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GROWNOTES

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 13
Rate-controller functions and settings Getting the best out of the functions available

Graham Betts and Bill Gordon

Key points

- A rate controller can only perform as well as the inputs it receives, the settings programmed into it, and the plumbing and components it will allow
- Consult the rate controller manual to know what functions it can perform
- Check the accuracy of all controller inputs and settings as well as the sprayer outputs before operating the sprayer
- Use total flow (litres per minute) and pressure on the screen to monitor sprayer performance
- Use spray plans to determine appropriate settings and outputs for various jobs to establish the limits for each nozzle type being used

1. Introduction: the primary function of a rate controller

A rate controller will take input signals and regulate the sprayer output to match the programmed settings and application rate (litres per hectare).

If the rate controller is not functioning correctly it will usually be related to a problem with one of the input values, a setting that has been entered into the controller or something affecting the output.

The following sections of this module highlight some of the common functions and settings available in most rate controllers, along with factors that may impact on the controller's ability to perform as intended.

2. Inputs required

A rate controller is only as good as the inputs it receives, both from sensors and the settings the operator programs into it. Common automatic spray rate controller inputs are speed, flow, pressure, boom section widths, alarms and the minimum settings.

Always record all controller settings, along with the date, before using the sprayer or starting to check calibration figures, especially if you plan to make any adjustments or changes to the settings.

PLAY VIDEO

Rate controller function – grower experience

Checking and adjusting calibration settings is essential before operating the sprayer.

Photo: Graham Betts

A Zynx X20 panel showing many of the required inputs on the sceen

2.1 Speed signal

The speed signal supplied to the rate controller can be received from a wheel sensor, radar or GPS.

When using a GPS or GNSS signal for the speed input, the reliability and accuracy of the system or network will be critical to being able to spray, when required. Even when using GPS information for the speed input it is important to have a back-up method for this input, such as wheel sensors, in case the GPS signal is lost for some reason.

Wheel sensors commonly use magnets and a sensor, or a fixed object and a sensor. Some sensors need to have an even number of magnets and/or magnets with alternating polarities.

Check the speed calibration number or factor by marking out a minimum distance of 100 metres, in paddock conditions, with the main spray tank half full and the boom unfolded. If you make an adjustment to the calibration number or factor in the controller, repeat the check again to ensure the input is accurate.

If the speed being displayed is erratic when using wheel sensors at slower speeds, the operator should consider increasing the number of magnets to achieve a calibration figure of 500 or below.

TIPS

- **A good place to install a speed sensor is on a rigid point near the front-wheel-drive transmission shaft or the four-wheel-drive shaft. You can use a hose clamp on the shaft when using the proximity sensor.**
- **Magnetic speed sensors can be vulnerable to being damaged or fouled with mud or debris. It can also be hard to have a speed calibration factor below 500, which can be an issue when spraying at slower speeds, producing an erratic speed on the screen. The speed reading can also be compromised when the sensor is on the inside of a turn 'slower than the actual speed' and outside of a turn 'higher than the actual speed'. An option is to install a proximity sensor on a constant shaft, which will give a constant reading when turning. The calibration factor should be below 500.**

2.2 Flow signal

There are two types of flow meters used in conjunction with rate controllers: impeller and electromagnetic.

The flow meter will typically send several pulses per litre to the rate controller based on the volume that passes through it. The flow meter should be accurately calibrated when leaving the factory and this calibration factor will normally be located on a tag or stamped on the unit.

Be aware that the flow meter will have been calibrated using water, and that changing the density of the spray solution is likely to impact on this calibration for impeller flowmeters, but usually not electromagnetic flowmeters.

