SOILS FOR FUTURE UNDER GLOBAL CHALLENGES
SERBIAN SOCIETY OF SOIL SCIENCE
University of Belgrade, Faculty of Agriculture
Sokobanja, 21-24 September 2021
III International and XV National Congress
https://congress.sdpz.rs/

TEMPERATURE AND MOISTURE REGIMES OF RENDZINA SOILS IN SERBIA ACCORDING TO THE USDA SOIL TAXONOMY SYSTEM

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INTRODUCTION

Rendzina is a soil type (Škorić et al., 1985) developed on parent rock containing more than 20% of calcareous material (except soils with an A-R profile developed on hard pure limestone or dolomite, which are classified as a distinct soil type: Limestone-Dolomite Black Soil - Kalkomelanosol).
In order to update and harmonize national with international soil classification systems, correlation of various soil classification units with both international systems, WRB and USDA Soil Taxonomy, has been common practice worldwide over the past couple of decades. As of this writing, correlation of Rendzina soils and Serbia's soils in general with the USDA Soil Taxonomy System appears to be missing. Soil moisture and temperature regimes are diagnostic characteristics used for higher categories of the USDA Soil Taxonomy System. The first step of Rendzina soil classification in Serbia according to this international system is to determine the soil temperature and moisture regime classes.

Table 1. Estimated mean soil temperature of Rendzina soils in Serbia (°C)

Weather station	Annual +1 degree[a]	Annual +2 degrees	Annual +3 degrees	Diff(MAAT-MAST)[b]
Novi Sad	12.4	**13.4**	14.4	**20.1**
Valjevo	12.4	**13.4**	14.4	**19.6**
Belgrade	13.5	**14.5**	15.5	**19.8**
Negotin	12.8	**13.8**	14.8	**21.4**
Sjenica	7.7	**8.7**	9.7	**18.6**
Niš	12.9	**13.9**	14.9	**20.0**

[a]Mean soil temperature approximated by adding 1, 2 and 3 °C to the mean air temperature.
[b]Difference between mean summer (June, July and August) and mean winter (December, January and February) soil temperatures.

MATERIAL AND METHODS

Given that measured soil moisture and temperature data on the investigated Rendzina profiles were missing, Rendzinas' SMR and STR were estimated based on climate data (30 years) downloaded from the Nation Hydrometeorological Service of Serbia website, including mean monthly and annual air temperatures and precipitation (1981-2010) and potential evapotranspiration (PE) (1971-2000). The mean annual soil temperature (MAST) was estimated by adding 2°C to the mean annual air temperature (MAAT). The difference between the mean summer (June, July, and August) and mean winter (December, January and February) soil temperatures (Diff(MSST-MWST)) was also calculated.
STRs are defined by MAST at a depth of 50 cm from the land surface (or at the densic, lithic, or paralithic contact if shallower than 50 cm) and Diff(MAAT-MAST). To obtain SMR, six graphs (one per weather station) containing precipitation, PE, actual evapotranspiration (AE) and soil temperature curves, were constructed: the area between the line that joins all of the precipitation normals and the line that joins all of the PE normals indicates the status of soil moisture. Beginning at the point where precipitation becomes greater than PE, the area to the right shows recharge (the amount of moisture stored in the soil). The point where PE exceeds precipitation is utilization. Utilization is the amount of PE necessary to remove the water held at a tension of less than 1500 kPa. Excess PE, if any, before the time that recharge begins, is called deficit.
Twenty-nine Rendzina soil profiles on marl, marly limestone and soft limestone were investigated. Given that Rendzina is widespread in many regions of Serbia, six weather stations were selected: at Novi Sad for the northern, Valjevo for the western, Belgrade for the central, Negotin for the eastern, Sjenica for the southwestern and Niš for the southeastern region.
The geomorphological and soil characteristics that can affect STR and SMR were presented as follows. Rendzina soils are found at altitudes starting from 150 m near Lajkovac to 1200 m on the Sjenica-Pešter plateau. The elevations of most sites, i.e. those in northen Serbia (Vojvodina), eastern Serbia, central Serbia (Šumadija region) and southeastern Serbia (Pirot and Bela Palanka), are up to 400 m. Altitudes exceeding 400 m were in western Serbia (Valjevo environs), whereas sites around Niš in southeastern Serbia exceeded 700 m. Eight soil profiles were flat, eight slightly sloping and thirteen sloping, with gradients in the range from 20 to 80° (49.2±30.8). All aspects were represented and those facing the west and southwest were dominant. Flattened areas and hilltops are generally used as arable land, while steep slopes are covered with forest and grassy vegetation. The largest soil profile depths were in the 15-30 cm range, with only a few 40-60 cm deep. Coarse fragment content ranged from 0.6 to 43.3% (16.4±13.5) in the A and 1.6-68.4% (32.0±24.7) in the AC horizon. Soil texture was sandy loam in two, sandy clay loam in three, loam in three and clay loam in twenty profiles. Soil organic carbon ranged from 0.5 to 5.3% (2.7±1.4) in the A and 0.2-2.8% (1.3±1) in the AC horizon.

