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EFFECT OF ALTITUDE ON THE WATER BALANCE OF LAND AREA OF SARAJEVO

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Abstract

This paper examined the impact of altitude on the water balance of the land area of Sarajevo (weather station Bjelave and weather station Bjelasnica) for the period 1991-2010 for the average, driest and rainiest hydrological year. The average annual potential evapotranspiration (ETP) in the weather station Bjelave was 529 mm, while in the weather station Bjelašnica potential evapotranspiraton (ETP) value was much lower, amounting to 54 mm.
In the area of weather station Bjelave, the mean annual precipitation (P) for an average hydrological year amounted to 1.144 mm, potential evapotranspiration (ETP) 595 mm, and actual evapotranspiration (ETR) to 522 mm. Water shortages in the area covered by the weather station appeared in the summer months (July and August), total of water of 158 mm, whereas the excess water in the soil, due to its water saturation occurred in the winter months (December, January, February) and in March and April, its total of 389 mm.
In the area of weather station Bjelašnica, the annual precipitation means (P) for an average hydrological year amounted to 955 mm, potential evapotranspiration (ETP) 70 mm, and actual evapotranspiration (ETR) 68 mm. Shortages of water were not present in a single month, and excess water might occur during all the months except October, in the amount of 719 mm.

Key words: altitude, evapotranspiration, water balance, lack of water, excess water

Introduction

Of all the natural factors, the air has the highest impact on the crop production. For the climate assessment climate of an area, long-term observation and knowledge of its elements, such as mean annual and mean monthly temperatures, amounts, i.e. total precipitations, number of days without frost, the frequency and intensity of the wind, the onset of hail, are needed. Crop production is mostly determined by the air temperature and precipitations, so the climate of a region may be assessed, accordingly.
According to Milosavljevic (1983), the area of Sarajevo is characterised to have pre-mountainous climate, with cold winters, lasting longer than the continental ones. The winds are rare, with moderately warm summers of the annual fluctuations in temperature, being 20-24ºC. The average annual temperature is below 10ºC, with the annual rainfall of 750-1000 mm, which corresponds to sub-humid climate.
The weather conditions determine the natural flow of water into the soil and water consumption on evapotranspiration and thus irrigation is needed. The most important are precipitations because they need to ensure a steady flow of water for normal growth and development of plants. Different plants have different water needs. The required amount of water for the cultivation of agricultural plants matches the values of potential evapotranspiration.

Agricultural crops requirements for water are expressed through evapotranspiration (Doorenbos and Pruitt, 1977), which includes plant transpiration and evaporation (evaporation) of the land covered with vegetation cover.
The increased quantity of water used in the ETP is usually accompanied by increase in the yield of agricultural plants to a certain level, when there comes to a stagnation. Then, the yield decreases, despite increased ETP values.
Based on the numerous analyses, for most sites it seemed sufficient to have values of minimum and maximum daily air temperatures (Popova et al., 2006; Jabloun and Sahli, 2008; Trajkovic et al., 2011). Measurements of air temperature are simple and are not prone to big errors, unlike other climate parameters.
The most commonly used methods are those of Thornthwait, the Turc, the Blaney-a - a-Criddle and Penman. In this paper, the calculation of potential evapotranspiration by the Thornthwaite method was used, giving the best results in terms of sub-humid climate.
Thornthwaite's method is applied worldwide, being very suitable because only the data on the mean daily air temperature calculated as the average value of the maximum and minimum air temperature, are necessary. Camargo et al. (1999) reported that the method of Thornthwaite, on a monthly basis, seemed more reliable, if instead of daily mean air temperature, the effective temperature was taken into account.
In this paper, an initial assumption was that climatic factors were very important in agricultural production, and that determining the type of climate and water balance calculation seemed to be very important in order to obtain information on shortages and excess soil water in a particular area, with the resulting need of introducing either watering or, if there need be, land drainage.

