



Knowledge grows

Yara Water Solution

User Manual



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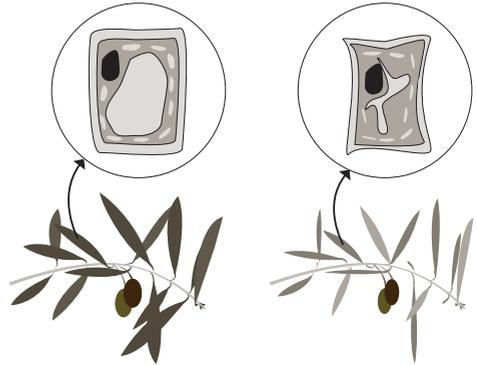
1) Introduction

With increased water scarcity and agriculture consuming 70% of the global freshwater resources, the demand for new agricultural solutions keeps growing. Precision agriculture / crop sensing technology increases nutrient and water use efficiency.

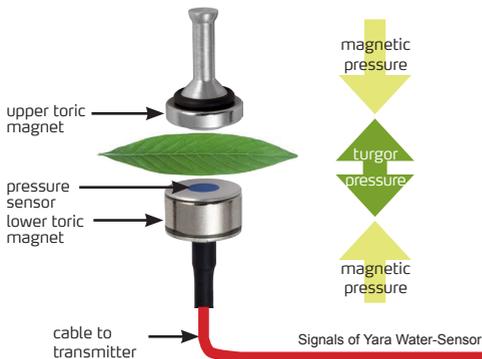
Yara has developed a continuous, non-destructive and remote measurement of plant water status in real time via the Internet. That allows you to apply water on demand to optimize the resources, while maintaining production quality and quantity. The irrigation recommendation given by the system is crop specific and validated. By implementing the Yara Water Solution it is possible to (i) save water (ii) save energy, (iii) reduce tree maintenance, (iv) sustain maximum yield and (v) water the plants on demand.

The system measures the relative changes in the leaf's turgor pressure – or “water” / “blood” pressure of the plant - together with other microclimate parameters. As the turgor pressure is the driving force for plant growth and fruit production, proper water management is important. If a plant is not able to access enough water, it can not maintain turgor pressure and it will begin to wilt. Turgor pressure is the pressure caused by fluid pushing against the cell wall of plant cells. It is needed to keep the plant's rigidity to stand straight and continue normal cellular functions.

The Yara Water-Sensor measures changes in leaf turgor pressure in real time. The turgor pressure in the leaf patch is opposed to the magnetic pressure, which is kept constant during the measurements. The Yara Water-Sensor measures the difference between magnetic pressure and turgor.

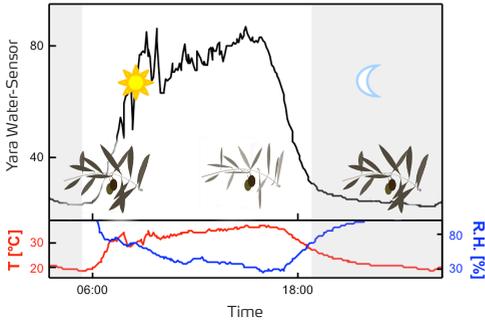


Turgor pressure is lost during the day due to water loss by transpiration and recovered during the night. If there is no water available the plants cannot recover their turgidity and the stress continues increasing. The Yara Water-Sensor signal changes with decreasing water content, and according to these changes we can detect different water levels for the plants.



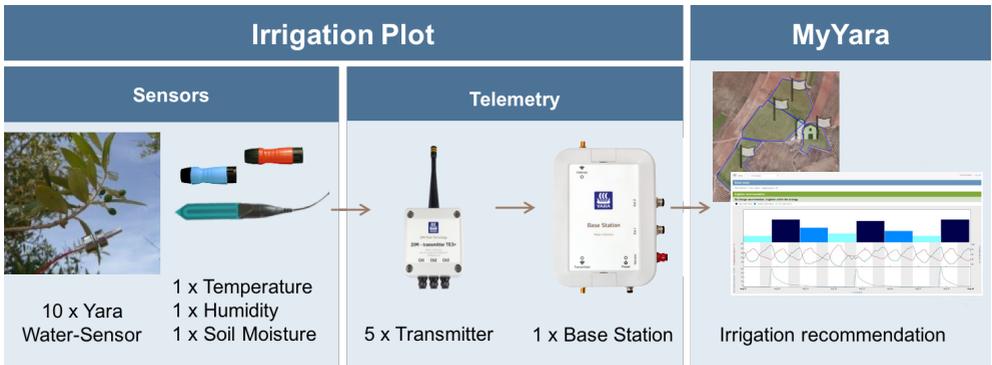
Signals of Yara Water-Sensor:
The Yara Water-Sensor measures the difference between magnetic pressure and turgor.





The Yara Water Solution controls and informs you continuously about the crop water status measuring the changes in turgor pressure. The Yara Water-Sensors and the microclimate sensors are connected by cable to the Transmitter. The data are sent wirelessly to the Base Station which is linked to an Internet server via a mobile phone network. The data signals are evaluated online and the results, including the irrigation recommendation, can be accessed by smartphone, tablet or PC/laptop. Thus, drought and irrigation effects on the plants are available in real time and adequate irrigation decisions on an objective basis can be made when they are needed.

Integrating Yara Water Solution and MyYara:



The data are sent wireless to MyYara and the recommendation is available for the farmer.

