Equitensiometer*

- Worldwide, the first highly accurate instrument for measuring soil matric potential
- Due to a patented technique long-term measuring stability
- Cover the whole range of soil water potential in which plant growth occurs (0- -1500 kPa or 0- -15 bar)
- Individually calibrated sensors
- Maintenance-free for outdoor conditions, not affected by over-range
- Independent operation on a wide range of soil types and conditions
- Very low power consumption
- Easy installation
- Data recording with data logger or display with simple voltmeter
- More than 5 years field testing

Type EQ15/Adapter: Equipped with screw adapter to connect with an extension tube, enabling deep soil installation

There are two types of Equitensiometers available. The two are identical sensor types except for the adapter, which allows deep soil installation.

Type EQ15/Basic: Basic version for use in shallow soil

What is matric potential?

There are two ways to measure soil moisture status, namely: Soil water content (SWC) and soil water potential (ψs). Soil water content describes the amount of water in a given amount of soil relative to the mass of oven-dried soil. Metric potential (ψm), defined as the amount of work that must be done per unit quantity of pure water in order to transport reversibly and isothermally an infinitesimal quantity of water, identical in composition to the soil water, from a pool at an elevation and the external gas pressure of the point under consideration (Glossary of Soil Science Terms, Soil Science Society of America (SSSA), July 2000). If the specified quantity is volume, the potential is referred to as pressure (Pascal). Matric potential (=suction, moisture tension resulting from combined effects of capillarity and adsorptive forces within the soil matrix) is the main component of total soil water potential. In non-saline soils the total soil water potential (ψs) is equal to the matric potential.

* Patented

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Why we need matric potential?

Plant-water relation studies require information on soil water availability (dryness of soil). Soil water availability is expressed as soil water potential (ψs), and not water content (swc). The two are however, related parameters:

Soil Water Availability = *Water Potential* = *f*(*Water Content, Soil Properties*)

Soil water availability is, therefore, accurately described by its water potential, which is a function of water content and the soil properties. It is not possible to derive water availability only from its water content. For example, a given plant could be turgid and growing very well in a sandy soil with 10% water content, but in clay soil with the same water content, the same plant could be wilting and dying.

Even if data on both water content and soil properties are available, the derivation of water potential from them is not simple, calling for actual measurements of soil water potential.

Due to lack of practicable instruments for measuring soil water potential under field conditions scientists have often used water content measurements to study soil-water–plant relationships. The disadvantage of such water content related studies is that the results cannot be reproduced and compared under different soil conditions. Many scientists have been working on plant-water relations to assist farmers identify the threshold value for irrigation water supply and several publications exist to the effect. However, none is able to answer the question; “How much soil moisture should I keep to meet optimal demands of my plants?” On a global context, this has lead to enormous loss of water resources. This problem could be solved, if we used soil water potential instead of soil water content for our research works and in water resource management.

Principle of operation

Equitensiometer consists of two parts: water content sensor and equilibrium body. The water content sensor is permanently attached to the equilibrium body and determines the water content in the equilibrium body instantaneously. The equilibrium body has a stable soil moisture characteristic. During measurements, the equilibrium body acquires matric potential of the surrounding soil and this is recorded by the water content sensor and converted into matricpotential.

Comparison of techniques for measuring matric potential

The concept of describing soil water availability for plants using water potential (Ψ) is known since 1907 (E. Buckingham). Scientists and engineers long recognized the importance of this measure and several attempts have been made in the last century to build equipment that can directly measure soil water potential (Ψs). Currently, there are only three existing techniques available namely; tensiometer, resistance block (gypsum block, watermark) and psychrometer. All the three techniques however, have practical limitations with regard to range of operation, accuracy and costs. Accurate monitoring of soil water potential under outdoor conditions is still a pipe dream for many scientists.

