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The Impact of Climate Conditions on the Yield of Some Fall Barley Cultivars for the Production of Beer in the Kosovo Plain

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ABSTRACT
Barley is a plant in Europe that occupies an important place in the structure of cultivated plants. The main use of barley is for brewing beer. Even in Kosovo, the main part of barley production is used in the beer industry. The beer industry in Kosovo produces beer prepared from barley; it is liked by the consumer, not only in Kosovo but also in Albania. Our brewing industry mainly uses locally grown barley. Our farmers have planted the traditional cultivars of barley but, recently and in the future, new cultivars have been introduced and introduced, preferring those that give high yields but also with good chemical and technological indicators. Our study aimed to determine the influence of climatic (temperature and humidity) and soil factors on the yield and quality of barley production in both areas of its cultivation. The presence of mineral elements in the soil are necessary for barley such as: Calcium, Iron, Magnesium, Phosphorus, Potassium, Zinc and climatic factors for the production of beer barley.

Keywords: metals, climatic factors, temperature, humidity, food.

INTRODUCTION

It is known that the main characteristics of malt production from barley depend on their chemical composition, which have a direct impact on the quality of beer, are controlled genetically, that is, by the cultivar, but also by environmental conditions, that is, by the conditions concrete cultivation represented by soil and climatic conditions. The average yield of barley, realized in our conditions during the last years, is around 25 qq/ha. This pollution is caused by the transmission and discharge of particles, in the form of dust. In this sense, heavy metals like Pb, Zn, Cd, Cu, etc. (Table 1) (Dreshaj et al. 2022). The productive potential for barley cultivars grown in our conditions is over 80 qq/ha (about 48.95 kg, and has been redefined as 100 kg mesures usuelles, thus called metric quintal with symbol qq.), which means that, on a national scale, this potential is currently used around 30–40%. The productive potential for barley cultivars grown in our conditions is over 8000 kg/ha, which means that, on a national scale, this potential is currently used around 30–40% (Shala et al. 2023).

Barley is grown for many purposes, but most of all barley is used for animal feed, human consumption, or brewing. Sources of water pollution in reducing its quality are the result of the discharge of wastewater without prior treatment. High protein barley is generally valued for food and forage, and as a source of starch for production. Barley is used for both dietary and medicinal

Table 1. The content of mineral elements in unlulled barley

Designation	Content per 100 g
Calcium	29.0 mg
Iron	2.5 mg
Magnesium	79.0 mg
Phosphorus	221 mg
Potassium	280 mg
Zinc	2.1 mg

purposes; as in the preparation of beer and other alcoholic beverages. Are being transmitted with air currents (wind) and sediment in the soil (Dreshaj et al. 2022).

MATERIALS AND METHODS

The experimental trials were set up in two places:

- on the lands of the Agricultural Institute of Kosovo, in Arbnesh, (Dukagjin Plain), 6 km away from Peja, 488 m above sea level, and,
- in Pestovo (Kosovo Plain), 560 m a.s.l.

The field trials were set up in three sampling sites and the barley cultivars in the trial were arranged according to the randomized block method. The area of each variant was 10 m^2 (10 × 1 m). Each variant consisted of 6 rows, with a distance of 11 cm between them. In order to carry out these analyzes on the soils where our field tests were carried out, relevant soil samples were taken, at a depth of 0–30 cm, which were subjected to relevant analyzes to determine the content of different chemical elements, as follows: organic matter (humus), total nitrogen, phosphorus, potassium, calcium, magnesium, and groundwater reaction (pH) (Table 2). Inductively coupled plasma atomic emission spectroscopy (ICP-AES), also referred to as inductively coupled plasma optical emission spectrometry (ICP-OES), is an analytical technique used for the detection of chemical elements (Dreshaj et al. 2022).