RESULTS

MAST should be estimated by adding 1, 2 or 3 °C to the mean annual air temperature (MAAT) . For four weather stations, except Sjenica and Belgrade, all three estimated MAST had the same impact on SMR and STR. The MAST obtained by adding 1 and 2 degrees to MAAT was 7.7 and 8.7 °C, respectively, in the mountainous Sjenica region (Table 1). The MAST obtained by adding 2 and 3 degrees to MAAT was 14.5 and 15.5 °C, respectively, in the area around Belgrade. Both Sjenica and Belgrade estimations significantly affected their STR classification, since a MAST of 8 °C is the boundary between frigid and mesic, and 15 °C between mesic and thermic STR classes. The Rendzina soil from Sjenica was shallow, west facing, at a gradient of 40°, under grass. Nonetheless, Sjenica is located at about 1200 m above sea level and characterized by an average of 103 days (1981-2010) of snow cover. Based on soil characteristics and literature data, it was concluded that MAST could be estimated by adding 2 degrees to MAAT for all locations in the present study, including the mountainous region of Sjenica and the area around Belgrade. Thus, the estimated MAST in all the studied locations ranged from 8.7 to 14.5 °C, which matches the criteria for mesic STR .
In all the study areas, MAST ranged from 8.7 to 14.5 °C and the mean summer and winter soil temperatures differed by 18.6-21.4 °C. As seen in Figs. 1 and 2, precipitation becomes greater than PE and water recharge begins in September in Sjenica and October in the other areas. PE exceeds precipitation and utilization starts in March (Novi Sad, Belgrade and Niš) or April (Valjevo, Sjenica and Niš). The duration of water recharge was four to six months. The amount of moisture stored in the soil during that period, plus precipitation, is believed to be sufficient to support PE and avoid a significant water deficit in western and southwestern Serbia (Valjevo and Sjenica). Utilization is expected to exceed recharge plus precipitation in all the other areas, causing soil water deficit to begin in April in Belgrade and May in Novi Sad, Negotin and Niš. According to available meteorological data, soils in the western and southwestern regions (Valjevo and Sjenica) meet the criteria for udic SMR, whereas other areas (central, east and southeast) correspond to ustic SMR.
In most of the investigated Rendzina soil profiles, available water capacity (AWC) was limited due to shallow depths and the presence of coarse fragments. Furthermore, 45% of the soils were on slopes and that can cause surface runoff, limit water infiltration and increase water deficit of the Rendzina soils. Nevertheless, due to lower temperatures (Sjenica STR was borderline mesic-frigid) causing lower evapotranspiration, and higher precipitation in the spring-summer period, any water deficit likely lasts for a very short period (late summer) in western and southwestern Serbia, with udic SMR. Other areas, with ustic SRM, have exhibited water deficits in the periods from April to September (Belgrade) or May to September (other regions). Possibly lower water infiltration and AWC, caused by topographic features and physical properties of Rendzina soils, can increase water deficit in the future, but precipitation in the summer months might be sufficient to avoid long periods of dry days (typical of soil with xeric or aridic SMR). Soil is certainly dry for less than 45 consecutive days in the four months following the summer solstice, which is proposed for the ustic SRM.

