International Journal of Horticultural Science 2011, 17 (1–2): 29–32.
Agroinform Publishing House, Budapest, Printed in Hungary
ISSN 1585-0404

Monitoring of water regime in an apple orchard

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Summary: Our investigation was carried out at an micro-irrigated intensive apple orchard in Debrecen-Pallag in 2010. The aims of the study were to monitor the effect of a compacted layer on soil water regime by tensiometers and supporting the water management of the orchard. The results suggest that the physical characteristic of the examined soil is sandy soil with low capillarity and total available water content. The soil water tensions were varied between pF 0 and 2.5 due to the extreme precipitation circumstances in 2010. Tensiometers in 40 cm depth resulted fast (few hours) and significant respond to precipitation than in the 70 cm soil layer. Based on daily measurements, the soils possess a daily fluctuation of soil moisture, however the changes become more moderate in deeper layers. In accordance with all of the results, the amount of drainable water regime was about 20.6 V/V% at 40 cm depth and 18.6 V/V% at 70 cm mainly. The harmful surplus water can be infiltrated by loosening of the compacted soil layer in 50–70 cm depth or led off by vertical drainage.

Keywords: apple orchard, surplus water, matrix potential

Introduction

The increasing frequency of extreme hydrological events (floods, water-logging, over-moistening and drought) due to the high territorial and temporal variability of atmospheric precipitation; the heterogeneous (micro) relief; and the unfavourable physical/hydrophysical characteristics of soils are pressing to improve agricultural water use efficiency and necessitates an efficient control of soil moisture regime in the Carpathian Basin (*Pálfai,* 2000; *Somlyódy,* 2000; *Várallyay,* 2002; 2007). Although orchards are relatively not highly water consumers comparison with cereal species, the insurance of optimal water capacity values by calculating breeding season irrigation and monitoring of soil moisture is one of the most important risk factors, especially on sandy soils. Besides drought, which can be successfully managed by irrigation, occurring surplus water often proves to be critical in the case of extreme humid years (*Juhász*, 2008).

Materials and methods

The examinations were carried out at a micro-irrigated intensive apple orchard in Debrecen-Pallag in 2010. The examination site is the part of the Experimental Pomology Site and Study-Farm of the University of Debrecen, Centre for Agricultural and Applied Economic Sciences. The aims of the study were to monitor the effect of a compacted layer on soil water regime and supporting the water management of the orchard. Since there is sandy soils at the examined orchard, and tensiometers can successfully be used on sandy soils to automate the monitoring of the soil water regime (*Tóth,* 1995), analogous tensiometers (*Figure 1.*) were chosen to measure the water tension, thus the matrixpotential of soils. The measurement interval of the tensiometers was pF 0–3. The examination period lasted from 1. June 2010. to 31. August 2010. The gauges were set at 6 sampling points in 40 and 70 cm depth. The soil moisture tension values were always measured in the morning at the same time. The measured tension values were converted to water height in cm so as the water content of soils can easily be determined if the pF curves of soils are known. The pF curves of the soil were measured in 40 and 70 cm depth in accordance with the MSZ-08-0205:1978 13 Hungarian standard.

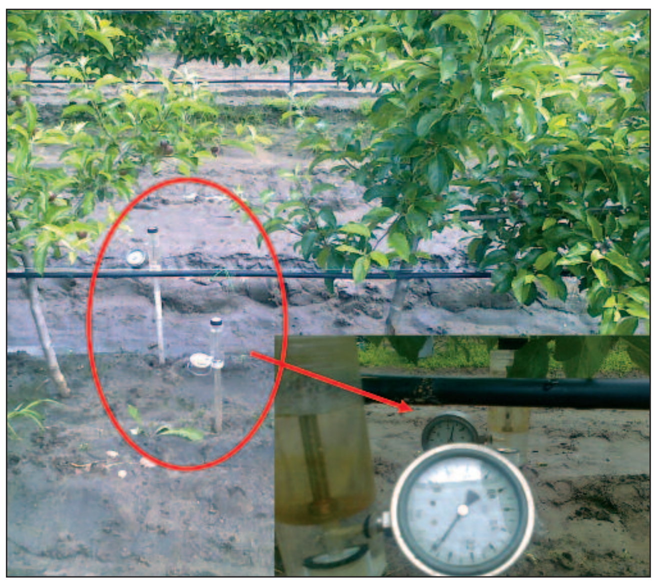


Figure 1: Tensiometers at 40 and 70 cm depth

The minimal pF=0 (VK_{max}) and maximal pF=0 (VK_{max}) waterholding capacities were also determined. The soil densities of the samples were measured in accordance with the MSZ-08-0205:1978 8 Hungarian standard. The geoinformatics assessments and interpolation of the results were carried out in Surfer 9 software environment.