Materials and method

The data on climate elements (air temperature and precipitation) of the area of Sarajevo (Bjelave and Bjelasnica) on a twenty-year basis (1991-2010), were used. Bjelave weather station is placed at an altitude of 630 m, whereas that of Bjelasnica is located at an altitude of 2067 metres. Based on the collected climatic data for each weather station, the potential evapotranspiration for each month and each year analysed, was determined. Also, based on the ETP value and rainfalls, water balance was determined as well as the water shortages and surpluses of the area.
The potential evapotranspiration was determined using Thornthwaite's method, based on the air temperatures values, so that the incorrect ETP was corrected with a certain coefficient for a given area.
Water balance was determined by the method of Thornthwaite, on the basis of two parameters: the monthly value of ETP (mm) and the sum of monthly precipitation (mm) for the analysed period.
Water balance was made for the reserve of readily available water (RRLW) in the soil of 100 mm, and the land was then assumed to be saturated with water.

Results and discussion

In farming, significant results are achieved thanks to the increasing advances in the field, but still the output is not stable due to water shortages during the growing season, because water is necessary for normal plant growth and development. The lack of moisture for plants is due to the high temperatures, low relative humidity, high values of potential evapotranspiration and insufficient rainfalls.
Precipitation is a meteorological element, the value of which is highly variable over space and time. The influence of topography is very important, rainfall increases with altitude, because the hills affect the air currents rise, leading to air cooling and condensation of water vapor. The nature and dynamics of rainfall also affects the temperature regimes.

The average annual ETP in Bjelave was found to be 529 mm, while in the Bjelašnica ETP value was much lower of 54 mm. The annual heat index values were also relatively low, because of low mean monthly temperature in Bjelašnica, and that is why the ETP value was very low compared to the value of the ETP of the weather station Bjelava.

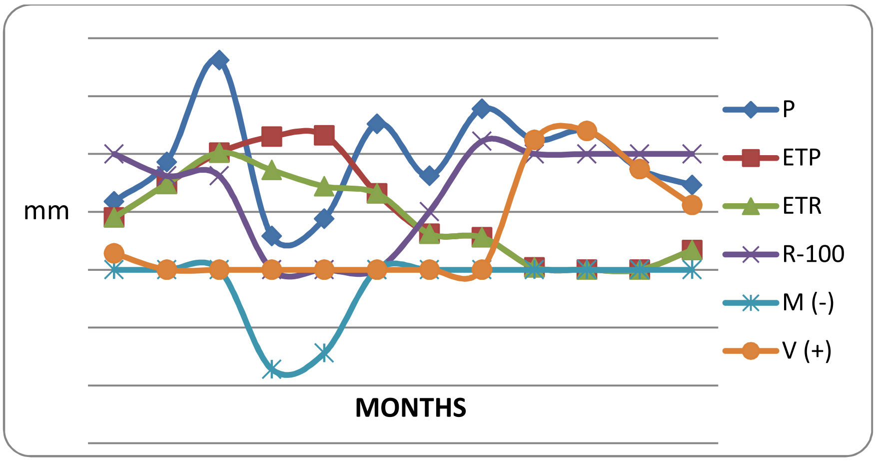

Figure 1. Water balance of the weather station Bjelava for the average hydrological year (2010)
P- precipitation, ETP-potential evapotranspiration, ETR-actual evapotranspiration, R-100- reserwe water in the soils, M (-)- water shortages, V(+)- surplus of water

In the area of weather station Bjelavea total annual amount of precipitation (P) was 1.144 mm, potential evapotranspiration 595 mm, and actual evapotranspiration (ETR) 522 mm. Water shortages in the area covered by the weather station appeared in the summer months (July and August), with the total sum of 158 mm, while the surplus of water occurred in the winter months (December, January, February) as well as in March and April, with their total amount being 389 mm, since the earth was then completely saturated with water (Fig. 1).