2) Irrigation recommendation

The irrigation recommendation is to the best of Yara's knowledge and expertise. This recommendation is based on a predefined irrigation protocol developed by Yara and it is specific for the crop during the selected phenological stage. To get a valid recommendation your farm data must include the crop name and in which phenological stage it is at any given moment.

The system processes the individual Yara Water-Sensor values and other environmental data and assigns a daily classification of the plot water status. The water status classification leads to an irrigation recommendation. The main target is to optimize irrigation avoiding both over-irrigation and uncontrolled drought stress.

Irrigation recommendation:

Decrease irrigation

No change recommended, irrigation within the strategy

Increase irrigation

Before you can start to use the system recommendation

The following instructions will guide you step-by-step to successfully manage your irrigation according to the Yara recommendation. The irrigation scheduling commonly consists in determining the duration and frequency of the irrigation events for a period of time. This manual uses the unit "time" for planning the irrigation schedule. If your planning is done in the unit "amount" (e.g. m³), you can convert it to time dividing it by your system discharge rate (e.g. m³/hour) in the plot.

As a starting point, and once the system is installed, it is recommended to keep the current irrigation practice for a minimum period of two weeks. This way you can confirm that the installation is correct and the system is tracking and processing the crop's water status evolution and environmental data. After that period, you can start using the recommendation for your irrigation schedule. Yara's irrigation recommendation always starts from existing irrigation practices, by increasing or decreasing time and/or number of events.

When recommendation includes a change on irrigation - either increase or decrease irrigation, it is recommended to work based on a predefined minimum and maximum duration of each irrigation event. These minimum and maximum event lengths are specific for each irrigation plot and depend on soil properties, drip system specifications or agronomical practices. You can find information on the maximum application rates recommended per soil type in the table below.

Maximum Application Rates Before Run Off Occurs

Infiltration rate (%), and hence maximum application rate (mm/hour), changes according to soil type

Soil - texture and depth	Percentage of wetted soil profile			
	0-5%	5-8%	8-12%	12-16%
Coarse sandy soil to 1.8m	50.0	38.0	25.0	13.0
Coarse sandy soils over more compact soils	38.0	25.0	19.0	10.0
Light sandy loams to 1.8m	25.0	20.0	15.0	10.0
Light sandy loams over more compact soils	19.0	13.0	10.0	8.0
Silt loams to 1.8m	13.0	10.0	8.0	5.0
Silt loams over more compact soils	8.0	6.0	4.0	2.5
Heavy textured clays or clay loams	4.0	2.5	2.0	1.5

REF: YARA

In a coarse sandy soil, with a depth of 1.8 m, an application rate of 50mm/hour will only wet 0 - 5% of this profile before run off occurs. If an emitter discharges water at a greater rate than the soil can absorb, the water will run off leading to water-loss and erosion.

Irrigation event length are usually in the range of 30 minutes to 4 hours. The shortest events, from 30 minutes to 90 minutes (may be even shorter), are normally used in pulse irrigation. While longer events, in the range of 2 to 4 hours, are often used in standard practices. Superficial or undergrown drip irrigation does not affect this procedure.

Example: The Yara Water Solution was installed on the farm beginning of April. During the first two weeks the farmer continued with his current practice: 2 events per week, each of the event was 2 hours long (120 minutes per event with a total time of 240 minutes of irrigation during the week). The plot has sandy soil, so the farmer estimated a maximum irrigation time of 2 hours per event, and a minimum of 45 minutes.

How to proceed with your irrigation based on the system recommendation

After two weeks of measurements you can adjust your irrigation accordingly to the irrigation recommendation that you receive via the MyYara website. First, look up your irrigation schedule of the last week (total irrigation time in the week). Based on this you can now increase or decrease your irrigation.

As a general rule we recommend to increase or decrease the irrigation time by 5-15% of the last week irrigation (please note that this is depending on the crop, the actual weather conditions, on soil properties and your agronomical practice). Divide the new total time evenly into actual irrigation events during the week.

When you come to the maximum time per irrigation event, you have to add one irrigation event and distribute the total time accordingly. And on the contrary, when you reach the minimum event time, you have to remove one event.

Important: Always make small adjustments to your irrigation schedule to avoid unwanted changes in the wetted bulb shape that may lead to salt penetration, run off or nutrient leaching.

We recommend to keep the new irrigation schedule at least for 5 days prior further changes.

Example "Increase irrigation":

After two weeks the farmer in our example received the message "Increase irrigation": The current schedule was 2 hours twice a week (240 minutes in total). He decided to increase the total irrigation time of 30 minutes (12.5% more than the current practice). In order to not exceed the maximum run-time of the single events, the new schedule has to contain 3 irrigation events of 1 hour 30 minutes each (270 minutes in total).

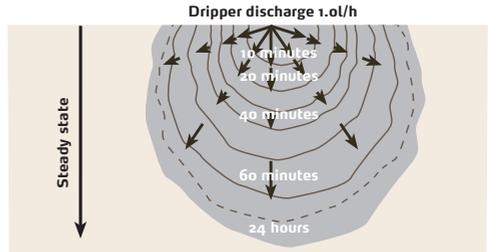
Example "Decrease irrigation":

After one week of increased irrigation the farmer received the message "Decrease irrigation": The current schedule was 90 minutes per event, 3 events per week (270 minutes in total). The farmer switches back to 2 hours twice a week (240 minutes in total).

One week later the farmer received again the message to reduce the irrigation. He can keep the same number of events, but reduce the duration to 105 minutes each (210 minutes in total).

