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Operation instructions Tensiometer

Description
Your Tensiometer is a precision instrument, measuring the soil moisture. Measuring the moisture of soil shows the necessity to irrigate plants, and helps to manage amount and frequency of irrigation water applications. Only plants growing under optimal soil moisture, can produce best results.



Your Tensiometer consists of:
1. the ceramic tip with Micropores
2. the shaft of transparent acrylic pipe (during operation filled with water)
3. the manometer with color range
4. the always airtight seal

The manometer measures low tension (soil water potential) in the area of 0 to -600 hPa (= mbar). It is a tool of the precision class 1.6, i.e. the maximum deviation is ± 1.6% of the shown value.
The green area of the color range shows the optimal soil moisture level for most vegetables, softfruit and Treecrops. This applies to all common kinds of sand-, silt-, loam- and clay soils.

Interpretation of the color range:
The manometer of your Tensiometers is equipped with a color range for easy interpretation of the soil moisture readings. This special feature enables also unskilled workers to use this equipment successfully.

Blue	(0 to 80 hPa)	Too wet
Blue green	(80 to 100 hPa)	Surface is water filled but not too wet
Green	(100 to 350 hPa)	Optimal soil moisture
Green orange	(350 to 450 hPa)	Beginning dryness (water gift possible)
Orange	(450 to 500 hPa)	Give water!
Orange red	(500 to 550 hPa)	High time to give water !!
Red	(550 to over 600 hPa)	Too dry -- dryness stress !!!

Precautions
To avoid damages to your Tensiometer, the following precautions must be observed:
- The components of the Tensiometer must be protected from shocks (do not drop on the ground, do not beat the instrument with a hammer into the soil etc.)
- The Tensiometer may not be exposed to temperatures below 0° degrees Celsius as long as it is filled with water
- The ceramic mustn't come into touch with grease, oil or other substances which could close the pores

Field of application
Per management unit (a management unit is an area with similar soil conditions, the same plant type and same development stage of the plants, like a bed) one Tensiometer is needed. To receive information about the penetration depth of the irrigation water or the water withdrawal of the plants from different layers of soil, additional Tensiometers can also be installed in different depths (e.g. 50 or 100 cm).

Operation Principle
Your Tensiometer measures the sucking tension of water in soil (= soil water potential), i.e. it measures the strength by with the water is held back in the soil, and thus also the power plant roots must apply to extract water from the soil.

For operation the Tensiometer-shaft is filled with water up to approx. 1 cm under the top edge of the shaft, after the manometer is put on airtight (turn around slightly, like a cork in a bottle). The water in the Tensiometer is in connection with the water of the surrounding soil by water bridges through the pores of the ceramic tip. If the soil dries, the soilwater "pulls" at the water inside the Tensiometer and a low pressure develops inside the

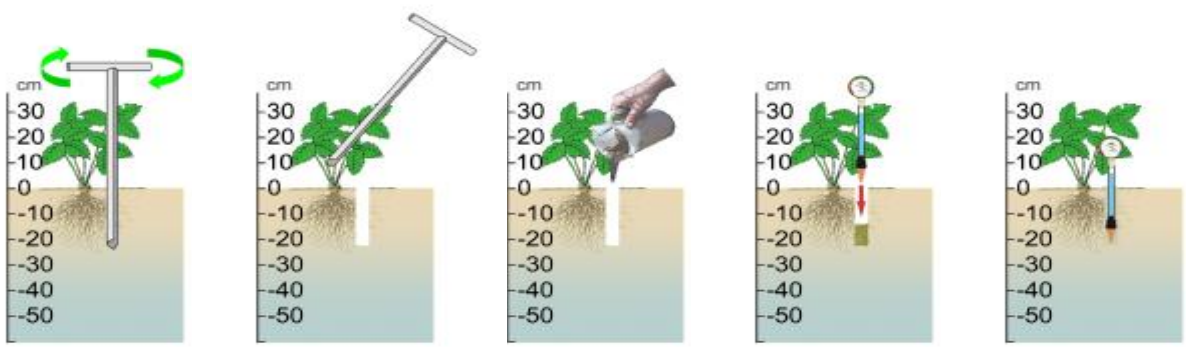
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Tensiometer-shaft, which is measured. This low pressure corresponds to the sucking tension (= soil water potential). Of course this process also works backwards, i.e. after an irrigation-event or rainfall the force with which the water is held back in the soil is less than the low pressure inside the Tensiometer. As consequence the Tensiometer "draws in" water over the porous ceramic tip from the surrounding soil and the low pressure in the Tensiometer decreases. After a water gift it lasts about 15 to 30 minutes until the Tensiometer shows the "true" value. This is so, because the water takes some time to penetrate into the deeper layers of soil. To obtain the exact value, it is necessary to substract the length of shaft (in cm) from the value the manometer is showing.

