

# Irrigation conditions (soil water balance) in highland and mountainous areas

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## Abstract

Estimation of rational irrigation regime is basic problem in irrigation systems planning. Different calculation methods for actual and potential evapotranspiration are used for those purpose. All of them are based on climatic factors. This paper evaluates the soil water balance in the region of Fruška gora during a number of seasons. There is an example for water balance calculation of vertical parameters of over unsaturated zone at the meteorological stations (MS) Gladnoš and Sremska Mitrovica area.

Key words: precipitation, evapotranspiration, irrigation soil

## Introduction

An analysis of crop water requirement depends on the value of potential evapotranspiration (PET). Evapotranspiration refers to the amount of water utilized by the plant for optimal growth, which suggests that optimal soil moisture which varied depending on the precipitation regime, crops etc., should be maintained under irrigated conditions. Climate conditions and soil water relationships as well as their variable and complex interactions are factors that define successful crop production (Šimunić et al., 2008). The soil water deficiency in the area covered by the M. S. Vršac occurs during July - October at 340 mm (Stojiljković et al., 2001). An annual water deficiency in the soils of Čačak has been forecast to be 285 mm every 10 years, 235 mm every 5 years and 143 mm every 2 years (Šekularac et al., 1996). The seasonal analysis of soil water balance in the region Čačak (Western Serbia) during 20-year period (Šekularac et al., 2009). The total deficiency of water required for plant during the growing season was 185 mm. The total amount of water lost by evapotranspiration during the growing season under the agro environmental conditions of Vojvodina is higher than the total amount of precipitation in Vojvodina. This indicates the fact that the water inflow from precipitation, included irrigation, cannot satisfy the water requirement of maize in this area (Rajić, 2003). The soil water deficiency in one part of southern Italy occurs between May- October, as calculated by the Thornthwaite and Mather method used (Marsico et al., 2007).

The value of PET was estimated by an empirical method, where the soil water balance was based on the regional relation ship between PET and climate. PET as an element of water balance, among the other elements, is used to define soil water deficiency/ surplus in particular region theirs annual, seasonal, monthly and daily fluctuations in PET value. Throughout the year, the values of climate elements are also variable, inducing variability in PET values and, hence, in the soil water content. The hydro balance, providing information on water deficiency and the time of its occurrence, as well as a basis for an irrigation system, is presented in this study for the region of Fruška gora, a part of Northern Serbia.

## Material and methods

PET was calculated following the method described by THORNTHWAITE. The aeration zone index (vertical balance parameters) was determined, coupled with the proportion of monthly evapotranspiration after Thornthwaite method, for the period of thirty years. The study includes an analysis of precipitation (P), readily available soil water reserves (RAWR) and PET. The readily available water reserve of 100 mm was

added calculation. The assumption accordingly was that the soil contains 100 mm of water reserves in the rhizosphere zone and that it is, completely saturated (Dragović, 2000). The obtained data on the amount of precipitation for the region of Fruška gora (MS of Sremska Mitrovica and Gladnoš) were used in the calculation.

Water balance was calculated for the most common soil types in the region of Fruška gora including alluvial soils, pseudogley and loess.

**Results and discussion**

**MS GLADNOŠ:** The mean annual precipitation across season was 153 mm during spring, 200 mm during summer, 144 mm during autumn and 145 mm during winter, giving the sum of 642 mm. The analysis of the long-term period indicates that June (84 mm), as shown in Table 1. The precipitation sum during the growing season was 361 mm.

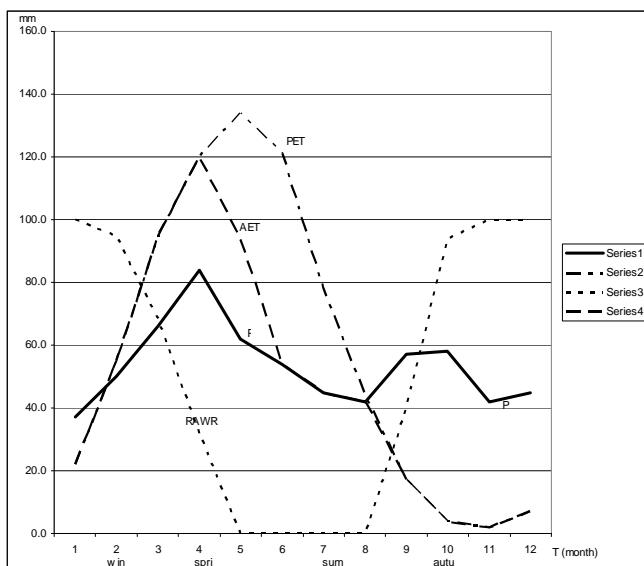
The mean annual value of PET was 699 mm, 172 mm during spring, 375 mm during summer, 139 mm during autumn and 13 mm during winter. The PET value during the growing season was 603 mm.

The plant water requirements (PET) were highest in July (134 mm), in August the plants needed 121 mm of water for their growth and development (PET), the average PET value during June was 120 mm (Table 1).

