VOLUME CHANGES OF OVERGROUND PARTS OF THE PLANTS AS AN EXPRESSION OF WATER STRESS

Viliam Bárek[1], Ján Horák[2], Alan Klimaj[1]

[1]Department of Landscape Engineering, Slovak University of Agriculture, Nitra, Slovakia

[2]Department of Landscape Engineering and Hydrology, Slovak University of Agriculture, Nitra, Slovakia

Abstract

The future of the primary agricultural production relies on the responses to enhanced changes of climatic factors associated with the global warming and greenhouse effect by releasing the new genotypes, more tolerant to drought, extreme temperatures, low nutrient content, changes in population density and pathogenicity of pests and diseases. The co-occurring phenomena, such as aridization or fluctuation of precipitation in the particular area would be probably present even in the Slovak conditions. It appears that not only the systematic change of the long-term mean temperature and precipitation compared to long-time average level, but also the diurnal and seasonal variability and frequency of weather fluctuations or extreme days would play an important role. Therefore, it is necessary to draw attention in advance to possible consequences and possibilities to optimize the production process. There is a need of specification of effects of weather fluctuations on the regulation of growth-production factors as well as the importance of a special gene expression needed to crop tolerance or resistance or running the protection mechanisms. Our experiment showed that introduction of multi-parametric approaches is useful for a deeper comprehension of interactions in the system soil - plant - atmosphere, as well as for manipulation of these interactions in all their components. Thus, it will lead to a more dynamic understanding of this interaction and to the production of new genotype constructs.

Key words: *dendrometer, precipitation, above-average high temperatures, diameter changes*

1. INTRODUCTION

Prognoses of the global climate change predict an increase of the greenhouse effect, thus increasing the importance of topics, such as desertification of regions, aridization, increasing of temperature of the aboveground atmospheric layer (and thus temperature of plant environment). These factors would increase the plant stress occurrences, but also the requests to ensure sufficient water regime of crop plants. Water in plants fulfils important functions, as it represents the environment for running of all metabolic processes. It allows transport of mineral nutrients and products of photosynthesis. The lack of water inhibits the growth, leaf expansions, CO2 assimilation, source-sink relations in terms of assimilates movement, biomass production as well as the final crop yield (Brestič, Olšovská, 2001). The sufficient plant water supply is essential for realization of crop genetic potential. Therefore, in a global scale, greater attention is paid to increasing of functional properties of crop plants and to their tolerance to drought and high temperature, as well as optimization of water regime by irrigations.

For the management of the agriculture soils soil moisture regime it has to be emphasized the specific property of Bioclimatology of agricultural plants and animals. Every ecosystem, but also any plant or animal species in the environment of implementing such a way that is in their genetic property and information about how the most successful survival in these climatic conditions, which not only adapts to average climate values, but also to change them. The adjustment process is the more conflicting, which is climate change faster and bigger. To be able to anticipate the possible consequences of climate change, and then prepare effective adaptation, it is necessary to know reactions of the various climate-sensitive systems to the limits in the past on the one hand and try to monitor continuously and consistently change and the implications of changes to various systems on other hand side.

Without the operational and functional irrigation systems will be in some cases threatened the agricultural production. Quick climate change may cause the instability of most agricultural and forest ecosystems, including soil ecological systems. These changes are reflected in the altered production and environmental functions of soil cover, which can affect many regions of Slovakia, especially the South. However, in some cases in terms of production potential of biomass, whether arable land or permanent grassland, when properly regulate the soil water regime, it can be a positive change (Bárek, 2006).

Highly profitable irrigation is operated in case of good organizing and management. Management must be based on the most correct and accurate set of crop irrigation regime for each characteristic soil-climate area. The main purpose of the irrigation system management for given crops is to operation in the shortest time to water shortage should be covered.

