THE ASSESSMENT OF AGRONOMICAL DRAUGHT IMPORTANCE IN RELATION TO INTENSIVE TURF

Eva Klementová[A], Tomáš Litschmann[B]

SUMMARY

From the viewpoint of a rainfed agriculture the recent decade's climatic condition during in Slovakia may be judged as dry. Therefore as regards irrigation water requirement by crops in course of growing period, farmers start to show more interest in the supplementary role of irrigation, especially for economically important crops. The aim of supplementary irrigation is to secure stable, moreover constantly high yields.

Growing interest in increased quality turfs in Slovakia has motivated us to determine the irrigation requirements in different climatic conditions. We have applied the AFSIRS Model to caculate the water regime balance of turfs for the statistical years 1971 to 2000 at 19 different sites distributed evenly in one-day steps throughout the territory of Slovakia. The model was applied to process and to evaluate multi-annual data series of daily values of meteorological and site-related characteristics as well as those concerning potential and actual evapotranspirations, daily values of water reserves in different strata of the active soil profile, infiltration of precipitation, etc. Using Weibull distribution the model can be also used to calculate the fundamental statistical characteristics and curves of surpassing monthly and yearly precipitation totals. The processing of voluminous sets of input data has produced results that may be generalised and the derived results may be transformed with a certain confidence level.

The presented paper is intended to contribute to dealing with the assessment of draught as associated with given site and year. The necessity to include the demands for irrigation water shown by specific crops in the assessment of agronomical draught has been indicated. Regarding that results of the draught-hardeness classification of different crops may vary, the year with the highest level of agronomical draught importance cannot be determined satisfyingly. This procedure may be applied to different crops and soil kinds, i.e. for specific conditions of a given site. Furher the model may be extended to determine more precisely the importance of draught for a given site with a given assortment of crops grown on required soil kinds.

The calculation of periodicity enables us to judge how the water deficiency in a given year is important from a long-term aspect. Similarly as periodicity is used to compare the importance of flood flow rates at a given site, the importannce of draught is mostly compared with those in other years, e.g. 1947.

The present paper constitute one part of VEGA 1/9364/02 grant project.

[A] Eva Klementová, Assoc. Prof. PhD., Department of Land and Water Resources Management, Slovak University of Technology Bratislava, Faculty of Civil Engineering, Radlinského 11, 813 68 Bratislava, Slovak Republic.
Tel.:++421 2 59274 618, E-mail: klement@svf.stuba.sk

[B] Tomáš Litschmann, RNDr., Amet. 691 02 Velké Bílovice, Žižkovská 1230, Czech Republic,
Tel.: ++420 519 346252, E-mail: amet@bva.sol.cz

1. INTRODUCTION

In our climatic conditions water reserves in at least surface soil strata use to be increased by periods of precipitation in course of growing season and it depends just on their "timing" and intensity whether specific crops are helped to overcome preceding or following critical periods of lacking precipitations. Various crops use to respond to insufficient precipitation or, eventually increased evapotranspiration differently, depending on the growth stages in which these phenomena have occurred. Apart from the above it also depends on the depth of their root systems and the water retention capacity of soils how individual crops can economise water. Draught need not to reflect on deep rooting crops that use to take up water from the soil water reserves remaining from winter time. On the contrary, crops with longer periods of growth may be more severly smitten by water defficiency.

An intensive turf represents crops with longer period of vegetation and relatively shallow root system. It may be described as a stand having limited reserves of water and high evapotranspiration demand throughout the entire period of vegetation.

2. MATERIAL AND METHODS

In order to calculate the irrigation requirements by intensive turf, meteorological data on precipitation, temperature, air humidity, wind speed and duration of sunlight were collected at 19 sites distributed thoughout Slovakia. The data for 1971 to 2000 were kindly provided by Slovak Hydro-meteorological Institute. The values of potential evapotranspiration were calculated by Penman-Monteith mehod and together with data on precipitation processed by AFSIRS application (SMAJSTRLA, 1990). The results of this processing also contain data on the amounts of precipitation water, that is necessary to keep soil water reserves in between the points of decreased availability and normal field capacity.

