FARMDROID

Spot Application System
user manual

Contents

1 General Information

This user manual is exclusively for the FarmDroid Spot Application System.

In this manual, two different symbols are used to indicate sections and paragraphs of special attention to the user.

 Used to draw special attention to important **operational** related information.

 Used to draw special attention to important **safety** related information.

For more detailed guidance and support, please refer to the FarmDroid Guidelines which can be found in the knowledge base or contact your local distributor.

FarmDroid Knowledge Base:

https://knowledge.farmdroid.io/

Manufacturer contact information:

FarmDroid ApS
Industrisvinget 5
DK - 6600 Vejen

Web: www.farmdroid.dk
Mail: info@farmdroid.dk

2 Technical data sheet

General	
Product Name	Spot Application System v1
Version	V1.0
Item no	104010005R00
Technical	
Water tank volume	60 litres
Application Tank volume	60 litres
Mix Tank volume	0,15 litres
System internal volume (1)	0,15 litres
System Design Pressure	10 bar
System Operating Pressure	2 to 4,5 bar
System flow	0,05 l/min to 0,4l/min
Operating Capacity Spot spray (2)	Up to 38 hours
Operating Capacity band spray (3)	Up to 17 Hours
Pump type Application tank circulation	Closed impeller type Qmax 20 l/min@0,5bar
Pump type fill/mix	Positive displacement Diaphragm Pump Qmax 1l/min@6 bar, 100 PSI bypass springs, VITON seals, Santoprene Diaphragm
Pump type Main system	Positive displacement Diaphragm Pump Qmax 1l/min@6 bar, 100 PSI bypass springs, VITON seals, Santoprene Diaphragm
Nozzle types	TeeJet TP250025 – 0,025GPM(0,1l/min)@3bar, 25° spray angle TeeJet TP250040 – 0,025GPM(0,1l/min)@3bar, 40° spray angle
Nozzle control	PWM controlled with adaptive frequency 0-20Hz, duty cycle control 0-100%
Operational power consumption	30-60 Watts
Standby power consumption (4)	15-20 Watts

1) Internal volumed calculated downstream Mix Tank, based on 6-row configuration.
2) Based on 6-row machine, 2,7m working width, 720 m/h working speed and 8x8cm spray on crop.
3) Based on 6-row machine, 2,7m working width, 720 m/h working speed and 8cm wide band spray.
4) Standby power consumption includes power for application circulating pump.

3 Spot Application System technical overview

The FarmDroid Spot Application System (hereafter mentioned as SAS) is an embedded add-on for the FD20 robot. The SAS enhance the operative capabilities of the robot by making possible to perform chemical weed control, or alternatively liquid fertilization, in combination with mechanical weed control.

The SAS is controlled by the FD20 and is fully integrated with the software of the robot. For this reason, please refer to the main FD20 manual to understand the functionalities of all the other systems and operations which are not covered by the Spot Application System.

The SAS is able to perform chemical weeding only in fields that have been seeded with the FarmDroid FD20 robots. It is not possible to run such operations in field where the crop has been seeded/transplanted with different machinery than the FD20.

3.1 OVERVIEW OF THE MECHANICAL COMPONENTS

The SAS consists of three main modules, which are shown in Figure 1:

1. A **LIQUID STORAGE SYSTEM**, including two tanks as well as the valves and hoses which feed the liquids to the spray system.
2. A **MIXER UNIT** and a **CONTROL UNIT**, located two stainless-steel cases in the right-end side of the main control box of the FD20, include the electronic components as well as the electro actuated pumps and valves.
3. A **SPRAY SYSTEM** which consists in hoses linking the mixer unit to the nozzles which apply the mix of agrochemical products.

