Scientific Papers. Series A. Agronomy, Vol. LVI, 2013
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

IMPACTS OF CLIMATE CHANGE ON AGRICULTURAL TECHNOLOGY MANAGEMENT IN THE TRANSYLVANIAN PLAIN, ROMANIA

Teodor RUSU[1], Paula I. MORARU[1], Ileana BOGDAN[1], Adrian POP[1], Camelia COSTE[1], Doru Ioan MARIN[2], Mircea MIHALACHE[2]

[1]University of Agricultural Sciences and Veterinary Medicine of Cluj-Napoca, 3-5 Manastur Street, 400372, Cluj-Napoca, Romania
[2]University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, 011464, Bucharest, Romania

Corresponding author email: rusuteodor23@yahoo.com

Abstract

The Transylvanian Plain, Romania is an important region for agronomic productivity. However, limited soils data and adoption of best management practices hinder land productivity. Soil temperatures of the Transylvanian Plain were evaluated using a set of twenty datalogging stations positioned throughout the plain. Each station stores electronic data of ground temperature on 3 different levels of depth (10, 30 and 50 cm), of soil humidity at a depth of 10 cm, of the air temperature at 1 meter and of precipitation. Monitoring the thermal and hydric regime of the area is essential in order to identify and implement sets of measures of adjustment to the impact of climatic changes. After analyzing the recorded data, thermic and hydric, in the Transylvanian Plain, we recommend as optimal sowing period, advancing those known in the literature, with 5 days for corn and soybeans, and maintaining the same optimum period for sunflower and sugar beet. Water requirements are provided in an optimum, of 58.8 to 62.1% for the spring weeding crops during the growing season, thus irrigation is necessary to ensure optimum production potential. The amount of biological active degrees registered in Transylvanian Plain shows the necessity to reconstruct crop zoning, known in the literature, for the analyzed crops: wheat, corn, soy, sunflower and sugar beet.

Key words: *climate monitoring, agricultural technology management, Transylvanian Plain.*

INTRODUCTION

Romania is placed in the area with the lowest capacity to adapt to climate change existing and that is going to occur, and the Transylvanian Plain (TP) is among the most affected areas (Ranta et al., 2008; Hemadi et al., 2011; Ramirez-Villegas et al., 2012; Lereboullet et al., 2013). Now and in the future are proposed a number of strategies and plans to counter climate change, but for their implementation requires a close monitoring of temperature and water regime of the area, for identifying and implementing adaptation measures to climate change (Fuhrer, 2003; Eastwood et al., 2006; Fowler et al., 2007; Casas-Prat and Sierra, 2012; Marin et al., 2012; Raymond and Robinson, 2013; Srinivasan et al., 2013). Very important are considered the measures for reducing the extreme weather events, agricultural use of new structures drought resistant plants, or even a review of optimal planting periods so that plants receive during the growing season optimum water intake (Bucur et al., 2011; Domuta et al., 2012; Stanila et al., 2012).

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 550-600 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 (Moraru and Rusu, 2010; Coman and Rusu, 2010).

In this context, the paper present an analysis of temperature and water regime of soils in the TP (temperature and soil moisture, air temperature and precipitation) with 20 stations, located on microclimatic areas, analysis and processing of data in connection with the main 5 recommended crops in this area and development of accurate agrotechnical measures to develop sustainable agricultural technologies (Molnar et al., 2012).