The basic condition for achieving maximum yields of agricultural crops is the production yield of the plants was carried out at a certain balance between temperature and precipitation. However this balance stage is for given crop and its development stage totally specific. Unbalancing, especially at a time when the plant is most demanding for moisture has a very negative impact on crop yields (Tkáč, 2000). Meteorological factors significantly affect the temperature and water content in soil and agricultural conditions in the hydrothermal system. From that knowledge bases raise the methods for the determination and management of irrigation schemes (Bárek, 2008).

2. MATERIALS AND METHODS

There is dimensional change in plants due to the growth and water content preventing to daily and seasonal plant dynamics. Daily changes reflect the changes of water content in the texture. Seasonal dynamics reflects long-term changes due to the growth. This shows our research assumption that water stress participates in important part on volume changes of overground parts, what predictive irrigation need.

It was chosen Malus domestica var. Yellow Transparent for measurement of volume changes of overground plant parts. It is undemanding variety originated from Baltic area, resistant to frost. Its region is in all areas (especially marginal), suitable for bigger free growing shapes, on middle to stronger growing stems, weakly growing stems are suitable only in warmer conditions. It is earliest summer apple variety; it matures from the half of July to the beginning of August. The age of monitored apple trees is about 20 years.

There were chosen two trees on one place for measurement needs, to have the same conditions due to minimalizing of mistakes caused by areal conditions. Each tree was connected with dendrometer on opposite places of the tree to have possibility to monitor potential changes caused by adumbration during the day. Own measurements were realised by Diameter dendrometer Type DD-S. Dendrometers are ideal equipment to fulfil the requests as a mean for exact and continual monitoring of radial and vertical changes in the plant texture, for example stalk, fruit, leaves. It is suitable especially for measurement of young plant parts. The precision of measurement is up to 2 μm, in datalogger using DL18 is ±0,1%, output signal is in the range of 0-11000 ohm. It is not necessary any connection from external source, equipment calibration. The equipment does not cause plant damage, it is not predisposed to bigger weather changes, and it is possible to use it in external temperatures in the range of 30 to 40°C and relative air moisture in the range from 0 to 100 %. It is made from rustless steel and aluminium. Temperature coefficient is lower as 0,04% to one K of the temperature. The equipment weight is only 13g, due to it does not cause needless load on the plants. Standard length of the cable is 5m with possibility of prolongation on 100m. Data are collected by datalogger from time to time according to the own setting. Only one restriction is the capacity of the internal memory card.



Fig. 1. Possibilities of dendrometer DD-S (Klimaj, 2015) installation

Measured data were recorded by datalogger DL18. Datalogger has the memory for seating of 1900000 reading. It connects with PC by USB cable. Immediately is possible to have connected maxima l4 dendrometers. Data collection is possible to set from one second interval to 18 hours interval. The battery life guarantees by producer is for one year in case the measurement is set on each 15-60 seconds. There are 2 AAA batteries in datalogger. The equipment is possible to use in external conditions from -20 to 70°C for relative air moisture 0-95%.



Fig. 2. Datalogger DL18 (Ecomatic)

3. RESULTS

The sensors were assembled on trees to have possibility the best measuring of sufficient data range, which the best reflect daily changes on the branches. During the measures occurred in Slovakia high extraordinary warm days and it was monitored more days periods without precipitation.