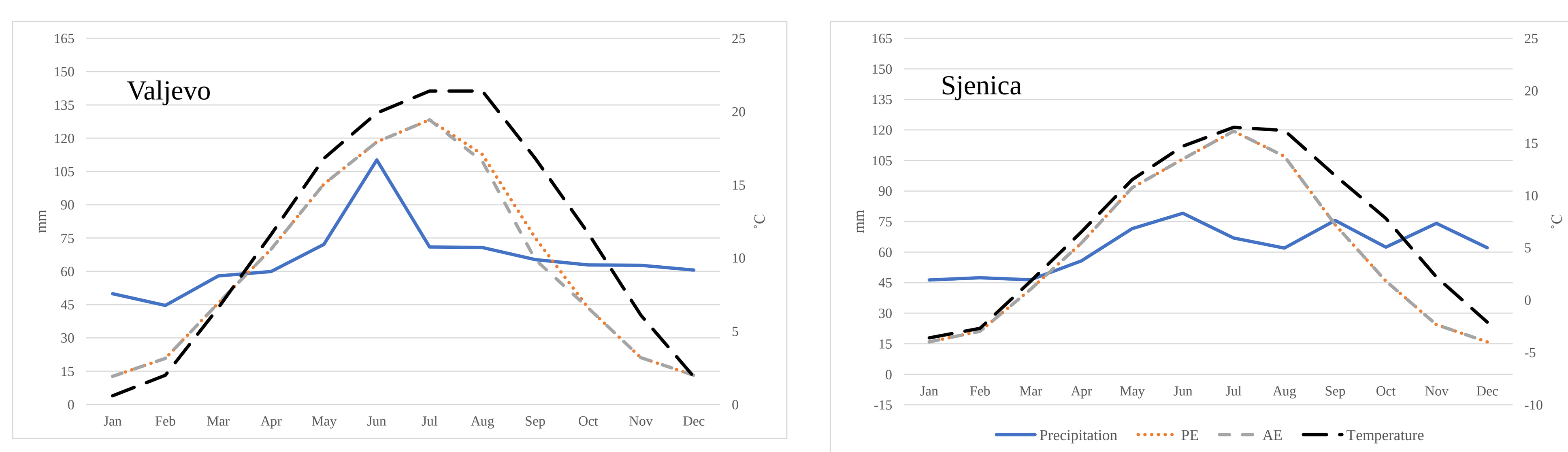

Figure 1. Mean monthly precipitation, potential (PE) and actual (AE) evapotranspiration (in mm), and soil temperature (in °C) in areas with **UDIC moisture regimes** of Rendzina soils in Serbia