Typical Wettable Bulb Shape and Water Infiltration Rate

Infiltration rate during one hour irrigation and until steady state is reached



Clay and Sandy Soil Infiltration Patterns



This procedure is the best way to improve irrigation scheduling according to the best of Yara's knowledge, based on our own experiences and trials done by us and other relevant institutions and research centres. Other procedures using the Yara system are not recommended, especially those which induce strong water stress by suddenly stopping irrigation completely and waiting for a recommendation from the system. The system is not designed to operate under such circumstances and may lead to an unreliable recommendation.

3) Components - Base Station



Description:

The Base Station receives the data from the Transmitters connected to the Yara Water-Sensors and other sensors via a short-range radio link (ISM radio). This data is time-stamped and stored on the internal memory of the Base Station. The Base Station has an implemented mobile network modem that establishes a mobile connection to the MyYara database on the Internet.

The Base Station is available with additional optional equipment, e.g. a cable, to supply the device using a car battery or a power supply based on solar energy.

The Base Station is able to process data from up to 100 Transmitters. The maximum distance between Transmitters and Base Station depends on the surrounding environment and can be up to 1,500 m (device variant 433 MHz).

Data are sent based on an adjustable transmission regime. The device will be delivered pre-configured.

The Base Station is optimized for low level energy input and can be run on mains voltage or solar energy (photovoltaic optional). Alternatively, it can run temporarily on a car battery.

Main characteristics:

- ISM-modem for receiving data and additional information from the Transmitters
- Mobile network modem (2G/3G) for sending data to the MyYara database on the Internet
- Internal memory to store the data
- 3 LED lights for monitoring the operational status
- Interface for monitoring, service and enhanced configuration
- Power supply with 6 - 14 V DC, low level energy intake, adapted also for solar energy power supply
- Internal rechargeable battery to buffer short power blackouts

Safety instructions:

- Store, transport and install the Base Station in the Power off-state (no power connector connected).
- To clean the Base Station, use only a wet cloth and soap. Do not use abrasives or other chemical cleaners.
- Do not apply supply voltage above 14.5 V DC.
- Do not install antennas close to other electronic devices or living organisms.

Installation:

For a step-by-step description, see the Yara Water Solution Installation Guide.

Power supply:

The device is delivered with an AC adapter. Alternatively for supplying the Base Station using a car battery, please use the following components:

- Car battery 12V
- Minimum capacity: 55 Ah
- You need typically 1.5Ah capacity per day, e.g. with a 60 Ah battery you can power the Base Station for >1 month. The ampere value (e.g. 300A) printed on some car batteries is not relevant. Please consider a second battery for the replacement in the field and a car battery charger.
- Car battery case:
- We suggest a robust outdoor enclosure for car batteries, e.g. one that is used for motor-boats.
- Cable with two car battery clips to connect to the Base Station (must be ordered separately).

For supplying the Base Station using solar energy, a ready to use Solar Energy Systemx must be ordered separately.

Note: the Base Station is switched on by connecting the power connector. If there is no mains power, the device is supplied by the internal rechargeable batteries.



Pole:

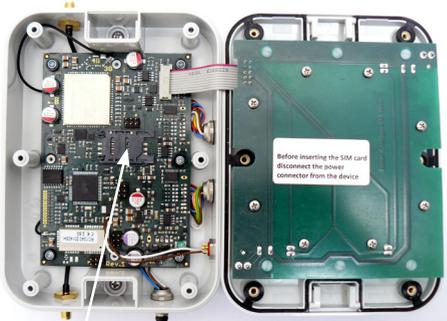
For mounting of the ISM antenna and also the Base Station, we suggest a robust pole. If possible, please mount the ISM-antenna above the plants.

SIM-card:

The device will be delivered with an included, permanently soldered and pre-configured SIM-card. Only when the Base Station cannot find any 2G or 3G network on the site, should you use your own SIM-card. Please select a provider with good 2G or 3G network coverage for this location (this can be tested with a mobile phone, configured for using 2G/3G only). The size of the SIM-card must be a mini-SIM. The monthly used data volume is typically 10 Mbytes.

To use your own SIM-card please take the following steps:

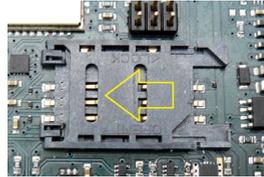
1. Disconnect the power connector from the Base Station.
2. Remove the six rubber feet on the back side.
3. Loosen the six screws and open the Base Station.



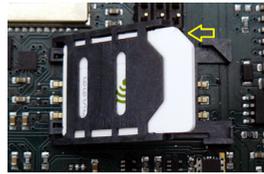
SIM-card socket

Inserting the SIM-card:

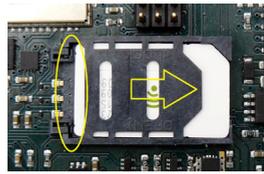
Push the cover of the SIM-card slot to the leftwards and fold it back. Insert the SIM-card into the cover as shown on the picture (note the notch in the card's corner). Fold in the cover again and push it rightwards until it is firmly shut and locked in place.



To open the cover, push it in the direction of the arrow. Then, fold it back.



Note the notch in the corner, when inserting the SIM-card.



Fold in the cover and push it in the direction of the arrow until it is locked in place. The SIM-card must not jut out on the left side (circle).

Close the Base Station and fix it by tightening the six screws firmly. Insert the six rubber feet.

To insert the PIN of the SIM-card and to check the internet configuration, connect the Installation Device to the Service connector of the Base Station using the Installation Cable. Then connect the power connector to the Base Station to start the device.

