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## RESEARCH CONCERNING GRAPE PRODUCTION IN A HILLY AREA OF ROMANIA UNDER THE IMPACT OF CLIMATE CHANGE

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**Rezume.** Lucrarea prezintă un studiu privind impactul factorilor climaterici asupra producției cantitative și calitative a 11 soiuri de viță de vie: Feteasca Albă, Feteasca Regală, Aligote, Sarba, Cabernet Sauvignon, Merlot, Babeasca Neagră, Feteasca Neagră, Chasselas Dore, Muscat de Hamburg și Coarna Neagră, selecționată în condițiile SCDVV Bujoru, Galați, pe suprafața de 148 ha plantație. Metodele de cercetare au fost: metoda indicilor, metoda sporurilor, metoda ponderilor, metoda comparației și metoda punctelor. Anul 2007 a fost Martor, iar 2008 Experimental. În 2008, temperaturile medii anuale, maxime și minime, precum și precipitațiile au contribuit la creșterea producției medii și totale de struguri, la sporirea acidității, a masei a 100 de boabe, a volumului ciorchinelui, dar și la reducerea conținutului de zahăr.

**Cuvinte cheie:** Climate change, Costs, Economic impact, Grape, Production.

## INTRODUCTION

During the last 15 years viticulture of many European countries is facing global climate change with a deep impact on growing areas, crop production, quality and efficiency (H. Schultz, 2008; C. Simion et al., 2008; K Anderson et al., 2009; V. Enache et al., 2009). Climate variability is a risk factor and determine vintage quality differences. According to various scenarios, till the year 2040, it is expected as the average temperature in Europe to increase by 2.04 – 4.5°C in summer and by 3.5°C - 6°C in winter. This means a change of the traditional limits of Vine growing, of phenological phases, grape yield and quality, production costs. Research has to look for solutions to monitor viticulture so that grape and wine market not to be affected too deeply. In this context, the aim of this paper is to analyze the evolution of the climatic factors and their impact upon grape, quality and production costs within a case study experimented at the well known Bujoru Vineyard, Romania (Research upon the Impact of World Climate Change on the Viticultural Ecosystem from the hilly areas. PN II Partnership Project, Globalclim 51075/2007, [www.usab.ro](http://www.usab.ro), [www.cnmp.ro](http://www.cnmp.ro)).

## MATERIAL AND METHODS

The experiments were carried out on 148 ha as follows: White Feteasca 49 ha, Royal Feteasca 12 ha, Aligote 17 ha, Sarba 11 ha for white wine grapes, Cabernet Sauvignon 5 ha, Merlot 14 ha, Black Babeasca 12 ha, Black Feteasca 1 ha for red wine grapes, Chasselas Dore: 17 ha for white table grapes, Hamburg Muscat 6 ha and Black selected Coarna 4 ha for red table grapes. The soil characteristics are: specific weight 2.65 g/cubic cm, total porosity 54.8%, air porosity 28.5%, hygroscopic coefficient 3.43%, withering coefficient 611 m<sup>3</sup>/ha, field capacity 2,615 m<sup>3</sup>/ha, total capacity 6,083 m<sup>3</sup>/ha, volumetric weight 1.19 g/cm<sup>3</sup>.

The following climate factors were analyzed: global, active and useful thermic balance, annual rainfalls and also during the vegetation period, annual average temperature and also average temperature in July, August and September, air minimum temperature, maximum average in August, average temperature in the 1<sup>st</sup> and 2<sup>nd</sup> decade of June, wind speed, air moisture, nebulosity, the number of days with maximum temperatures, the length of bioactive period, the real heliothermic index, hydrothermic index, the bioclimate index of vine and oenoclimatic index. Also, average and total grape production and grape quality were studied.

