Comparison of nuclear and non-nuclear techniques to measure the soil moisture content

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Abstract

Soil moisture measurement helps to improve the soil water management for better irrigation scheduling and growing of appropriate crops. It is of prime importance to select the right methodology for soil water monitoring. Measuring soil moisture by gravimetric method is time consuming and difficult to apply for long-term studies. Therefore, accurate soil moisture measuring methods should be introduced.

A study was conducted to compare the newly improved continuous type nuclear and non-nuclear soil moisture measuring techniques in Seibersdorf, Austria during May - September 2002. The neutron probe was used as the nuclear technique for measuring soil moisture. Time Domain Reflectrometry (TDR) meter and capacitance sensors (Diviner 2000 and EnviroSCAN)) were used to measure soil moisture as non-nuclear techniques.

The suitability and advantages of each instrument were evaluated in a spring wheat field. The soil moisture measurements obtained by above mentioned instruments were compared with the standard gravimetric method. The results revealed that there was no significant difference in soil moisture values obtained by neutron probe method and Diviner 2000 method, compared to the soil moisture measurements obtained by gravimetric method. The good agreement could be due to the larger sphere of measurement of the neutron probe, making small spatial variability due to the in homogeneity of the soil. However, the EnviroSCAN and the TDR either over- or under-estimates soil moisture. The results revealed that both nuclear (neutron probe) and non-nuclear (Diviner 2000) techniques could be applied to measure moisture content of soil.

Keywords: Diviner 2000, Neutron probe, irrigation, water management

Introduction

Water scarcity is a serious problem worldwide. In developing countries, Agriculture uses up to 80% of available water; however, crop-water productivity is often low. Effort is needed to improve the management of this precious and finite resource.

Soil moisture management can help to improve the management of water by better scheduling of irrigation and growing of appropriate crops. Choosing the right instrument for soil water monitoring is equally crucial.

Neutron probe (SMNP) has been the widely used technique for measuring soil moisture in recent years, nevertheless non-nuclear techniques (such as the Time Domain Refrectrometry (TDR) capacitance sensors (Diviner 2000 and EnviroSCAN) are gaining popularity in the recent past.

Materials and Methods

A spring wheat field experiment was conducted at Seibersdorf experimental field in Austria. The aim of the experiment was to compare the neutron probe techniques with non nuclear techniques such as capacitance approaches (e.g. EnviroSCAN and Diviner 2000), time domain Reflectrometry (TDR) for soil water content and to compare the advantages and disadvantages of the soil water measuring techniques.

There were four major treatments in the experiment A, B, C, and D (Fig. 1)

A- Irrigated field with fertilizer application.
B- Irrigation without fertilizer application.
C- Reinfed condition without fertilizer.
D- Rainfed with fertilizer application.

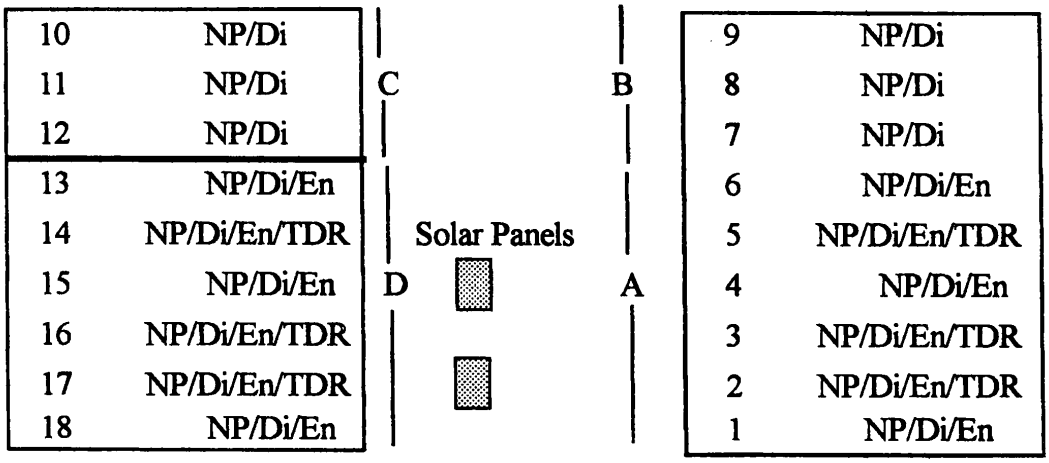

Fig. 1: Layout of the experiment

NP- Neutron probe, DI- Diviner 2000, EN- EnviroSCAN,
TDR- Time Domain Reflectrometry