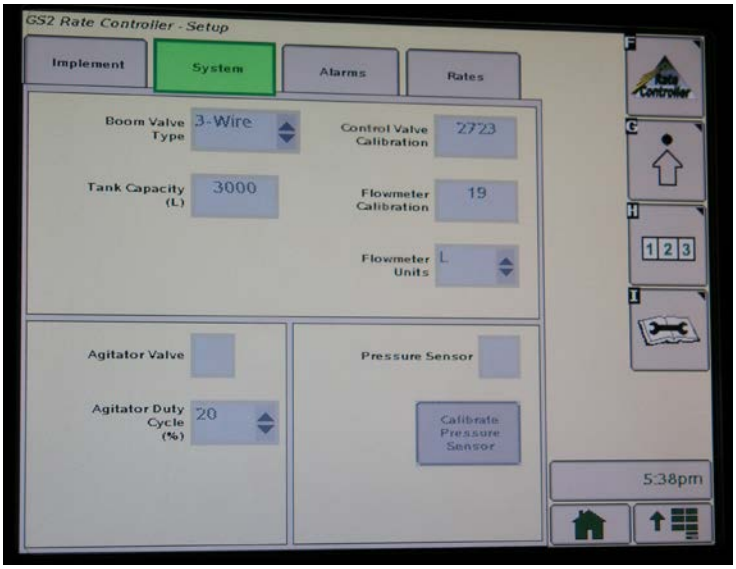
TIP

- **If you plan to regularly alternate between applying foliar fertilisers and standard tank mixes, an electromagnetic flow meter may be more appropriate.**

Ensuring that the flow meter calibration factor and regulating valve settings are correct will ensure the sprayer output and functioning are accurate.

Photo: Graham Betts

John Deere 2630 screen



Density of spray solution

In many controllers it is possible to adjust the density setting for the tank mix being used. Before making such an adjustment, the operator must be sure that he or she has accurately measured the weight of the spray solution (grams per litre) to determine the density of the tank mix.

Where a density function is not present, the operator may be able to use the measured density and then consult a density conversion chart (Table 1) to adjust the current flow calibration by multiplying this figure by the conversion factor.

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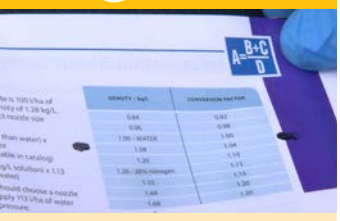


Impact of density on the accuracy of the calibration

Table 1 Density conversion factors.

Density (kg/L)	Conversion factor
0.84	0.92
0.96	0.98
1.00 (water)	1.00
1.08	1.04
1.2	1.10
1.28 (28% nitrogen)	1.13
1.32	1.15
1.44	1.20
1.68	1.30

Source: TeeJet Technologies Catalog 51-AM, p141

For more information on measuring density, go to Module 8: Calibration of the spray system

Always return the density setting or flow calibration factor to its original setting after completing a spray job.

Positioning the flow meter

The ideal positioning of a flow meter is vertical. Mounting the flow meter vertically will reduce the chance of the flow meter reading air and, more importantly, will help to ensure that solids and debris are not able to settle in the flow-meter housing.

When mounting the flow meter, it is ideal to have a straight piece of hose approximately 10 times the size of the thread on the flow-meter housing before the actual flow meter. This will help to reduce turbulence as the liquid passes through the flow meter.

Raven® flow meter mounted vertically on a sprayer

Correctly mounting the flow meter will improve performance and reduce potential blockages.

Photo: Graham Betts

TIPS

- Flow meters are designed to operate within specific ranges of flow rates (e.g. 15 to 150L/min) and different models may have different ranges that they can operate between.
- To ensure you have the most appropriate flow meter model for your sprayer, it pays to work out the range of flows that you require for your spraying operations. Use the following formula to compare your lowest and highest application rate at the range of spraying speeds you intend using:
- Total litres per minute through the boom = L/ha x km/h x total spray width (in metres)

2.3 Pressure signal

The pressure signal required by the controller is an electronic signal.

The electronic pressure sensor is usually mounted at the back of the sprayer, as close to the nozzle as practical. It is useful to check the pressure sensor by using a calibrated pressure gauge on the nozzle. If the pressure sensor needs to be calibrated make sure there is no pressure in the plumbing system.

Correct positioning of the pressure sensor

Having the pressure sensor mounted on the boom line will provide the most accurate pressure information to the controller.

Photo: Graham Betts

Checking pressure at the nozzle

The pressure indicated by the pressure sensor should be checked at the nozzle with a calibrated pressure gauge.

Photo: Bill Gordon

To be able to monitor pressure while you are driving it is useful to have a pressure gauge that measures pressure in the spray line mounted outside of the cab.

Never mount a pressure gauge plumbed into the spray line inside the sprayer's cab.

Never mount a pressure gauge connected to the sprayline in the cab

Having any plumbing containing actual product in the cab with the operator is too dangerous. Pressure gauges should be mounted outside the cab.