Results and discussion

Soil density of the soil varies between 1.51–1.57 t m^{-3}. The measured pF curves are typical for sandy soils (*Figure 2.*). The watermanagement properties of soils can be determined by this pF curves.

The total available water capacity was 8.61 V/V% at 40 cm depth and 9.24 V/V% at 70 cm depth. The amount of water, that a soil doesn't hold against gravitational forces and could be drained, was 23 V/V% at 40 cm layer and 18 V/V% at 70 cm layer. Concerning these data, the examined sandy soil with low capillarity loses the great amount of its water content even in the case at low tensions. So the water retention of this soil is slight, and has small amount of total available water regime, which means that this soil can only satisfy the watercontent of the apple orchard for a short term dry period.

Despite the fact, that there is a sandy soil at the examined site, surplus water occurred at the whole vegetation period in

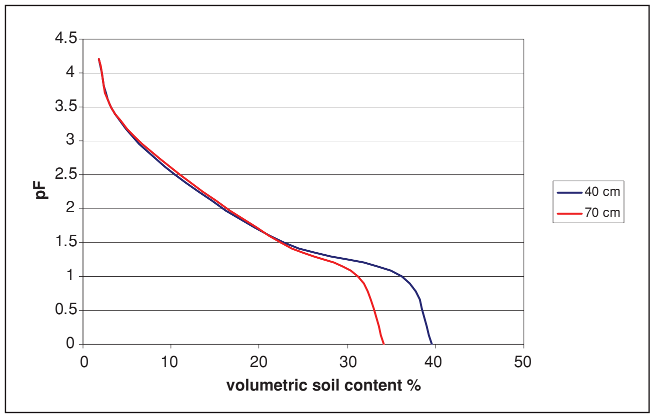


Figure 2: The pF curves of the examined sandy soils in 40 and 70 cm depth

2010, due to the frequent, intensive and large amount of precipitation (*Figure 3.*). The presence of surplus water was even supported by the presence of compacted layer at 40–60 cm depth (*Nagy and Tamás* 2009). Based on this study in the 20-30 cm soil layer the soil density reached and exceeded the 3MPa soil penetration resistance value, which is the threshold for the high soil density, according to measurements of *Birkás* (2002).

The soil water tensions measured by tensiometers varied between pF 0 and 2.5 due to the extreme precipitation circumstances in 2010 between 1. June and 30, which also showed the presence of excess water in soils. At the same

