RESEARCH ARTICLE **(Open Access)**

Agro-Climatic Characterization and Determination of Thermal and Pluviometric Limits in the Area of Debar, Albania

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Abstract

Different climatic regimes play a determining role not just on the geographical and agronomic distribution of plants, but on the intensity of agricultural plant growth also. Climate affects the mass of structural features and especially the pace of plants development. Regarding climate Albanian territory is part of the sub-band subtropical western coast and it is divided into two climatic zones: Atlantic Mediterranean area and Continental Mediterranean area. But the microclimatic effects arising in our territory make the climate quite diverse. In a relatively small area major changes of climate elements are created, thus a variety of areas with different climatic characteristics and determining impacts on agricultural plant breeding are present. Knowing of the thermal and rainfall limits is important in the cultivation of agricultural plants; the lack of knowledge poses a risk to agricultural cultivations. On the other hand these limits must be seen closely linked to their dynamism and should be studied in relation to possible climate changes. In accordance with the climatic characteristics of agro-ecological zones, should be developed plant cultivation technologies which should take into account the different agricultural systems that are applied in these areas. This study takes into consideration for agro-climatic characterization a developed agricultural area, that of Debar, in the northeast of Albania.

Keywords: climate, temperature, rainfall, relative humidity, climate change.

1. Introduction

Increasing the sustainability of agro-ecosystems and receiving an acceptable and stabilized in time production of crops, requires a good understanding of climatic and microclimatic conditions of agricultural areas also. Fluctuations of inter-annual climate elements directly affect the intensity of growth and production of agricultural plants. Given the fact that plants and differentiated climatic requirements extend their period of development in different periods of the year, climatic conditions of an area can not appear similar and suitable for all plants grown in that area. Despite climatic features of defined areas, expressed in climate classifications (climatic divisions of Albanian territory) [11], in the case of agricultural plants it is necessary to accomplish agro-climatic classification of areas. Such a classification coincides with agro-climatic regionalization of the territory [16]. Based on the construction of agro-climatic relationships we can determine inter-annual fluctuations in production and make the assessment of sustainability of agricultural production areas. In literature there are few examples of studies, in which the normal fluctuations of inter-annual climate are incorporated into an agricultural risk assessment methodology for a territory [17, 7, 5]. On the other hand, these studies should be conducted in a dynamic way, seen in terms of the impact of climate change. In the past 150 years the planet's surface temperature is increased by an amount between 0.6 and 0.8° C [8]. According to some studies [8], Southern Europe, part of which is Albania also, is becoming drier with hot and with less rainfall. Agriculture and rural areas will be affected more by climate change and especially by the lack of rainfall [1]. Current recognition based on a set of evidence indicates that most of the analyzed agricultural lands have a significant increase of the minimum and maximum temperature from the beginning of the twentieth century [4]. However, there is only a moderate level of confidence in reducing the daily thermal excursion and the thorough impact on the probability distribution remains an open question

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[6]. In Europe and the Mediterranean has an obvious seasonal variability of regional rainfall and mostly during winter time [10]. A problem for agriculture is the drought. Its frequency was evaluated in a comprehensive manner in the report of SREX [9]. Even Albania is not exempt from these influences which are also analyzed by previous studies [18, 15]. Albania is located in the South-east Europe, in the west of the Balkan Peninsula, on the Adriatic and Ionian seas. It has an area of 28,745km^2 and Albania terrain is mountainous. Hill and mountain areas cover about 77% of the territory with an average altitude of 708 meters above sea level, almost double that of Europe. Western lowland coastal part has the main areas of agricultural production. The area of Debar is part of the Mediterranean pre-mountainous area, of the Albanian territory, this area lies at height 657 m above sea level, in latitude 41^0 41' and longitude 20^0 26'. In this study the behavior of the climate area of Debar referring to the main indicators and their variations in time (temperature, rainfall, relative humidity, wind speed, solar lighting), magnitude were analyzed defining impacts on agricultural production.