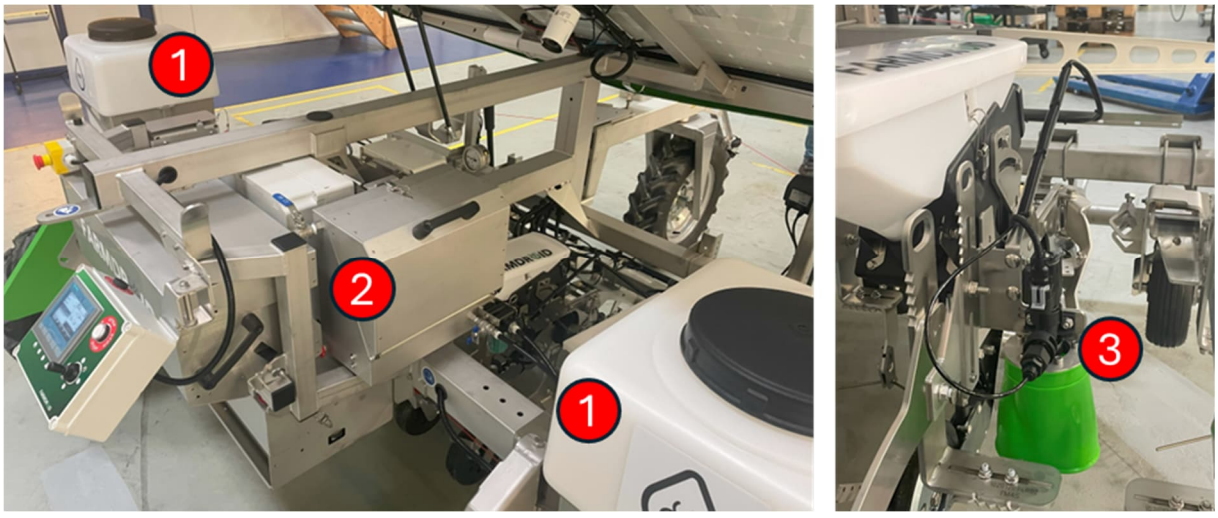


Figure 1: overview of the SAS components

3.1.1 Liquid storage system

Consists of two tanks of 60 Liters each, placed underneath the solar panels:

- The **WATER TANK**, placed in the left side of the robot, must be filled only with clean freshwater.
- The **APPLICATION TANK**, placed in the right side of the robot, must be filled with
  - The full dose of agrochemical product for the specific spray operation
  - Half of the volume of water for the specific spray operation

  The content of the WATER tank and the APPLICATION tank will be automatically mixed by the robot and will be diluted to the correct dose rate.

The two advantages of this solution are that the robot can perform an automatic cleaning of the nozzles after it has been inactive for a specific amount of time, as well as rinsing the application tank, which contains the chemical mixture.

Figure 2 Pictogram of the WATER tank

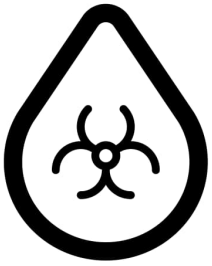
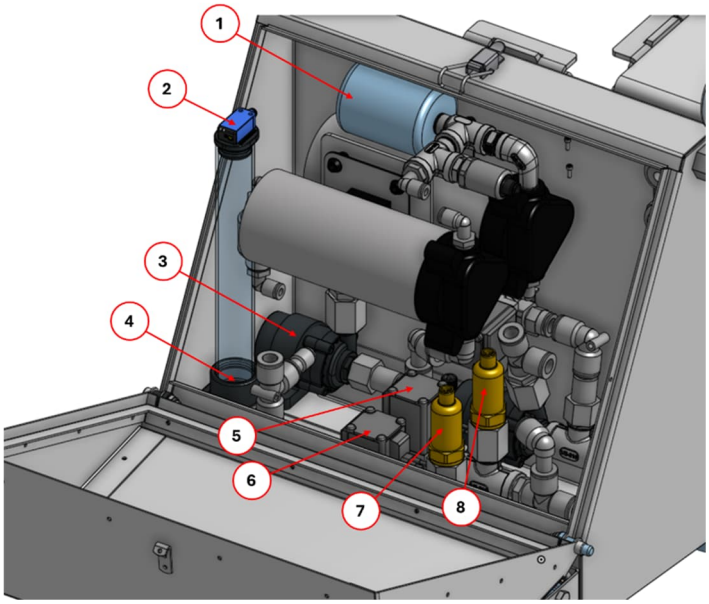


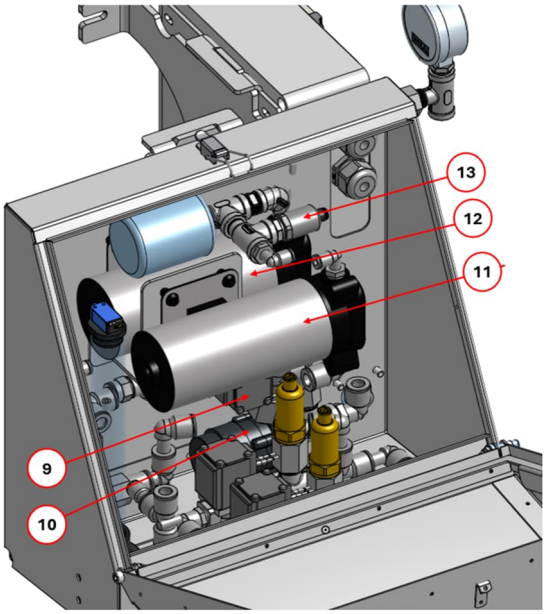
Figure 3 Pictogram of the APPLICATION tank