The following methods were used: **Index Method**, in order to calculate the individual indices of 22 climate factors, according to the formula:  $R_i = X_i / X_{B_i}$ , where:  $i=1, \dots, 22$ ; if  $R_i > 1$ ,  $i$  factor is increasing; if  $R_i < 1$ ,  $i$  factor is decreasing and if  $R_i = 1$ , the  $i$  factor is constant; **Gain Method**, based on the formula:  $S_i = R_i - 1$ , where  $S_i$  = the gain of the  $i$  climate factor and  $R_i$  as mentioned above; if  $S_i > 1$ ,  $i$  factor is increasing; if  $S_i < 1$ ,  $i$  factor is decreasing and if  $S_i = 1$ , the  $i$  factor is constant; **Share Method**, based on the formula:  $P_i = |S_i| 100 / \sum |S_j|$ , where  $P_i$  = the weight of the climate factor and  $S_i$  as mentioned above; **Point Method** for ranking the vine types and **Comparison Method** for setting up the economical analysis in grape production and identifying the change from a year to another. The year 2007 was Control and 2008 the Experimental year.

## RESULTS AND DISCUSSIONS

**Climate Factors.** In the year 2008, thermic balance, average annual temperature and also temperature in the month of August, the air minimum temperature and the average maximum temperature in August, wind speed, air relative humidity and the bioclimatic index have increased compared to 2007. The hierarchy of the climate factors in the decreasing order of their 2008 level was: annual rainfalls, wind speed, the number of days with temperatures higher than 30°C, average temperature in July and the 1<sup>st</sup> and 2<sup>nd</sup> decades of June, hydrothermic index, rainfalls during the vegetation period and heliothermic index. As presented in Table 1, in 2008, the rainfalls registered 285.7 mm by 50% less than in 2007. The sunstroke counted for 1,332.7 hours compared to 1,477.4 hours in 2007. The average temperature in July was 24°C compared to 28.1°C in 2007. The average temperature was 25.9°C in August and 17.1°C in September. The minimum temperature was -14.5°C in 2008 compared to 13°C in 2007. The number of days with temperatures higher than 30°C was 52 compared to 66 in 2007. The bioactive period has ranged between 177-178 days. The heliothermic index was 250 compared

to 275 in 2007. The hydrothermic index was 0.6 compared to 0.6 in 2007. The bioclimatic coefficient was 11.8 to 11.5 in 2007 and the oenoclimatic coefficient was 2 (tab. 1).

Table 1

*Individual indices, gains and shares of the climatic factors at Bujoru Research and Development Station ,Galatzi*

Climatic Factor	Individual index of the climatic factor	Gains, $S_i$	Shares, $P_i$ %
Global thermic balance ( $\Sigma t^\circ g$ )	1.006	0.64	0.303
Active thermic balance ( $\Sigma t^\circ a$ )	1.007	0.75	0.355
Useful thermic balance ( $\Sigma t^\circ u$ )	1.009	0.91	0.431
$\Sigma$ annual rainfalls (mm)	0.515	-48.47	22.948
$\Sigma$ rainfalls during the vegetation period (mm)	0.883	11.47	5.525
$\Sigma$ sunstroke hours during the vegetation period	0.902	9.79	4.635
Average annual temperature ,°C	1.037	3.70	1.752
Average temperature in July ,°C	0.854	-14.59	6.907
Average temperature in August, °C	1.015	1.57	0.743
Average temperature in September ,°C	0.982	-1.72	0.814
Air Minimum temperature ,°C	1.110	7.41	3.508
Maximum average temperature in August ,°C	1.045	4.58	2.168
Average temperature in the 1 <sup>st</sup> and 2 <sup>n</sup> decades of June	0.869	-13.10	6.020
Wind speed (km/hours)	1.304	30.43	14.407
Air relative humidity (%)	1.052	5.26	2.490
Nebulousness	1.071	7.14	3.380
Number of days with maximum temperatures > 30 °C	0.787	-21.21	10.042
The length of bioactive period , days	0.994	-0.56	0.265
The real heliothermic index	0.909	-9.09	4.304
Hydrothermic coefficient	0.857	-14.29	67.65
Bioclimatic index	1.026	2.61	1.236
Oenoclimatic index	0.982	-1.73	0.819
		$\Sigma  S_i  = 211,22$	100.00

