470,6°C, of which 3422°C are recorded during the vegetation period (April 1-September 30), but the year 2020 has by far exceeded these values (5515,6°C, of which 3914,8°C during the growing period). The active thermal balance represents the average daily sum of temperatures higher than 10°C. In the wine year 2019 - 2020, this sum recorded 1215,1°C more than normal - 3801,2°C, while during the vegetation period, the active temperatures sum was of 3875,7°C, with 453.7°C more than normal.

Table 1

The thermic regime of the wine year 2019-2020

Month	Average monthly temperature		Sum of temperature degrees			
			Global		Active	
	Normal average	2020	Normal average	2020	Normal average	2020
I	0,5	2,1	4,1	65,6	2,6	0,0
II	1,3	6,1	62,6	176,3	14,7	38,6
III	4,2	9,8	125,6	302,9	41,3	237,2
IV	10,5	12,5	369,7	375,9	219,8	336,8
V	16,2	18,6	513,7	576,3	513,7	576,3
VI	20,4	23,3	620,1	698,5	620,1	698,5
VII	22,6	26,3	726,3	814,1	726,3	814,1
VIII	22,6	25,8	671,0	799,5	671,0	799,5
IX	17,6	21,7	521,2	650,5	521,2	650,5
X	12,0	16,6	373,1	515,8	311,4	515,8
XI	7,2	12,4	228,1	371,8	134,9	308,3
XII	2,3	5,4	255,1	168,4	24,2	40,7
Year	**11,5**	**15,05**	**4470,6**	**5515,6**	**3801,2**	**5,016,3**

The useful temperatures sum represents the sum of the differences between the average values higher than 10 °C (the biological threshold of vegetation start for the grapevine) and had a value of 2477,3 °C, of which 2095,7 °C were during the vegetation period (Figure 1). These very high values are a characteristic of a very warm wine year.

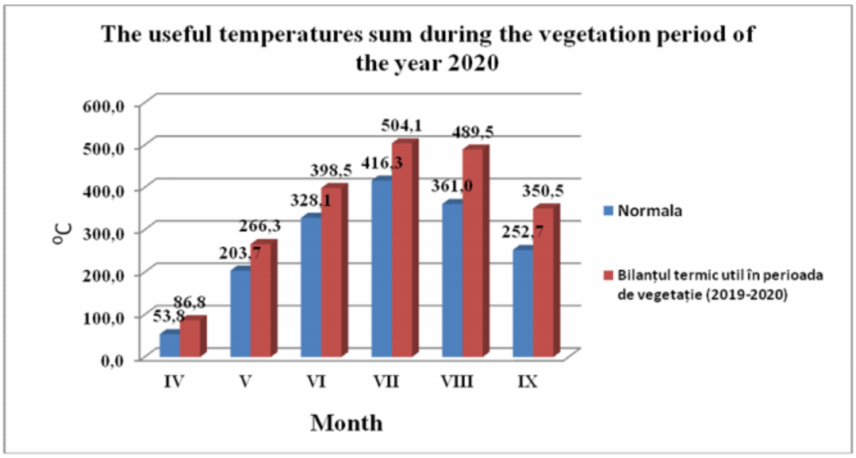

Figure 1. The evolution of the useful temperatures sum in the vegetation period of the year 2020

In the wine year 2019 - 2020, there was a water deficit of 147,3 mm. Analyzing the data (Table 2) in terms of rainfall, 2020 shows a significant decrease compared to the normal average rainfall. Thus, compared to an average of 436 mm of annual rainfall, the precipitation of 2020 accumulated 288,7 mm. The most important aspect is that during the growth period, only 161,7mm of rainfall were recorded. July and August were very dry, while June and September exceeded the normal average value.

For a better representation of the precipitation regime of 2020, the number of days with precipitation was also analyzed, and the data indicate that during this year, there were 57 days with precipitation, of which 16 days had precipitation with values over 5mm and only 9 days had precipitation values over 10 mm.