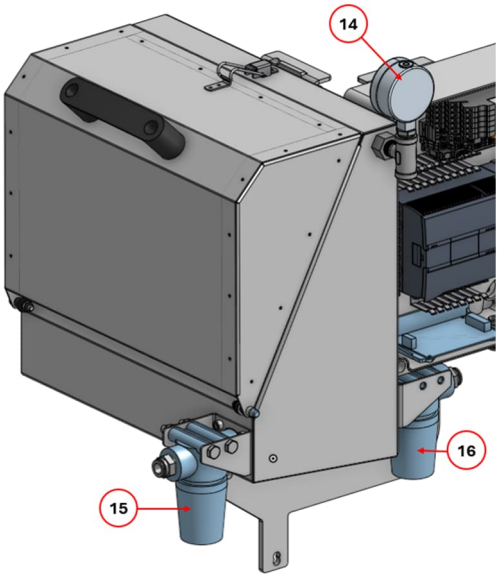
Pouring the wrong amount of agrochemical product and/or water in the APPLICATION tank will cause the robot to spray with the wrong concentration.

3.1.2 Mixer unit

In the following images you can find an overview of the components of the mixer unit







1	Pulsation damper	9	Spray system rinse valve
2	Mix-tank fill sensor	10	Application tank circulation pump
3	Spray system rinse pump	11	Application tank dosing pump
4	Mix tank	12	Spray system pressure pump
5	Water tank valve	13	Spray system pressure sensor
6	Application tank valve	14	Spray system pressure gauge
7	Application tank level sensor	15	Application tank mechanical filter
8	Water tank level sensor	16	Water tank mechanical filter

3.1.3 Spray system

It is formed by the pipes and the nozzles assemblies which apply the mix of agrochemical products. In standard configurations, a spray nozzle is installed on each active trailer.

The robot supports two types of nozzles to personalize the spray pattern. Each nozzle is provided with a cover to minimize the wind drift.

- **TeeJet TP250025** – 0,025GPM(0,1l/min)@3bar, 25° spray angle
- **TeeJet TP250040** – 0,025GPM(0,1l/min)@3bar, 40° spray angle

Figure 4 - nozzles with and without the wind-drift cover

In Figure 5 there is an overview of the spray system of the SAS:

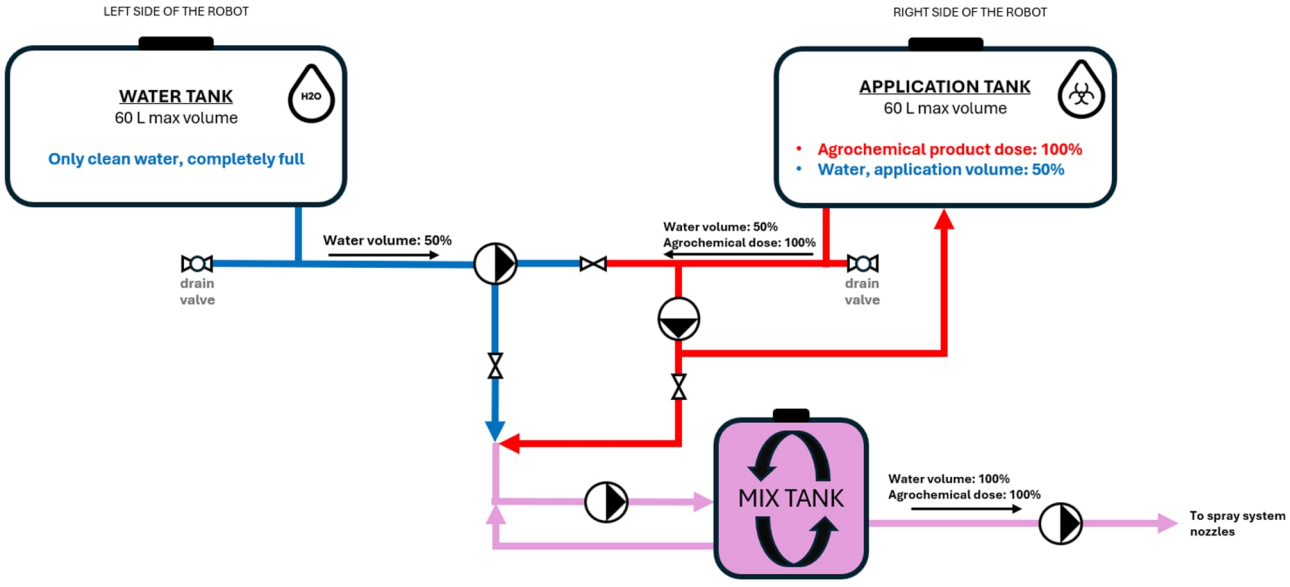


Figure 5 - technical overview of the spray system of the SAS

4 Procedure to start the spray operations

To start an autonomous spray operation, you need to follow these steps:

1. Select the field
2. Turn ON weeding mode
3. Turn ON the SAS and insert the correct settings
4. Fill the water tank (left side) with clean freshwater
5. Fill the application tank (right side) with half of the current application volume
6. Run the priming function to expel all the air from the spray system
7. Add the full dose of chemicals to the application tank (right side)
8. Check the route settings
9. Select “AUTO” in the main page and start the autonomous operations

4.1 FILLING THE TANKS

As mentioned previously, the liquid storage system of the SAS consists of a **water tank** and an **application tank**. Both can contain up to 60 litres each, giving a total capacity of up to 120 litres of agrochemical solution.