**Grape Production. Grape Yield.** In the year 2008, grape yield was higher than in 2007 for all the vine types varying between 13,188 kg/ha for Royal Feteasca and 7,547 kg/ha for Black Babeasca, reflecting a favorable influence of the climatic factors. In order, the vine type ranking in 2008 was : Royal Feteasca, Chasselas Dore, Hamburg Muscat , Black selected Coarna, Merlot, White Feteasca, Aligote, Black Feteasca, Cabernet Sauvignon and Black Babeasca. **The Total Grape Production** was influenced by grape yield, but also by cultivated area for each vine type. Grape production was higher in 2008 compared to 2007 and varied between 406,700 kg for White Feteasca and 8,000 kg for Black Feteasca. The decreasing order of the vine types was White Feteasca , Chasselas Dore, Royal Feteasca, Aligote, Sarba, Merlot, Black Babeasca, Hamburg Muscat, Cabernet Sauvignon, Black Coarna and Black Feteasca.

**Grape Quality.** In the year 2008 compared to 2007, the acidity, weight of 100 berries and grape weight increase while sugar content decreased (tab. 3). **The sugar content** increased by 34 g for Black Babeasca, by 10 g for Royal Feteasca, and decreased in case of the other types. **The Acidity** increased for Cabernet Sauvignon, Black Babeasca, Hamburg Muscat, Black Coarna, Black Feteasca, Chasselas Dore, Aligote and Sarba, and decreased for Royal Feteasca and Merlot . **The weight of 100 berries** increased for White Feteasca (+59 g), Royal Feteasca (+64 g), Hamburg Muscat (+91 g), Black Coarna (+74 g), Black Babeasca (+37 g), Chasselas Dore (+37 g) and Sarba (+ 39 g), while in case of Cabernet Sauvignon, Black Feteasca, Merlot and Aligote it registered a decrease compared to 2007. **The volume of 100 berries** also increased : White Feteasca alba (+ 15 m<sup>3</sup>), Royal Feteasca (+ 34 m<sup>3</sup>), Hamburg Muscat (+ 100 m<sup>3</sup>), Black Coarna (+ 132 m<sup>3</sup>), Merlot (+ 6 m<sup>3</sup>), Chasselas Dore (+ 43 m<sup>3</sup>) and Sarba (+ 43 m<sup>3</sup>), while for Carbernet Sauvignon, Black Feteasca, Black Babeasca and

Table 2

*The Hierarchy of Vine Types according to Grape Yield and Production*

Vine Type	Grape Yield/Position		Grape Production/Position	
	2007	2008	2007	2008
White Feteasca	5,307/3	8,300/7	260,043/1	406,700/1
Royal Feteasca	7,119/1	13,188/1	85,428/3	158,000/3
Cabernet Sauvignon	2,720/9	7,650/10	13,600/8	38,250/9
Muscat Hamburg	1,163/11	11,438/4	6,978/9	68,620/8
Selected Black Coarna	1,350/10	9,010/5	5,400/10	36,040/10
Merlot	2,888/8	8,800/6	40,432/6	123,200/6
Black Babeasca	3,677/5	7,547/11	44,124/5	90,564/7
Black Feteasca	3,515/6	8,000/9	3,515/11	8,000/11
Chasselas Dore	4,000/4	13,000/2	68,000/4	221,000/2
Aligote	6,290/2	8,200/8	106,930/2	139,400/4
Sarba	3,500/7	11,700/3	38,500/7	128,700/5

Aligote decreased compared to 2007. **The grape average weight** increased as follows : Black Coarna (+202 g), Hamburg Muscat (+105 g), Black Feteasca (+ 93 g), Sarba (+77 g), Cabernet Sauvignon (+ 52 g), Black Babeasca (+ 49 g), Chasselas Dore (+49 g), Merlot (+ 35 g), Aligote (+ 11 g), Royal Feteasca (+ 3 g). Only White Feteasca remained with the same grape average weight (tab. 3).