The course of AFSIRS application run can be followed in a simplified manner on **Figure 1** and **Figure 2**. The soil profile has been divided into two strata, an upper one whose water reserves are replenished by irrigation and a lower, not irrigated one wherefrom uptake of water mostly prevails, or it may be utilised as a reservoir of water infiltrated through the upper, water-soaked stratum after abundant precipitations. Some at least 70% of water demands by a given stand are believed to be settled by the upper stratum and this value increases with correspondingly reduced water reserves in the lower stratum.

The actual evapotranspiration of a given stand may be calculated from the referential evapotranspiration as reduced by a crop coefficient (K_c) and expressing the association of the actual evapotranspiration and the calculated referential evapotranspiration shown by a turf stand approximately 7 to 15 cm high. In **Table 1** the coefficients applied in the calculation together with the values of decreased availability point as expressed by the percentage share of utilisable water capacity (Θ_{UWC}) [%] are provided.

Table 1: The values of K_c coeffcient and % utilisable water capacity for an intensive turf

Month	**V**	**VI**	**VII**	**VIII**	**IX**	**X**
K_c	0.85	0.78	0.78	0.82	0.83	0.83
(Θ_{UWC}) [%]	60	60	60	60	60	60

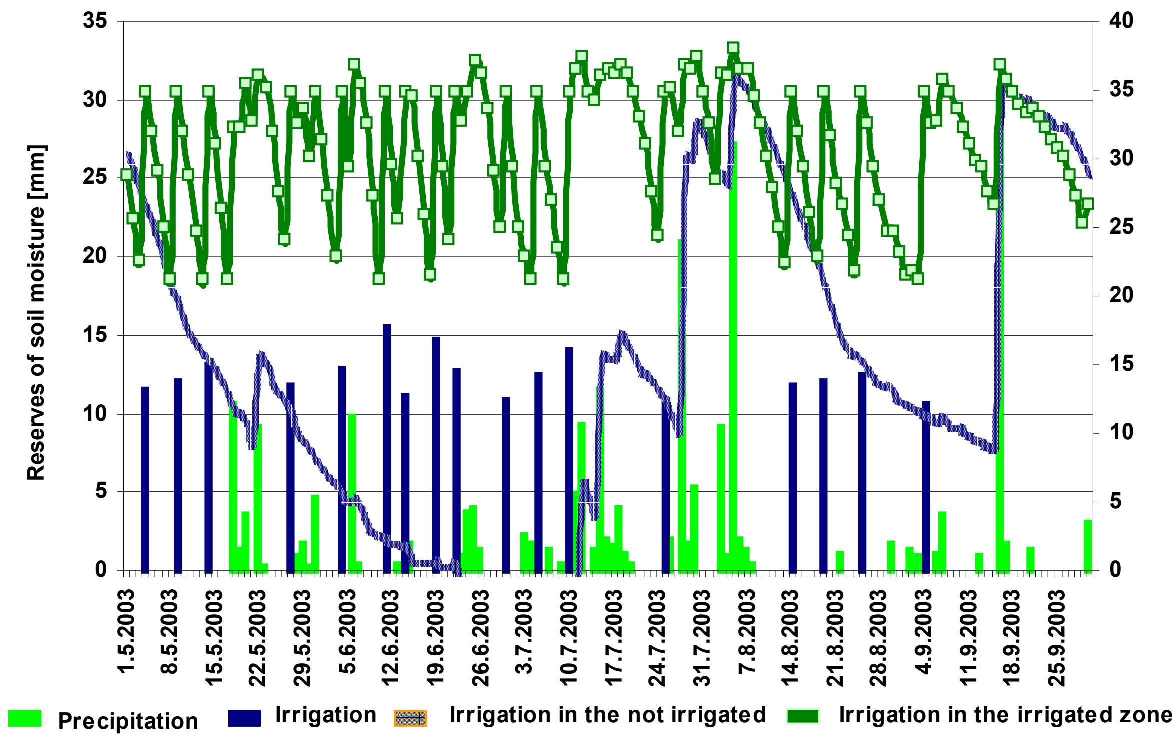

Figure 1: Water reserves balances in individual soil strata according to an AFSIRS model for intensive turfs in 2000