Soil analysis showed that both soils were generally rich in humus, medium in phosphorus and potash, and rich in calcium and magnesium. Based on these data, nitrogen, phosphorus and potash fertilization doses were determined, while there was no need for calcium and magnesium fertilization. The calculation of the sums of active temperatures was carried out based on the following formula:

$$TA = \frac{Tmax - Tmin}{2} - T\ basis \tag{1}$$

From different authors it results that the basic temperature for barley, as well as for other crops, can be calculated as 0 °C (Cao and Moss 1989), or even 5 °C (Table 3). For this reason, the calculations of active temperatures were made taking

Table 2. Data of chemical analyzes of soil in Peja and Pestovo (mg/100g)

Location	pH	$CaCO_3$ (%)	Mineral nitrogen (mg/100 g)		Hummus (%)	Nutrient element (mg/100 g)			
			N^-NH_4	N^-NO_3		P_2O_5	K_2O	Ca	Mg
Peja	5.6	5	0.425	0.375	4.0	15.4	26.8	202.7	15.2
Pestovo	5.9	6	0.820	0.315	3.6	13.2	17.6	360.5	42.0

Table 3. Values of average monthly temperatures and precipitation for the year 2021 (Kosovo Hydro Meteorological Institute)

Month	Average tempered			Monthly rainfall			Solar lighting		
	Monthly average °C		+/-	mm rainfall/month		+/-	Monthly sundial		+/-
	Peja	Pestovo		Peja	Pestovo		Peja	Pestovo	
I	-0.7	-0.3	-0.4	36.0	20.3	15.7	71.3	65.1	6.2
II	2.6	0.2	2.4	29.0	20.3	8.7	100.8	95.2	5.6
III	7.1	6.4	0.7	23.0	26.1	-3.1	148.8	133.3	15.5
IV	11.3	11.1	0.2	32.0	33.8	-1.8	183.0	180.0	3.0
V	18.2	15.1	3.1	24.0	66.0	-42.0	220.1	213.9	6.2
VI	19.6	19.6	0.0	16.0	23.9	-7.9	258.0	258.0	0.0
VII	20.8	22.3	-1.5	2.0	54.4	-52.4	297.6	310.0	-12.4
VIII	25.6	22.7	2.9	2.8	3.1	-0.3	288.3	294.5	-6.2
IX	17.5	20.2	-2.7	36.8	34.1	2.7	222.0	222.0	0.0
X	12.1	9.9	2.2	52.4	48.1	4.3	167.4	173.6	6.2
XI	9.4	3.4	6.0	63.0	4.5	58.5	96.0	81.0	15.0
XII	3.8	1.6	2.2	81.6	72.3	9.3	65.1	58.9	6.2
Average	12.3	11.0							
Amounts			15.1	398.6	406.9	-8.3	2,118.4	2,085.5	32.9
IV+V+VI			3.3			-51.7			9.2

into consideration the two basic temperatures for the calculation of the active temperatures that were needed by the different varieties of barley during the three years and in the two climatic zones studied.

RESULTS AND DISCUSSION

The scientific work, aimed at recognizing and determining the influence of climatic conditions on the production and quality parameters of some cultivars of autumn barley for the production of beer, was based on field tests which were carried out in two experimental areas, in Peja and in Pestovo. during the years of analysis. After the outbreak of the pandemic, there has been a decrease of 20% in the tourism sector, a decrease of 19% in exports (Dreshaj et al. 2022). Thus, for example, in Peja, the cultivars Vanessa, Bingo and Zlatko are classified in first place with, respectively, 53.5, 52.8 and 52.0 qq/ha; while in Pestovo only one cultivar is in the first group, Vanessa with 58.5 qq /ha, the other cultivars have significant differences compared to the first ones, especially Rex in Peja and Esterel and Rex in Pestovo (Table 4).