1. The **water tank**, located on the left side of the robot, **must contain only clean fresh water**.
2. The **application tank**, located on the right side of the robot, must contain the **full dose of agrochemical product plus half of the application volume** for that specific volume of product.

During the autonomous operation, the system mixes the liquid from the two storage tanks in a 50/50 solution in the mix tank before sending it to the nozzles.

Here below a practical example to calculate the amount of chemical to use:

SPRAYING TASK REQUIREMENTS	
Required agrochemical application rate	**0,5 L pr. ha**
Desired water rate	**200 l/ha**
Mixture rate on finished product	**2,5 ml/Liter water** (0,5l/ha /200*1000)
APPLICATION TANK (manual filled)	
Added water in the Application tank	**50 L (out of 100L total to be used)**
Required dosing of agrochemical in application tank	**250 ml** (50 Liter water*2,5ml/l product*2)
Mixture rate in Application tank	**5 ml/Liter water** (250 ml product/50 Liter water)
SPRAYING DOSE (automatic dosing)	
Mixture rate after mix tank	**2,5 ml/Liter in finished product** (5ml/(1 part water + 1 part application)

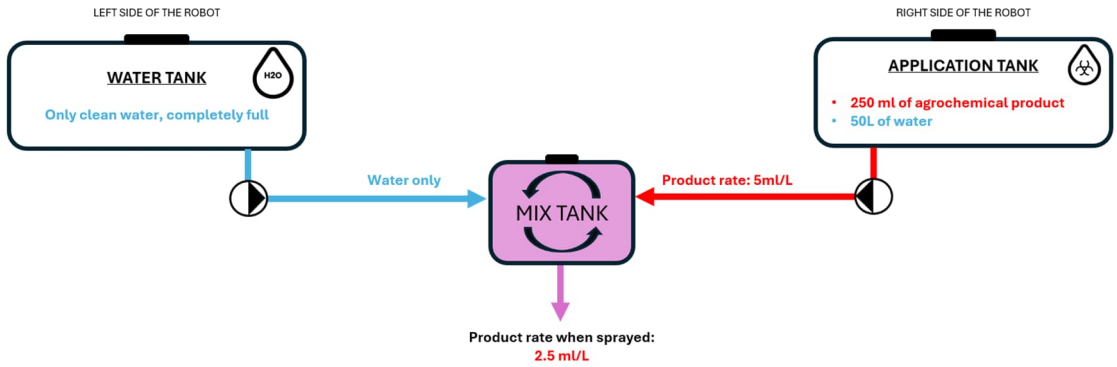


Figure 6: according to the example in the table above, the operator must pour in the APPLICATION TANK the full dose of chemical product (250 ml) plus half of the application volume of water (50L)

4.2 INSERT PARAMETERS

The first step for preparing the SAS to apply chemicals in the field is to access the “Tool page” 4.1.2 from the main menu of the robot, by pressing the icon with tools (Figure 7) and pressing on “SAS” (Figure 8).

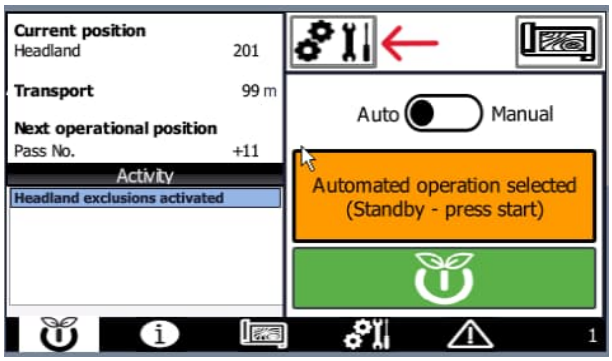


Figure 7

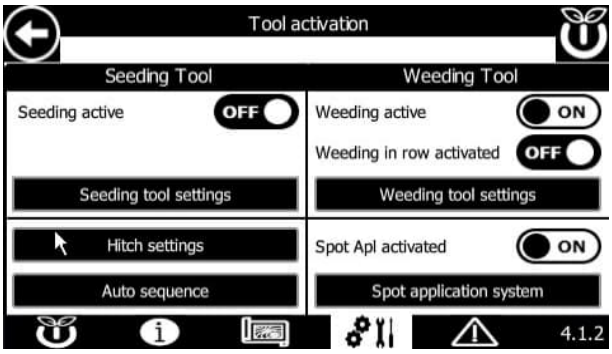


Figure 8

Afterwards, select SETTINGS and fill in the relevant information. (Figure 9).