Table 3

*Grape Quality in 2007 and 2008 at Bujoru Vineyard*

Vine type	Year	Sugar Content g/l must	Acidity g/l must H <sub>2</sub> SO <sub>4</sub>	Weight of 100 berries-g	Volume of 100 berries m <sup>3</sup>	Average grape weight G
White Feteasca	2007	220	3,3	79	84	90
	2008	220	3,3	120	99	90
Royal Feteasca	2007	200	4,3	89	94	89
	2008	210,4	3,64	153,4	120	92
Cabernet Sauvignon	2007	223	2,4	127	95	45
	2008	167,68	6,38	67	60	97
Hamburg Muscat	2007	229	2,35	220	200	80
	2008	195,2	3,52	311,5	300	185
Black Coarna	2007	215	2,69	200	180	102
	2008	154	3,55	274,68	312	300
Merlot	2007	231	3,64	107	82	50
	2008	214	3,30	104	88	85
Black Babeasca	2007	190	3,6	168,5	180	90
	2008	224	4,03	205,64	124	139
Black Feteasca	2007	218	2,56	153	137	59
	2008	213	2,84	97	85	152
Chasselas Dore	2007	206	2,1	120	100	54
	2008	173,2	3,14	157,93	143	103,2
Aligote	2007	212	1,98	140	122	84
	2008	175	3,98	96	92	95
Sarba	2007	243	2,79	110	90	78
	2008	202,8	4,2	149,28	133	155,4

Table 4

*The Hierarchy of Vine Types based on Grape Quality in 2008 at Bujoru Vineyard*

Vine Type 1	Sugar Content g/l must	Acidity g/l must H <sub>2</sub> SO <sub>4</sub>	Weight of 100 berries-g	Volume of 100 berries m <sup>3</sup>	Average grape weight g	Total points/ Position
White Feteasca	2	3	7	7	10	29/7
Royal Feteasca	5	5	5	6	9	30/8
Cabernet Sauvignon	10	9	11	11	7	48/11
Hamburg Muscat	7	4	1	2	2	16/1
Black Coarna	11	4	2	1	1	19/2
Merlot	3	3	8	9	11	34/9
Black Babeasca	1	7	3	5	5	21/3
Black Feteasca	4	1	9	10	4	28/6
Chasselas Dore	9	2	4	3	6	24/4
Aligote	8	6	10	8	8	40/10
Sarba	6	8	6	4	3	27/5

### CONCLUSIONS

1. In the year 2008, the order of climate factors based on their importance is: average annual rainfalls, wind speed, number of days with maximum temperatures higher than 30°C, average temperature of July, the hydrotermic coefficient, the average temperature in the 1<sup>st</sup> and 2<sup>nd</sup> decades of June, rainfalls during the vegetation period, sunstroke hours, real heliothermic index, air minimum temperature, nebulousness, air relative humidity, average temperature in August, annual average temperature, bioclimatic index.

2. In the year 2008, grape yield was higher than in 2007 varying between 7,547 kg/ha for Black Babeasca and 13,188 kg/ha for Royal Feteasca. Total grape production has also increased, varying between 883% for Hamburg Muscat and 30% for Aligote.

3. The decreasing order of vine types according to grape quality is Hamburg Muscat, Black Coarna, Black Babeasca, Chasselas Dore, Sarba, Black Feteasca, White Feteasca, Royal Feteasca, Merlot, Aligote, Cabernet Sauvignon. In the year 2008 an increased acidity, grape weight and volume, but a decreased sugar content for almost all the vine types were noticed.

4. Production costs have also increased by 18-19% in the year 2008 compared to 2007.

5. Climate change has to be taken into consideration concerning grape production, quality and production costs in close relation to vine type.

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