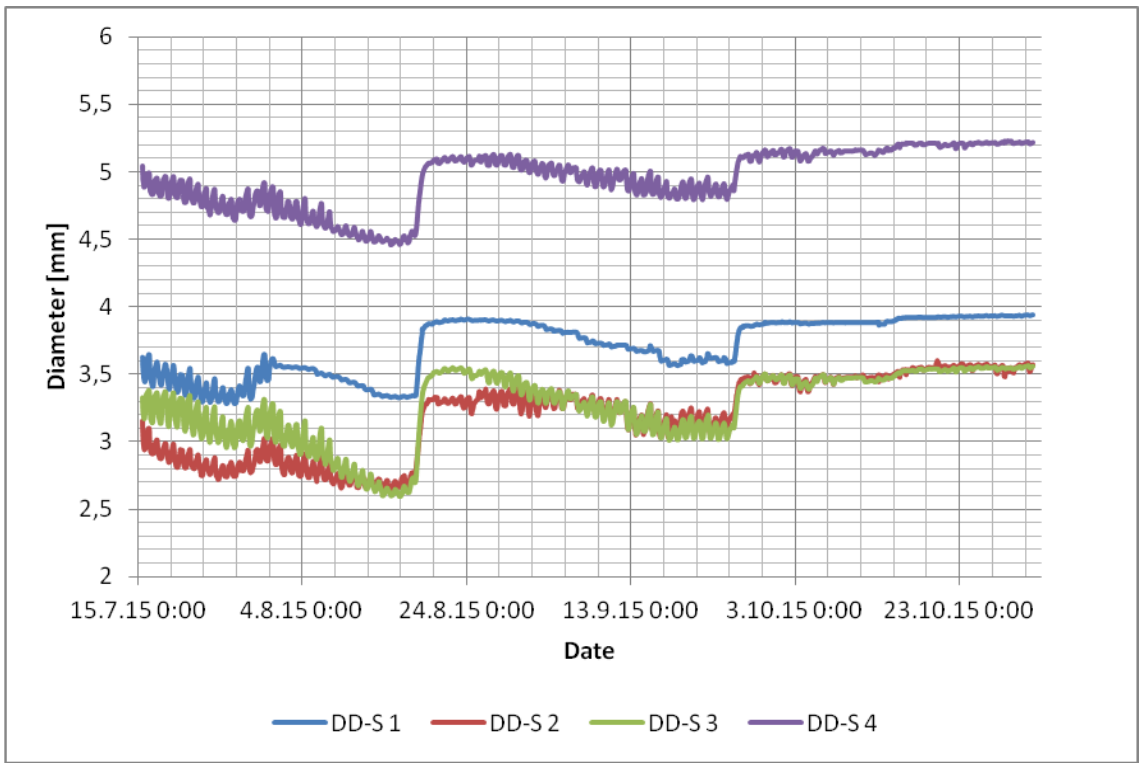


Fig. 3. Graphical course of the diameter changes during the day for the period from 15.7.2015 to 31.10.2015