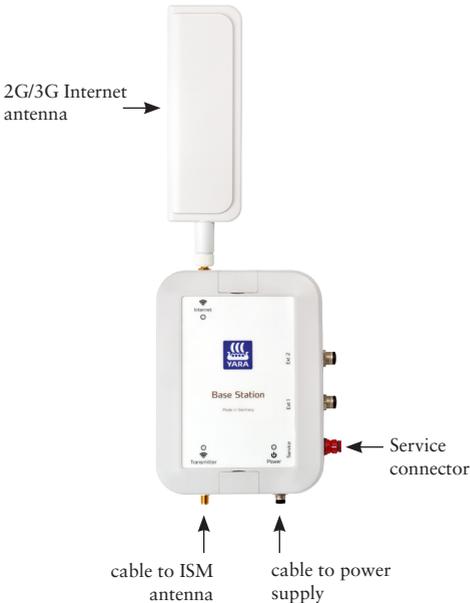
Antenna connection:

Connect the Internet antenna for the mobile network modem (2G/3G) to the connector on the top side of the Base Station.

Connect the cable of the ISM antenna to the connector on the bottom side of the Base Station and mount the ISM antenna (instructions included in the bag with the antenna).

While installing the antennas, make sure that they:

- Stand upright
- Have a clear line of sight to the Transmitters and/or the mobile network tower
- Have correct distance (min. 50 cm) to:
 - Living organisms (including plants)
 - Other antennas
 - Any sort of metal
 - Electronic devices



Operating the Base Station:

Check the LEDs (>5 s after power on):

Power-LED	
off	no power connected, device off
on	ok
flickers	blackout or low car battery

Internet-LED	
off	device off
blinks	initialization, searching network (please wait 1 minute for online)
on	online
flickers	error

Transmitter-LED	
off	no power connected, device off
blinks	no transmitter online
on	online
flickers	error

Check the status with the Installation Device:

To have access to more status information, connect the Installation Device to the Service connector of the Base Station using the Installation Cable.

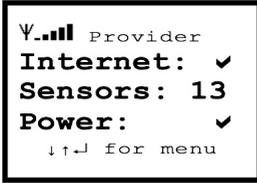


Pressing a button on the Installation Device calls up the menu. Navigate through the menu by using the up and down buttons (↓ and ↑). Confirm your selection by pressing the return button (↵). If no button is pressed for several minutes it automatically returns to the status screen.

Power supply using mains voltage:

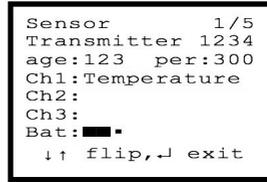
Connect the power connector from the power adaptor (supplied with the Base Station) to the appropriate socket on the lower side of the Base Station.

The Status screen:



Line	Content
Headline	Signal quality and provider name of the Internet connection
1: Internet	Internet-connection to the MyYara database (internet server)
2: Sensors	Number of sensors and sensor status
3: Power	Power supply status

Go to the Sensor menu by pressing the return button again. Browse the Transmitters by using the up and down buttons (↓ and ↑).

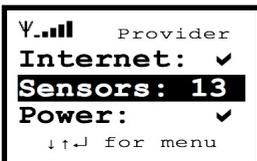


Line	Content
2	Transmitter identification code
3	Age of the last transmission / transmission period
4-6	Connected sensor types
7	Battery status (radio signal quality)

Troubleshooting:

- Check the LED status (see table in section “Operating the Base Station”)
- Check the device status by connecting the Installation Device by using the Installation Cable to the Service-connector of the Base Station (see section “Operating the Base Station”).
- Check the Internet-connection (Signal quality Ψ... and provider name) in the Headline and the Status (✓) in the first line; if there is no or poor connection (less than 3 bars, e.g. Ψ.....)
 - check if the antenna on top is well tightened
 - check if the antenna is installed vertically
 - remove leaves or other objects which are near the antenna
 - install the device above the leaves of the plants with clear path to the supposed network station
 - use an antenna elongation cable to install this or another antenna in a more suitable position.
- Check the sensor status on the second line; activate the menu by pressing the return button (↵).

- check the power status (✓) on the third line



Technical specifications:

Dimensions:	(W x L x D) 120 x 170 x 55 mm, plus connectors and antenna
Chassis:	Plastic chassis, degree of protection IP67
ISM-radio:	Device variants: - 433 MHz - 9xx MHz Antenna connector: SMA-reverse
Internet-radio:	Internal 2G/3G-modem 2G (GSM): Quad band 850/900/1800/1900 MHz, 3G (UMTS): Five band 800/850/900/1900/2100 MHz Antenna connector: SMA SIM-card included, customer owned SIM card 3 V or 1.8 V possible (size: mini-SIM)
Power supply:	9 V DC (Input voltage range 5.5 – 14.5 V DC) 800 mA (maximum) Internal rechargeable buffer battery (3 Ah LiFePo4)
Operating Temperature:	-20 °C to +55 °C Mains adapter: 0 °C to +45 °C
Scope of supply:	- Base Station - Internet antenna - ISM antenna - Wall plug transformer - Material for mounting on walls - Material for mounting on poles The scope of supply may vary depending on different projects
Only for 433 MHz version:	The Base Station is marked with the CE mark. The declaration of conformity is available upon request.
Only for 9xx MHz-Version:	Contains Transmitter Modules FCC ID: Y2NRC1290, FCC ID: QIPEHS6 This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. Any use of ISM antenna with gain > 3 dBi is strictly forbidden.