Within the four treatments there were 18 plots with a total area of 532 m^2. Access tubes for neutron probe (NP), Diviner 2000 (Di), EnviroSCAN (En) were installed in the plots. According to the layout (Fig.1) TDR probes were installed up to 60 cm depth at 0-20cm, 20-40cm and 40-60cm intervals. Two solar panels for EnviroSCAN were also installed within the field.

In the field plots, (ABCD) soil moisture measurements were conducted by the different methods. Results obtained from all the plots were averaged.

Nuclear and non-nuclear methods of measuring soil moisture were compared with standard gravimetric method. The irrigation was done using sprinkler irrigation system and fertilizer rate was 200 kg N/ha of urea. Data collection was carried out twice a week. In addition, soil samples were taken at 10cm to 40cm depth in 10cm intervals from 6 of the plots for gravimetric moisture determination on 18th July 2002.

Results and Discussion

The rainfall distribution on spring wheat field from April to mid August is shown in Fig.2. It was clear that there has been sufficient rainfall throughout the summer, so that irrigation is not a critical component of this study.

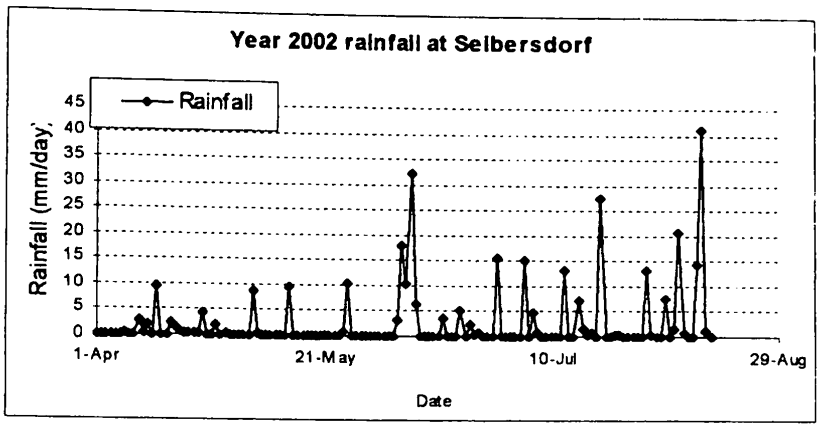

Fig. 2: Rainfall at Seibersdorf

The average soil moisture profiles measured using the various techniques (Soil moisture neutron probe (SMNP), EnviroSCAN, Diviner and TDR) are given in Figs. 3-6. There was no significant difference between fertilized and non-fertilized treatments.