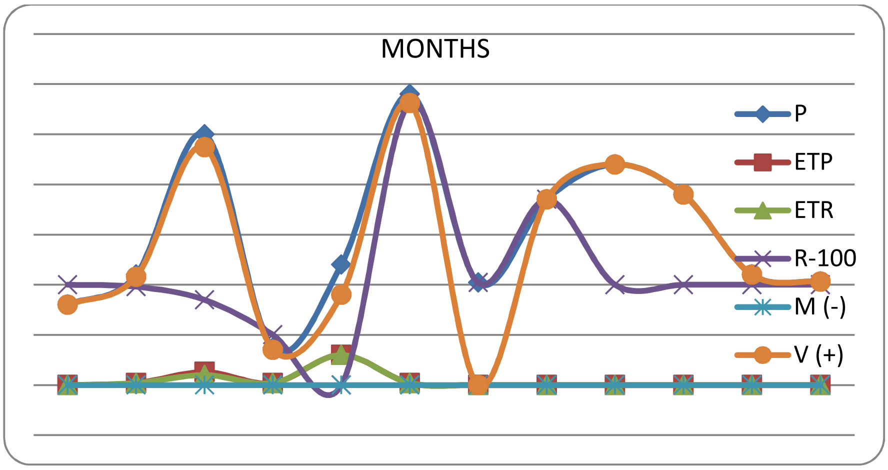

Figure 2. Water balance of the weather station Bjelašnica for the average hydrological year (2010)

In the area covered by the weather station Bjelašnica, the annual amount of rainfall was much higher amounting to 1.797 mm. Since a lot of low air temperature prevailed in this area because of higher altitudes, the average annual potential evapotranspiration (ETP) was only 49 mm, and the actual annual one (ETR) 46 mm. Shortages of water were not present in a single month, and excess water could occur in all months except for October, amounting to 1,639 mm per year.

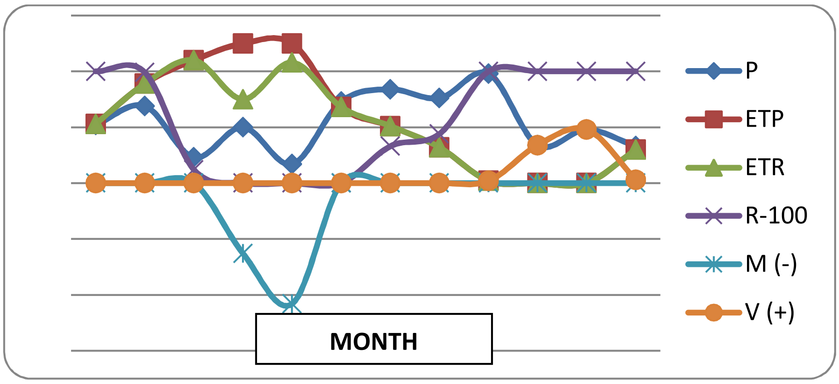

Figure 3. Water balance of the weather station Bjelava for the driest year (2000)

On the area of the weather station of Bjelava, the total annual precipitation sum (P) for the driest year amounted to 657 mm, potential evapotranspiration was 657 mm, and the effective one (ETR) 618 mm. Water shortages in the area covered by the weather station appeared in the summer months (July and August), with the total sum of 171 mm, whereas the surplus of water occurred in the winter months (December, January, February, March) in the amount of 87 mm, (Fig. 3)

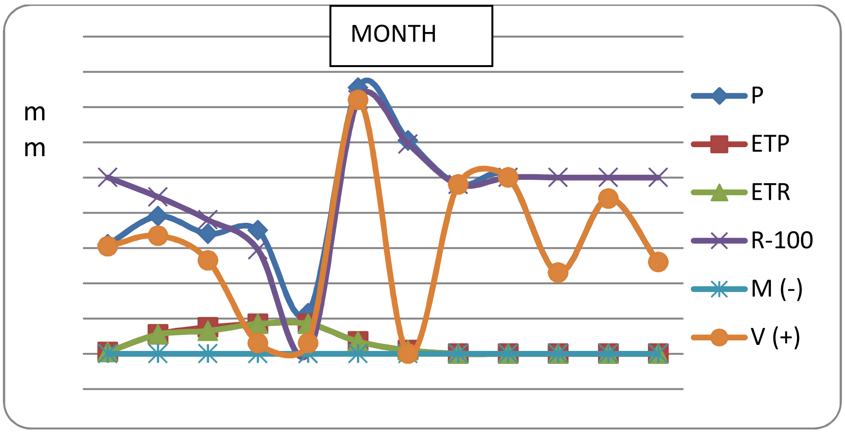

Figure 4. Water balance of the weather station Bjelašnica for the driest year (2000)

In the area covered by the weather station Bjelašnica, the mean annual precipitation (P) was 955 mm, potential evapotranspiration (ETP) 70 mm, and actual evapotranspiration (ETR) 68 mm. No water shortages were recorded in a single month, whereas its surpluses were in all months except October, but in much less quantity than being in the rainy years, with the surplus water per year being 719 mm (Fig.4).