2. Material and methods

Climatic data used for this study refer to meteorological stations of Debar for meteorological indicators (rainfall, temperature, relative air humidity, wind and solar radiation). The historical series include various intervals of time (1970-1990 and 1990-2009) and are provided by publications [11, 18]. The study analyzed data obtained from all meteorological stations in the area of Dibra (Peshkopi, Kastriot, Zalli i Kalise, Fushe Lure, Selishte, Shupenze, Zerqan, Ostren i Vogel, Klenje, Kostenje, Qarrishte). Data for the respective periods are digitized for obtaining the values of climate variables: a) daily and monthly records of rainfall each year; b) daily and monthly data of temperature: average, absolute minimum and maximum; d) monthly data on the number of days with relative humidity less than or equal to 50% (≤50%); e) monthly data on the number of days with relative humidity greater than or equal to 80% (≥ 80%) for 14 hours; f) monthly data on wind direction and speed; g) monthly data on solar energy. Precipitation data are available for a higher number of years (about 30 years). On the basis of data frequencies in excess of predetermined values of rainfall monthly and yearly are calculated [3]. Frequency of rainfall surplus (P) greater than or equal to a value (Pz), is calculated:

$$F(P \geq Pz) = \frac{z}{n+1}$$

Frequency of no excess rainfall (P) smaller or equal to a value (Pz), is calculated:

$$F(P \geq Pz) = 1 - F(P \geq Pz) = 1 - \frac{z}{n+1}$$

where: n - is the total number of observations available for the series considered; z - number in descending way of values of considered batch of rain. Consequently, the values of excess and not excess of rainfall frequency of 25% and 75% with monthly and annual average values are calculated [14]. Determination of periods of dryness was performed according to the method of ombrothermic diagrams Bagnlous & Gossen [2]. Temperature and precipitation anomalies and their trends are analyzed by means of regression equations and correlation coefficients. Regarding the data on the relative humidity of air water vapors pressure (absolute humidity of the air) and moisture deficit are analyzed. Monthly data were analyzed for the direction and velocity of wind and solar energy to highlight their agro-climatic impact.

3. Results and discussion

On the basis of available data and their processing, climatic features of the area of Debar are defined. On the basis of four variables analyzed: average precipitation (mm); the average annual temperature (^{0}C); average number of days of the year with relative humidity ≥80% and average number of days of the year with ≤50% relative humidity for 14 hours, the climatic features of Debar area are calculated. This area presents specific climatic features compared with other areas.

Figure 1. Homogeneous climatic zones of Albania and the position in the area of Debar.

Table 1. Determination of climatic parameters in the area of Debar.

Annual Rainfall (mm)	*The average annual temperature (^0C)*	*The average number of annual days with humidity ≥ 80% for 14 hours*	*The average number of annual days with humidity ≤50% for 14 hours*
982.6	10.6	68,3	151,9

Albanian territory is characterized by a relatively high amount of rainfall ranging from the minimum values of 649 to 1060 mm per year in the area of western lowland and hilly areas and the maximum values of 2295 to 3117 annual mm in mountainous areas. Debar area is part of the area with less precipitation (annual precipitation with 75% probability are not smaller than the values included between 694 and 968 mm and with a probability of 25% are not smaller than the values included between 944 and 1396 mm) [14].

Table 2. The average monthly amount of precipitation (mm) of the area of Debar.

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Annual
214.1	116.9	123.5	59.7	71.4	41.4	6.4	87.0	111.8	24.9	81.7	43.8	982.6

Precipitation trends were analyzed through regression equations and correlation coefficients: *y = -0.858x+962.03 (r = 0.211).* The analysis shows a downward trend in rainfall regime in recent years, which seems likely affected by climate change.

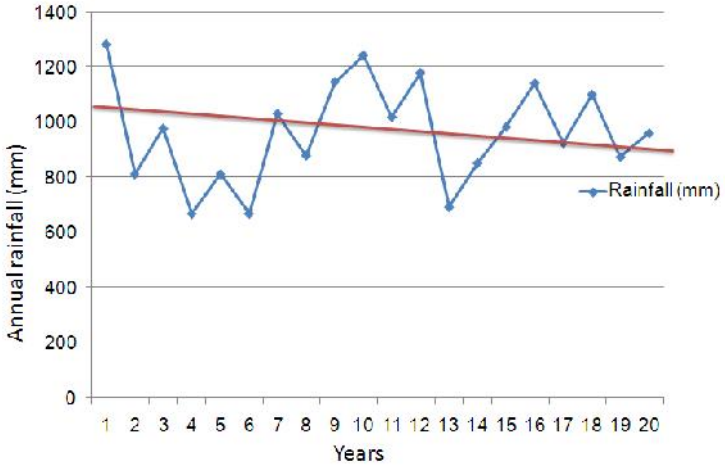

Figure 2. Performance behavior of precipitation in the area of Debar.