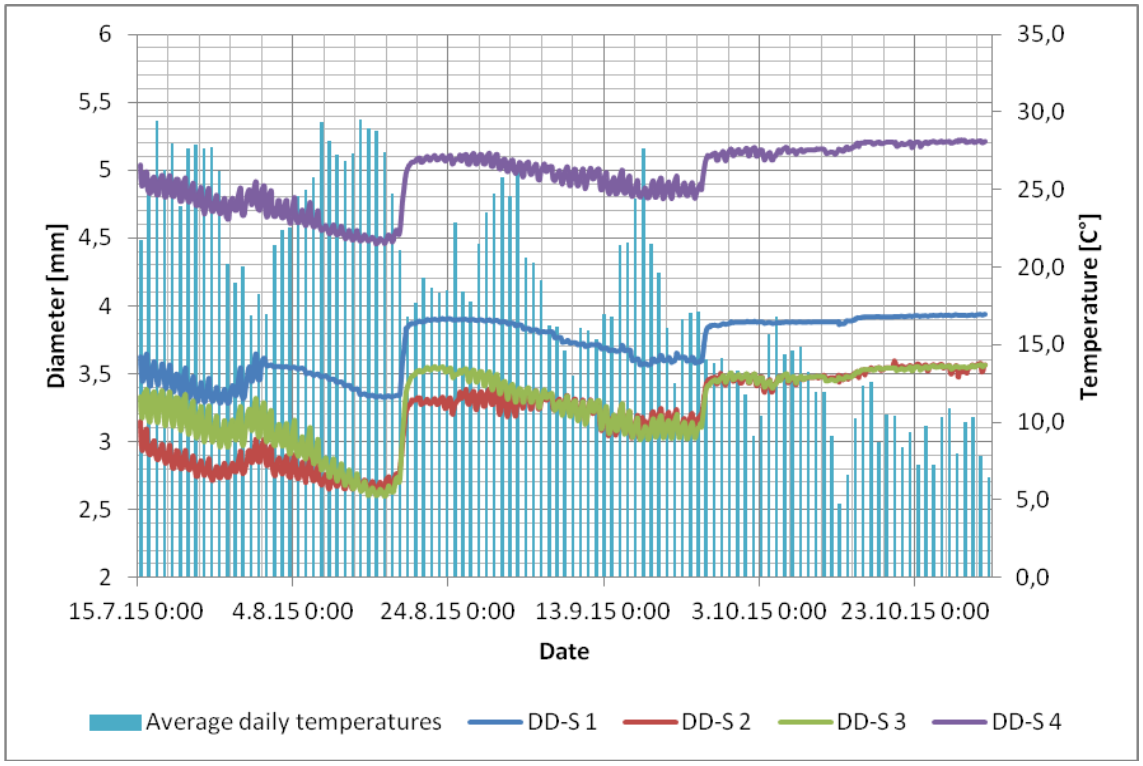


Fig. 4. Graphical course of diameter changes during the day for the period from 15.7.2015 to 31.10.2015 with attention to average daily temperatures

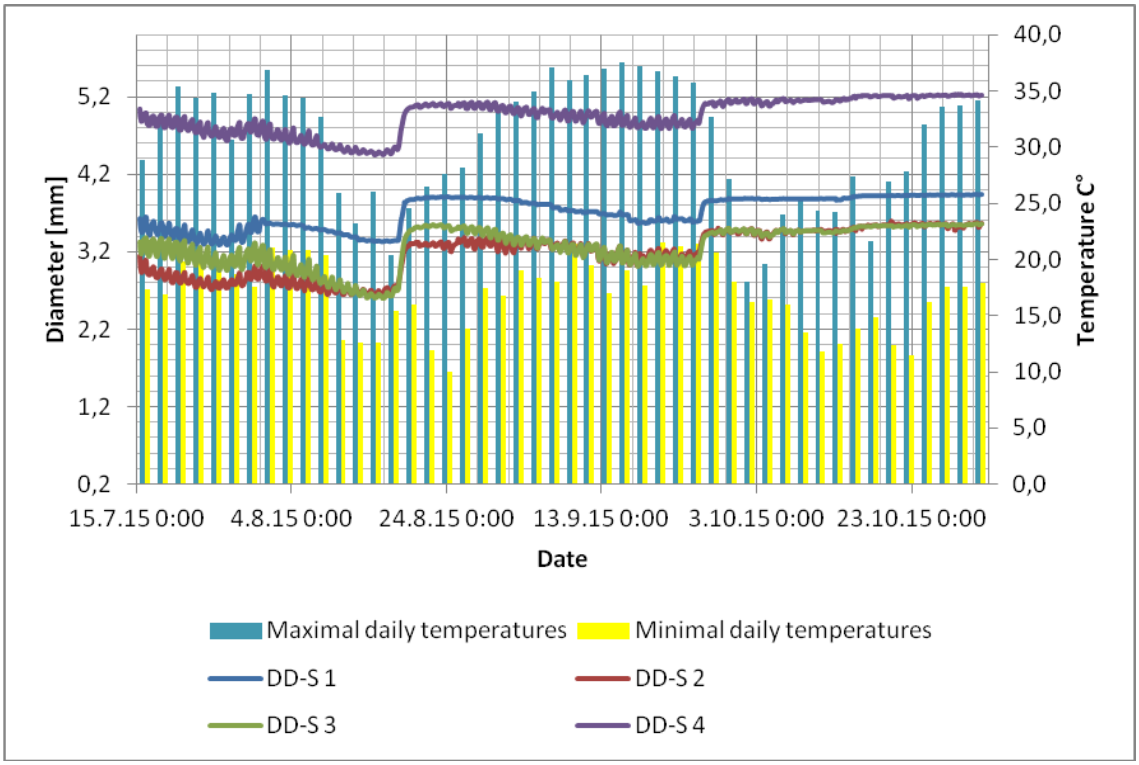


Fig. 5. Graphical course of diameter changes during the day for the period from 15.7.2015 to 31.10.2015 with attention to maximal and minimal daily temperatures