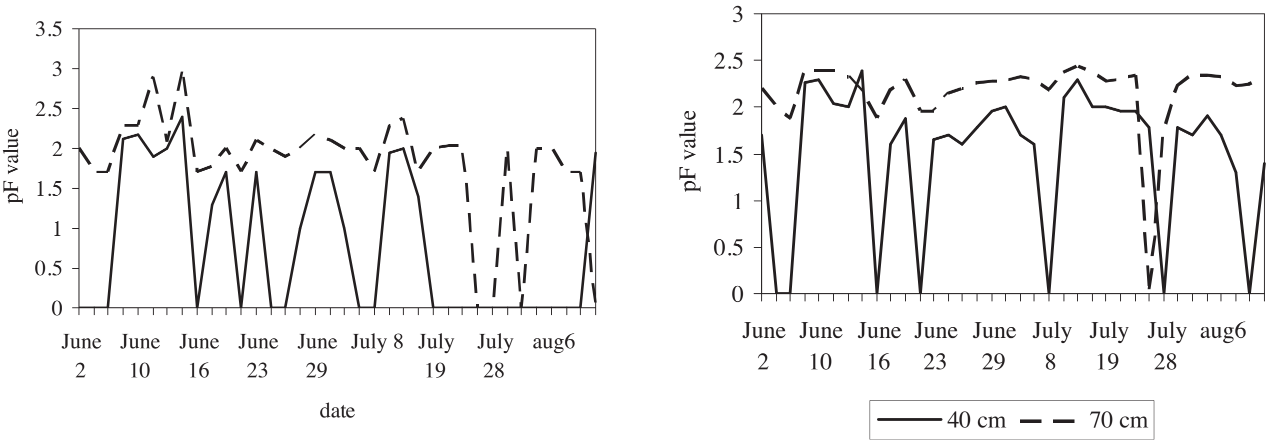
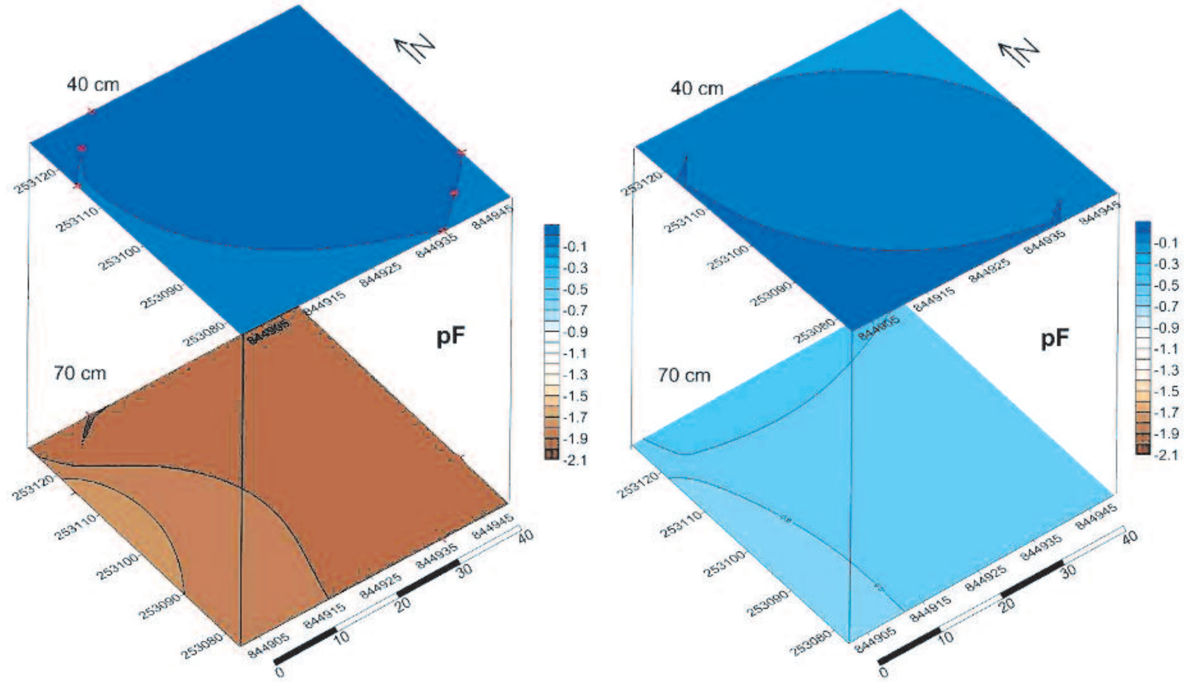


Figure 4: The pF changes in two sampling points



3. June 2010. 28. July 2010.

Figure 5: The pF in

time, the measured pF values represent the effect of the high intensive precipitation, fallen in the summer period, on soil water content (*Figure 4*).

Based on both of the soil moisture tension values and pF curves the rate of easily drainable gravitation pore volume was considerable. Tensiometers in 40 cm depth resulted fast (few hours) and significant response to precipitation; the tension was dropped markedly. While in 70 cm depth, rainfall had slight and slower (24–36 hours) effect on soil moisture tension due to the intensive water consumption from the root zone. Total water content was only measured at concerned dates, after long lasting heavy rainfalls, e.g. at the end of July (*Figure 5.*). This phenomenon also suspects the presence of a compacted layer at 40-70 cm depth.