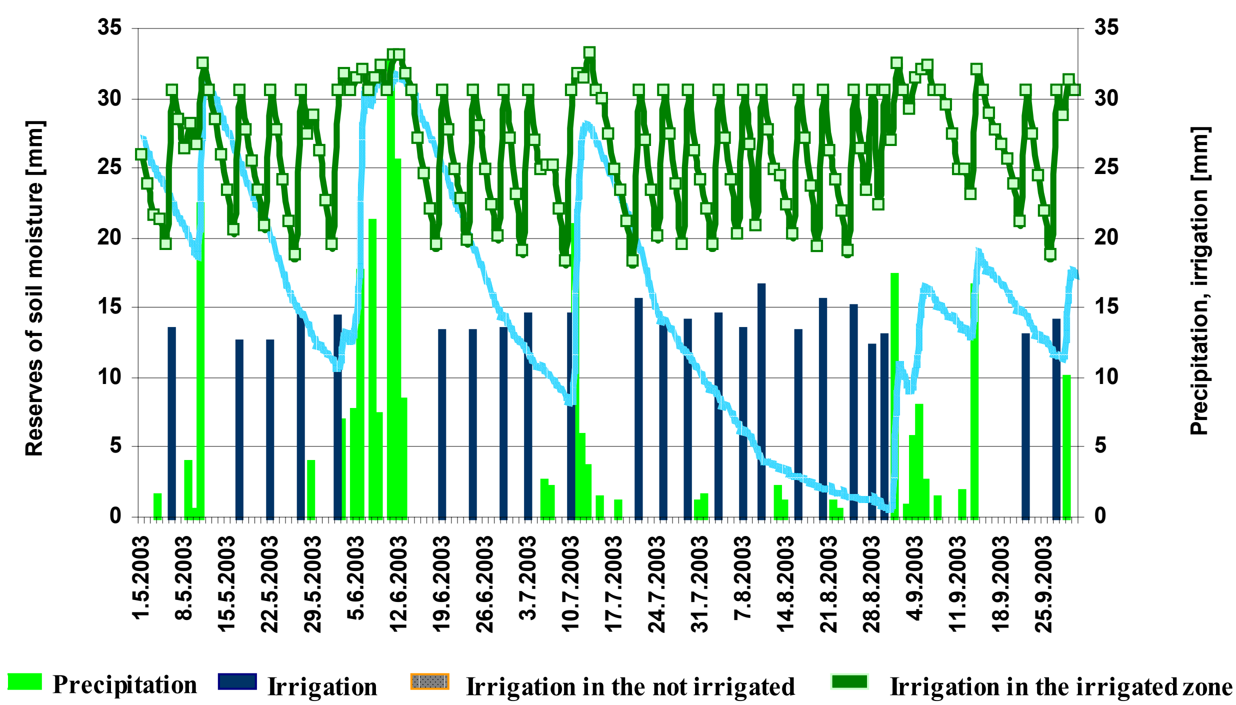

Figure 2: Water reserves balances in individual soil strata according to an AFSIRS model for intensive turfs in 1992

As irrigation is applied by the computer application as soon as the decreased availability point (Θ_{DAP}) has been reached, any reduction of evapotranspiration due to water defficiency is not counted with and therefore no other water stress coefficient K_S needs to be introduced. The actual evapotranspiration of a given stand is therefor equal to that potential one.
For the case of turf the depths of irrigated horizon and rooting zones were supposed 15 and 30 cm respectively. The soil profile has been supposed as homogeneous in the entire rooting zone with the Θ_{UWC} value of 20 % vol., which approximately corresponds to a loamy soil.
In intensively farmed regions of Sovakia there are relatively evenly distributed climatologic stations with the most complete series of required meteorological elements for the processed three decades.