It is of interest to note that in 2020, firstly, yields were higher compared to 2019 and, secondly, higher yields were obtained in Peja compared to Pestovo. It seems that the cultivation conditions were more suitable in 2020, as well as in Peja, compared to Pestova (Table 5 and 6). Environmental experts claim that the increase in the level of pollution in the cities of Kosovo affects: vehicle traffic (Dreshaj et al. 2022) .The 2020 data are also statistically proven and give us a completely different picture from the first years. In both test sites, the cultivar Barun is in first place with, respectively, 71.2 qq/ha and

Table 4. Yield, Peja and Pestovo in 2020 (qq/ha)

N0.	Cultivar	Peja				Pestovo			
		REPEATING (qq/ha)				REPEATING (qq/ha)			
		I	II	III	Average	I	II	III	Average
1.	Bingo	54.0	51.8	52.6	52.8a	57.2	53.4	52.0	54.2b
2.	Zllatko	53.3	51.7	51.0	52.0a	55.2	52.9	53.9	54.0bc
3.	Vanessa	54.5	52.4	53.6	53.5a	59.8	58.2	57.5	58.5a
4.	Esterel	50.9	52.0	50.1	51.0b	52.1	51.0	51.4	51.5c
5.	Rex	47.9	48.4	47.7	48.0b	49.9	51.1	49.0	50.0c
D_{01}		2.40				3.24			
D_{05}		1.65				2.22			

Table 5. Variance analysis for yield, Peja 2020

Source of variation	Degree of freedom	Quadratic sum	Mean squared	„F" Values		
				"F" Factual	"F" Theoretical	
					0.95	0.99
Variants (V)	4	55.3	13.8	18.06**	3.84	7.01
Repetition (P)	2	3.4	1.7	2.2	4.46	8.65
Mistake (E)	8	6.124	0.7655			
Amounts	14	64.856				

Table 6. Variance analysis for yield, Pestovo 2020

Source of variation	Degree of freedom	Quadratic sum	Mean squared	„F" Values		
				"F" Factual	"F" Theoretical	
					0.95	0.99
Variants (V)	4	125.7	31.4	22.49**	3.84	7.01
Repetition (P)	2	11.6	5.8	4.10	4.46	8.65
Mistake (E)	8	11.176	1.397			
Amounts	14	148.436				

69.2 qq/ha, followed by Bingo with 67.8 qq/ha and 65.0 qq/ha (Table 7). Construction without urban plans and ways of cleaning cities (Dreshaj et al. 2022)

If we treat the annual average data of both tests as a single test, then with 6 repetitions we will have a different picture. Even in this case, the data is verified, but the behavior of the cultivars takes a different form. In this case, almost the cultivars are presented with the same level of yield, except the cultivar Esterel (table 8 and 9), (Dreshaj et al. 2022). According to this point of view, since we cannot predict the climatic course of the year, we can cultivate any cultivar and have satisfactory yields. This manuscript aims to further develop the understanding of the marketing involvement for tourism business (Table 10), (Millaku et al. 2021).

Barley is more tolerant than wheat to soil salinization, which may explain the increase in barley cultivation in Mesopotamia from the second millennium BC. Barley is not as cold tolerant as common wheat (*Triticum aestivum*), rye (*Secale cereale*), or winter triticale (*Triticosecale*), but it can be planted as a winter crop even in relatively cold areas. But have environmental conditions influenced the behavior of cultivars for their productive capacity? To that end, let's examine the data by presenting it by field trials, via the three-year average, and by years, via the field trial average (Table 11 and 12).

In order to come to a more accurate conclusion on the influence of climatic conditions on the yield of different barley cultivars in both climatic zones, the Kosovo Meteorological Institute provided daily data on minimum and maximum temperatures and rainfall in both zones where set up the experiment. Atmospheric precipitation is another major source of cadmium in the environment (Table 13 and 14) (Dreshaj et al. 2021).