MATERIALS AND METHODS

The thermal and hydric regime monitoring of the TP (soil temperature and humidity, air temperature and precipitations) has been achieved during the period 2008-2012. Twenty datalogging HOBO Micro Stations (H21-002, On-set Computer Corp., Bourne, MA, USA) have been deployed across the TP on divergent soil types, slopes, and aspects. Soil types where the stations were located: chernozem (Caianu), Phaeozem (Balda, Band, Craiesti, Triteni, Dipsa, Jucu, Ludus, Cojocna, Voiniceni), eutricambosoil (Matei, Silivasu de Campie, Branistea, Unguras, Zau de Campie), districambosoil (Filpisu Mare), preluvosoils (Taga, Nuseni, Sic, Zoreni). The majority have a loam-clay texture, pH between 6 to 8.69 and humus content of 2.5 and 4.15 in the 0-20 cm horizon. The stations were placed so as to cover the three subunits of TP: Low Hills Plain, High Hills Plain and Bistrita-Sieu Hills Plain. HOBO Smart Temp (S-TMB-M002) temperature sensors and Decagon EC-5 (S-SMC-M005) moisture sensors were connected to HOBO Micro Stations. Additionally, at 10 of the 20 sites, tipping bucket rain gauges (RG3-M) were deployed to measure precipitation (On-set Computer Corp., Bourne, MA, USA). Each station stores electronic data of ground temperature on 3 depths (10, 30, 50 cm), the humidity at the depth of 10 cm, the air temperature (1 m) and precipitations. Data was 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 stations' configuration (Weindorf et al., 2009; Haggard et al., 2010).

Table 1. Stations' configuration in the Transylvanian Plain

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

NE = northeast; SE = southeast; V = west; N = north; NV = northwest; E = east; SV = southwest; S = south MS = Mures county; CJ = Cluj county; BN = Bistrita-Nasaud county

RESULTS AND DISCUSSIONS

The research conducted in this study allow us to see how and if the optimal sowing period of crop plants has changed over time and with all the climatic changes taking place, by comparing data recorded in the 20 locations where located stations with data in the literature on optimal sowing period in the TP. Research of optimal sowing period included: first and last frost date, recording of the minimum temperature of germination, ensuring optimal soil moisture, monitoring of days with temperatures above 30°C.

For the monitoring period, 2008-2011, the earliest frost of autumn, at 10 cm soil depth was recorded at Balda, on October 19, 2008 (-2.10°C), then, at all stations for the period, soil frost was recorded in November and 13 November 2011-to Triteni (-1.07°C) and Taga (-0.68°C), followed by November 18, 2011-Zoreni (-0.2°C) and November 18, 2008-Band (-0.14°C). At the same time there were stations reaching the first frost is soil next year at the latest, on February 17, 2010 Silivasu de Câmpie (-0.06°C), on February 16 2011 at Triteni (-0.12°C) and on February 5, 2010 at Branistea (-0.06°C). The latest spring frost was recorded for the period 2008-2011, on March 13, 2011 (-0.06°C) at stations Taga, Triteni and Zoreni, followed by March 7 2009 at Dipsa (-0.26°C) and March 3 2009 at Caianu (-0.31°C) and Silivasu de Câmpie (-2.28°C). In the same time we have station that recorded the last frost in January 26, 2011 (-0.12°C, Craiesti), and most stations show last frost to 10 cm in the soil, in February.

The conclusion of the analysis on the first and last frost for the monitoring period, 2008-2011, is that these values do not affect the optimum time of sowing for the studied crops, with no risk. Throughout the period and at all stations, the last frost in the spring was March 13 and the first in autumn on 19 October.

To analyze data on optimum sowing time we considered the recorded minimum temperature for seed germination, which for 3 consecutive days does not fall below this value and tends to increase in the days ahead. These temperatures were: 8°C for corn (figure 1), 7°C for soy, 7°C for sun flower, 6°C for sugar beet.