Table 2

The hydric regime in the wine year 2019-2020

Month	Precipitation (mm)				
	Normal average	2020	Number of days with rain		
			> 0.1 mm	> 5 mm	> 10 mm
I	31,0	1,2	2	0	0
II	33,0	41,4	9	3	1
III	21,7	13,1	4	1	1
IV	33,5	12,5	3	1	0
V	50,2	16,6	7	0	0
VI	53,2	73,4	9	1	2
VII	35,6	8,6	4	1	0
VIII	31,6	2,2	1	0	0
IX	41,6	48,4	4	3	2
X	30,2	20,8	3	3	2
XI	40,4	8,1	3	1	0
XII	34,0	42,4	8	2	1
Year	**436**	**288,7**	**57**	**16**	**9**

The lack of precipitation was accompanied by insolation with values close to the normal during the vegetation period, (1568 hours - the normal average; 1594,7 hours - the value for 2020 - Figure 2). This fact greatly increased the suitability of this year for the ecological system of grapevine culture for the Mamaia red grape variety, which needs high values of brightness for the synthesis of anthocyanins. A duration of less than 1250 hours of light is not compatible with obtaining quality organic red wines.

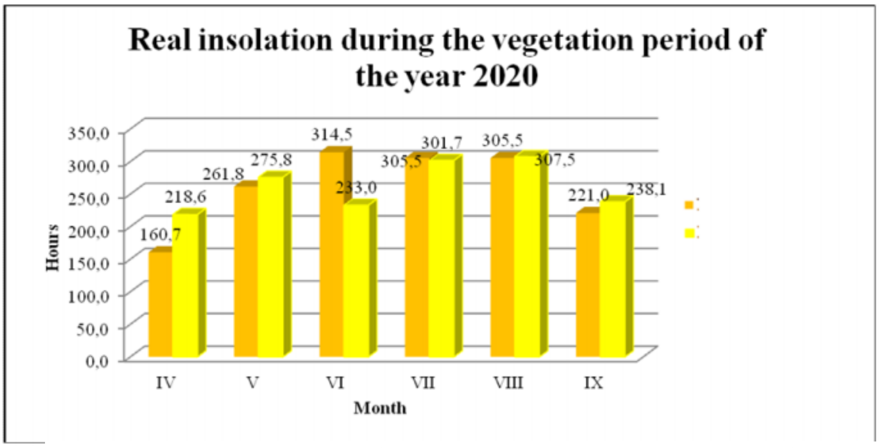

Figure 2. The evolution of insolation during the vegetation period of the year 2020

The abundant insolation led to a high frequency of days with temperatures higher than 30°C, reaching a total of 63 days in 2020, with the highest frequency being recorded in August (74%). The lack of precipitation during the vegetation period led to the decrease of air relative humidity, recording a hygroscopicity in the range of 51-75%, with values lower than 60% (the minimum limit of useful hygroscopicity, necessary for the growth and development of shoots and grapes) in the months of July and August (Table 3).

Table 3

Higroscopicity and the number of days with temperatures over 30°C during the vegetation period of the wine year 2019- 2020

Year	Month	Higroscopicity (%)		Number of days with temperatures over 30°C
		Normal	2019-2020	
2020	IV	72.0	59	0
2020	V	68.0	65	3
2020	VI	65.0	63	10
2020	VII	60.0	51	20
2020	VIII	60.0	53	23
2020	IX	68.0	65	6
2020	X	70	75	1
Sum				63

From a climatic point of view, 2020 can be characterized as a year with a pronounced hot and dry climate, due to the deficit of precipitation recorded during the period of active vegetation of the grapevine. During this year, the vine suffered a strong water stress, that led to the uneven vegetation onset, slowing the growth and development of shoots and grapes (Figure 3).

Figure 3. Uneven starting and development of shoots on the cane of the Columna variety, cultivated in the ecological system, in the year 2020