Table 7. Yield, Peja and Pestovo in 2021 (qq/ha)

No	Cultivar	Peja				Pestovo			
		REPEATING (qq/ha)				REPEATING (qq/ha)			
		I	II	III	Average	I	II	III	Average
1.	Bingo	56.1	54.9	57.3	56.1 c	53.2	51.3	52.1	52.2bc
2.	Zllatko	70.9	69.7	68.5	69.7 a	55.9	53.8	54.9	54.9a
3.	Vanessa	63.1	58.5	61.9	61.2 b	55.3	53.3	54.9	54.5a
4.	Esterel	58.4	55.2	57.4	57.0 b	52.7	51.7	52.3	52.2bc
5.	Rex	56.9	59.1	57.9	58.0 c	55.2	52.5	53.9	53.9a
6.	Barun	59.6	60.6	58.4	59.5 b	54.3	52.3	55.4	54.0a
D_{01}		3.95				1.44			
D_{05}		2.77				1.01			

Table 8. Variance analysis for yield, Peja 2021

Source of variation	Degree of freedom	Quadratic sum	Mean squared	„F" Values		
				"F" Factual	"F" Theoretical	
					0.95	0.99
Variants (V)	5	370.9644444	74.19288889	31.88**	3.33	5.64
Repetition (P)	2	4.084444444	2.042222222	0.88	4.10	7.56
Mistake (E)	10	23.27555556	2.327555556			
Amounts	17	398.3244444				

Table 9. Variance analysis for yield, Pestovo 2021

Source of variation	Degree of freedom	Quadratic sum	Mean squared	„F" Values		
				"F" Factual	"F" Theoretical	
					0.95	0.99
Variants (V)	5	19.41777778	3.883555556	12.48**	3.33	5.64
Repetition (P)	2	12.24777778	6.123888889	19.68**	4.10	7.56
Mistake (E)	10	3.112222222	0.311222222			
Amounts	17	34.77777778				

Table 10. Yield, Peja and Pestovo 2022 (qq/ha)

No.	Cultivar	Peja				Pestova			
		REPEATING (qq/ha)				REPEATING (qq/ha)			
		I	II	III	Average	I	II	III	Average
1.	Bingo	67.2	70.0	66.2	67.8b	66.3	63.8	64.9	65.0a
2.	Zllatko	67.8	64.5	66.5	66.3b	66.0	61.5	64.5	64.0 b
3.	Vanessa	61.1	64.6	63.8	63.2b	60.5	63.0	61.8	61.8bc
4.	Esterel	61.0	59.7	58.4	59.7c	59.3	55.4	56.8	57.2c
5.	Rex	68.0	66.0	63.9	66.0b	62.3	64.2	61.4	62.6b
6.	Barun	72.8	69.5	71.4	71.2a	67.7	69.0	71.0	69.2a
D_{01}		4.65				4.62			
D_{05}		3.27				3.25			

Table 11. Variance analysis for yield, Peja 2022

Source of variation	Degree of freedom	Quadratic sum	Mean squared	„F“ Values		
				“F” Factual	“F” Theoretical	
					0.95	0.99
Variants (V)	5	233.5	46.7	14.44**	3.33	5.64
Repetition (P)	2	4.9	2.5	0.8	4.10	7.56
Mistake (E)	10	32.3	3.2			
Amounts	17	270.7977778				

Table 12. Variance analysis for yield, Pestovo 2022

Source of variation	Degree of freedom	Quadratic sum	Mean squared	„F“ Values		
				“F” Factual	“F” Theoretical	
					0.95	0.99
Variants (V)	5	237.0	47.4	14.88**	3.33	5.64
Repetition (P)	2	2.3	1.2	0.4	4.10	7.56
Mistake (E)	10	31.8	3.2			
Amounts	17	271.18				

Table 13. Yield by country of study (qq/ha)