3. RESULTS AND DISCUSSION

The calculated values of irrigation water demands by turf have been sorted out for each station in descending order. were in descending In **Table 2** the order of the three years with the highest demands by an intensive turf for moistening irrigation are shown.
It is obvious from the above **Table 2** that year 1992 holds the first position the most frequently (in 11 cases). The year 2000 has often been judged as very dry, thanks to its medialisation the attention also of professional public has been attracted to the issue of draught, however, as regards turfs this year has only four times been judged as the driest one. This may be owing to the defficiency in 2000´s precipitation mainly in spring months (April to June) that affeted the development of particularly spring cereals. In succeeding months certain precipitation allowed to replenish water reserves at least in the upper soil stratum. More deeply rooting crops took up water from lower strata that had been saturated by preceeding more humid period lasting up to late March. This may be seen in Figure 4 whereon the 2000 course of water reserves in individual strata has been illustrated (Kuchyňa, nearby Malacky in Záhorská Lowland). At ths site the year 2000, as regards intensive turfs, held the second position.
In year 1992 (the driest one from the viewpoint of the applied method) before all the rains in the first decade of June more significantly and a less significant, more humid period one month later were reflected, however, the remainder of the vegetation period was without more important precipitation and soil water reserves had to be replenished thorugh irrigation. This can be seen from **Figure 2**.
From the viewpoint of both shallow and deep rooting crops, lacking more significant precipitation in top summer is a less favourabe option manifested by higher consumption of irrigation water. Owing to this the year 1992 holds the first position at the most of studied sites as regards the need for irrigation.
Further we tried to establish, on the basis of the results from all the studied stations, the order of the driest years. As it is obvious from **Table 2**, apart from a prevailing top positions of the year 1992, the appearance of other years on next position depended on the course of local precipitation at given stations.
After having been sorted in descending order according to the consumption of irrigation water at given stations, the driest years were assigned scores corresponding to their respective positions, i.e. the year with the highest demand for irrigation water was assigned score 1. In this way, 19 series have been gained and after having calculated the means from individual years' scores, we have drawn conclusions given in the lowest line of **Table 2**. For turfs, the first position is held by the year 1992, the next ones are held by 2000 and 1993.
The chosen calculation procedure enables us to draw a theoretical curve of surpassing with irrigation requirement values calculated for each site and to determine therefrom the periodicity with which a given irrigtaion requirement would occur in individual years. We have applied Weibull distribution illustrating on **Figure 3** the periodicity line at the meteorological station in Víglaš and **Figure 4** The periodicity of occurrence of the irrigation requirements by intensive turf in 1992.

Table 2: The three years ordered by the highest demands by an intensive turf for irrigation water

Name of station	Abbreviation in the map	IV-IX [mm] precipitation total	IV-IX ETP [mm]	Order
Bratislava, letisko	Br	305	622	2000, 1992, 1986
Čaklov	Ca	429	513	1982, 1992, 1983
Hurbanovo	Hu	307	622	2000, 1993, 1990
Jaslovské Bohunice	JB	318	620	1992, 2000, 1990
Košice	Ko	411	599	1992, 1994, 1986
Kuchyňa	Ku	378	577	1992, 2000,1994
Michalovce	Mi	386	538	1994, 2000, 1986
Milhostov	Ml	361	556	1999, 1992, 1993
Oravská Lesná	OL	622	411	1992, 1983, 1976
Piešťany	Pi	348	602	1992, 1973, 1983
Poprad	Po	399	500	2000, 1992, 1994
Rim. Sobota	RS	363	544	1993, 1992, 2000
Rožňava	Ro	434	521	1992, 1986, 1994
Sliač	Sl	386	528	1992, 2000, 1973
Somotor	So	353	554	1992, 1994, 2000
Štós	St	508	523	1992, 2000, 1993
Telgárt	Te	551	457	1992, 1993, 1994
Víglaš	Vi	371	505	1992, 2000, 1973
Žiharec	Zi	320	582	2000, 1992, 1973
Total				**1992, 2000, 1993**