**Table 1. Average monthly sums of precipitation (P), mean monthly values of PET, mean readily available water reserves in the soil (RAWR), actual evapotranspiration (AET)**

date	III	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	Sum of years
<b>MSGladnoš</b>													
P	37.0	50.0	66.0	84.0	62.0	54.0	45.0	42.0	57.0	58.0	42.0	45.0	642.0
PET	22	55.0	95.0	120.0	134.0	121.0	78.0	44.0	17.0	4.0	2.0	7.0	699.0
RAWR	100	95.0	68.0	32.0	0.0	0.0	0.0	0.0	40.0	94.0	100.0	100.0	629.0
AET	22	55.0	95.0	120.0	94.0	54.0	45.0	42.0	17.0	4.0	2.0	7.0	557.0
<b>MS Sremska Mitrovica</b>													
P	39.0	50.0	57.0	82.0	65.0	50.0	42.0	42.0	54.0	48.0	38.0	36.0	603.0
PET	23	56.0	99.0	121.0	134.0	120.0	79.0	45.0	16.0	4.0	1.0	6.0	704.0
RAWR	100	94.0	52.0	13.0	0.0	0.0	0.0	0.0	38.0	44.0	100.0	100.0	541.0
AET	23	56.0	99.0	121.0	78.0	50.0	42.0	42.0	16.0	4.0	1.0	6.0	538.0

The analysis of the soil water balance in the Fruška gora region revealed that the readily available water reserves (RAWR) could be completely consumed during May-October. The soil had lowest water supply during summer (32 mm) and autumn (40 mm). During spring and winter, readily available soil water reserves were 263 mm and 294 mm, respectively. During



**Figure 1. Average monthly sums of precipitation P (series 1), mean monthly values of PET (series 2), mean readily available water reserves in the soil RAWR (series 3), actual evapotranspiration AET (series 4) in MS Gladnoš**

The growing season, in the MS Gladnoš, plants had an average supply of 195 mm of readily available soil water, which is 31% of the annual amount of readily available water, the average value is 629 mm. The lowest soil water supply was during June, July, August and September.

The sum of mean annual actual evapotranspiration (AET) in the region was 557 mm. The estimated AET during spring, summer, autumn and winter was 172 mm, 268 mm, 104 mm and 13 mm, respectively. The value during the growing season was 463 mm (90% of the average sum of annual AET value). During the growing season, AET was highest in June 120 mm, followed by May 95 mm and July 94 mm.

The soil water deficiency in MS Gladnoš was most pronounced during summer 107 mm.

**MS Sremska Mitrovica:** The mean annual precipitation across season was 146 mm during spring, 197 mm during summer, 138 mm during autumn and 122 mm during winter, giving the sum of 603 mm. The analysis of the long-term period indicates that June (82 mm), as it has been showed in Table 1. The precipitation sum during the growing season was 346 mm.

The mean annual value of PET was 704 mm, 178 mm during spring, 375 mm during summer, 140 mm during autumn and 11 mm during winter. The PET value during the growing season was 609 mm.

The plant water requirements (PET) were highest in July (134 mm), in August the plants needed 120 mm of water for their growth and development (PET), the average PET value during June was 121 mm (Table 1).

The analysis of the soil water balance in the Fruška gora region revealed that the readily available water reserves (RAWR) could be completely consumed during May-October. The soil had lowest water supply during summer (13 mm) and autumn (34 mm). During spring and winter, readily available soil water reserves were 246 mm and 244 mm, respectively. During the growing season, in the MS Sremska Mitrovica, plants where having an average supply of 159 mm of readily available soil water, which is 29% of the annual amount of readily available water, the average value is 541 mm. The lowest soil water supply was during June, July, August and September.

The sum of mean annual actual evapotranspiration (AET) in the region was 538 mm. The estimated AET during spring, summer, autumn and winter was 174 mm, 249 mm, 100 mm and 11 mm, respectively. The value during the growing season was 446 mm (32% of the average sum of annual AET value). During the growing season, AET was highest in June 121 mm, followed by May 99 mm and July 78 mm.

The soil water deficiency in MS Sremska Mitrovica was most pronounced during summer 126 mm. It was found to be 40 mm during autumn and 0 mm during spring and winter. The highest deficiency was recorded in August 70 mm, July 56 mm, followed by September 39 mm.

### Conclusions

The results of this analysis shows that the soil of the area of study does not have a sufficient supply of water during the growing season under the regional climate conditions, particularly during summer and autumn. Given results are supporting the use of irrigation practice as supplementary character in plant production.

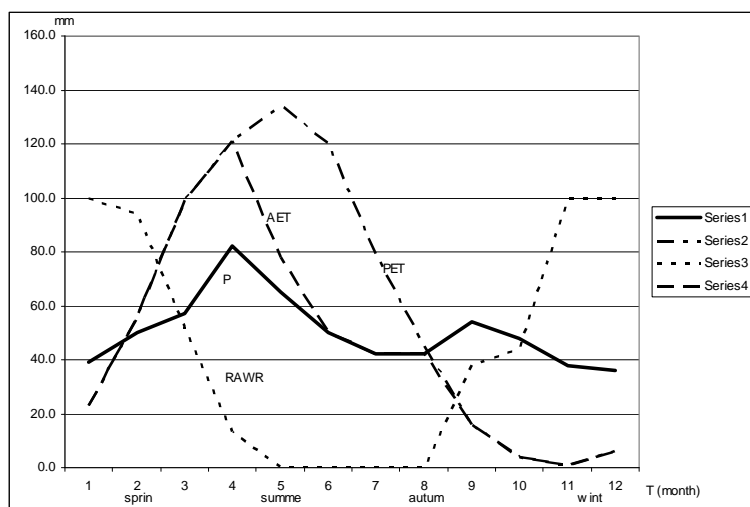


Figure 2. Average monthly sums of precipitation P (series 1), mean monthly values of PET (series 2), mean readily available water reserves in the soil RAWR (series 3), actual evapotranspiration AET (series 4) in MS Sremska Mitrovica

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