The average annual temperatures range between 9.1 and 10.7°C and maximum average temperatures are included between 13.3 and 15.6°C and the minimum between 4.4 and 6.0°C. Absolute maximum temperatures have been recorded in July, 29.8°C with a probability of 75% and 33.3°C values with a probability of 25%, the absolute minimum temperatures are in January at -7.8°C with a probability of 75% and -14.0°C with a probability of 25%.

Table 3. Levels of average, minimum and maximum annual temperatures (°C) (Debar)

	I	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*	*IX*	*X*	*XI*	*XII*	*Annual*
$T_{average}$	2.2	1.4	4.1	8.4	15.1	17.6	20.4	19.5	17.2	14.0	7.3	0.2	10.6
$T_{maximum}$	6.0	4.6	8.4	13.4	21.4	23.7	27.4	25.6	23.4	19.3	12.4	3.5	15.8
$T_{minimum}$	-1.6	-1.7	-0.2	3.4	8.7	11.4	13.3	13.3	11.0	8.7	2.3	-3.0	5.5

From the analysis of the maximum average temperatures 64 annual days are recorded with average maximum temperature over 25°C and 84 annual day with average minimum temperatures below 0°C; 16 annual days with average maximum temperature over 30°C.

Table 4. The absolute maximum and minimum levels of temperature (area of Debar)

The absolute maximum and minimum levels of temperature				
Months	The absolute maximum temperature (°C)		The absolute minimum temperature (°C)	
	P (0.25) ≥x	P (0.75) ≤x	P (0.25) ≥x	P (0.75)≤x
I	11.3	8.0	-14.0	-7.8
II	14.9	10.7	-13.1	-7.2
III	21.4	15.3	-9.4	-4.4
IV	24.6	21.0	-2.8	0.0
V	30.3	24.3	3.2	5.6
VI	29.7	28.1	5.3	8.2
VII	33.3	29.8	6.9	9.8
VIII	32.4	29.4	8.3	10.4
IX	29.6	26.4	2.6	7.7
X	24.4	20.8	-2.9	1.8
XI	19.5	16.4	-7.9	-2.1
XII	13.7	11.2	-12.6	-6.6

For the analysis of air relative humidity two variables were taken into account: number of days, monthly or annually, with relative air humidity ≥ 80% for at least 14 hours daily and the number of days with relative humidity lower than 50%. In areas with a high number of days with humidity ≥80% and with a small number of days with relative humidity ≤50%, crops such as vegetables tend to be affected by different pathogens, particularly fungal. Debar area has a relatively high number of days (68.3) with humidity ≥ 80% and with a relatively low number of days (151.9) with humidity ≤50%, which means, there is high probability for fungal pathogens spread. The graphical analysis of the data shows that areas of Debar are characterized by high relative air humidity at levels about 71% as annual average and with an average number of annually days with humidity ≤ 50% for 14 hours for 150 days.