Putting into operation
The ceramic tip of the Tensiometer should be watered before the installation. To do this it is best to put the Tensiometer (without manometer put on) into a container with water overnight. The inside of the Tensiometer is not filled with water, however. In the morning after some water should have collected inside the Tensiometer shaft. Before the installation the shaft of the Tensiometer is filled with water up to about 1 to 2 cm under the top and the manometer is pushed, under easily shifting, into the shaft until it sits airtight.

Where shall the Tensiometer be placed?
First the measuring location must be fixed. The measuring spot shall be representative of the soil moisture for the complete field. Therefore eliminate the edges of the field, also the soil should correspond to the prevailing soil conditions on the total field. Furthermore the measuring location should be at an "average" plants. Therefore the plants in the immediate neighborhood of the measuring location should be neither too weak nor extraordinarily strong. If a field shows very variable soil-types, it is advisable to use several Tensiometers.
For the control of the water gifts the Tensiometer shall be installed in the main root zone. E.g. an installation depth of approx. 20 cm has proved to be favorable at many vegetable and softfruit cultures. Please see the enclosed table for more exact notes.

Installation of the Tensiometer to the soil
Tensiometers are installed under moist (not wet) soil conditions. Usually they remain at their site during a complete growing season. Tensiometers must, however, be recollected from fields, and emptied of water before the first frost (winter).
For the installation a hole of 30 to 35 mm of diameter down to a few cm under the desired depth is drilled (example: If the Tensiometer shall be installed at 20 cm under the soil surface, a hole of 23 to 25 cm depth is drilled).
Suitable for drilling the hole are normal soil augers (drills) for taking soil samples. But also a metal tube (best cut open at the side) can be used instead of the soil auger. Please use no solid stick or rod because the soil is compacted strongly with that type of tool around the hole and the measurements are biased by this.
After the hole is drilled, surface material is put through a sieve or screen to remove any rocks. The soil then is mixed with water to obtain a thick slurry (best consistence like Porridge). A smaller portion of this slurry is then poured into the Tensiometer hole so that the slurry is sitting in the hole at about 10 cm high.
Afterwards the Tensiometer is pushed carefully into the slurry down to the desired depth (work with caution, do not apply too heavy pressure!). The top 5 to 10 cm of the shaft is still above the surface after achieving this depth. The remaining gap between Tensiometer shaft and hole is then filled in with the soil slurry. On sandy soils it works best to wash in the soil between Tensiometer shaft and hole with water. It is most important to achieve good contact between the ceramic tip of the Tensiometer and the surrounding soil.
After the installation, the soil moisture in the immediate surroundings of the Tensiometer must adjust with the soil moisture of the rest of the field. Because of this, it lasts approximately 1 hour up to a half day (depending on soil type) until the Tensiometer can deliver the first meaningful measurements.

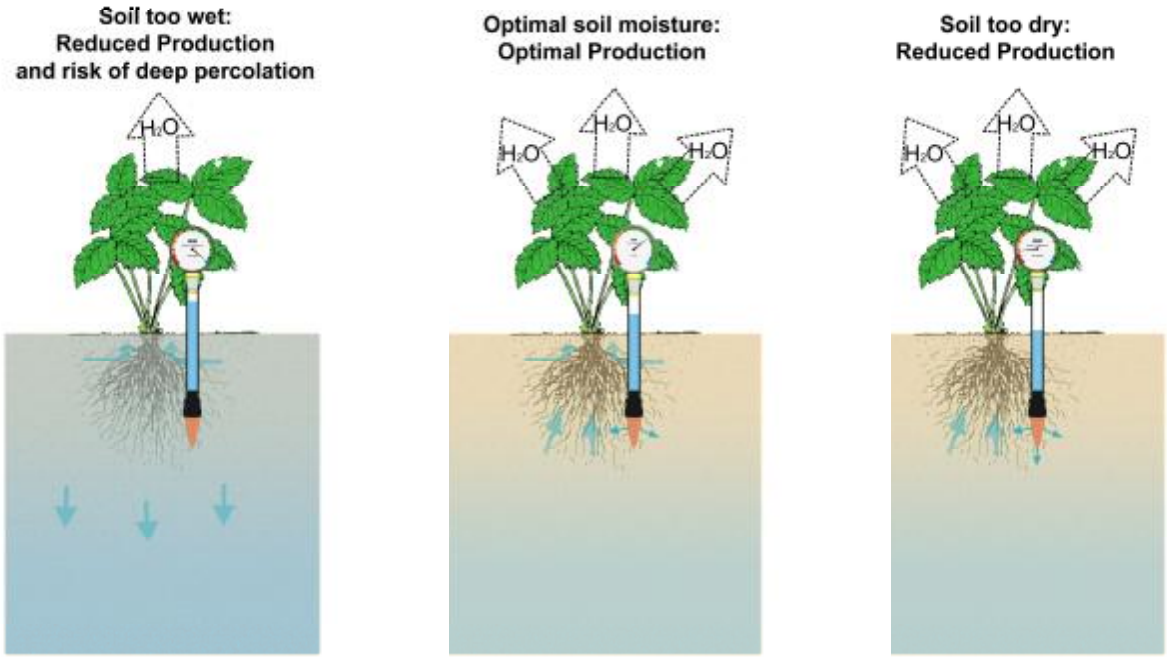


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Solving potential Problems

Your Tensiometer can keep water up to a sucking tension of about -700 to -850 hPa. Should the sucking tension increases to higher values, (i.e. the surface dries out beyond this value), the water is sucked out completely from the Tensiometer and the manometer shows the measurement zero. In this case air will penetrate into the inside of the Tensiometer, and the water bridges are cut.