Photo: Graham Betts

2.3.1 Pressure and flow rate in combination

Some controllers are able to regulate sprayer output based on either flow or pressure, while other models may be able to use a combination of both.

For example, in some models the rate controller can read the range of flow rates the flow meter is capable of measuring. Even when the flow falls below the minimum, the flow meter is able to accurately measure and the rate controller can switch over to using pressure control. Once the flow returns to above the minimum, the controller can revert to using the flow again.

It is important to understand what functions the controller you have, or purchase is capable of performing so you can take full advantage of the functions it offers.

TIPS

- **Mount the pressure sensor so the liquid entry point is facing down and use a calibrated pressure gauge on the nozzle body to check the calibration of the pressure sensor.**
- **A spraying system that can use three-way boom valves allows the flow meter to work in its optimum flow range because the flow through the flow meter does not change if a boom section is turned off.**

2.3.2 Multi-step systems and transitions

Some multi-step systems (where the system can change from one nozzle to another to increase the speed and application volume) will require the operator to enter into the controller where the transition from one nozzle type or size to another should occur. This may be based on speed, flow rate or pressure.

For more information on multi-step systems go to Module 18: Single line and multi-step systems

2.4 Boom width and section widths

Always check and record the exact nozzle spacing measurements for all nozzles on the boom, the number of boom sections and the number of nozzles plumbed into the individual boom sections. This information will give the spray operator the inputs that are required for boom width when setting up the controller.

Make sure that the controller is set in the correct units (usually metric) before starting any programming or before adjusting settings.

If you are working on a sprayer that has just been delivered, complete all of the pre-operational checks listed in Module 6, ‘Pre-operational checks’.

3. Settings available on common controller types

Most rate controllers will come with a range of standard features that allow the operator to customise when warnings or alarms register. The sensitivity of regulating valves and settings will ensure the nozzles can function correctly at low speeds (minimum setting).

Alarms

Alarms can be set up to be audible or visual, or both. There are many different alarm settings in each brand of controller. Always consult the controller manual to determine which functions are available on the model you have.

Common examples of alarms that may be set or adjusted by the operator include:

- **low tank level reached;**
- **outside the programmed application rate;**
- **maximum speed or pressure reached; and**
- **minimum setting reached.**

Example of a tank volume warning

Setting up alarms to notify the operator when a limit is reached can help to alert the operator.

Photo: Graham Betts

TIP

- Don't assume that the tank capacity is exactly as stated by the manufacturer. Calibrating spray tanks is very important. Markings or graduations on the tank are often not correct, and most manufacturers state they are only a guide. Too many spray operators change the flow meter calibration figure to match the perceived tank capacity, which may impact on the accuracy of all future applications.

PLAY VIDEO

Using minimum setting in the rate controller

3.1 Minimum settings

Setting a minimum pressure, speed or flow (total flow or litres per minute per nozzle) at which the rate controller will not drop below when you reduce your spraying speed can be very useful to ensure nozzles continue to work effectively.

If you are not sure if the minimum setting has been programmed into your controller, you should see the L/ha on the screen increase above the programmed L/ha as you slow down; generally this will indicate that the minimum hold has been engaged.

TIP

- Check that the controller can go down to zero output by putting the controller in manual with the spray system running, then turning the boom section on and pushing switch/button to lower pressure/flow.

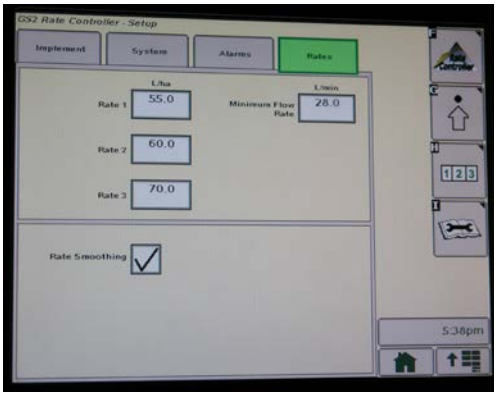
When determining what the appropriate minimum setting should be, be aware that once the controller engages the minimum hold, further reducing the spraying speed will result in overdosing.

It is a good idea to match the minimum setting to the type of nozzle being used and to allow large enough headlands to minimise overdosing.