Daily water tension measurements were carried out in 20 July and 12 August without any significant precipitation (*Figure 6.*), to monitor the daily changes of soil moisture regime. The changes were registered in every 30th minutes. Both in the 40 and 70 cm depth there were measurable changes in pF, so the soils possess a daily fluctuation of soil moisture, however the changes become more moderate in deeper layers, which was detected in the values of 70 cm depth. Due to the decreasing evaporation intensity, the pF values dropped markedly (till zero) in 40 cm depth from the evening hours, which means amount of soil water content was growing. Then the pF began to increase from dawn and reached 2 in the early afternoon due to the more and more intensive water consumption, evapotranspiration of the vegetation, and increased evaporation of soils. These results represent the suction effect of the apple trees at daytime and the horizontal and capillary water support in soils at night. Although, there weren't any rain in 20. July, but in the case of the measurement in 12. August, highly intensive precipitation started to fall at 8 A.M., of which effect occurred in the results as a slight decrease in pF at 9 A.M. and 9:30 A.M. measurements.

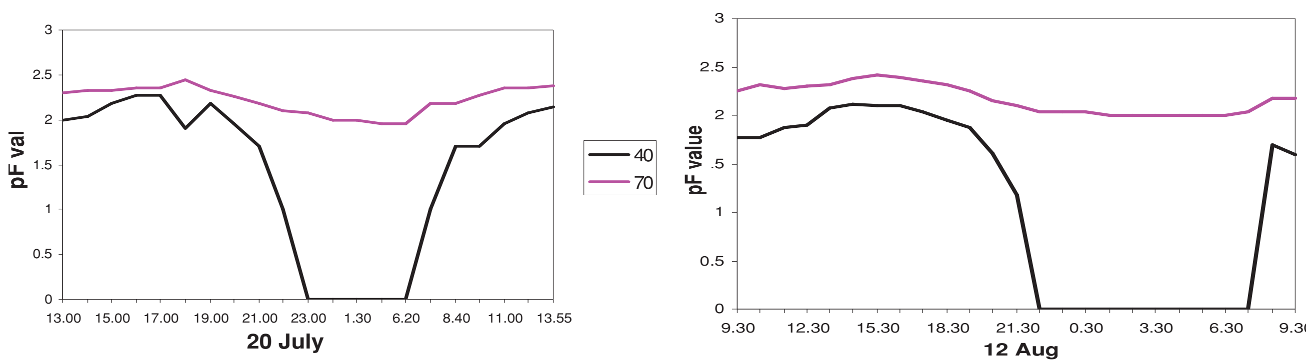


Figure 6: Daily fluctuation of pF

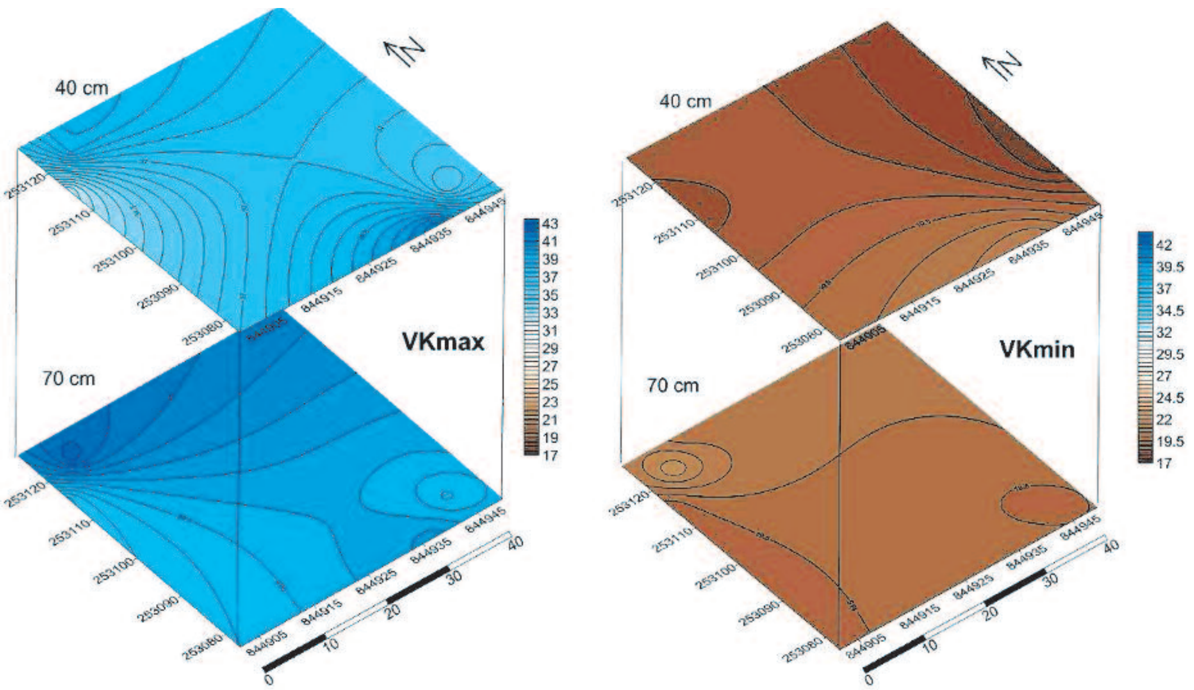


Figure 7: Total and field watercapacity of the soil layers

Permanent presence of surplus water causes anaerobic conditions in soils, which damages due to the insufficient root respiration and physiological processes. To determine the accurate amount of the drainable gravitation water regime total and field watercapacity was also measured and described in 3 dimensions (*Figure 7.*). In accordance with the results the amount of drainable water regime was about 20.6 V/V% at 40 cm depth and 18.6 V/V% at 70 cm mainly. These results differed slight from the measured pF curves, which probably due to the spatial heterogeneity.

Conclusion