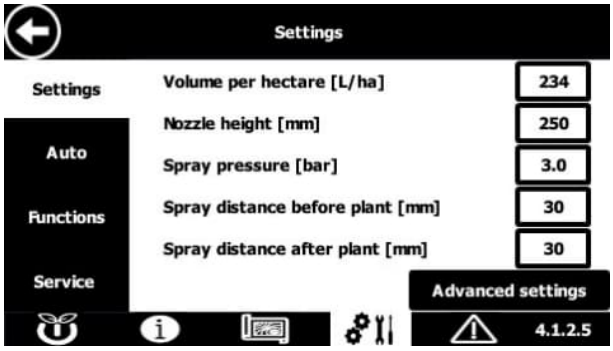


Figure 9 - Standard settings

The main inputs you must provide are:

1. **Volume per hectare**
2. **Nozzle height** – above ground level
3. **Spray pressure -** 3 bars is the standard value
4. **Spray distance before the plant**
5. **Spray distance after the plant**

4.2.1 Advanced settings

If you wish, you can edit the following advanced settings (Figure 10). Please note that the advanced settings are not mandatory to edit, as they are pre-filled with recommended values. FarmDroid recommend to familiarize with the Spot Application System before editing the advanced settings

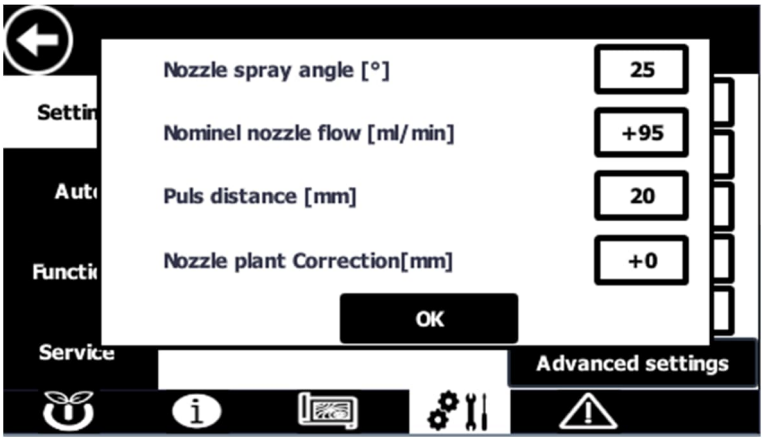


Figure 10 - Advanced settings

6. **Nozzle spray angle** – set it to 25° when using the TeeJet TP250025 nozzles, or to 40° when using the Teejet TP250040
7. **Nominal nozzle flow** – the standard for both nozzles is +95 ml/min
8. **Pulse distance** – it is the distance between the spray pulses (Figure 11 in the next paragraph as reference)
9. **Nozzle plant correction** – to anticipate or delay the spray impulse, for example to spray between the plants, instead of on top of them.

4.2.2 Spray pattern: how to adjust

The spray pattern is a key factor to achieve good results when applying chemical products. While some parameters affecting the spray pattern can be set in the software (*e.g. application rate, operating pressure, etc.*) some others are merely mechanical (*e.g. nozzle type, nozzle height etc.*) and therefore requires the operator to check that they are uniform for all robot's trailers, before starting any autonomous spray task with the SAS.

The parameters influencing the spray pattern are reported in the table below, as well as shown graphically in Figure 11.

Parameter description	Scale/unit of measure	Influence on
Agronomic parameters		
In-row spacing of the plants	Millimetres	Timing to open/close the nozzles
Spray technical parameters		
Application rate of the chemical solution	Liters pr. hectare	Amount of solution applied
Nozzle type	25° or 40° spray angle	Width of the spray pattern
Desired operating pressure	Bar	Size of droplets and width of the spray pattern
Nozzle height from the soil	Millimetres	Width of the spray pattern
Spray selection	Band or spot application	Continuous or spaced spray application
Desired distance between the sprays	Millimetres	Higher or lower density of sprays per length unit
Distance before and after the crop	Millimetres	Timing to open/close the nozzles