The analysis of phenological data presents a synchronization of the phenological stages in the first part of the growth stage, for both of the cultivation systems. The deficit of atmospheric and pedological humidity during the rest period and the beginning of the vegetation period led the weeping phenophase of 2020 to be almost unnoticed, suddenly turning to the phenophases of budding and shoot growth. Compared to the specific period for the Murfatlar area (the second half of April), budding of the Columna variety took place in the first decade of the mentioned month (13-14.04.2020) for both of the culture systems. The Mamaia variety physiologically reached the budding period in the second decade of April (21-22.04.2020). Flowering occurred simultaneously for the studied varieties, on 4-5.06.2020 and lasted only 7 days, compared to the duration of the period specific to the Murfatlar wine-growing area (10 days). Thus, for the Columna variety, the duration from budding to flowering was 52 days, while for the Mamaia variety it was 44 days. The ripening time of the grapes for the Columna variety amounted to 32-33 days, whereas the grapes from the Mamaia variety reached full maturity in an interval of 27 days in the ecological system and 29 days in the conventional system. The grapes were harvested at commercial maturity - Mamaia on September 9 and Columna on September 15. Regarding the duration of the budding-full maturity period of the grapes, it is observed that the Mamaia variety cultivated in the ecological system had a total of 138 days, two days less than the conventional system, whereas for the Columna variety the difference was insignificant.

Table 4

Phenological data in the wine year 2019-2020

Variety / method	Calendar dates						
	Weeping	Budding	Flowering	Veraison	Full maturity	Harvest date	Days between budding and full maturity
Columna / conventional	31.03	14.04	5.06	12.08	14.09	15.09	153
Columna / ecological	30.03	13.04	4.06	10.08	12.09	15.09	152
Mamaia / conventional	3.04	22.04	5.06	11.08	9.09	9.09	140
Mamaia / ecological	2.04	21.04	4.06	10.08	6.09	9.09	138

To create good soil fertility, it is necessary to supply with organic matter. In the ecological farming system of 2018, 20 tons of decomposed sheep manure were administered per hectare, the equivalent of 170 kilograms of nitrogen (active substance), with a remanence of 4 years. In the conventional system, complex NPK fertilizers were administered (16:16:16) in the spring of 2020, in an amount of 160 kilograms per hectare, by subsoiling. Foliar fertilizers were applied on 50% of the surface, in two rounds: the first after the flowering phenophase, when 2L were used per hectare, and the second in the first part of June, during the period of berry growth and development, using the same amount per hectare.

In the wine year 2019-2020, the studied varieties had a satisfactory tolerance to biotic factors, the attack of Plasmopara viticola and Uncinula necator being absent in the plantations of Columna and Mamaia. The attack from Botrytis cinerea was manifested once the grapes entered veraison, but with a very low intensity (9.3% in the conventional system and 11.3% in the organic system). The reaction of the studied varieties to the main pest, Lobesia botrana, was satisfactory, the intensity of the attack on grapes being in the range of 1,6 - 6,8 (1,6 for Columna cultivated in the conventional system and 6,8 for Mamaia cultivated in the ecological system). The attack on inflorescences was of an insignificant intensity for the Columna variety, while for the Mamaia variety, it was in the range of 9,3 (conventional system) - 11,3 (ecological system). The climatic conditions of the wine year 2019 - 2020 can be described by a water deficit, excessive heliothermal balance and very low atmospheric hygroscopicity, all contributing to the reduced the attack of pathogens (Table 5).

Table 5

The tolerance of the Columna and Mamaia varieties to the impact of biotic factors in the conditions of 2020

Pest agent	Variety							
	Columna ecological		Columna conventional		Mamaia ecological		Mamaia conventional	
	F%	I%	F%	I%	F%	I%	F%	I%
Downy mildew (Plasmopara viticola)								
Attack on leaves and shoots	-	-	-	-	-	-	-	-
Attack on grape bunches	-	-	-	-	-	-	-	-
Powdery mildew (Uncinula necator)								
Attack on leaves and shoots	-	-	-	-	-	-	-	-
Attack on grape bunches	-	-	-	-	-	-	-	-
Bunch rot (Botrytis cinerea)								
Attack on leaves and shoots	-	-	-	-	-	-	-	-
Attack on grape bunches	-	-	-	-	1,1	11,3	0,8	9,3
European grapevine moth (Lobesia botrana)								
Attack on inflorescences	-	-	-	-	1,0	3,8	0,9	2,3
Attack on grape bunches	4,3	2,6	2,8	1,6	3,2	6,8	1,0	4,3