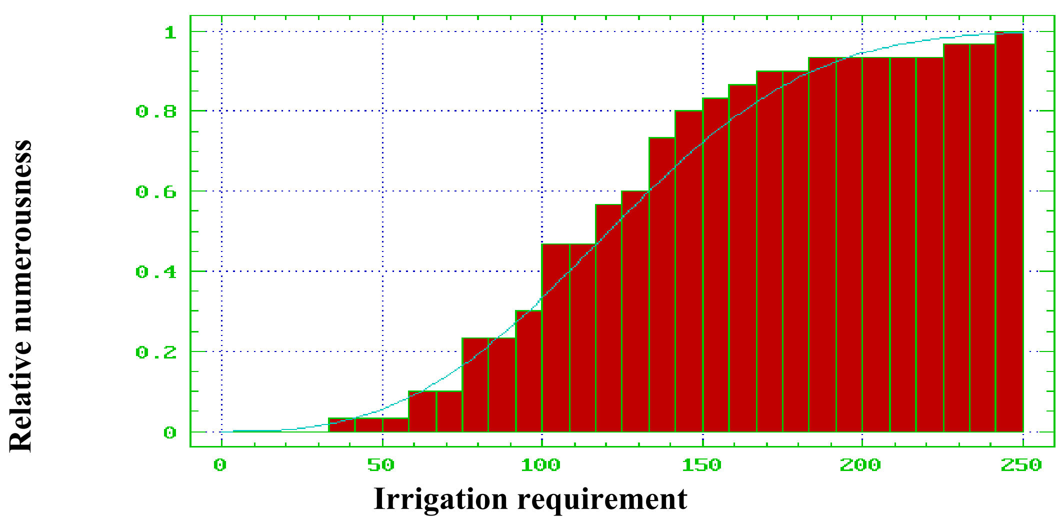

Figure 3 Drawing of Weibull distribution curve with empirical values of irrigation requirtements by intensive turf in Víglaš

PL

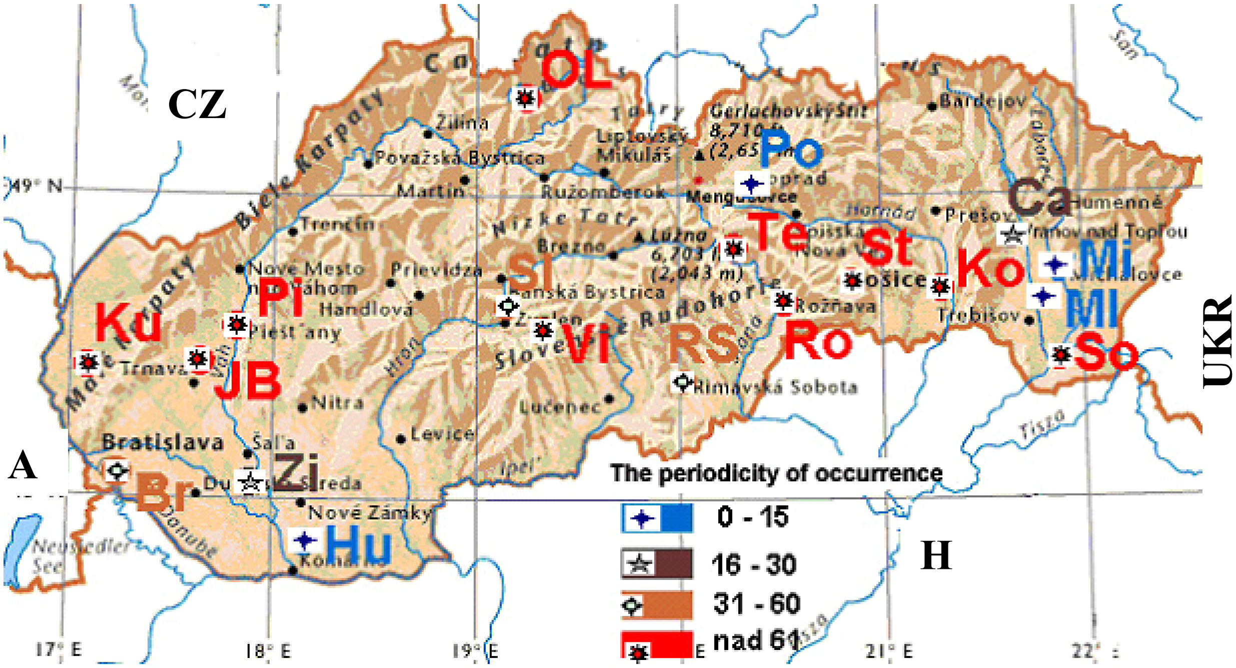

Figure 4 The periodicity of occurrence of the irrigation requirements by intensive turf in 1992

Similarly the periodicity curves can be drawn for any year and site. **Figure 5** illustrates the distribution of periodicity in 2000. On the contrary to the preceding case the regions with the longest periodicity have been concentrated in southern Slovakia, however, in eastern Slovakia the periodicity mostly reached up to 15 years.