A spray plan will help to identify suitable settings for different nozzle types.

A number of manufacturers identify the minimum settings in the controller by different names, three examples are shown below.

John Deere Screen controlling a Raven rate controller



This system operates on minimum flow rate through the boom. The operator must determine what that setting should be – (based on the number of nozzles and the flow rate of each nozzle at the minimum pressure they should be operated at).

Photo: Graham Betts

Hardi® 6500 E8 minimum speed setting

Using minimum speed settings requires the operator to determine the speed at which the nozzle will reach its minimum pressure, based on the application volume selected.

Photo: Graham Betts

FarmScan® slow hold function

The minimum hold function can be under various names, including slow hold.

Photo: Graham Betts

TIP

- Caution needs to be exercised when determining where to set the minimum hold function when applying residual herbicides or other products at the maximum label rate. Operators should carefully plan spraying speed and the size of headlands to minimise the amount of time that the minimum hold function will engage to avoid possible overdosing. Preparing a spray plan to work out appropriate speeds and pressures is critical for minimising overdosing.

Table 2 Common rate controller types and minimum setting requirements.

Controller brand	Model	Minimum setting	What to do in the controller menus
TeeJet®	844E	'Minimum pressure'	'Minimum pressure' can be found by holding the '+' & '-' buttons and pressing 'PRO' twice. 'SI' should be showing on the screen, then cycle through to 'Min Prs' and enter the minimum pressure you do not want the nozzle to go below.
Raven	400 series	'Total flow'	Hold the 'VOL/MIN' button down until the screen flashes. Enter the result of working out the minimum pressure you don't want the nozzle to go below.
Raven	4000 series	'Low Limit' under 'Alarm Settings' under 'PROD 2 : 1'.	
Hardi®	5500	'Minimum speed, km/h'	Go to the extended menu E8.1.2 and open up the 'Minimum speed' screen and enter the calculated speed. Work out the minimum pressure you do not want the pressure to go below.
John Deere		'Minimum pressure, kPa'	Go to 'Sprayer Setup' screen, then go to 'Minimum Spray Pressure (kPa)' (note that 100kPa = 1 bar).
Topcon	X20, X30	'Minimum flow per nozzle'	Adjust the minimum flow per nozzle to match the nozzles selected. To do this consult controller manuals.
Capstan	SharpShooter® PinPoint®	'Minimum	Go to 'System Set Up', go to number 50 and enter a figure no lower than 30%.
Case	Aim Command™, Aim Command Pro™	duty cycle'	Go to 'Product Control Setup' and enter a figure no lower than 30%.

Aim Command™ minimum duty cycle setting

For pulse-width modulation (pwm) systems the minimum duty cycle acts as a minimum hold.

Photo: Graham Betts

4. Factors affecting the controller's ability to effectively regulate sprayer output

The rate controller can only function as well as the components, the plumbing and the settings allow.

Rate controllers will struggle to achieve or maintain the desired application rate if the plumbing is not correct, the valve types are not appropriate, or the regulation is not correctly set-up or adjusted correctly. Issues may also arise if the pump capacity is too small, there are plumbing restrictions or the oil flow to the pump is restricted.

Where the rate controller is not able to achieve or maintain the application rate you require (e.g. higher application volumes and higher spraying speeds) you should complete the checks listed in the pre-operational checks module (Module 6), and ensure that the plumbing is appropriate for the system and pump.

For more information on plumbing and plumbing components, go to Module 11: Pumps, plumbing and components

5. Functions the operator should consider using

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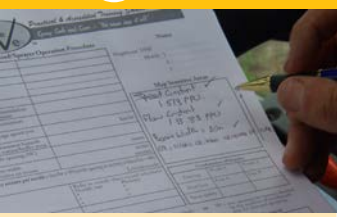

Checking controller inputs and settings

It is important to spend time going through the controller manual before operating the sprayer and highlight important functions and features. Each controller will have a range of useful functions that the operator, and the person delivering the sprayer, may not be aware of.

Two particularly useful functions that are common to many rate controllers are the simulated speed or test speed function and the automatic adjust function.

Simulated or test speed function
The simulated speed, function allows the operator to simulate various spraying speeds while the sprayer is stationary. This is very useful for calibration and pre-operational checks.