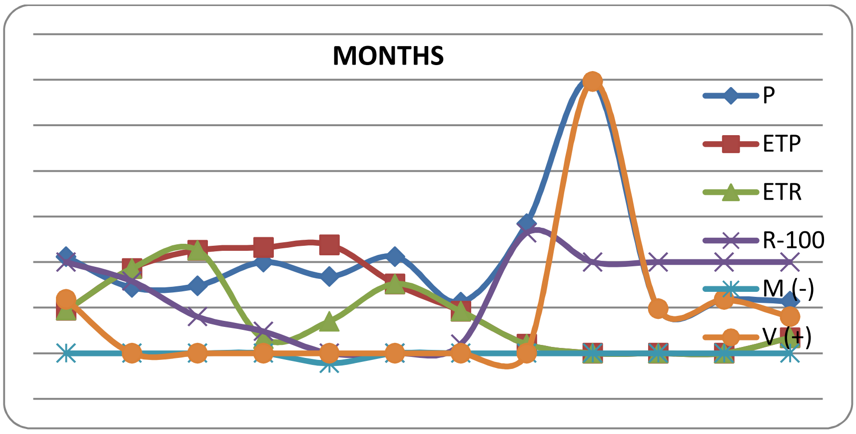

Figure 5. Water balance of meteorological station Bjelave for the rainiest year (1999)

In the area Bjelava, total rainfall was 1,203 mm during the year, potential evapotranspiration (ETP) 637 mm and actual evapotranspiration (ETR) 453 mm. Water shortages were reported only in one summer month (August), while its surpluses were recorded in the winter months, the total of 505 mm (Fig. 5).

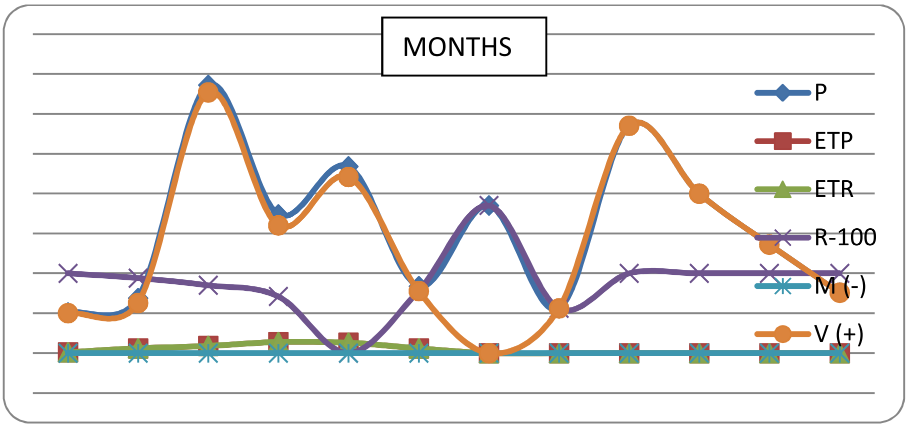

Figure 6. Water balance of the weather station Bjelašnica for the driest year (1999)

In the area of MS Bjelašnica, the annual rainfall was reported to be 1,886 mm, potential evapotranspiration (ETP) 49 mm, and the actual one (ETR) 49 mm. Water shortages were present not in a single month during the hydrological year, but its surplus was in all the months except for October, with the total amount being 1.652 mm (Fig. 6).

Conclusion

In the area of the meteorological station Bjelave (630 meters), high temperature over the summer caused extremely high values of the potential evapotranspiration, reaching their maximum in July and in August, after which, the decrease in the average monthly air temperatures brought about the decreased potential evapotranspiration value. High air temperatures and high values of potential evapotranspiration led to water shortages in the summer months. Low temperature, the decreased value of potential evapotranspiration and increased precipitation also led to water excess in the soil.

In the area covered by the weather station of Bjelašnica (2067 m), the average annual temperature was significantly lower, and air temperatures were extremely low, too, along with reduced values of the potential evapotranspiration throughout all the months, and increased precipitation, resulting in the water surplus in the soil in almost all the months except for October.

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