SOIL TEMPERATURE, MOISTURE MONITORING AND RECOMMENDATIONS ON THE OPTIMUM SOWING PERIOD FOR THE MAIN CROPS IN THE TRANSYLVANIAN PLAIN

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Abstract

The Transylvanian Plain (TP) is a geographical region located in north-central Romania and is bordered by large rivers to the north and south, the Someş and the Mureş, respectively. The TP is 395,616 ha and ranges from 231-662 m in elevation, with some of the highest elevations occurring in the NW region. Contrary to the name, the TP consists of rolling hills with patches of forests located on the tops of hills. Soil temperatures of the TP were evaluated using a set of 20 datalogging stations positioned throughout the plain. Soil temperatures were monitored at the surface and at depths of 10, 30, and 50 cm. Soil moisture was monitored at 10 cm. The presence of the Carpathian mountains ring and the arrangement, almost concentric, of the relief from Transylvanian Depression, determines the development of a zonal sequence of soil types, a horizontal zonality as a direct influence of lithology and indirect of the relief, by changing climate and vegetation. Diversity of the pedogenetical factors - highly fragmented relief, forest and herbaceous vegetation grafted on a lithological background predominantly acid in the north – west and predominantly basic in south – est, parent rock composition and especially their combination in the contact zones, have conditioned in this hilly area of TP a tessellated soil cover. During soil pedogenesis, soil properties and features developed in response to differential lithology and macro/microrelief. Evaluated soils were found to largely be a complex mix of Cernisols, Luvisols and Antrisols. Soil temperatures of the TP are mesic, with small differences between the northern and southern extents. However, differences in seasonal warming and cooling trends across the plain were noted. These have important implications for planting recommendations. Recorded data allow us to say that towards the optimal sowing period known from the literature, during 2010, for all cultures were recorded minimum temperatures for germination with approx. 5-10 days earlier. The optimum sowing period was recorded 15 days earlier at soybeans, with 10-12 days earlier at corn and beans, 2-3 days earlier at potato, sunflower and sugar beet.

Key words: soil temperature, sowing recommendations, Transylvanian Plain

Transylvanian Plain (TP) with an area of approx. 395,616 ha, includes areas of three counties (Cluj-CJ, Mures-MS, Bistrita-Nasaud-BN) and is characterized by hilly climate floor with oceanic influences. Zoning cultures and establishing the optimum sowing periods was made after the observations arising from practice and after the results obtained in the agricultural experimental research stations. Climate changes in recent years and climate monitoring from TP offers the possibility to check the calendar for the optimum sowing period.

TP has a predominantly agricultural character, and in the past, because of the large areas of agricultural land, with fertile soil, produced large quantities of grain, for economic and social needs of the country. Cereal and steppe character (or anthropogenic steppe) of the area, led to widespread of the popular term "plain", as over 30 villages, located in mid-southern region, wears, along with their name, the addition "plain". Contrary to its name, the TP is characterized by extensive rolling hills and is bounded by two main rivers, the Someş to the north and west, and the Mureş to the south and east. Elevation of the TP ranges from 231 to 662 m. Original geologic deposits in the area are Miocene, with contemporary hills largely derived from Pliocene and Quaternary materials (Balteanu, D., 1997).

Over time, the rugged terrain, deforestation, erosive slopes, and irrational agrotechnical practices for crop production have combined to degrade large areas of agricultural land, reducing its productivity. Within the TP, tens of thousands of hectares of land show signs of denudation or reduced productivity (Ministry of Agriculture and Rural Development, 2011). Furthermore, most of the land is non-irrigated, owing to a lack of available groundwater and limited access to surface waters in the central TP (Man, T., Pop, R.,

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2000). Another feature of the TP is that, although it is lower than the surrounding region, no major river valleys, no major roads, do not converge to its center, but it surrounds it on the periphery. So it is a poor area in water resources, avoid by the heavy traffic, and so it partly explains its rural character and layout of cities around the edges (Rusu, T. et al., 2009).