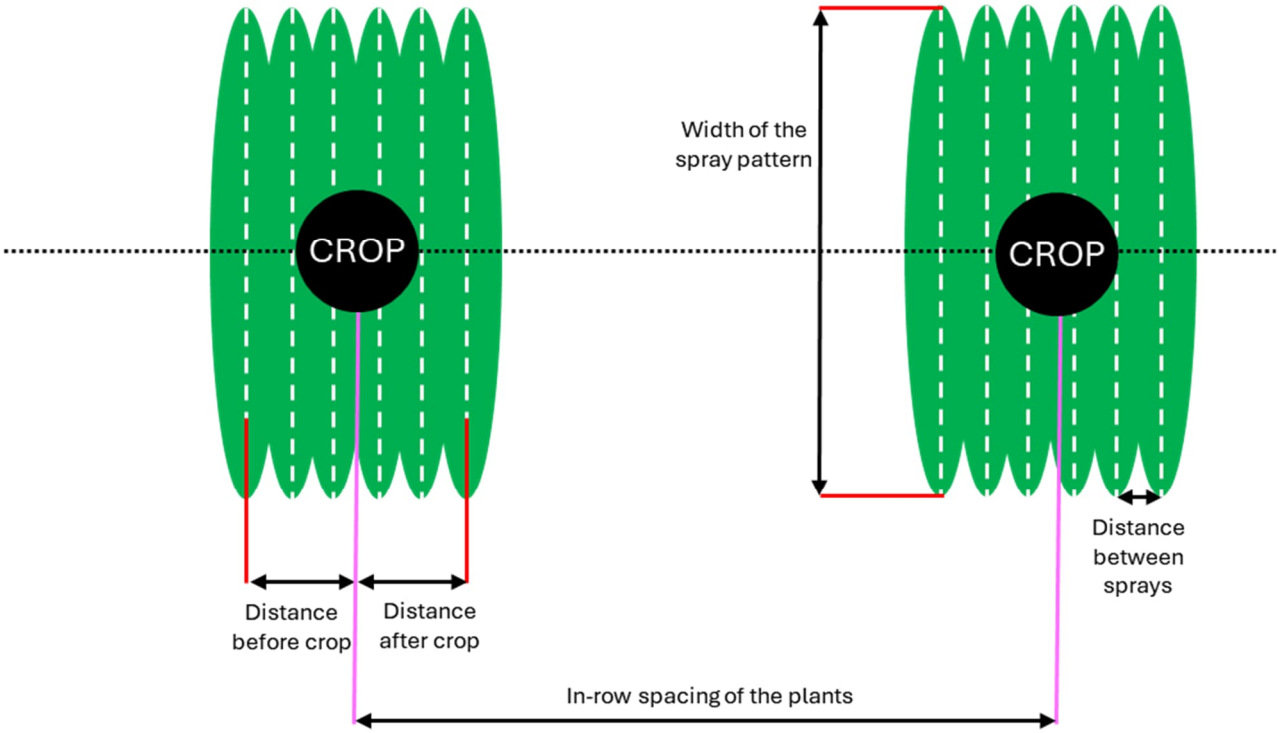


Figure 11 - Spray pattern adjustments: the vertical dashed lines illustrate each spray pulse from the nozzle

4.3 INITIALIZE THE AUTONOMOUS OPERATION

After you have filled in all the correct values in the "SETTINGS" page (4.1.2.5), it's time to look at the AUTO page (4.1.2.5.1, Figure 12).

In this page it is possible to:

- Check that the spray settings are correct.
- Prepare the spray operations, by selecting "*Auto mode*" ON
- Oversee the SAS operation routine, making sure it takes all the necessary steps before the spray task starts:
    - *Settings* – check that the settings are OK
    - *Spray system primed and calibrated*
    - *Tank level* – check that there is liquid in both tanks
    - *No fault* – check that there are no active faults in the SAS

4.3.1 Sequence and description of the initialization procedure

PREPARATION

Powering up the unit and input range tests of all internal modules and sensors. If successfully completed, you have to turn ON "*Auto mode*" to proceed to the next step.

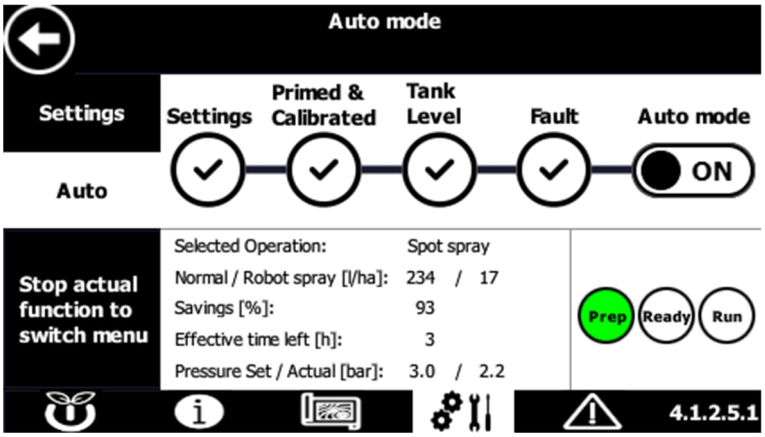


Figure 12 Preparation

NON-OPERATIONAL STANDBY

The system is being prepared by stirring the content of the application tank (60L tank on the right side). Additionally, it doses and mixes the content from the two 60L tanks with a 50:50 ratio inside the small Mix Tank (located in the mixer unit box) to reach the correct spray dose. This task takes approximately 10 seconds.