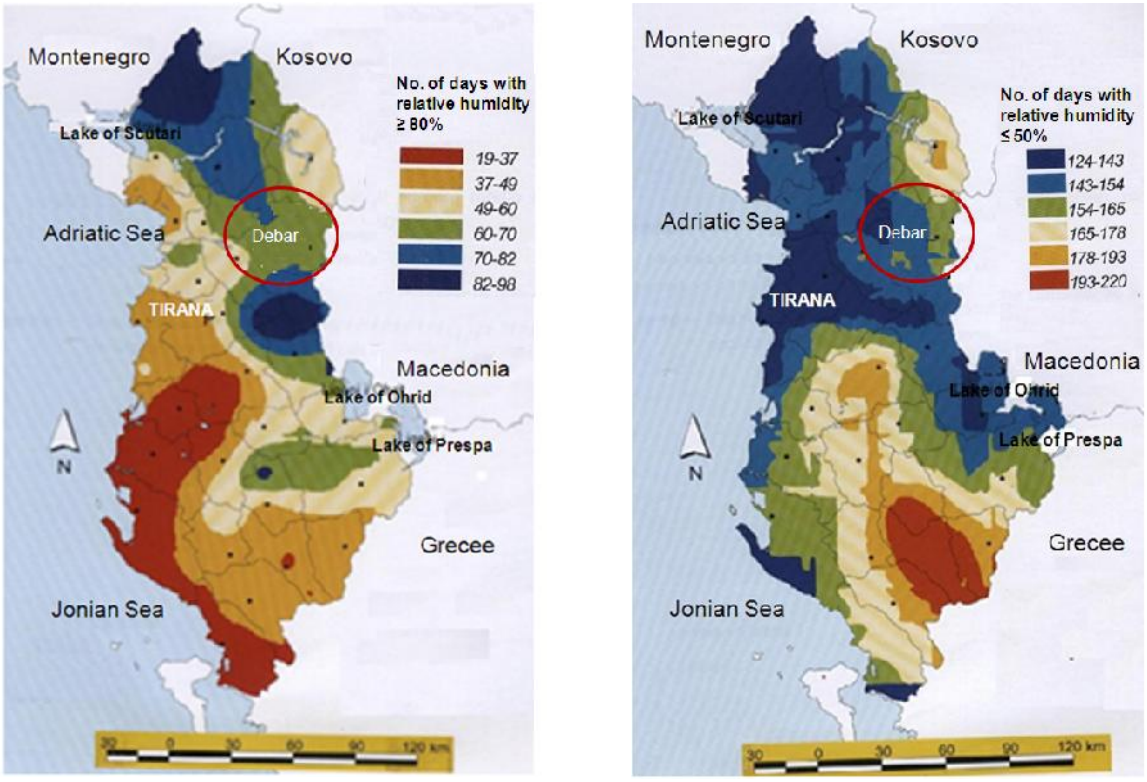

Figure 3. Homogeneous climate spaces in terms of the number of days with relative humidity ≥ 80% and ≤ 50% for 14 hours in the territory of Albania and of the area of Debar.

Based on pluviometric and thermometric data the probability of relative humidity at three different times during 24 hours (7.00, 14.00 and 21.00) is calculated. From this analyzes it is verified that the highest levels of relative humidity are at 7.00 a.m. with 82% as annual mean, while the lowest values are at 14.00 with annual mean of relative humidity of 58%. The annual mean of relative humidity is 71% so we have high relative humidity in Debar area. The months with highest values of relative humidity are December 87%, followed by February with 84%, January with 81% and November with 78% relative humidity. There are 22 days with relative humidity <30%, 152 days with relative humidity <50% and 70 days with relative humidity <80%. The annual mean water vapor tension is 9.4 and the monthly higher values are in August with the value of 14.5. Moisture deficit results 5.4, as annual average and it is higher in July with 13.7.

Table 5. The tension of water vapor (mb) and the moisture deficit d (mb)

	The time of the measurement of the vapor pressure of water			*Average (e)*	*Moisture deficit (d)*
	7	14	21		
Annual values	9.1	9.6	9.5	9.4	5.4

The dryness periods of the year are analyzed through Bagnoulus and Gaussen diagrams. These diagrams show that the dryness periods in Debar area are very short and with little importance, they happen during July and August when it would be necessary to intervene with irrigations especially for vegetable crops. From the graphical analyzes it is observed that the dryness period in the agro climatic contest starts from the first decade of June and continues until last decade of August. Through the analyses of this period it was observed that there are rainfalls, though with low intensity, that weaken the effects of dryness and shorten it in time.