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Comparison of techniques for measuring matric potential

Techniques	Range (kPa)	Advantages	Disadvantages
Resistance blocks	-100- -700	1. Inexpensive	1. Must be calibrated individually by user 2. Unreliable measurement 3. Just for rough estimating the matric potential
Psychrometer	-200- -10000	1. Useful in very dry soil 2. Measures totals water potential	1. Does not function in wet soil 2. Sensitive to temperature gradients in the soil 3. Expensive 4. Not suitable for outdoor conditions
Tensiometer	0- -85	1. Relatively reliable	1. Does not function in dry soil 2. Costly maintenance and service 3. Not suitable for monitoring water availability for plants
Equi-Tensiometer	0– –1500	1. Relatively reliable 2. Covers the whole range of matric potential for plant growth 3 Maintenance-free measurement	1. No linear output

Working with Equitensiometer

● Accuracy and Range

Equitensiometers are individually calibrated during production and every sensor has its own calibration certificate. This guarantees high sensor accuracy. A standard version sensor has a measuring range from 0 to -1500 kPa (0- -15 bar). For special requirements, the range can be extended up to -2500 kPa (fig. 1), but with reduced accuracy. A refill such as in transducer tensiometer is also not necessary.

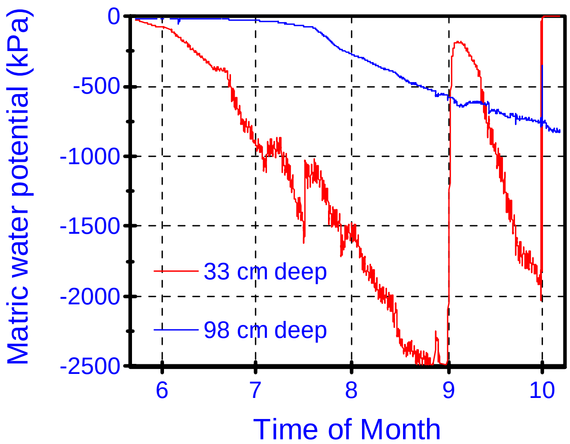

Fig. 1: Course of matric potential in a Quercus suber Stand

● Effect of soil properties on the measurements

Unlike water content, water potential is an absolute measure and is independent of physical soil properties. For this reason the performance of Equitensiometer is not affected by the variation of physical soil properties (density, clay/sand/stone content and organic matter content).

The matric potential is derived from water content read within the equilibrium body. This is a decisive deviation from the gypsum block, which converts the electrical conductivity of soil solution to matric potential and is very sensitive to conductivity of soil solution. Thus the EQ15 operates within a wide range of conditions and is independent of the soil chemical properties (fig. 2). However, in saline soils with conductivity>1 m S/cm, the results may be shifted to the dry range.