3) Components - Transmitter

Description:

The Transmitter is a wireless measurement transducer equipped with three channels to which the Yara Water-Sensors can be connected. Microclimate sensing devices (e. g. for humidity or temperature) can be connected as alternative to the Yara Water-Sensors. Recording and transmission occurs automatically upon connection of a sensor to the Transmitter (transmission of the first value can take up to 60s). The recorded data are transferred via short range wireless connection to the Base Station for further processing.

Up to 250 transmitters can operate in parallel. The maximum transmission distance between Transmitter and Base Station depends on the surrounding environment (antennas, vegetation, etc.) and can be up to 1,500 m (device variant 433 MHz).

The Transmitter is powered by commercially available AAA batteries (included). This ensures reliable operation over one vegetation period (provided that the data-acquisition interval is set to 5 min).

Transmitters equipped with different radio frequencies are available. The maximum transmission power and radio frequency shall be in accordance with the country law.

Main characteristics:

- Three precisely measuring amplifiers for connection of up to three Yara Water-Sensors or plant microclimate sensing devices (temperature, humidity, light etc.)
- ISM modem for wireless data transmission of the measurement values, battery voltage and additional information
- Weatherproof case
- Power supply by three AAA batteries
- Automatic switch-on when a sensor is connected
- Remote-configurable



Safety instructions:

- Store, transport and install the Transmitter in the deactivated state (no sensor connected). For longer storage, the three batteries must be removed.
- To clean the Transmitter, use only a wet cloth and soap. Do not use abrasives or other chemical cleaners.
- We recommend the use of leak-proof brand batteries. Replaced batteries must be disposed appropriately.

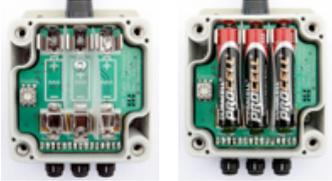
Installation:

See Yara Water Solution Installation Guide.

Insert or replace the batteries:

Three commercial batteries (primary cell type alkaline, size AAA/LR03/Micro) are used to supply the Transmitter with current (batteries are included). The battery status is transmitted via radio and can be checked on the Base Station and/or the MyYara database. The battery status can also be checked by connecting the Transmitter to the Installation Device (see section “Troubleshooting”).

To insert or replace the batteries, loosen the four screws (recommended screwdriver: PH2) on the top of the Transmitter and carefully open the cover. Remove the batteries and replace them with three of the same type. Pay attention to the polarity of the batteries (see the labeling on the bottom of the battery holder)! Always replace all three batteries at once.



After changing the batteries, please replace the transmitter cover, check that the rubber seal is in place and then carefully tighten the four screws.

We recommend the use of leak-proof brand batteries.

Troubleshooting:

- Check the device status by connecting the Installation Device by using the Installation Cable to the “Ch3”-connector of the Transmitter.



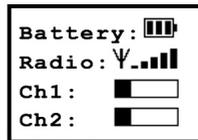
a) Installation Device always shows:



- Check the battery polarity, all three batteries must be shown in the same direction,
- Check the battery number; if only one or two sensors are connected, three batteries are still needed,
- Check the battery status, for example by inserting three new batteries or by measuring the battery voltage (1.5 V: new battery; 1.1V: flat battery),
- Check the battery contacts, you might need to bend them towards each other (note arrows) to assure a sustained current flow.



b) Installation Device shows:



- Check the battery status on the first line, and replace the batteries if an empty battery () is shown,
- Check the radio link on the second line; the link quality is shown in bars. If there are less than three filled (e.g. Ψ _____) bars:
 - remove leaves or other objects which are near the antenna,
 - check if the antenna is vertical,
 - check the radio channel (press \uparrow -button and look in menu line “RF-Channel:”, the value should 0 (if not the channel can be adjusted by turning the internal rotary switch; the channel chosen on the Base Station must match the channel on the Transmitters),
 - select another position for the Transmitter (closer to the Base Station or above the plants),
 - check the ISM-antenna and antenna connector at the Base Station.

A new radio link test can be started by pressing the \downarrow -button.
- Check the Sensors: the connected sensors are shown in lines 3 and 4 (e.g.  for Yara Water-Sensor).

The Transmitter might send its first value only after a short period of time (up to 60 s). All further values follow due to the configured data-acquisition interval.

Technical specifications:

Dimensions:	(W x L x D) 65 x 85 x 44 mm, plus connectors and antenna. Typical installation length with connectors, cable and antenna: 320 mm
Chassis:	IP65 (weather-, dust-and splash-resistant)
ISM-radio:	Device variants: - 433 MHz - 9xx MHz Permanently mounted antenna.
Measuring transducer:	Three specific amplifiers for connection of one to three Yara Water-Sensors or microclimate sensing devices, 12 BIT-AD-Converter.
Battery pack:	Three primary cell type alkaline, size AAA (LR03, Micro) We recommend the use of leak-proof trademark batteries.
Typical current consumption:	20 µA, during data transmission up to 30 mA
Temperature range:	Operation -20 °C to +54 °C (guaranteed) Operation -20 °C to +60 °C (typical)
Weight:	190 g
Delivery contents:	- Transmitter - Battery pack
Only for 433MHz-Version:	The Transmitter is marked with the CE-mark. The declaration of conformity is available upon request.
Only for 9xx MHz-Version:	Contains Transmitter Module FCC ID: Y2NRC1290 This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.
	