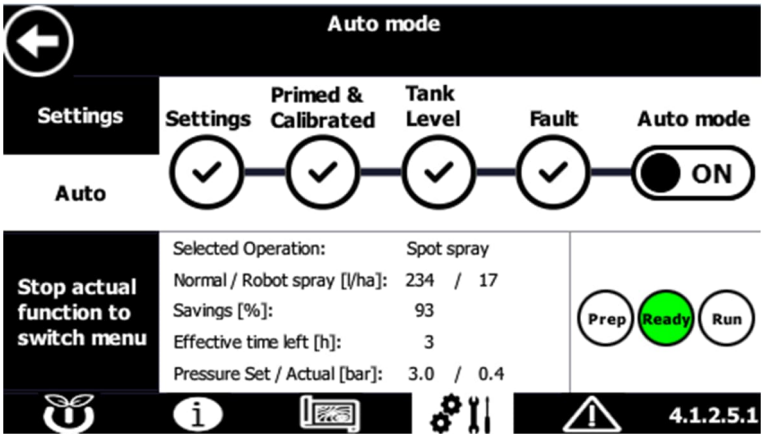


Figure 13 Standby

OPERATIONAL STANDBY

The spraying system is now at the correct operating pressure. The content of both the application tank and mix tank is kept agitated.

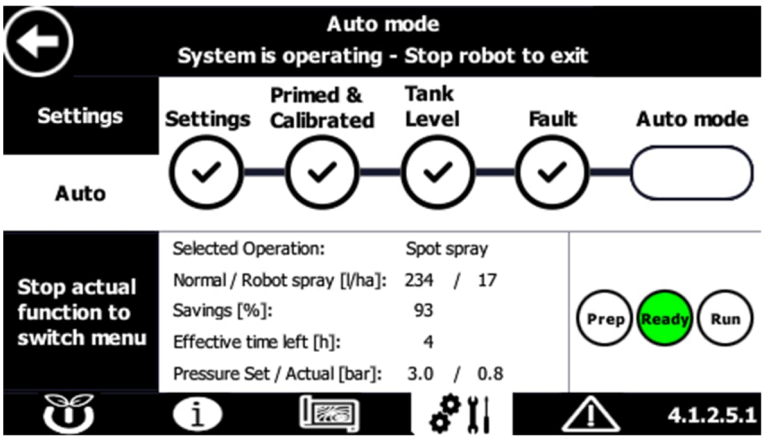


Figure 14 Operational standby

5 Start the autonomous spray operation

Once the robot shows it's ready, as shown in Figure 14, you can now select the route settings and start the autonomous operation from the main page of the HMI.

The system applies chemical according to user-customizable parameters. **The nozzles are opening and closing according to the seeding pattern and the seed valve settings, which are decided by the user prior to seeding the field**.

- **SPOT SPRAY** – is enabled if the seed has been seeded with the seed valve automatic opening being "**ON**". The nozzles are operated simultaneously if the robot has seeded with a line pattern and individually if the robot has seeded with a diamond pattern.

- **BAND SPRAY** – is enabled if the seed has been seeded with the seed valve automatic opening being "**OFF**". the nozzles are operated simultaneously.

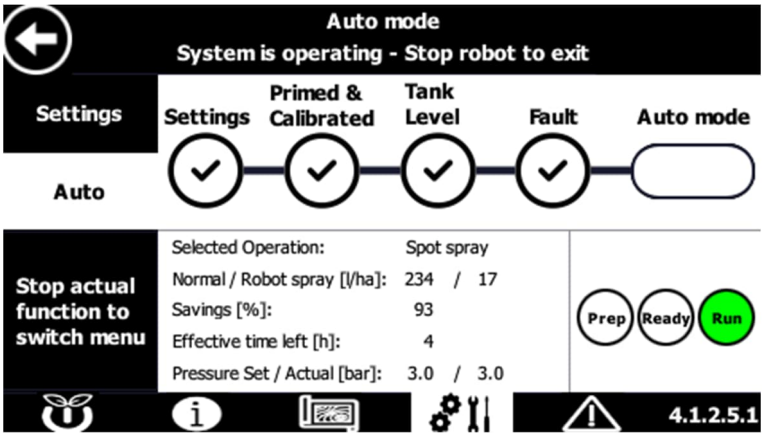


Figure 15 SAS running

6 Cleaning the system after an operation

After use or if changing to a product with a different active ingredient, the system must be emptied and cleaned.