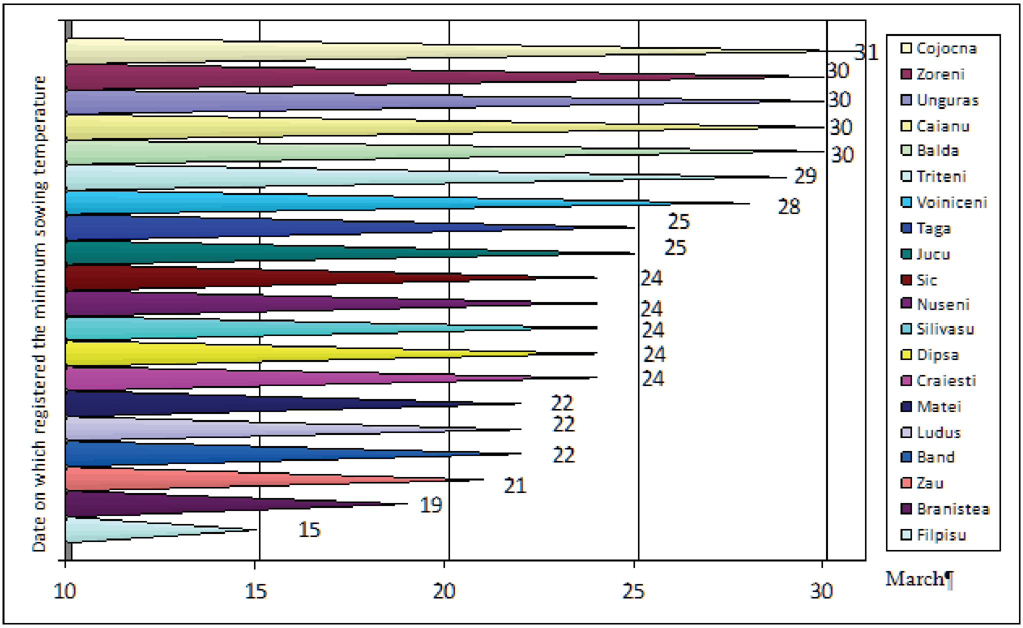

Figure 1. Date on which registered the minimum sowing temperature for corn in the Transylvania Plain (2009-2012)

After analysis of data recorded at stations, we can say that the minimum temperature for corn germination was recorded, compared to the considered optimal, even 15 days earlier, sunflowers by 5-7 days earlier, the beet sugar 3-4 days earlier, except 2010 and 2011, where for some stations the optimum temperature has been registered earlier even with 6-9 days. Regarding soybean, minimum germination temperature for sowing recorded earlier by about 15 days.

Amount of biological active degrees or Thermic Constant (TC), was calculated taking into account the longest period of growth in primary cultures analyzed, hybrids / varieties late or semi late, and base temperature or biological threshold (temperature below which no longer visible growths) was: > 0^0C for wheat, 290 days; 8^0C for corn, 150 days; 10^0C for soy, 150 days; 7^0C for sun flower, 140 days; > 0^0C for sugar beet, 183 days.

Wheat, from 25 September to 12 July, the plant needs 1800-2300°C to develop. At all stations in all years studied biologically active degree requirements for wheat, ensures maximum or exceed specified limits from literature, provides between 2182-2874°C.

For corn, the TP is surrounded by literature in the III area, the amount of biologically active temperature is 800-1200^0C. In most of the station in plants growing season for the monitoring period, during 2008-2011, were accumulated the biologically active temperature levels needed for corn, beyond the limits specified in the III area. TC were recorded between 1229-1868°C, placing culture in the I and II area. Stations with TC over 1400^0C are: Filpisu Mare (1599-1868^0C), Craiesti (1513-1708^0C) and Triteni (1339-1508^0C) especially the stations in central and southern of TP, placing the culture in I area. Stations with TC under 1400^0C are: Sic (1296-1344^0C) and Zoreni (1229-1416^0C), the stations in the west and north of the TP, falling maize crop in the II area.

For soybeans, the TP is surrounded in literature, in the IV area, with a thermal potential of 1100-1250^0C. Amount of biological active degrees registered for soybean, during 2008-2011 in the TP, is between 1044-1568^0C, placing the culture in the II, III and IV area not only in the IV area, as shown in the literature. Specifically, station with values equal to the II culture area is Filpisu Mare (1430-1568^0C), station with values equal to the III culture area is Craiesti (1221-1396^0C), respectively with values equal to the IV culture area station Zoreni (1126-1183^0C) and Sic (1044-1193^0C).