The last research upon the evolution of the climate inside the Carpathian basin, pointed out an increase of the air temperature in the last one hundred years with about 0.7°C. This fact is also shown by the fact that, six of the warmest years of the 20th century were registered in 1990's. Contrary to its name, the TP is not a geographically flat plain, but rather a collection of rolling hills approximately 300 to 450 m above sea level in the south and 550 to 600 m above sea level in the north. Climate of the TP is highly dynamic, ranging from hot summers with high temperatures of >25°C to very cold winters with lows ~-5°C (Climate charts, 2007). The southern TP generally has a xeric moisture regime with steppe vegetation while moisture increases somewhat in the northern TP as an udic moisture regime.

Under these conditions, the research project: monitoring the temperature and water regime of soils in the TP, is the first paper, on large-scale, on soil monitoring (temperature, humidity, precipitation) of the TP which is a first for the Romanian science. The datalogging stations determines air temperature (at a height of 1 m) and precipitation (in 10 locations) as well as temperature (10, 30, 50 cm) and soil moisture (10 cm, by reflectometry), data being transmitted to a data collector of data storage capacity of about one year (depending on the frequency set for collection). The immediate objectives of the research are related to soil resource assessment, determining the thermal regime of soils and determining the relationship between the thermal regime of soils and optimum sowing period.

MATERIAL AND METHOD

Twenty datalogging stations have been deployed across the TP on divergent soil types, slopes, and aspects. The location of each site was recorded using Garmin eTrex Vista (Olathe, KS, USA) handheld GPS units. Ten datalogging stations were installed in March of 2008, with an additional ten stations installed in March of 2009. HOBO Smart Temp (S-TMB-M002) temperature sensors and EC-5 (S-SMC-M005) moisture sensors were connected to HOBO Micro Stations (H21-002) at each site (On-set Computer Corp., Bourne, MA, USA). Additionally, at 10 of the 20 sites, tipping bucket rain gauges (RG3-M) were deployed (On-set Computer Corp., Bourne, MA, USA, figure 1; Weindorf, D.C. et al, 2011).

At sites with a tipping bucket rain gauge, the following data were recorded: soil temperature at 10, 30, and 50 cm; soil moisture at 10 cm; surface air temperature; and precipitation. At sites without a tipping bucket rain gauge, the following data were recorded: soil temperature at 10 and 50 cm; soil moisture at 10 cm; and surface air temperature. Data is downloaded from the Micro Stations every two months via laptop computer using HOBOware Pro Software Version 2.3.0 (On-set Computer Corp., Bourne, MA, USA). Table 1 shows the station configuration (Rusu, T. et al, 2011).

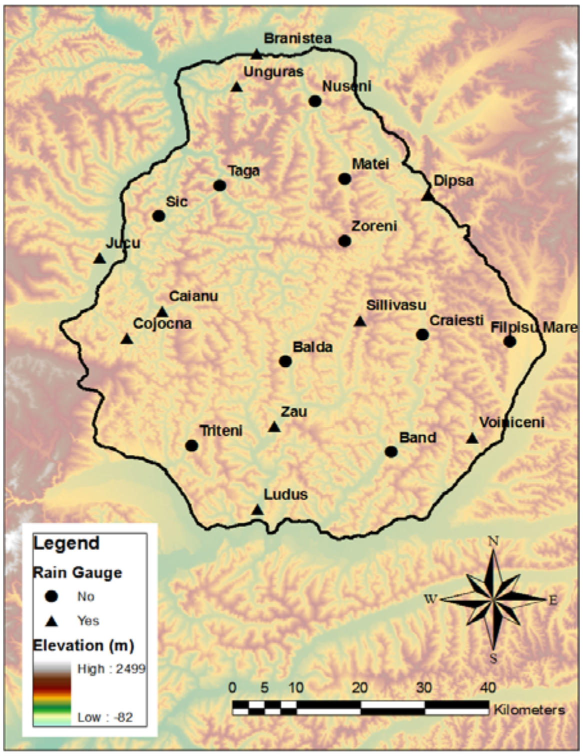

Figure 1 **Location, elevation, and configuration of soil temperature and moisture monitoring stations within the Transylvanian Plain**