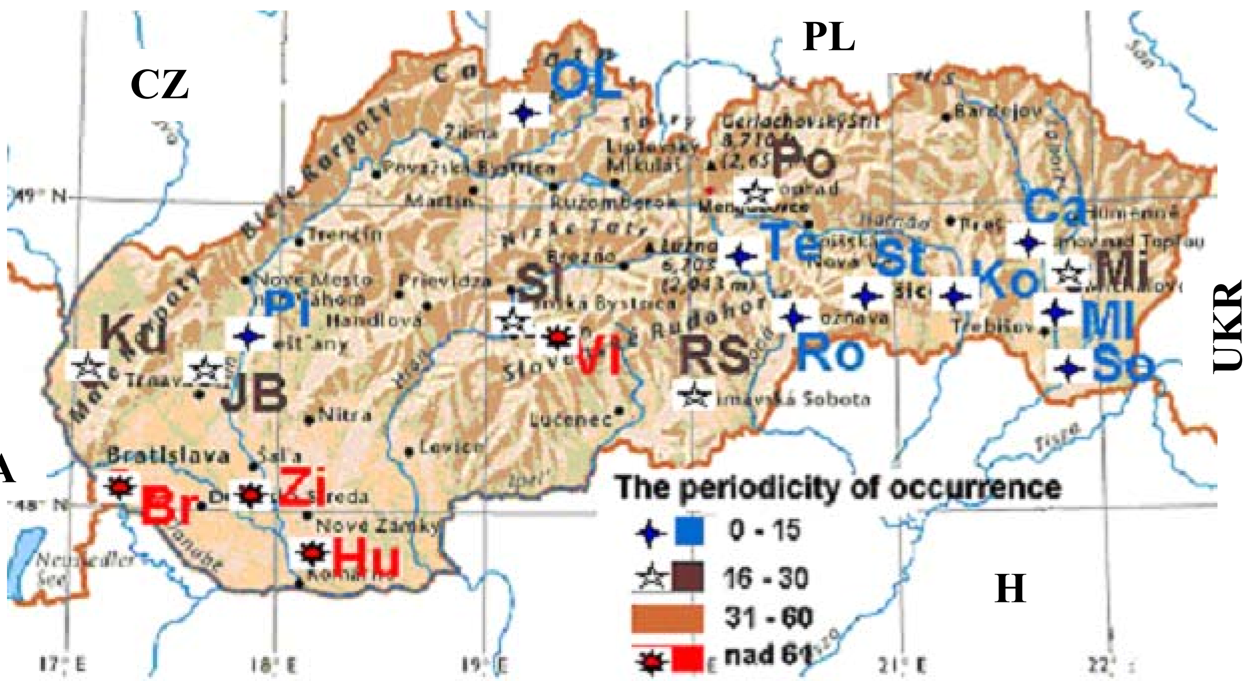

Figure 5 The periodicity of occurrence of the irrigation requirements by intensive turf in 2000

4. CONCLUSION

The presented paper is intended to contribute in dealing with the assessment of draught as related with a defined site and year. The necessity to take into account by the assessment of agronomical draught the demands for irrigation water shown by specific crops has been indicated. Regarding that results of the draught-hardeness classification of different crops may vary, the year with the highest level of agronomical draught importance cannot be determined satisfyingly. The used procedure may be applied to different crops and soil kinds, i.e. for specific conditions of a given site. Furher the model may be extended to determine more precisely the importance of draught for a given site with a given assortment of crops grown on required soil kinds.
The calculation of periodicity enables us to judge how the water deficiency in a given year is important from a long-term aspect. Similarly as periodicity is used to compare the importance of flood flow rates at a given site, the importannce of draught is mostly compared with those in other years, e.g. 1947.

5. REFERENCES

BROWN, P., KOPEC, D. (2000): Converting reference evapotranspiration into turf water use. Turf irrigation management series II, University of Arizona, 6pp.

LITSCHMANN, T., KLEMENTOVÁ, E. (2002): *Spotřeba závlahové vody teplomilnými ovocnými dřevinami* (Irrigation water uptake by thermophilous fruit woody crops). X. poster day with international participation "*Transport vody, chemikálií a energie v systéme pôda – rastlina – atmosféra*" ("Transport of water, chemicals a energy in the system soil - plant - atmosphere"). Bratislava 28.11.2002, ISBN 80-968480-9-7.