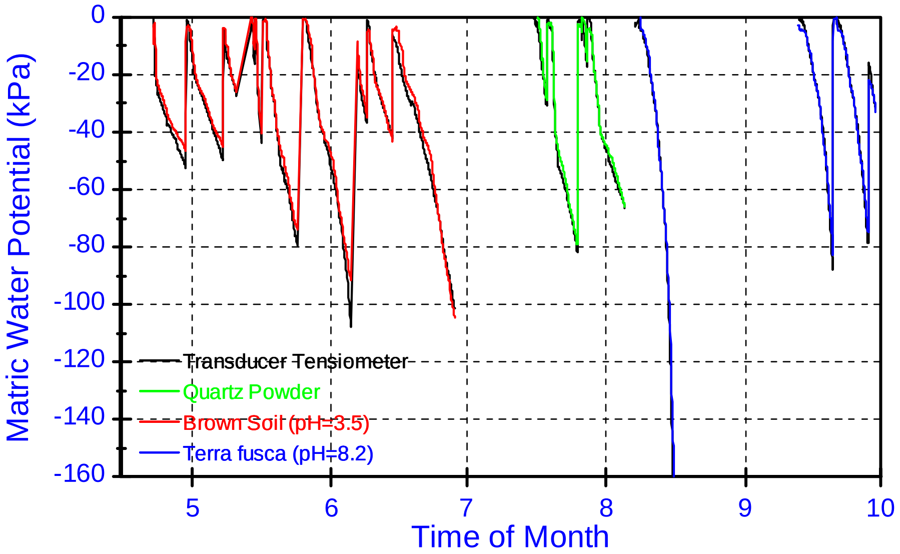

Fig. 2: Comparing EQ15 with transducer tensiometer (black line) in different soils: April 20, to June 28. in brown soil (pH=3.5, red line); July 15, to August 8 in Quartz powder (green line), and August 8, to September 30, in Terra fusca (pH=8.2, green line). In the pH range 3.5 to 8.2 no effect of soil chemical properties on the results of EQ15 could be detected.

- **Hysteresis**

Equitensiometer is especially suitable for continuously monitoring matric soil water potential. The equilibrium body consists of materials with higher water conductivity than any soil types. Under natural rains or irrigation conditions, the sensor can accurately follow any changes in soil matric potential without hysteresis (see fig. 3). But under artificial conditions if the matric potential is rapidly changed by more than 20 kPa/minute, the sensor may show hysteresis. This property limits instantaneous measurements with the Equitensiometer.

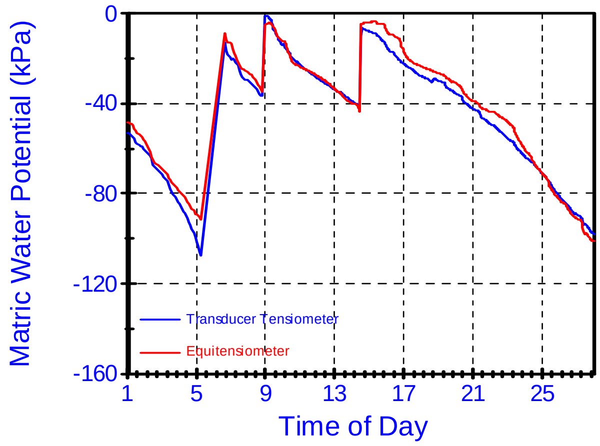

Fig. 3: Comparing the sensitivity of the EQ15 (red line) with transducer tensiometer (blue line). The soil was periodically irrigated. Either during the wetting or drying phases there were no significant differences between both sensors.

- **Installation**

Equitensiometer is easy to install. The sensor is installed at the desired depth by burrowing and refilling the hole. In case of stony soil the sensor should be covered with quartz powder (or soil material with particle size between 20 to 100 µm) to improve the contact between the equilibrium body and soil. For installation in deep soil the use of the type EQ15/Adapter with an extension tube is recommended. The disturbed soil structure does not affect the sensor performance.

- **Data recording and Data processing**

The Equitensiometer output is volt and ranges between 100 and 1000 mV. Any data logger with function of voltage measurement can be used for continuous data recording. For dis-continuous measurements, the data can be read out with a simple voltmeter. Ecomatik supplies different logger types for different requirements.

Each Equitensiometer is provided with its own calibration certificate (fig. 4), which gives the relationship between mV output, as read

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by the Equitensiometer, and its corresponding matric water potential in kPa. With the calibration certificate (fig. 4), the data output can easily be automatically converted into kPa by data logger or by calculating using a computer.

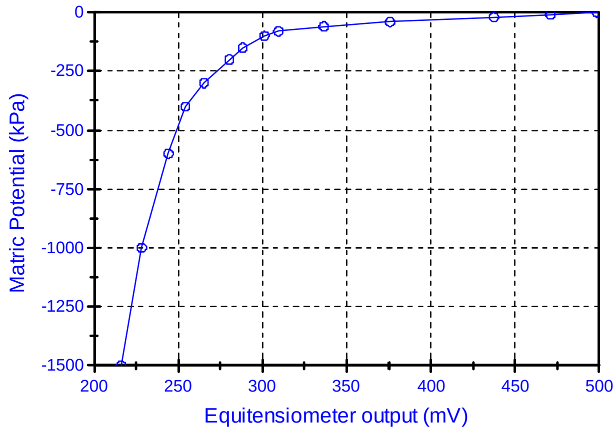

Fig. 4 Typical Calibration data of Equitensiometer

- **Long term measurements**

Fig. 5 shows results from Equitensiometer, when measurements were conducted in two neighbouring spruce and beech stands in Bavaria. The sensors worked for more than two years without any servicing.