3) Components - Yara Water-Sensor



Description:

The Yara Water-Sensor provides real-time measurements of changes in turgor pressure within leaves. It consists of two stamps equipped with a magnet. One stamp also contains a sensitive pressure sensing-element, which sends the detected pressure changes to the Transmitter.

Provided the Yara Water-Sensors are installed correctly, they can be applied to leaves for several months without cell damage or impact on turgor. Depending on the species only a slight depletion of the chlorophyll occurs in the area beneath the Yara Water-Sensor.

Safety instructions / application notes:

The Yara Water-Sensors surface is very sensitive. For cleaning, use a slightly moistened cloth and detergent. Never use abrasive cleanser or other chemical cleaners. Do not press on the sensor surface while cleaning.

Keep and use Yara Water-Sensors away from children, as small parts may be swallowed or inhaled.

Do not use tools with metal components near Yara Water-Sensors such as scissors, blades, metal bars etc. since Yara Water-Sensor's magnets are attracted to magnetic metals and may be pulled off the leaves.

The Yara Water-Sensor and the Transmitter are fine-tuned and only the use of these two components guarantees the correct function of the Yara Water-Sensor. Please do not connect the Yara Water-Sensor to another transmitter or a data logger. In these cases the Yara Water-Sensor will not measure the correct turgor values.

Please also avoid rapid changes in temperature because otherwise hysteresis effects can occur in the polymeric matrix, which disappear only after a long period of time.

The Yara Water-Sensor should not show any significant dependency on temperature. After long-term use changes in the polymeric matrix can induce a dependency on temperature. Similarly, damages of the polymeric surface (even if they are hardly visible) can lead to a dependency on temperature. Therefore, it is advisable to test the Yara Water-Sensor in the closed state (no leaf or other material between the two magnets) from time to time at the place where the measurements had been performed. Changes of 3-4 kPa over a temperature range from 5° C to 35° C are tolerable and correspond to the specifications of the pressure-sensors manufacturer. If the changes are larger, the polymeric matrix must be replaced with a new one. For more information please check the maintenance chapter in this manual.

We do not recommend to place a filter paper, a microslide or other material between the two magnets instead of the leaf because elastic materials as well as the enclosed air (e.g. in filter pores or in the deepening of the counter magnet) show pressure changes in response to temperature changes.

We do not recommend either to place a sticky material (e.g. parafilm) between the two magnets because the polymeric surface can be destroyed or pulled out.

Please try to store the Yara Water-Sensor when it is not in use at ca. 20° C.

This device has to be used exactly according to the instructions of this manual as the measurement of a visco-elastic pressure response shall be avoided. The device will result in false measurements, if used for measuring visco-elastic pressure response of a plant.

Installation:

See Yara Water Solution Installation Guide.

Technical specifications:

The Yara Water-Sensor is designed for use during several seasons. The durability also depends on environmental conditions during the use and will be determined by:

- Intensity of UV radiation
- Contact with fertilizers and pesticides
- Contact with secretions of the plant
- Mechanical damage
- Temperature

Temperature range: +5 °C to +60 °C

Connection cable: Length ca. 2 m

Delivery contents: - Yara Water-Sensor
- Mounting clips for wire

3) Components - Temperature-Sensor and Humidity-Sensor



Description:

The Temperature-Sensor and the Humidity-Sensor provide real-time measurements of the ambient air temperature and the ambient relative air humidity, respectively. Both sensors are available in two versions, the standard version where the sensor is built in the connector and a version with cable for remote mounting. These sensors can be connected to every free channel of the Transmitter.

Installation:

See Yara Water Solution Installation Guide. The sensor-status can be checked by connecting to the Installation Device.

Technical specifications:

Temperature-Sensor:

- measurement range -20°C to $+65^{\circ}\text{C}$
- accuracy typically $\pm 1^{\circ}\text{C}$
- version with cable: cable length 2 m, radiation shield available

Humidity-Sensor:

- measurement range 0 - 100%
- accuracy typically $\pm 3\%$ (in the range of 11% - 89% RH), 7% (in the range of 0% - 10% RH and 90% - 100% RH)
- operating temperature -20° to $+65^{\circ}\text{C}$
- version with cable: cable length 2 m, radiation shield available

3) Components - Soil Moisture-Sensor



Description:

The Soil Moisture-Sensor provides real-time measurements of the field's soil moisture status. The sensor is made by Spectrum Technologies, Inc. (sensor type Water Scout SM100) and measures volumetric water content (VWC) of the soil. More detailed information can be found in Spectrum's manual included in the shipment. This sensor can be connected to every free channel of the Transmitter.

Installation:

See Yara Water Solution Installation Guide. The sensor-status can be checked by connecting to the Installation Device.

Technical specifications:

Soil Moisture-Sensor:

- measurement range 0% VWC to saturation
- accuracy typically 3% VWC @ EC < 8 mS/cm
- operating temperature 0.5° C to +65° C
- cable length 6 m

3) Components - Installation Device



Description:

The Installation Device is used to find the optimal clamping pressure for the Yara Water-Sensor, for a successful installation of the Soil Moisture-Sensor, as display for the Base Station and to test the proper functioning of the Transmitter. For convenience the Installation Device can be fixed to the arm by the velcro allowing users to visualize the display whilst clamping the Yara Water-Sensor.

Safety instructions:

- Store, transport and install the Installation Device in the deactivated state (no cable connected). For longer storage, the three batteries must be removed.
- To clean the Installation Device, use only a wet cloth and soap. Do not use abrasives or other chemical cleaners.
- We recommend the use of leak-proof brand batteries. Replaced batteries must be disposed of appropriately.
- Protect the device from moisture.