The total drainable water regime is 920 m^3 ha^{-1} from the upper 40 cm soil layer and 1460 m^3 ha^{-1} from the upper 70 cm soil layer. This amount of water should have been drained several times in 2010 to prevent the orchard from the negative effect of surplus water. Since the conventional horizontal drainage system can damage the present apple orchard significantly, the harmful surplus water can be infiltrated by the loosening of the compacted soil layer in the 50–70 cm depth or led off by vertical drainage. Therefore one, solo knife coulter is suggested to use at 80–90 cm depth. The narrow loosening width does not injure considerably the pomaceous tree root zone, but the surplus water can be infiltrated to deeper soil layers. Thus the harmful effects (fruit crack, fruit drops, tree necrosis) can be prevented.

Acknowledgement

Research was sponsored by NFÜ TECH_08-A3/2-2008-0373 and TECH_08-A4/2-2008-0138 grants.

References

Birkás, M. (2002): Környezetkímélő és energiatakarékos talajművelés. Akaprint Nyomdaipari Kft.

Juhász, Cs. (2008): Vízgazdálkodás. In.: Agrárium és környezetgazdálkodás. Szerk.: Tamás J. Mezőgazda Kiadó. Budapest,

Nagy, A. & Tamás, J. (2009): Integrated airborne and field methods to characterize soil water regime. [In: Celkova, A. (ed.) Proceedings of peer-reviewed contributions, Transport of water, chemicals and energy in the soil-plant-atmosphere system] Institute of Hydrology, Slovak Academy of Sciences, Bratislava, 412–420.

Pálfai, I. (2000): The role and significant of water in the Hungarian Plain. (In Hungarian) Nagyalföldi Alapítvány, Békéscsaba

Somlyódy, L. (2000): Strategy of Hungarian water management (In Hungarian). MTA Vízgazdálkodási Tudományos Kutatócsoportja, Budapest, 370. p.

Tóth, Á. (1995): Az esőszerű és mikroöntözés gyakorlata. KITE RT. Nádudvar

Várallyay, Gy. (2002): The role of soil and soil management in drought mitigation . In: Proc. Int. Conf. On Drought Mitigation and Prevention of Land Desertification, Bled, Slovenia, April 21–25 ICID-CIIC. (CD)

Várallyay, Gy. (2007): Soil resilience (Is soil a renewable natural resource?). Cereal Research Communications, 35: 1277–1280.