For sun flower, the TP is surrounded in literature, in the II area, with a thermal potential of 1100-1250^0C 1400-1600^0C. Amount of biological active degrees registered for sun flower, during 2008-2011 in the TP, is between 1250-1890^0C, is a great diversity of conditions registered from culture area I, II, and III. Near I culture area we have the stations (1582-1890^0C), Craiesti (1487-1763^0C), in II culture area, Triteni (1387-1562^0C), respectively III culture area, Sic (1250-1463^0C) and Zoreni (1250-1463^0C). Zoning is similar to that of corn, the central and southern TP is favorable for semi late hybrids, and the north, hilly area, for early hybrids.

For sugar beet, we took into account the vegetation period equal to 183 days, the plant needs 2400-2900^0C, in the first year of vegetation and 1800^0C, in the second year. At all stations, the necessary of biologically active degrees is accumulated in the growth period of sugar beet, values ranged from 2954^0C at Sic and 3857^0C at Filpisu Mare.

The optimum humidity range for plants, is the range in which plants grow properly, and is equal to 60-90% from active humidity range. Insurance percentage averages of the optimum humidity range for plants, during 2008-2011, at all stations in the TP looks its best insurance for wheat crop, or 63.8% of the vegetation, humidity values are below the optimal range in 20.8% of the wheat growing season, and 15.4% were insured humidity values over this range. Spring crops have a much higher moisture deficit, which is between 37.9 to 38.9% for sugar beet and soybean, 40.9 to 41.2% for sunflower and maize during the growing season time the soil moisture is below optimum humidity range for plants. Water requirements are provided in an optimum, in 58.8 to 62.1% of the crop during the growing season of spring weeding crops.

To determine periods when moisture is not provided necessary we determined periods of droughts (figure 2). For Romania, dry periods are characterized by lack of rain for a period of at least 14 consecutive days within the cold of the year (October to March) and at least 10 days during warm (April to September). Droughts analysis shows a number of 36 (Branistea)-86 (Caianu) days without precipitations, in 2009, 15 (Branistea)-40 (Silivasu de Câmpie) days in 2010 and 57 (Caianu)-83 (Dipsa) drought days in year 2011.

Temperatures above 30^0C during flowering, accompanied by atmospheric heat (dry winds and low relative humidity) causes significant damage output, both in maize (optimum 18-24^0C) and sunflower (optimal 16-20^0C), because pollen loses viability and significantly reduce the production of grain and seeds, and sunflowers oil percentage. Average number of days at all stations, with temperatures above 30^0C were 16.33 days in 2008, 58.04 days in 2009, 47.8 days in 2010 to 53.96 days in 2011. These days occurred in 20-25% since June, but the majority of the days in July and August. Amplitudes temperatures above 30^0C during the day and below 10^0C at night, that occur during flowering and grain filling, prevents anther, pollen default development and the normal process of fecundation. Thermal shock after fecundations disturb accumulation of reserve substances in beans and corn shrivelled phenomenon occurs.

Amplitude of high temperatures adversely affect crops in the summer months, June-July-August and vegetation phases of flowering and grain formation, when droughts are most common, soil moisture is very poor. Maximum amplitude of temperature is recorded on a station located on a southern slope – Filpisu Mare, in the southeastern part of the Transylvanian Plain, where there were differences between high and low in the following days: 28 June 2009, 9.83-47.97^{0}C (38.14^{0}C); 7 July 2010, 13.74-48.44^{0}C (34.7^{0}C); 1 June 2011, 11.3-49.31^{0}C (38.01^{0}C). Brani? tea station on a slope which faces west, representative of the northern and north-western Transylvania Plain maximum thermal amplitude recorded in 24 hours, was: 15 June 2009, 7.98-42.4^{0}C (34.42^{0}C); 7 June 2010, 10.36-41.23^{0}C (20.87^{0}C); 22 August 2011, 8.58-42.16^{0}C (33.58^{0}C).