Battery replacement:

Three commercial batteries (primary cell type alkaline, size AAA/LR03/Micro) are used to supply the Installation Device with current (batteries are included). The battery status can be checked on the Display.

To insert or replace the batteries, first remove the green rubber cover and then remove the battery cover by shifting it in the direction of the arrow. Remove the batteries and replace them with three of the same type. Pay attention to the polarity of the batteries (see the labeling on the bottom of the battery holder)! Always replace all three batteries at once. After changing the batteries, insert the battery cover and put the rubber cover back on starting from the connector side.

We recommend the use of leak-proof brand batteries.

Only for USA: Model 16-32

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

4) **MyYara**

See the Yara Water Solution Installation Guide.

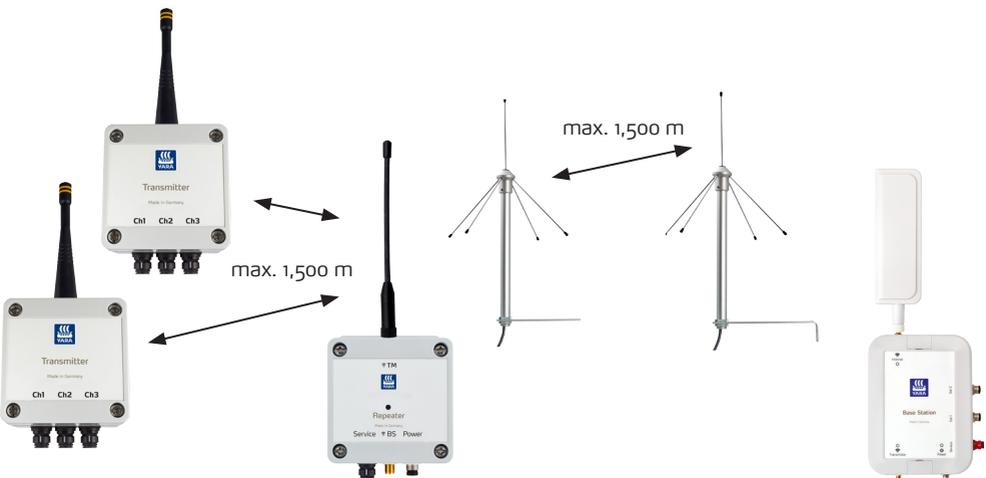
5) Other devices - Repeater



Description:

The Repeater increases the radio range of the Transmitter, enabling the use of the Yara Water-Sensors and environmental sensors to larger fields. The device is placed between Transmitters and Base Station. Up to 100 Transmitters can operate in parallel on one Repeater. The maximum transmission distance is up to 1,500 m (device version 433 MHz) depending on the environmental conditions (clear path between the antennas, antennas arrangement, leaves around antennas, etc.).

Working principle:



Main characteristics:

- Extending the transmission range between the Transmitters and the Base Station
- Two antennas (antenna 1: radio to Transmitters, antenna 2: radio to Base Station)
- Possibility of connecting a wide range of antennas depending on the transmission requirements
- Possibility of connecting several Repeaters in series to extend the range
- Weatherproof case
- Several options for power supply available: car battery (typical battery life: 3 months); mains adapter; solar system
- Supply voltage is transmitted together with other data and presented in the MyYara database.

Safety instructions:

- Store, transport and mount the Repeater without any cables connected.
- Clean the Transmitter only with wet cloth and soap. Do not use abrasives or other chemical cleaners.
- Do not install antennas close to other electronic devices or living organisms.

Technical specifications:

Size:	(W x L x H) 65 x 85 x 44 mm, plus connectors and antennas
Case and mounting:	Plastic case, Degree of protection IP65 (weather, dust and spray water resistant)
Power supply:	6 – 18 V DC
Typical power consumption:	20 mA (operated at 12V)
Temperature range:	Working between -20 °C to +55 °C (guaranteed) Working between -20 °C to +60 °C (typically)
Only for 433MHz-Version:	The Repeater is marked with the CE-mark. The declaration of conformity is available upon request.
Only for 9xx MHz-Version:	Contains Transmitter Modules FCC ID: Y2NRC1290 This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation. Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment. Any use of radio antennas with gain > 3 dBi is strictly forbidden.



FCC Repeater
Model 14-21

5) Other devices - Global Light-Sensor



Description:

The Global Light-Sensor provides real-time measurements of the global radiation. The sensor is made by Spectrum Technologies, Inc. (sensor type 3670I) and measures solar radiation between 300 and 1,100 nanometers. More detailed information can be found in Spectrum's manual included in the shipment. This sensor can be connected to every free channel of the Transmitter.

Installation:

Position the sensor in an appropriate area that represents the plot conditions. Make sure the sensor is not being shadowed or blocked by another external sensor. Install the sensor so that it is level. Once the sensor is mounted, use the adjustment screws to level the sensor so that the bubble is centered on the level indicator. Read carefully the Spectrum's manual included in the shipment.

Technical specifications:

Global Light-Sensor:

- measurement range 0 to 1,010 W/m²
- accuracy typically 5%
- operating temperature -20° to +65° C
- cable length 1.8 m

5) Other devices - Elongation Cable and Solar Energy System



Description:

The Elongation Cable can be used for all probes. The Elongation Cable is used between the Transmitter and selected sensor, the length is 4m. You can connect a maximum two Elongation cable in series.