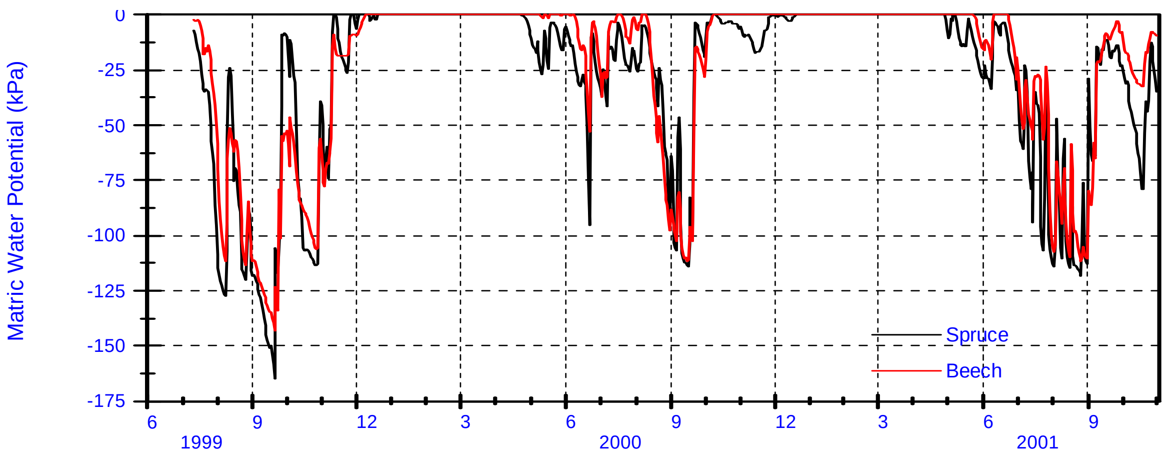

Fig. 5 Matric water potential in two neighbouring spruce and beech stands in Bavaria continuously measured with Equitensiometers. Corresponding to the transpiration characteristics the soil under spruce stand in Spring and in late Autumn is dryer than under beech stand (Unpublished data of Technical University of Munich).

Technical specification

Measuring parameter	Matric potential of soil.
Range	0 to –1500 kPa (0 to –15 bar).
Accuracy	Between 0 kPa and -100 kPa: ±10 kPa. Between -100 kPa and -1500 kPa: 10%.
Hysteresis	Very low, can accurately follow any changes of matric potential in soils.
Use area	Monitoring of soil hydrology, plant physiology, soil water status, Irrigation control etc.
Environment	Wide ranging soil types for long periods.
Interface	Input requirements: 5-15 V DC, Current consumption: max. 23 mA, Output signal: 100 -800 mV DC.
Case material	Stainless steel.
Dimensions and weight	Length × width × thickness = 17 cm × 4 cm × 2 cm, standard cable length: 5 m, max. Length: 100 m, weight: 350 g without cable.

Ordering Information

EQ15/Basic	Basic version for use in shallow soils
EQ15/Adapter	Equipped with a screw to connect with an extension tube, enabling installation in deep soils.
EQ15/Tube-1m **EQ15/Tube-2m**	1 m PVC extension tube. 2 m PVC extension tube.
EQ15/Cable	Additional cable fitted to EQ15. Max. recommended length 100 m.
Quartz powder	To improve the contact of EQ15 to soil, recommended for use in stony soils.
Data Logger	On request.

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Papers related to Equitensiometers

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