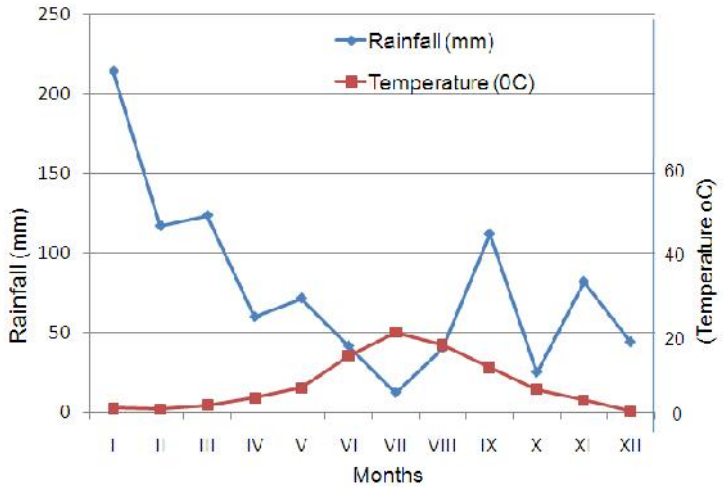

Figure 4. Ombro-thermal diagrams Bagnoulus & Gaussen for periods of drought, for the climatic zone of Debar.

Knowing the period of dryness, has agro-climatic value, as it can be used for programming of many agronomic practices.

By analyzing the direction and wind speed in the area of Debar, it resulted that the Northwest dominates with 63 annual cases, and then come those from the Southwest with 55 cases and West with 51 cases. Winds with greater speeds were observed blowing from the North with 8.4 m / sec, Northeast with 5.5 m/sec, followed by those that blow from the Northwest at 5.2 m/sec, then South with 5 m / sec as an annual average.

Table 5. Wind, direction and velocity

Cases of direction and speeds	N		NE		E		SE		S		SW		W		NW		Quiescent state
	ca.	sp.	ca.	sp.	ca.	sp.	ca.	sp.	ca.	sp.	ca.	sp.	ca.	sp.	ca.	sp.	
	17		3		17		55		18		15		51		63		859

***ca**.-cases; **sp**.-speeds*

The distribution of solar energy in the entire territory of our country (amount of hours of sunshine) and especially the relative solar energy, used as an indicator of the level of cloudiness, ranges over 2400 hours of sunshine, in the South and West part of the country it is over 2500 hours, while in lowland area of the field of Myzeqeja it is over 2700 hours.

Table 6. Average monthly amounts of annual extension of solar energy (in hours)

Months												The annual amount
I	II	III	IV	V	VI	VII	VII	IX	X	XI	XII	
75.0	33.0	96.9	148.5	245.5	287.7	368.3	252.5	227.5	173.2	143.2	62.3	2113.6

The analysis of Debar area showed an average amount of solar energy about 2,100 hours annually, which makes it a very suitable area for cropping of plants not very demanding for light as fruit trees like apples, plums etc. By analyzing the number of days with special atmospheric events it was noticed that Debar area has an annual average of about 107 days of rain, 23 days with thunderstorms rain, 39 days with fog, 52 days with frost, 28 days with thunderstorms, 166 cloudy days and 74 frank days.

4.Conclusions

By analyzing historical series in the area of Debar it resulted as follows:

The rainfall regime is characterized by an average annual amount of rainfall of 982.6 mm with a downward trend likely affected by climate change. The average annual number of days with precipitation is 85.5.

This area has 18 annual days with temperature $<0^0$C, and 16 annual days with temperatures $> 30^0$C.

The absolute minimum temperature is -14.0^0C recorded in January. There are 64 annual days with average maximum temperature over 25^0C.

The regime of air relative humidity is characterized by relatively high levels with 71% annual average, which adversely affects many disease and pathogens; 70 days with relative air humidity ≥ 80% for 14 hours a day and 152 days with relative air humidity ≤ 50% for 14 hours a day; 22 days annual average humidity <30% for 14 hours.

The dry period of the year in this area starts from the first decade of June until the third decade of August; it is relatively short, punctuated by summer rainfall.

The Northwest winds dominate in this area with 63 annual cases. Highest wind speeds were recorded from north with 8.43 m/sec.

The average amount of hours of sunshine is about 2,100 hours annually, which makes it a very suitable area for cropping of plants not very demanding for light like apples and plums.

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