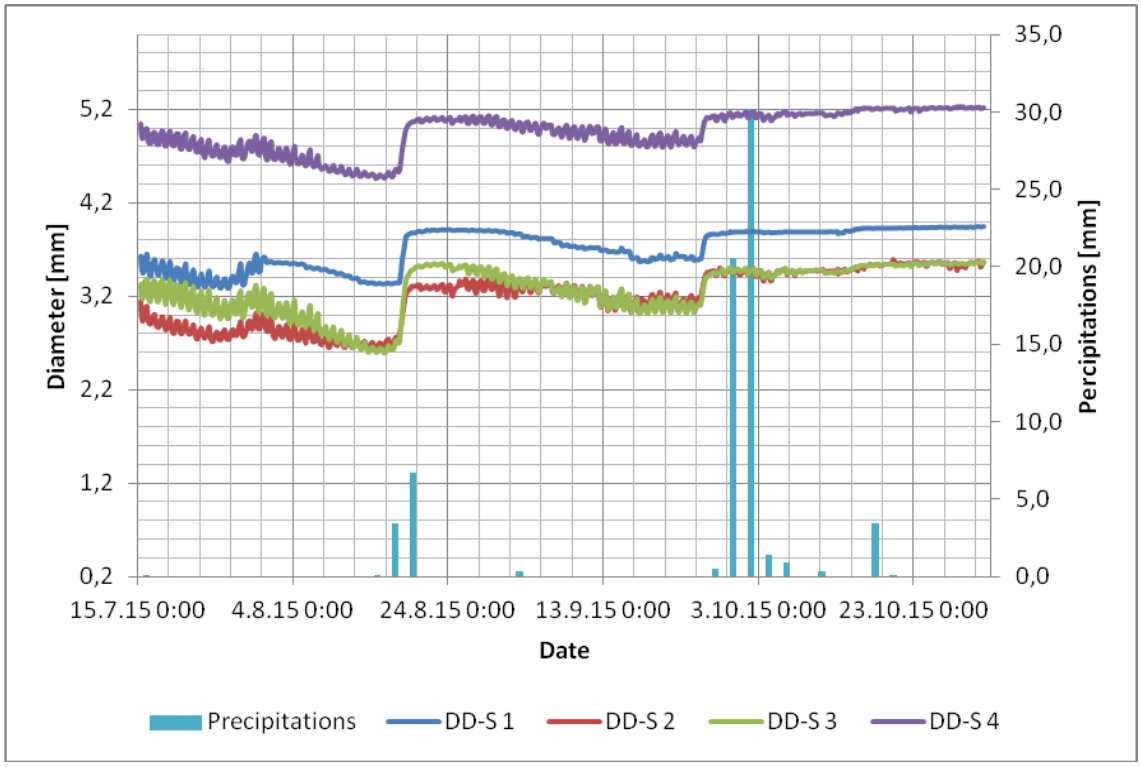


Fig. 6. Graphical course of diameter changes during the day for the period from 15.7.2015 to 31.10.2015 with attention to precipitations