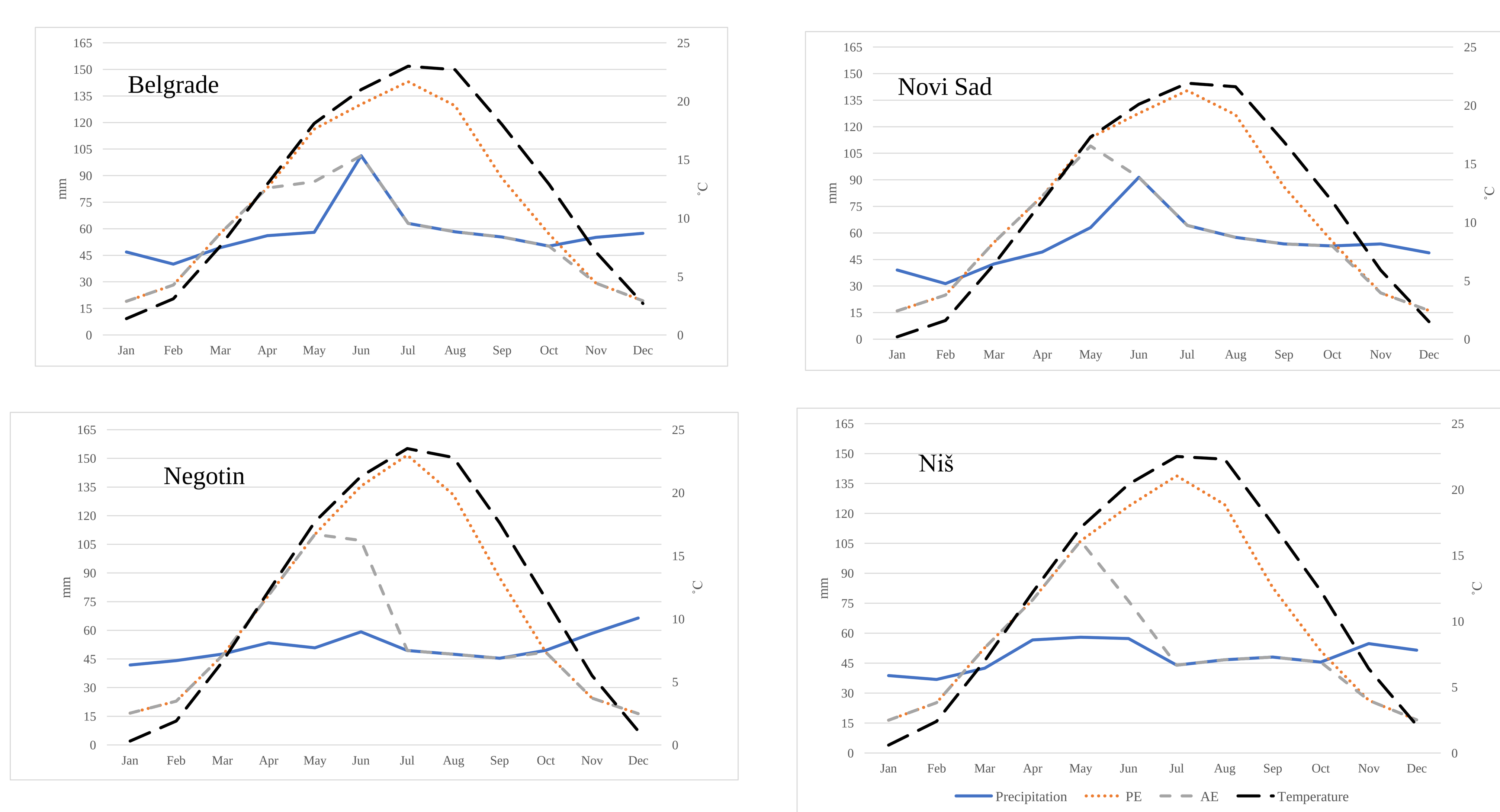

Figure 2. Mean monthly precipitation, potential (PE) and actual (AE) evapotranspiration (in mm), and soil temperature (in °C) in areas with **USTIC moisture regimes** of Rendzina soils in Serbia

CONCLUSIONS

Rendzina soils in all the areas matched criteria for mesic STR.
Rendzina soils in the western and southwestern areas meet the criteria for udic SMR, while other areas (central, east and southeast) correspond to ustic SMR.
Possibly lower water infiltration and AWC, caused by geomorphologic and physical properties of Rendzina soils, can increase water deficits in the future, but precipitation in the summer months will likely be sufficient to avoid long periods of dry days.
Separation of Rendzina soils in Serbia into two SMRs, udic and ustic, might influence their classification at higher taxonomic levels according to the Soil Taxonomy System.