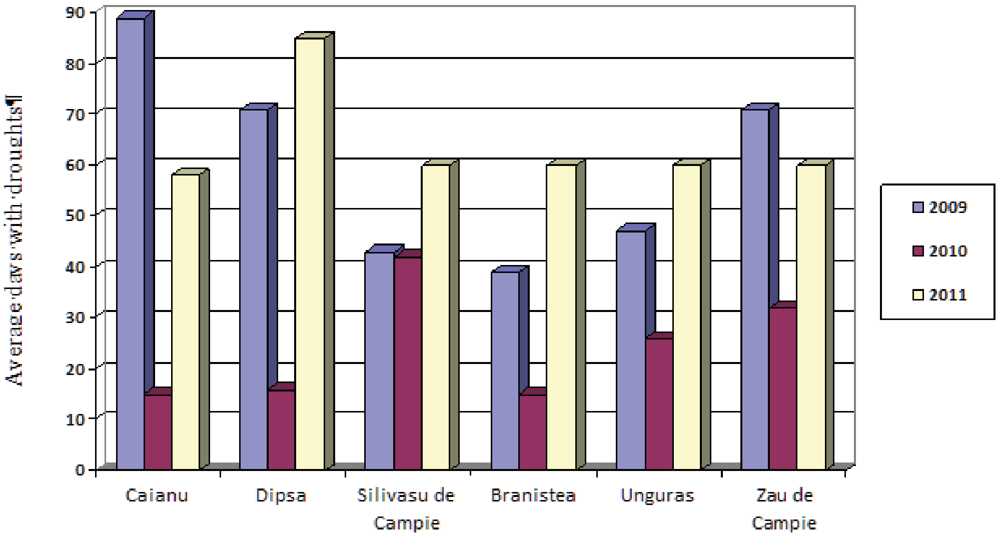

Figure 2. Days with droughts recorded during 2009-2011

CONCLUSIONS

After analyzing the recorded data, thermic and hydric, in the Transylvanian Plain, we recommend as optimal sowing period, advancing those known in the literature, with 5 days for corn and soybeans, and maintaining the same optimum period for sunflower and sugar beet, thus: Corn: 5 to 25 April; sunflower: March 25 to April 10, sugar beet: March 20 to April 10; soybean: April 5 to 15. Great differences are recorded from one station to another, the results are influenced by soil type and its exhibition, so in practice it is very important to take into account the differences in slope morphology. For crop growing season of spring (April to October) southern, south-eastern and eastern slopes have lower precipitation with approx. 43.8 mm, higher temperatures with 0.37^{0}C in air, with 1.91^{0}C at 10 cm in soil, with 2.22 ^{0}C at 20 cm and with 2.43^{0}C at 30 cm depth in soil, compared to northern, north-western and western slopes.

Water requirements are provided in an optimum, of 58.8 to 62.1% for the spring weeding crops during the growing season, thus irrigation is necessary to ensure optimum production potential. Droughts are recorded in June-July-August, in a total of 36 (Branistea, 2009)-83 (Dipsa, 2011) droughts days, overlapping temperatures above 30^0C, between 47.8 – 58.04 days, during 2008-2012.

The amount of biological active degrees registered in Transylvanian Plain shows the necessity to reconstruct crop zoning, known in the literature, for the analyzed crops: wheat, corn, soy, sunflower and sugar beet, ensuring higher levels for their zoning, respectively the possibility of cultivation of varieties/hybrids semi late or late in a higher percentage.

REFERENCES

Bucur D., Jitareanu G. and Ailincai C., 2011. Effects of long-term soil and crop management on the yield and on the fertility of eroded soil. Journal of Food, Agriculture & Environment 9 (2), p. 207-209.

Casas-Prat M. and Sierra J.P., 2012. Trend analysis of wave direction and associated impacts on the Catalan coast. Climatic Change, 115,p. 667-691.

Coman M,, Rusu T., 2010. New ways in using far-infrared radiations for agricultural production. Journal of Food, Agriculture& Environment 8, p. 714-716.