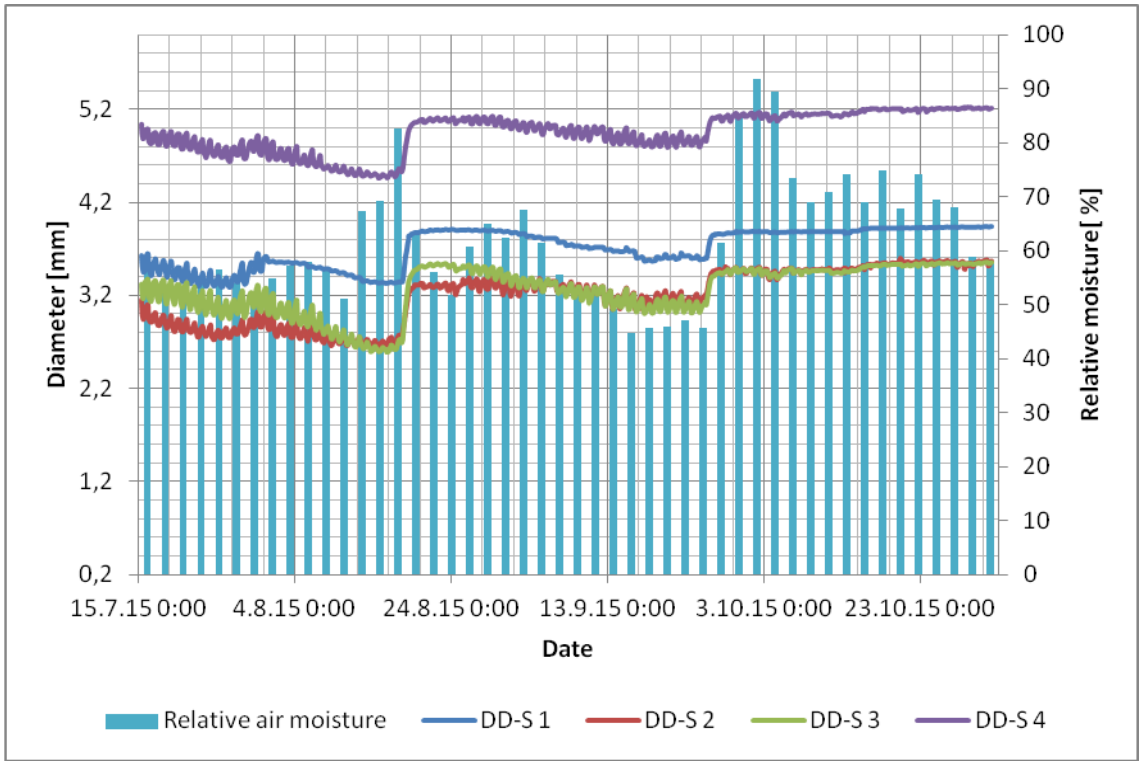


Fig. 7. Graphical course of diameter changes during the day for the period from 15.7.2015 to 31.10.2015 with attention to relative air moisture

In period from 16.7.2015 to 25.7.2015 occurred the first period of extraordinary high temperatures and longer dryness. All dendrometers recorded temperate daily fall of branches calibre, proportional daily changes were minimal. Next days were colder and due to it stopped reduction of branches calibre and after precipitations on 28.-30.7.2015 the branches calibre started to grow.

In period of 3.-16.8.2015 Slovakia was hit by extraordinary high temperatures, where maximal daily temperature exceeded 30°C and from 31.7.2015 to 16.8.2015 with exception of 5.8.2015 (0,5 mm) were not registered the precipitation. During this period the branches calibre markedly reduced and were markedly lowered daily changes especially on DD-S1. From 16.8.2015 in the evening the front occurred in territory and brought precipitations and colder weather. The precipitations occurred especially on 17. and 18.8.2015. Colder weather and precipitation caused immediately rapid growth of branches calibre, which reflected on measured data on dendrometer. The losses caused by dryness were compelled during two days and were higher as at the beginning of the measurement. Precipitations on 25.8.2015 caused renovation of the changes during the day, which did not reach the range of the changes from the beginning of the measurement.

4. CONCLUSIONS

The sensibility of the crop- plant on extreme climatic changes is big problem, because plant breeding oriented on higher resistance to climatic extremes is slower and less successful as plant breading on diseases and pests resistance and also because the losses in lower harvest due to increased resistance are higher. Harvest stability is possible to increase by agronomic and genetic changes. Higher and varied energy inputs lead to bigger control and harvest stability, if the irrigation presents. Contribution of the works seems in optimization of the term of irrigation rate supply and its amount on the basis of complex physiological plant characteristics knowledge, reflex spectrometry of plant habitat and hydro physical soil characteristics. The comparison of these input data can help to manage the irrigation with the lowest economic and technologic inputs, to find widest practical application in research. A

concrete dendromertic measurement of volume changes of overground plant parts by simple equipment with consecutive physiologic monitoring of stress plant state probably provides basic solutions of submitter project solution.