Table 1

Station configuration in the Transylvanian Plain

Station number	Station name	Latitude	Elevation, m	Rain gauge
1	Balda (MS)	46.717002	360	No
2	Triteni (CJ)	46.59116	342	No
3	Ludus (MS)	46.497812	293	Yes
4	Band (MS)	46.584881	318	No
5	Jucu (CJ)	46.868676	325	Yes
6	Craiesti (MS)	46.758798	375	No
7	Sillivasu de C. (BN)	46.781705	463	Yes
8	Dipsa (BN)	46.966299	356	Yes
9	Taga (CJ)	46.975769	316	No
10	Caianu (CJ)	46.790873	469	Yes
11	Cojocna (CJ)	46.748059	604	Yes
12	Unguras (CJ)	47.120853	318	Yes
13	Branistea (BN)	47.17046	291	Yes
14	Voiniceni (MS)	46.60518	377	Yes
15	Zau de C. (MS)	46.61924	350	Yes
16	Sic (CJ)	46.92737	397	No
17	Nuseni (BN)	47.09947	324	No
18	Matei (BN)	46.984869	352	No
19	Zoreni (BN)	46.893457	487	No
20	Filpisu Mare (MS)	46.746178	410	No

MS = Mureş county; CJ = Cluj county; BN = Bistriţa-Năsăud county

RESULTS AND DISCUSSIONS

TP belogns geographically in the Transylvanian Depression. This represents the largest negative morphological inter-Carpathian area, formed during the alpine folding, with general appearance of hills and plateaus, divided tectonic in geomorphological succession of areas, arranged almost concentric, from exterior to interior, with large variations of structure and relief from one area to another. The relief prints considerable differences throughout the hilly area of TP. Here are the biggest contrasts of the stationary factors due to the very fragmented relief and the varied lithologic sublayer. In general, any relief change entail fundamental changes in all local factors, forming interdependencies in topoclimat, in soil characteristics and vegetation physiognomy. The relief creates exhibition contrasts, temperature inversions, patches of vegetation unequal haunted by the wind and subjected to different rainfalls etc. Also, the relief is the one that determines differences in soil characteristics, namely: deeper soils in the mild portions of the slope, thin and eroded soils in highly inclined portions, more advanced or less, with higher or lower trophicity etc. Micro relief also creates differences and discontinuities on the distribution of soils and phytocoenoses even on slopes relatively small.

Like other components of the geographical landscape in the TP, soils, are only apparent uniformly distributed. On closer analysis, it appears that they are some of the most complex elements, through the variety and distribution on the two distinct sectors of the region: Somesan Plain and Muresan Plain. What was considered in 1967 as a „pedo-geographical limit in Transylvanian Plain" (Mac, I. et al, 1990), namely the gradual tansition from the forest soils from the Somesan Plain to chernozem which is specific for the Muresan Plain, turns out to be not only a „limit with significance in agricultural land evaluation", but also an ecological threshold. The differential action of air masses on the two sectors, the „shadow" of rainfall which is the south - west) and the energy of the relief which is greater in the northern sector, required the development of different vegetation and fauna, with repercussions on the development of the edaphic support.

Soils of the TP were digitized and converted into the contemporary taxonomic system used in Romania, SRTS - 2003 (Florea and Munteanu, 2003). A total of 1472 polygons were digitized and classified by soil class, type, and subtype (figure 2, table 2; Weindorf, D.C. et al, 2011).