No	Year	Cultivar (qq/ha)						Average
		Bingo	Zllatko	Vanessa	Esterel	Rex	Barun	
1.	Peja	59.3	63.1	59.6	55.9	57.3	61.0	59.4a
2.	Pestovo	57.1	57.6	58.3	53.6	55.5	59.0	56.9b
D_{01}		2.44						
D_{05}		1.56						

Table 14. Analysis of variance for yield by study site

Source of variation	Degree of freedom	Quadratic sum	Mean squared	„F“ Values		
				“F” Factual	“F” Theoretical	
					0.95	0.99
Variants (V)	1	18.83342593	18.83342593	17.11**	6.61	16.26
Repetition (P)	5	47.19046296	9.438092593	8.57*	5.05	11.00
Mistake (E)	5	5.503796296	1.100759259			
Amounts	11	71.52768519				

From a look at the active temperatures in different areas and years, we notice that there is considerable variation regarding the total amount of active temperatures that barley plants need to complete their vegetative cycle. These changes are both between areas and between years, for the same variety. In our opinion, this means that not only the average temperature has had an impact on the ripening of plants, but also very high temperatures or even the lack of humidity, which affect the earlier ripening of plants (Table 15 and 16).

The differences in the total amount of active temperatures between varieties within the same area and year are similar to the differences between the lengths of the developmental stages. These changes were discussed above and need not be repeated here. Interesting are the changes in active temperatures between different years (Table 17 and 18).

The differences in the total amount of active temperatures between varieties within the same area and year are similar to the differences between the lengths of the developmental stages. These changes were discussed above and need not be repeated here. Interesting are the changes in active temperatures between different years. The course of changes of the sums of active temperatures calculated with a base temperature of 5 °C are similar to those calculated considering a base temperature of 0 °C, but the total values are significantly lower (Table 19). However, there are also quite a few changes that are observed especially in the periods from reporting to ripening.

Table 15. Yield by year of study

No	Year	Cultivar (qq/ha)						Average
		Bingo	Zllatko	Vanessa	Esterel	Rex	Barun	
1.	2020	54.1	53.7	56.5	51.2	49.0	53.1	52.9c
2.	2021	54.2	62.3	57.9	54.6	56.0	56.8	56.9b
3.	2022	66.4	65.2	62.5	58.5	64.3	70.2	64.5a
D_{01}		5.29						
D_{05}		3.72						

Table 16. Analysis of variance for yield by year of study

Source of variation	Degree of freedom	Quadratic sum	Mean squared	„F" Values		
				"F" Factual	"F" Theoretical	
					0.95	0.99
Variants (V)	2	415.6436111	207.8218056	24.83**	4.10	7.56
Repetition (P)	5	70.78569444	14.15713889	1.69	3.33	5.64
Mistake (E)	10	83.68972222	8.368972222			
Amounts	17	570.1190278				

Table 17. Active temperatures based on 0°C in 2020 according to development stages

Varieties	TA Peja 2020					
	Germination	Increase	Narration	Flowering	Annealing	TOTAL
Rex	116.8	809.65	145.4	72.8	1010.7	2155.4
Zllatko	116.8	811.05	105.7	84.2	1035.4	2153.2
Bingo	116.8	714.25	128.8	82.85	1044.3	2087.0
Vannesa	121.86	741.05	116.3	90.6	1066.9	2136.7
Esterel	127.86	784.35	124.7	77.1	1028.6	2142.6
Varieties	TA Pestovo 2020					
	Germination	Increase	Narration	Flowering	Annealing	TOTAL
Rex	103.25	682.75	120.05	89.7	1010.8	2006.6
Zllatko	103.25	706.5	126.05	102.85	1040.4	2079.1
Bingo	92.95	655.95	115.45	85.7	1058.7	2008.8
Vanesa	103.25	731.6	100.95	102.85	1164.1	2202.8
Esterel	103.25	706.5	114	89	878.05	1890.8

Table 18. Active temperatures based on 0°C in 2021 according to development stages