Installation:

Connect the cable from any sensor to the Transmitter and fix it.

Technical specifications:

Elongation Cable:

- operating temperature -20° to $+65^{\circ}$ C
- cable length 4 m



Description:

The Solar Energy System provides solar energy to supply the Base Station or the Repeater. The Solar Energy System includes a solar module, a buffer battery and the solar controller in a weatherproof case.

Different connection cables to connect the Solar Energy System to the Base Station or to the Repeater are available.

Safety instructions:

- To transport and install, disconnect the power connector from the Base Station or Repeater.
- To clean, use a wet cloth and soap. Do not use abrasives or other chemical cleaners.

Installation:

The Solar Energy System needs to be installed outside with the Base Station (Repeater) nearby, in a place with full sunlight. Instructions are included in the package.

Technical specifications:

Solar Energy System:

- operating temperature -20° C to $+60^{\circ}$ C
- size: 600 x 130 x 30 mm (plus mounting material)
- buffer battery: 6 Ah LiFePo4
- cable length 5 m

6) System maintenance

During the season:

Yara Water Solution devices do not require intensive maintenance during the season. However some errors may happen during season, which may need your attention (e.g. drop of the clamped leaf due to heavy winds or empty batteries of the Transmitter). MyYara will let you know during the season if any action is required.

It is recommended to mark the trees that are equipped with Yara devices to avoid damage by machinery. Mechanical pruning of the trees will require removal of the whole equipment except of the Soil Moisture-Sensors, meanwhile hand made one not. Sprays or any other field operation can be done without removal of any part of the equipment.

Removal of the equipment from the field:

For mechanical harvest it is necessary to remove the equipment from the trees in advance. If the harvest is done manually, it is necessary to be careful not to damage the equipment.

Once the irrigation season has finished, and before the new season starts, the equipment has to be removed from the field.

Recommended procedure for removal of the equipment:

Removal of Yara equipment can be done by following this simple procedure at each tree:

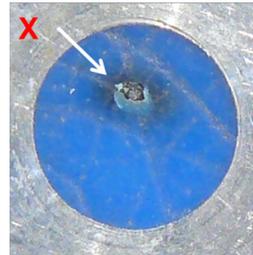
- Unplug the Yara Water-Sensors and Soil Moisture-Sensor from the Transmitters and let the connectors hang. The Temperature-Sensor and Humidity-Sensors do not require unplugging and may remain connected. Remove the Transmitters from the trees.
- Remove the Yara Water-Sensors from the leaves.
- Start retrieving the cables carefully. Avoid strong pulling of the cable, connector or tree. Please, fold the cable of the Yara Water-Sensor and keep it in a bag or a box for collection.
- Take care as tree branches can be fold due to weight of fruits, or in dense foliage trees. Starting the process in inverse order may help.
- Remove the Soil Moisture-Sensor by digging carefully with a spade or similar. Do not pull the cable as it may break it.
- Collect all remaining equipment from the field.

Equipment check after the season

The Yara Water-Sensors require a review before using them during the next season. If the Yara Water-Sensor's blue silicone surface is damaged it will disturb the measurements. The blue silicone may be imprinted by some parts of the leaves. Very deep impressions can affect clamping time, i.e. increase the time needed to install the Water-Sensor.

Please carefully clean the surface of the Yara Water-Sensor using soft tissue and water, and check the blue silicone surface in good lighting. Replace the Yara Water-Sensor if:

- the blue surface has any holes



Electrical devices and microclimate probes:

Please remove the batteries of the Transmitters and the Installation Device. Clean the microclimate probes (e.g. Temperature, Humidity and the Soil Moisture-Sensor) carefully. Disconnect the power connector from the Base Station (because otherwise the buffer battery supplies the device). Store all devices (e.g. Base Station, Transmitter, Installation Device) and the sensors in a dry place and at room-temperature. The antennas of the Base Station can stay outside.

What do I need to do before installing the Yara Water-Sensors in the next season?

Please buy new batteries for the Transmitters and the Installation Device and follow the steps in the Yara Water Solution Installation Guide.

Repair:

Maintenance and repair may only be done by the manufacturer. If one of your devices is broken, replace the device.

Disposal of devices:

Do not dispose electronic devices with domestic waste. The disposal and recycling of electronic devices should be done according to the EU-guideline 2002/96 EG (WEEE). Manufacturers of electronic devices for commercial use are obliged to take back electronic devices and recycle them free of charge. Yara Water Solution will take back used devices and recycle them properly without charge. Please send your used devices via parcel service to Yara Water Solution. Please make sure the device is properly packed. Yara Water Solution covers all costs, including postal charges (lowest transport rate), as well as disposal and recycling costs.

Disposal of batteries:

Do not dispose batteries in domestic waste. Batteries should be disposed of at designated collection points (such as municipal recycling centres).

7) Disclaimer

Whilst every care is taken to ensure that the results from the Yara Water Solution are as accurate as possible, it is important to note that the analyses and the recommendations relate to the trees measured by the Yara Water-Sensor, and are representative for those trees only. No warranty is given by Yara that results from analyses from certain trees relate to any other part of a field or growing area. It is important to ensure that trees chosen for analysis are representative of the area requiring analysis.

Because of this and the multitude of different production systems, on various soils and under countless climatic conditions, Yara disclaims all warranties, express or implied, as to the accuracy of the information gathered by the tool and takes no liability for management decisions based on this information. When using the Yara Water Solution the user accepts that he will take full responsibility for all management decisions.

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