LITSCHMANN T., KLEMENTOVÁ E., ROŽNOVSKÝ J. (2001): Palmerov index závažnosti sucha a jeho použitie v našich podmienkach (Palmer's draught seriousness index and its application in our conditions). In: "Transport vody, chemikálií a energie v systéme pôda – rastlina – atmosféra" ("Transport of water, chemicals a energy in the system soil - plant - atmosphere"), Bratislava 29.11.2001.

KLEMENTOVÁ, E., LITSCHMANN, T. (2001): Drought and their Evaluation. 9th International Conference of Horticulture, vol. 2, ZF MZLU, Lednice na Moravě, pp. 447 – 443.

KLEMENTOVÁ, E., LITSCHMANN T., (2001): Hodnotenie sucha s ohľadom na doplnkové závlahy (The assessment of draught with regard to moistening irrigation). In.: Extrémy prostredia (počasia) - limitujúce faktory bioklimatologických procesov (Environmental (weather) extremes – the limiting factors of bioclimatological processes), Bioklimatologické pracovné dni (Bioclimatological workshop), Račkova dolina 10.-12.9.2001.CD ROOM 8p.

ROŽNOVSKÝ, J., KLEMENTOVÁ, E., LITSCHMANN, T. (2002): Kritériá hodnotenia klimatických pomerov (The criteria for the assessment of climatic conditions). In: Proceedings from the 7th Scientific Conference with International participation. Košice, 22.-24.V. 2002, pp. 156 – 159.

KLEMENTOVÁ, E., LITSCHMANN, T. (2002): Detekcia výskytu sucha v Hurbanove (The detection of the occurrence of draughts in Hurbanovo). Ed: Antal, J.: Očakávané globálne zmeny klímy a ich možný dopad na vodný režim, poľné a lesné hospodárstvo (The expected global climatic change and its possible impact on water regime, agriculture and forestry). Slovak Academy of Agricultural Sciences, Zborník 27 SAPV, Nitra 2002,: ISBN 80-968665-3-2, pp. 45-50.

KLEMENTOVÁ, E., LITSCHMANN, T. (2002): Hospodárenie s vodou pri návrhu závlahovej stavby (Economising water by irrigation construction design). Projekt a stavba. Vol. 4, no. 12, 2002 SKSI IAS: 17-20 ISSN 1335-5007.

KLEMENTOVÁ, E., LITSCHMANN, T., ROŽNOVSKÝ, J: Assessment of Drought in Landscape. In: Participation of women in the fields of meteorology, operational hydrology and related sciences. Bratislava, 16-17. V. 2002, pp.143 – 148.

KVĚTOŇ, V., VALTER, J., KOTT, I. (2000): Metodika hodnocení sucha na území ČR v období IV - VI.2000. (Methods to assess draught on the territory of the Czech Republic in IV-VI 2000) Internal information Czech Hydro.meteorological Institute (ČHMÚ).

LITSCHMANN, T., KLEMENTOVÁ, E., ROŽNOVSKÝ, J.: Vyhodnocení period sucha v časových řadách pražského Klementina a Hurbanova pomocí PDSI (The use of PDSI to assess draught periods in time series by Praha-Klementinum and Hurbanovo). In: Rožnovský, J., Litschmann, T. (ed.): XIV. Czecho-Slovak Bioclimatological Conference, Lednice na Moravě September 2-4 2002, ISBN 80-85813-99-8, pp. 280-289

SMAJSTRLA, A.G. (1990): Agricultural Field Scale Irrigation Requirements Simulation (AFSIRS) Model. IFAS, University of Florida. Technical Manual. Gainesdville FL. 1990, 252 pp.

ZAVADIL, J. (2000): Efektivní a ekonomická závlaha trávníkù (Efficient and economical irrigation of turf). IN.: Trávníky 2000, pp. 7-10.

Zborník prác Slovenského hydrometeorologického ústavu v Bratislave (Bulletin of scientific works by Slovak Hydro-meteorological Institute in Bratislava), Vol. 33/I, ALFA, Bratislava 1991, 239 p.