Varieties	TA Peja 2021					
	Germination	Increase	Narration	Flowering	Annealing	TOTAL
Rex	66.8	588.6	176.9	139.2	1083.6	2055.0
Zllatko	66.8	625.4	202.5	128.5	1111.0	2134.2
Bingo	66.8	610.8	175.1	151.7	1076.3	2080.6
Vanesa	66.8	687.9	199.5	112.6	1092.9	2159.7
Esterel	66.8	625.4	200.2	109.7	1103.0	2105.1
Barun	66.8	625.4	202.5	90.3	1076.3	2061.2
Varieties	TA Pestovo 2021					
	Germination	Increase	Narration	Flowering	Annealing	TOTAL
Rex	67.9	642.6	177.8	115.1	1047.8	2051.1
Zllatko	67.9	642.6	194.9	114.4	1107.4	2127.0
Bingo	67.9	615.5	188.2	98.7	1056.5	2026.7
Vanesa	67.9	710.2	174.4	89.7	1159.6	2201.7
Esterel	67.9	658.7	178.8	105.7	1089.0	2100.0
Barun	67.9	642.6	194.9	105.7	1141.1	2152.1

Table 19. Active temperatures based on 0°C in 2022 by stages of development

Varieties	TA Peja 2022					
	Germination	Increase	Narration	Flowering	Annealing	TOTAL
Rex	118.8	771.5	98.4	91.2	1045.4	2125.2
Zllatko	113.3	840.4	91.2	134.6	1004.9	2184.3
Bingo	97.8	791.0	108.0	72.6	1066.3	2135.6
Vanesa	97.8	791.0	122.5	72.7	1006.3	2090.2
Esterel	97.8	800.5	125.1	88.6	1048.0	2159.9
Barun	83.8	794.3	102.2	118.3	970.9	2069.5
Varieties	TA Pestovo 2022					
	Germination	Increase	Narration	Flowering	Annealing	TOTAL
Rex	82.15	595.75	121	79.25	974	1852.15
Zllatko	89.85	614.7	104.8	96.85	993.65	1899.85
Bingo	89.85	627.85	111.15	109.5	986.35	1924.7
Vanesa	89.85	607	120.9	73.6	960.8	1852.15
Esterel	82.15	614.7	102.05	139.45	891.15	1829.5
Barun	96.2	670.05	81.25	142.4	956.9	1946.8

CONCLUSIONS

Based on observations, biometric measurements, chemical analyzes and our scientific evaluations on plant period indicators, production elements, on quantitative and qualitative production indicators obtained on 6 barley cultivars studied in two field trials and three years, we concluded:

1. For the features, characteristics and quantitative and qualitative indicators of cultivar production, we make the following scientific generalizations – for absolute weight (weight of 1,000 grains) cultivars Vanessa, Bingo and Barun had the highest value. For the weight of the ear, the Esterel and Rex cultivars had the lowest values, the other four had the highest weight. The cultivars Zllatko, Barun, Vanessa and Bingo stood out for the highest grain yield.
2. Regarding the influence of the environmental conditions, of the areas where the field tests were carried out, we make the following generalizations – the number of grains/ear was influenced by the conditions of the field trial site. Barley cultivars formed more crops/cobs in Peja, compared to Pestovo. In the area of

Peja, the Zllatko cultivar had the highest yield, and in Pestovo, the Vanessa cultivar. From the observation of the active temperature values, it was observed that the active temperatures with TBase equal to 5°C correlate better with the yield of different cultivars for the conditions of Kosovo than the active temperatures realized with TBase equal to 0 °C. Environmental conditions, represented by the place of cultivation, have also influenced the association of traits.

3. Regarding the influence of the climatic conditions of the year, we make the following generalizations – the impact of the climatic conditions of the year has been significant on the yield of barley cultivars, the highest yields were obtained from cultivars in 2013 and the lowest in 2011, even the correlations between different features or indicators are influenced by the climatic conditions of the country.

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