The SAS has a semi-automated cleaning process which is accessible from page 4.1.2.5.2 "*Functions*" (Figure 16)

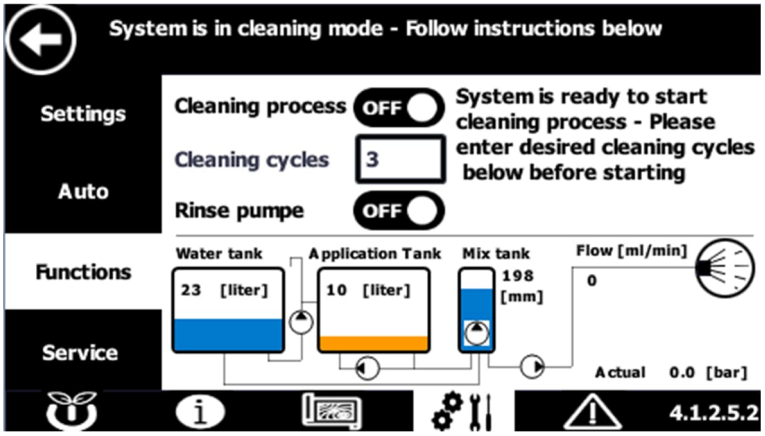


Figure 16

The cleaning process will drain the tank through the nozzles until the dosing pump is not able to draw any more liquid. At that point, approximately 1.5 liters of clean water will be transferred from the water tank to the application tank (approximately 10 seconds) where it will circulate automatically to further rinse the pipes. Finally the system will drain the application tank from the nozzles again, until the pump is not able to draw any further liquid.
The above mentioned procedure is only 1 cleaning cycle. You can decide how many times this cleaning process should be repeated by changing the value into the *"cleaning cycles*" slot.

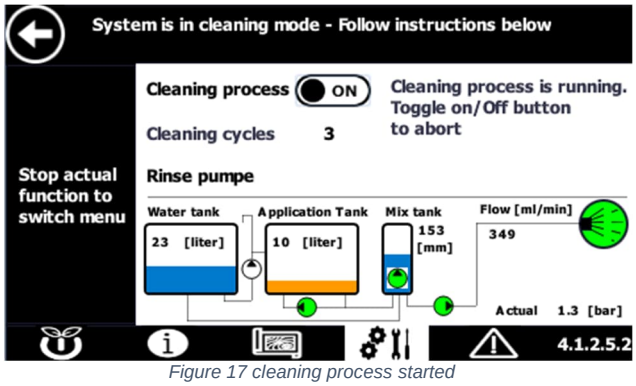


Figure 17 cleaning process started

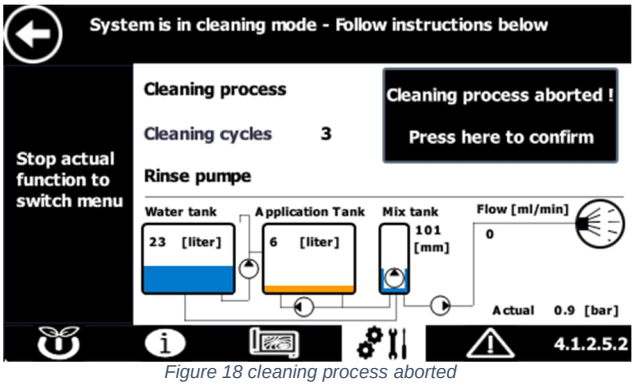


Figure 18 cleaning process aborted

6.1 PROCEDURE TO CLEAN THE SAS

EMPTY THE APPLICATION TANK

1. Use the drain valve below the application tank to let the chemical solution flow into a suitable container. Always dispose the solution according to local laws and regulations.

RUN THE AUTOMATIC CLEANING PROGRAM

2. Make sure the **water** tank has at least 10 Liters of clean fresh water for running the cleaning program.
3. Run the cleaning program with the desired amount of cleaning cycles

WASH AND EMPTY THE TANKS

4. Wash manually the inside of the application tank and drain by opening valve. Dispose of the chemical solution according to local laws and regulations
5. Drain both the water and application tanks using the drain valves.

The system is now cleaned. If further rinsing is required, you can repeat the procedure using a rinsing agent. Always follow the instructions on the product label, as well as local laws and regulations.

If there is a risk for frost, the system must be completely drained or applied anti frost liquid in the liquid system

7 Service and maintenance

Daily	Weekly	Seasonal	Yearly
Check visually nozzle performance	Clean nozzle filters	As weekly	Clean the spraying system inside and outside
Check visually line filters	Clean line filters	Calibrate system flow	Clean water tanks inside
	Check hose couplings		Empty the liquid system completely or fill it with anti-freeze liquid
	Check and clean the main unit interieur		
	Inspect application tank inside and clean if needed		