Domuta C., Sandor M., Ciobanu Gh., Samuel A., Ciobanu C., Domuta A., Borza C., Domuta Cr., Brejea R. and Gatea M., 2012. Influence of the crop system on soil erosion and on the soil physical properties under the Romanian north-western area conditions. Journal of Environmental Protection and Ecology 13 (2), p. 736-745.

Eastwood W. J., Leng M.J., Roberts N., Davis B., 2006. Holocene climate change in the eastern Mediterranean region: a comparison of stable isotope and pollen data from Lake Gölhisar, southwest Turkey. J. Quaternary Sci., 22, p. 327–341.

Fowler H.J., Blenkinsop S., Tebaldi C., 2007. Linking climate change modelling to impacts studies: recent advances in downscaling techniques for hydrological modelling. Int. J. Climatol. 27 1547–1578.

Fuhrer J, 2003. Agroecosystem responses to combinations of elevated CO_2, ozone, and global climate change. Agriculture, Ecosystems & Environment 97, p. 1-20.

Haggard B., Rusu T., Weindorf D., Cacovean H., Moraru P.I., Sopterean M.L., 2010. Spatial soil temperature and moisture monitoring across the Transylvanian Plain in Romania. Bulletin of USAMV-CN Agriculture 67, p. 130-137.

Hemadi K., Jamei H., Houseini F.Z., 2011. Climate change and its effect on agriculture water requirement in Khuzestan plain, Iran. Journal of Food, Agriculture & Environment 9, p. 624-628.

Lereboullet A.L., Beltrando G., Bardsley D.K., 2013. Socio-ecological adaptation to climate change: A comparative case study from the Mediterranean wine industry in France and Australia. Agriculture, Ecosystems & Environment 164, p. 273-285.

Marin D.I., Rusu T., Mihalache M., Ilie L., Bolohan C., 2012. Research on the influence of soil tillage system upon pea crop and some properties of reddish preluvosoil in the Moara Domneasca area. Annals of the University of Craiova-Agriculture, Montanology, Cadastre Series, 42, No 2, p. 487-490.

Molnar A., Drocas I., Ranta O. and Stanila S., 2012. Development of Software for Soil Compaction Assessment. Bulletin UASVM Agriculture, 69 (1-2), p. 88-93.

Moraru P.I. and Rusu T., 2010. Soil tillage conservation and its effect on soil organic matter, water management and carbon sequestration. Journal of Food, Agriculture& Environment, Vol. 8 p. 309-312.

Ramirez-Villegas J., Salazar M,. Jarvis A., Navarro-Racines E. C., 2012. A way forward on adaptation to climate change in Colombian agriculture: perspectives towards 2050. Climatic Change 115, p. 611-628.

Ranta Ov., Koller K., Ros V., Drocas I., Marian Ov., 2008. Study regarding the forces in correlation with geometrical parameters of the coulter discs used for no till technology. Buletin USAMV-CN 65, 223-229.

Raymond C.M. and Robinson G.M., 2013. Factors affecting rural landholders' adaptation to climate change: Insights from formal institutions and communities of practice. Global Environmental Change 23, p. 103-114.

Srinivasan V., Seto K.C. Emerson R., Gorelick S.M. 2013. The impact of urbanization on water vulnerability: A coupled human–environment system approach for Chennai, India. Global Environmental Change 23, p. 229-239.

Stanila S., Drocas I., Ranta O., Molnar A. and Nagy M., 2012. Studies regarding comparative analysis of main working indicators at primary soil tillage's. Bulletin UASVM Agriculture, 69 (1-2), p. 114-119.

Weindorf D., Haggard B., Rusu T., Cacovean H., Jonson S., 2009. Soil Temperatures of the Transylvanian Plain, Romania. Bulletin of USAMV-CN Agriculture 66, p. 237-242.

***Climate Charts, 2007. Climate, global warming, and daylight charts and data for Cluj-Napoca, Romania [online]. Available at http://www.climate-charts.com/.