ACKNOWLEDGEMENT

This study was supported by Slovak Grant Agency VEGA, No. 1/0604/16 and Slovak Research and Development Agency under the contract No. APVV-0512-12.

REFERENCES

Bárek, V., (2006), *Klimatická zmena a závlahy*. 1st ed., Bratislava : Slovenská bioklimatol. spoločnosť pri SAV.,: obr., tab. - (Štúdia Slovenskej bioklimatologickej spoločnosti pri SAV ; 13.). - ISBN 80-228-1717-2, p 37

Báreková, A., Kaufman, P., Halaj, P., Čimo, J. and Igaz, D. (2011). *Zastúpenie odpadov z obalov v modelovom zložení komunálneho odpadu*. In Waste Forum : recenzovaný časopis pro výsledky výzkumu a vývoje pro odpadové hospodářství., [Roč. 4], č. 3, ISSN 1804-0195, pp. 136-142.

Bay, R.R. (1963). *Soil moisture and radial increment in two density levels of Red Pine*. U.S. For. Serv. Res. Note LS-30.

Bormann, F.H. and Kozlowski, T.T. (1962). *Measurement of tree growth with dial gauge dendrometers and vernier tree ring bands*. Ecology, (43), pp. 289–294.

Brestič, M. and Olšovská, K. (2001). *Vodný stres rastlín: príčiny, dôsledky, perspektívy (Water stress: causality, consequences, perspectives)*. SPU Nitra, ISBN 80-7137-902-6, p 149.

Bullock, S.H. (1997). *Effects of seasonal rainfall on radial growth in two tropical tree species*. Int. J. Biometeorol. 41: pp. 13–16.

Čimo, J., Igaz, D., Špánik, F. and Maderková, L. (2009). *Changes in temperature assurance of the most grown sorts of vegetables in conditions of climate change*. In Journal of International Scientific Publications: Ecology & Safety. vol. 3, no. 1, pp. 201-209. ISSN 1313-2563

http://www.ecomatik.de

Igaz, D., Čimo, J. and Maderková, L.(2009). *Wilting point as the indicator for soil drought evaluation*. In Journal of International Scientific Publications: Ecology & Safety., vol. 3, no. 1, pp. 210-216. ISSN 1313-2563

Kozlowski, T.T. and Winget, C.H. 1964. *Diurnal and seasonal variation in radii of tree stems*. Ecology, (45), pp. 149–155.

Macura, V. and Halaj, P.(2013). *Úpravy a revitalizácie vodných tokov*. 1st ed. Bratislava : Slovenská technická univerzita,. p 228. ISBN 978-80-227-3925-2

Ortunõ M.F., W. Conejero, F. Moreno et al. (2010). *Could trunk diameter sensors be used in woody crops for irrigation scheduling A review of current knowledge and future perspectives*. Agricultural Water Management (97), pp. 1-11.

Sheil, D. (2003). *Growth assessment in tropical trees: large daily diameter fluctuations and their concealment by dendrometer bands*. Published on the NRC Research Press Web site at http://www.nrcresearchpress.com/doi/abs/10.1139/x03-121#.VgkW5X33Ehk on 14 October 2003.

Szomorová, L., Halaj, P. and Čimo, J. (2013). *Analýza zrážkových zmien v lokalite Nitra*. In Veda mladých 2013. 1st ed. 1 CD-ROM (376 s.).. Veda mladých. Nitra : Slovenská poľnohospodárska univerzita, pp. 285-294, ISBN 978-80-552-1081-0

Takáč, J. and Zuzula, I.,(2000). *Adaptácia poľnohospodárstva v Slovenskej republike na klimatickú zmenu*, Národný klimatický program SR, V, ,zv.9.