Table 2

Total area and extent of soil classes for soils of the Transylvanian Plain, Romania derived from digitization of 1:200,000 scale soil maps

Class	Area (ha)	% of TP
Antrisoluri	58921	14.9%
Cambisoluri	35679	9.0%
Cernisoluri	200543	50.7%
Hidrisoluri	6816	1.7%
Luvisoluri	86410	21.8%
Pelisoluri	6737	1.7%
Protisoluri	154	0.0%
Salsodisoluri	356	0.1%
Total:	395616	100.0%

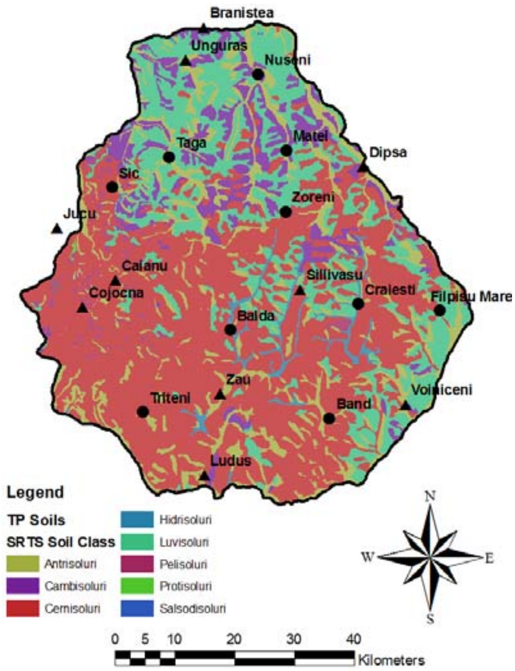

Figure 2 **Soil classes of the Transylvanian Plain, Romania derived from digititation of 1:200,000 scale soil maps**

Cherni-soils occupies the southern sector of the plain on the obverse and the interfluvial cuesta peaks and are characterized by high fertility (fertile to middle fertile), generally negligible surface erosion, locally affected by landslides, medium porous and with heavy texture.

Luvi-soils occupies the northern region and the south - eastern sector, potentially fertile soils, cold, with heavy texture, exposed to erosion due to clay content.

Proti-soils soils with different fertility (aluviosoluri – fertile, but displayed to flood, rogosolurile – used successfully in a period for vineyards, erodosolurile – with properties losses, resulting from poor agrotechnics or overgrazing).

Hydri-soils meadow soils affected by stabilized landslides, late soils with excess moisture on the surface and in depth, potentially fertile, with adverse physical and biological properties, clay-loam and silty-clay texture.

Pedogeographical, regional differences are clearly expressed in the studied areas, in the northern sector – Somesan Plain and the southern region – Muresan Plain. The predominance of forest in the north was a definite reality, and the correlation with the presence of forest soils was easily accomplished.

The pedogeographical areas characteristic for the Plain are:

1. The northern area with forest soils. Here we have soils from Lusivsol and Cambiosol classes, in overwhelming extent. Typical Preluvisols dominates the north - western sector to the marginal border area of the inferior Fizeş and Bandău. Follows a series of typical and stagnant Luvisols, alternating with Preluvosols, in the central - northern area. In the upper basin of Bandău eroded Luvisols and Erodisols are correlated with heavily deforested areas, on both cuesta overheads and on the obverse. In the eastern and southern area, stagnic Luvisols occur in alternation with typical and eroded Eutricambisols, while the origin of the valley developed on the left side of the consequent rivers – have as edaphic support the clinogleic Phaeozems. Erodisols from the upper basin of Fizeş supports a grassy associations in advanced stage of decay. Southern boundary of this area with forest soils, we draw it on a line on a clear hint of Phaeozems argic.

2. Central area of argic Phaeozems alternating with forest soils. The superior basins of River of Plain, Sesul and Comlod are predominating mollic and typical Preluvisoils, typical and eroded Eutricambisoils, clinogleic Phaeozems.

3. South – west area, of Chermozems. The rain shadow of Trascău, weather conditions have allowed the development of Chernisoils, that, independent of diverse land use over time, are a presence and a geo-ecological reality. To the west line of River of Plain Valley cambic Chernozem (typical, vertic and eroded) are dominant, alternating with Erodisoils, Vertisoils and Phaeozems.