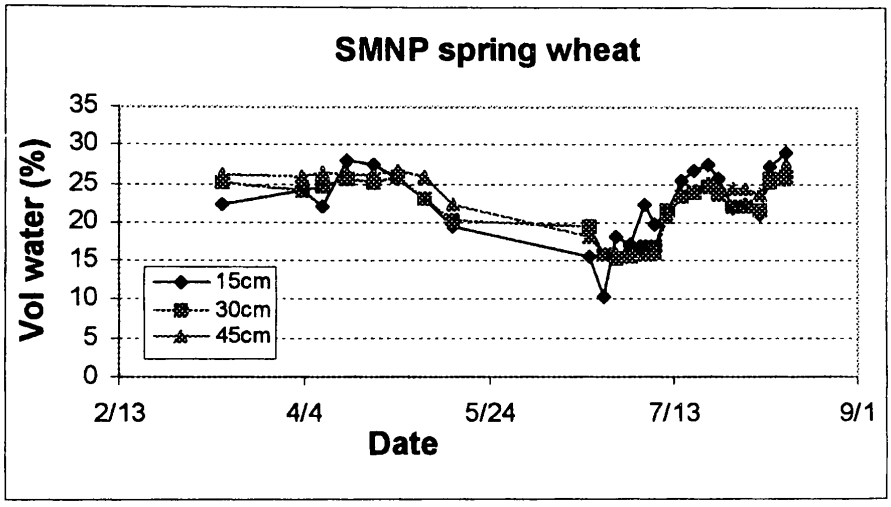

Fig. 3: Soil moisture measurement obtained using neutron probe

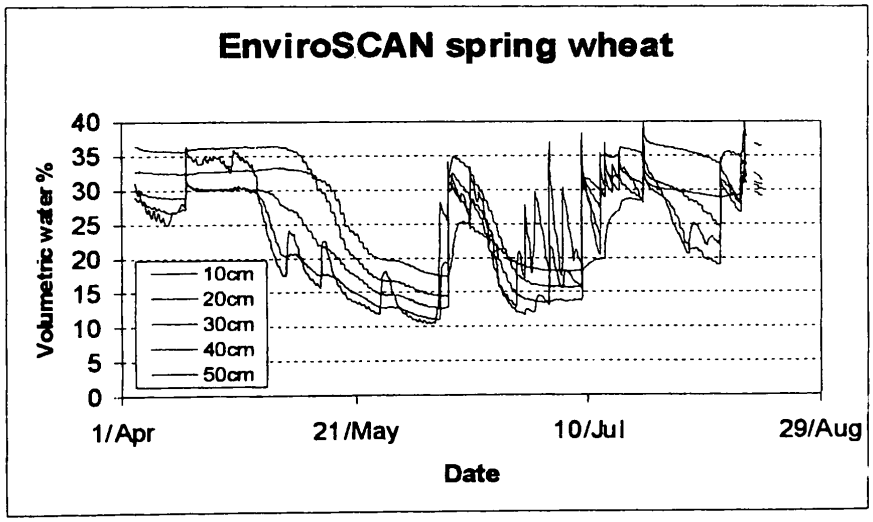

Fig. 4: Soil moisture measurement obtained using EnviroSCAN

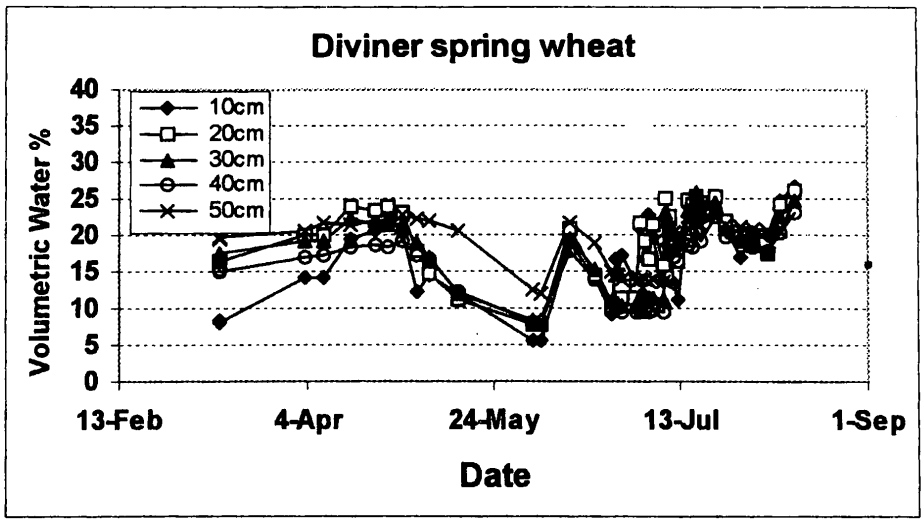

Fig. 5: Soil moisture measurement obtained using Diviner 2000

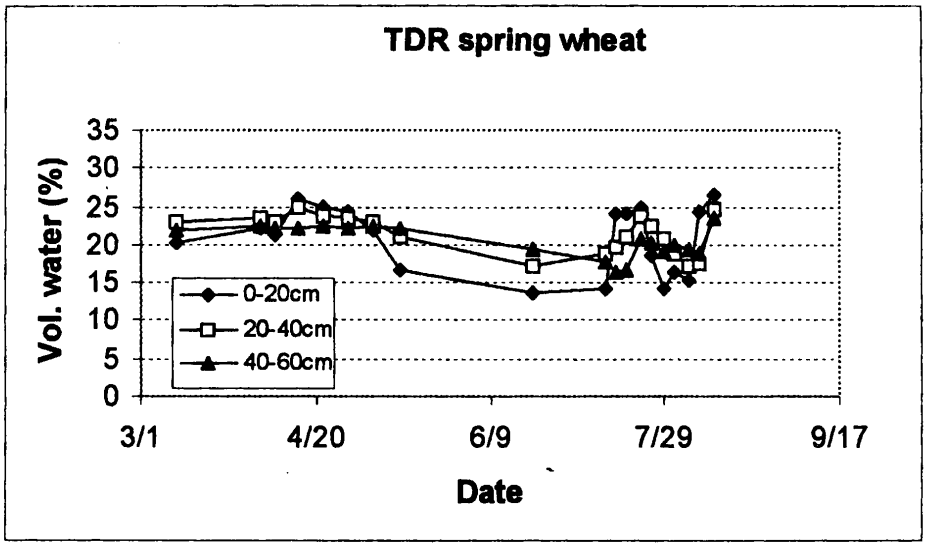

Fig. 6: Soil moisture measurement obtained using TDR

The results of the comparison of soil moisture content measured by different methods are shown in Fig. 7.

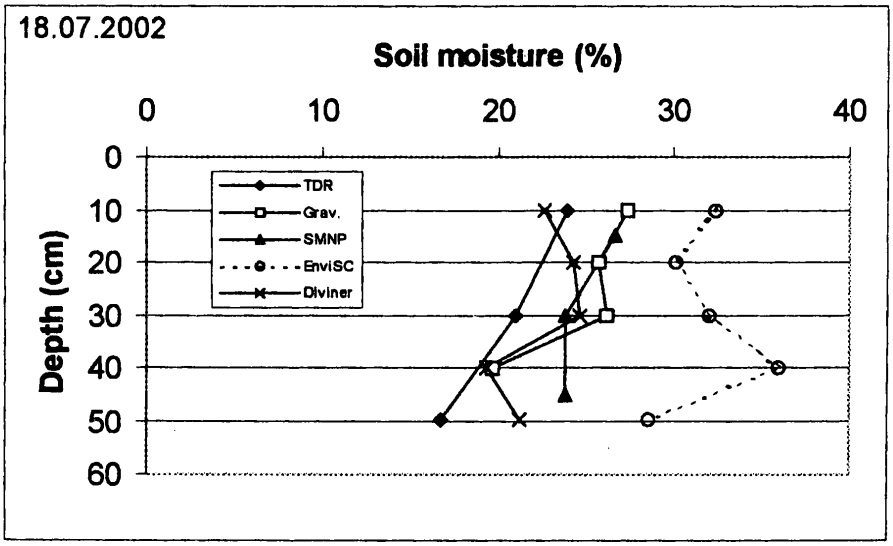

Fig. 7: Comparison of various soil moisture techniques with the gravimetric method

It can be observed that the soil moisture measured by neutron probe agreed very closely with the gravimetric method. The good agreement could be due to the larger sphere of measurement of the neutron probe, making small spatial variability due to the homogeneity of the soil. The Diviner 2000 also showed good agreement. However, the EnviroSCAN and the TDR either over- or under-estimates soil moisture. These results showed that one has to be very careful when choosing the right sensor for soil water measurement.

Conclusion

Neutron probe method, standard gravimetric method and Diviner 2000 method can be successfully used to measure soil moisture. However, soil moisture values, obtained from neutron probe method, were more closer to standard gravimetric method than Diviner 2000 method.

EnviroSCAN and the TDR methods have a significant difference with gravimetric method, in soil moisture estimations. Therefore all sensors cannot be recommended for soil moisture measurements in different soils.

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