Problem	What to do
The manometer shows zero, and no water is in the shaft	1. Fill the tensiometer with water and put on manometer airtight 2. check the ceramic tip for fine cracks and other damages 3. Check if all seals are undamaged
manometer shows zero, water is in the shaft	1. Is the manometer airtight put on the shaft? 2. Is the manometer seal undamaged?
Manometer shows dryness (high sucking tension) but the surfaceis wet	1. Has the ceramic tip good soil contact? (evetually relocate the Tensiometer) 2. Please contact MMM tech support



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Table: Crop specific recommended soil moisture levels and typical measuring depths

Crop	Recommended soil moisture	Typical measuring depth	When irrigate?
Aubergine	100 to 450 hPa	20 cm below surface	Flower & fruit formation
Apple	100 to 350 hPa	30-40 cm below surface	Volume increase
Apricot	100 to 400 hPa	30-40 cm below surface	Volume increase
Pear	100 to 500 hPa	30-40 cm below surface	Volume increase
Cauliflower	100 to 350 hPa	20 cm below surface	Head development
Annual Flowers	100 to 350 hPa	15-20 cm below surface	Pemanent
Broccoli	100 to 250 hPa	20 cm below surface	Head development
Dwarf beans	100 to 350 hPa	30 cm below surface	Flowering
Chinese cabbage	100 to 250 hPa	20 cm below surface	Permanent
Pickling Cucumbers	100 to 350 hPa	20 cm below surface	Flower & fruit formation
Strawberries	100 to 250 hPa	20 cm below surface	Fruit formation & harvest
Green peas	100 to 350 hPa	30 cm below surface	Flower
Kale	100 to 250 hPa	30 cm below surface	Permanent
Huckleberry	100 to 300 hPa	20 cm below surface	Flower & fruit formation
Raspberry & Blackberry	100 to 350 hPa	30 cm below surface	Flower & fruit formation
Red currant	100 to 500 hPa	30 cm below surface	Flower & fruit formation
Carrot	100 to 450 hPa	20 cm below surface	Shoots, volume increase
Potato	100 to 350 hPa	30 cm under dam	After the flowering
Cherry	100 to 350 hPa	30-40 cm below surface	Volume increase
Cabbage	100 to 350 hPa	20 cm below surface	Head development
Potherbs	100 to 250 hPa	15 cm below surface	Permanent
Pumpkin	100 to 250 hPa	20 cm below surface	Volume increase
Melon	100 to 250 hPa	20 cm below surface	Volume increase
Mirabelle	100 to 500 hPa	30-40 cm below surface	Volume increase
Peppers	100 to 450 hPa	20 cm below surface	Flowering to ½ fruit size
Parsnip	100 to 500 hPa	20 cm below surface	Volume increase
Peach	100 to 400 hPa	30-40 cm below surface	Volume increase
Plum	100 to 500 hPa	30-40 cm below surface	Volume increase
Porre/Leek	100 to 250 hPa	20 cm below surface	Permanent
Radish	100 to 250 hPa	15 cm below surface	Permanent
Brussels sprouts	100 to 250 hPa	20 cm below surface	Rose development
Salads	100 to 250 hPa	15 cm below surface	Head development
Chip cucumbers	100 to 450 hPa	20 cm below surface	Flower & fruit formation
Celery	100 to 250 hPa	20 cm below surface	Permanent
Mustard	100 to 250 hPa	30 cm below surface	Permanent
Asparagus young plant	100 to 300 hPa	30 cm below surface	After leaf formation
Asparagus yield plant	100 to 500 hPa	50 cm under dam	After leaf formation
Spinach	100 to 250 hPa	15 cm below surface	Permanent
Scarlet runners	100 to 350 hPa	30 cm below surface	Flower
Tomato	100 to 450 hPa	30 cm below surface	Volume increase
Grapes	100 to 500 hPa	40 cm below surface	Volume increase
Zuccini	100 to 450 hPa	20 cm below surface	Volume increase
Sweet Corn	100 to 450 hPa	20 cm below surface	m. flower, grain filling
Pomegranate	100 to 300 hPa	30 cm below surface	Volume increase
Onion bunch	100 to 250 hPa	15 cm below surface	Onion formation, volume increase
Onion dry	100 to 250 hPa	20 cm below surface	Onion formation, volume increase

Disclaimer:
Above recommendations are based on results of scientific trials and literature review. Because of the variability of environmental, site and managerial conditions the Company MMM tech support does not accept liability for lack of performance based on these recommendations. Recommendations are made in good faith. We recommend that water applications are adjusted to specific growing conditions on field.

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