There are various ways different manufacturers identify the minimum hold function in their controllers, including in the following.

Having a simulated speed or test speed function allows the operator to complete stationary tests of the spray system.

Photo: Graham Betts

Hardi 5500 speed simulation function

Simulated speeds are useful for calibration and checking spray plans.

Photo: Graham Betts

Bravo 1805 speed simulation function

Table 3 Where to find the simulated (test) speed function for selected rate controller models.

Controller brand	Model	Comments
TeeJet®	844E	'Speed simulation' can be found by holding '+' and '-' and pressing 'PRO' twice. 'SI' should be showing on the screen, then cycle through to 'SIM' and hold the '+' or '-' button until the required km/h displays.
Raven®	400 series	'SELF TEST' can be found by pressing the self test button, pressing 'ENTER', entering the simulated speed figure and then pressing 'ENTER' again.
Raven®	4000 series	'Test Speed' under 'Speed Cal' under 'PROD 1 : 2'.
Hardi®	5500	'Simulated speed': go to Menu 4.6 and enter the simulated speed (km/h).
John Deere	Various models	Go to 'Nozzle Flow Check' and enter the km/h of the simulated speed.
Topcon	X20	Click on km/h 'Speed Readout' button and use the increase and decrease 'Speed Window' arrows to change the test speed.

'Automatic adjust' function for application volume

Another useful function of controllers is the 'automatic adjust function', which allows the operator to program a predetermined adjust figure into the controller to increase the application rate by a certain amount, either by a known L/ha or by a percentage increase of the L/ha.

For example, if the automatic adjust figure is set at 10L/ha and the spray operator decides he or she would like to increase the application rate because of a heavy patch of weeds, the operator can push a switch or button to adjust the application rate (e.g. go from 10L/ha to 20L/ha). Then after passing the heavy patch of weeds, push a switch or button to resume the rate originally programmed into the controller.

Using this function should only be considered in situations where the applied rate is less than the maximum rate permitted on the product label, and the increased rate will not exceed the maximum label rate.

For more information on pulse-width modulation systems, go to Module 17: Pulse width modulation

Pressure adjust in pulse-width modulation systems

With many pulse-width modulation systems, the operator has the ability to set more than one pressure while still being able to achieve the target application rate. This function allows the operator to change droplet size without changing nozzles, provided the selected duty cycle remains within the useful range.

6. Display outputs

It is possible to have a lot of information displayed on the main screen, such as speed, litres per hectare, nozzle pressure, tank volume and hectares sprayed. **But litres per minute and nozzle pressure are the most pieces of important information** to have visible on the main screen while spraying.

All the above pieces of information are useful to check during or after a job is complete, but total litres per minute and nozzle pressure will alert the spray operator to whether the sprayer is working properly while he or she is spraying. Litres per hectare (L/ha) and speed (km/h) are a guide only.

TIPS

- If the flow rate (L/min) remains constant, but the pressure begins to increase, check filters for blockages.
- If flow rate remains constant and pressure drops dramatically, stop and check for leaks or blown hoses or fittings.
- If pressure appears correct but flow rate is less than anticipated, check all sections are fully engaged and the section control/valves are responding correctly.
- Use the controller subtotals and totals at the end of a tank, paddock and day to make sure that everything is working out correctly. If the difference between sprayed hectares and paddock hectares is too great, double-check that the controller settings are correct. If they are, a decision may need to be made to change the sprayer technology or spraying practices.
- Make use of the field litres, total litres and hectares. Zero all the screen totals before starting a day's spraying. When the spray operator finishes a paddock, he or she should check and record the field litres and hectares.

7. Summary

Rate-controller functions continue to evolve as different models and spraying systems are released onto the market. Spending time consulting the controller manual may alert the operator to functions he or she was not aware the controller could perform.

Before operating any sprayer, the operator should check all controller inputs and settings for accuracy to ensure it can perform as intended.

A spray plan is a useful way to record all of the considerations the operator uses when selecting the spraying parameters, controller settings and the sprayer performance indicators.

Knowing what the flow rate (L/min) through the boom and the operating pressure should be at your typical spraying speeds will help to identify if the system is operating correctly.

For more information go to Module 5: Spray plans and Module 6: Pre-operational checks

NEXT MODULE

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 14 Boom stability and height control The importance of design and control

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