For the technological characterization of the studied varieties, the productivity elements were determined, as shown in table 6. Thus, the average weight of a grape bunch from the conventional Columna variety was 114 grams, whereas for the ecological Columna, it was 109 grams. For the conventional Mamaia variety, the average weight of a grape was 132 grams, while for the organic Mamaia, the average weight was 116 grams. Thus, the productions obtained in an ecological system for the Columna variety were 13% lower, compared to those of the conventional system, and for the Mamaia variety they were lower by 16%, compared to the conventional system. In general, the yields of both of the varieties were well below their technological potential. In the case of the weight of 100 berries, the value differences were significantly influenced by the treatment and by the climatic conditions specific to the wine year 2020. Heliothermal excess and water deficit favored the accumulation of sugar in higher concentrations in grapes: 199,31 g/l for the Columna variety cultivated in the organic system, with 5,45 g/l more than the conventional variant, and 217,16 g/l for the Mamaia variety cultivated in the ecological system, with 3,66 g/l more than the conventional variant. As for the acidity, no major differences are observed between the conventional and ecological variants.

Table 6

The elements of productivity and quality that characterize the Columna and Mamaia varieties, observed in the wine year 2019-2020

Variety - method	Average weight of a grape bunch (gr)	Average production		Weight of 100 berries (gr)	Physico-chemical characteristics of the must	
		(kg/ha)	(kg/trunk)		Sugars (g/l)	Total acidity (g/l H_2SO_4)
Columna - conventional	114	5650	1,482	164	193,86	4,9
Columna - ecological	109	4985	1,316	138	199,31	4,7
Mamaia - conventional	132	6732	1,715	172	213,5	3,8
Mamaia - ecological	116	5464	1,392	152	217,16	3,8

In order to technologically characterize the studied varieties and to promote them, a series of indices of the mechanical composition of the grapes were taken into account: berry index, berry composition index and grape composition index (Table 7). The berry index varies between 51 and 68, 51 for the Mamaia variety in the conventional system and 68 for the Columna variety in the ecological system. The values of the indices of berry composition, grape yield and grape structure have close values for the same variety in the two technological systems, slightly larger differences can be seen in the grape composition index, which has the values of 13,28 for the variety Columna, cultivated in the conventional system and 10,76 for the ecological one, while for the Mamaia variety, the values of this index exceed the upper limit of 14, thus registering values of 16.85 in the conventional system, respectively of 14.15 for the ecological system, which indicates a weak development of the rachises, due to water deficit. Grape yield and berry composition indices have values below the lower limit of 5, being directly influenced by the special climatic conditions of the wine year 2020. The grape structure index has normal values, that fall between 3 and 8, with Mamaia being the only variety in conventional system which has a value below the lower limit of 3 (2,76), materialized by a pronounced skeletal material.

Table 7

The main indices of grapes in the year 2020

Variety - method	Berry index	Berry composition index	Grape composition index	Grape yield index	The structure index of the grape
Columna - conventional	62	4,16	13,28	3,07	3,60
Columna - ecological	68	4,5	10,76	2,87	3,26
Mamaia - conventional	51	3,08	16,85	2,57	2,76
Mamaia - ecological	57	3,65	14,65	2,73	3,06

Figure 4. The aspect of grapes from the Columna and Mamaia varieties, cultivated in the two technological systems (conventional and ecological), at full maturity

Conclusions

The year 2020 was a contradictory one in terms of the favorability for the cultivation of vines in an ecological system in the Murfatlar wine-growing area. On the one hand, it was an extremely hot year, characterized by temperatures well above the average multiannual limit during the months of 2020, which is beneficial to the organic vine under certain conditions. This high temperature level was manifested especially during the summer and autumn months, from July to October, a period that coincides with the process of grapes ripening, from the veraison stage until harvest. On the other hand, it was a year with extremely low rainfall, which was not evenly distributed throughout the year.

In 2020, the growth and development of trunks, productivity and production quality were influenced by abiotic stressors (drought and heat), manifested during the active vegetation of the grapevine. Climate change is expected to bring new challenges to the wine sector [10]. Although the grapevine has several survival strategies (a deep root system, effective stomatal control), viticulture is strongly dependent on climate. Therefore, the growing evidence of significant climate change in the coming decades calls for adaptation measures, appropriate for coping with the impact of climate change. Considering the great incidence of droughts in the last years, it is recommended for the Murfatlar vineyards to install a dripping irrigation system, which will supplement the soil water deficit.

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