4. The area of forest soils in south – eastern border. In this case, the Mures valley was not a pedological barrier, forest soils in this sector are developing in synchrony with the surrounding plain areas. Typical and stagnant Luvisols, typical Preluvisoils have a considerable way, aside Eutricambisoils from the eastern side and Phaeozems (Pseudorendzine).

Calculation of soil temperature regime according to the Soil Survey Staff (2010) consists of averaging soil temperatures at 50 cm between summer (June, July, and August) and winter (December, January, and February). The Soil Survey Staff (2010) defines mesic soil temperature as a “mean annual soil temperature that is >8°C, but <15°C where the difference between mean summer and mean winter soil temperatures is more than 6°C at 50 cm or at a densic, lithic, or paralithic contact, whichever is shallower.” Data from the monitoring sites clearly indicated that all sites have a mean annual soil temperature of ~10°C at 50 cm with more than 6°C variation between summer and winter. Thus, the soil temperature regime of the TP was determined to be mesic.

Recorded data allow us to say that towards the optimal sowing period known from the literature, during 2010, for all cultures were recorded minimum temperatures for germination with approx. 5-10 days earlier (*table 3*). The optimum sowing period was recorded 15 days earlier at soybeans, with 10-12 days earlier at corn and beans, 2-3 days earlier at potato, sunflower and sugar beet.

Table 3

The optimum sowing periods recorded in Transylvanian Plain

No	Crop	Area (ha)			MTG ^{0}C	OSP	OSP, 2010		
		CJ	MS	BN			Căian, CJ	Luduş, MS	Branişte, BN
1.	Corn	42063	60822	28316	8-10	10-30.IV	07.IV.	26.III.	02.IV.
2.	Potato	9984	5978	11727	>5	20.III-20.IV	23.III.	20.III.	18.III.
3.	Sun flower	2727	2972	1388	6-8	25.III-15.IV	25.III.	22.III.	22.III.
4.	Sugar beet	1721	3038	103	5-6	20.III-15.IV	23.III.	20.III.	18.III.
5.	Soybean	725	1075	39	7-8	10-20.IV	27.III.	24.III.	25.III.
6.	Bean	456	34	20	8-10	15-30.IV	07.IV	26.III.	02.IV.

MTG - minimum temperatures for germination (^{0}C).
OSP - optimum sowing period (Gus, P. et al., 2004).
OSP, 2010 – the date when the optimum germination temperature was registered (2010).

CONCLUSIONS

Soil temperatures of the Transylvanian Plain, Romania were evaluated via 20 datalogging stations in 2008 and 2010. Data from the loggers indicated that the soil temperature regime of the TP is mesic. More than 50% of the soils on the TP were Cernisoluri, followed by Luvi-soils (21.8%) and Antri-soils (14.9%).

The presence of the Carpathian mountains ring and the arrangement, almost concentric, of the relief from Transylvanian Depression, determines the development of a zonal sequence of soil types, a horizontal zonality as a direct influence of lithology and indirect of the relief, by changing climate and vegetation. Diversity of the pedogenetical factors - highly fragmented relief, forest and herbaceous vegetation grafted on a lithological background predominantly acid in the north – west and predominantly basic in south – est, parent rock composition and especially their combination in the contact zones, have conditioned in this hilly area of TP a tessellated soil cover. During soil formation, soil properties and features have changed under the direction and intensity of pedogenesis, on the basic lithologic fund according to the micro and macrorelief forms. The result is a complex and specific soil cover, represented by Cernisols, Luvisols, Hidrisols and Antrisols.

Zoning cultures and establishing the optimum sowing periods was made after the observations arising from practice and after the results obtained in the agricultural experimental research stations. Recorded data allow us to say that towards the optimal sowing period known from the literature, during 2010, for all cultures were recorded minimum temperatures for germination with approx. 5-10 days earlier. The optimum sowing period was recorded 15 days earlier at soybeans, with 10-12 days earlier at corn and beans, 2-3 days earlier at potato, sunflower and sugar beet.

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