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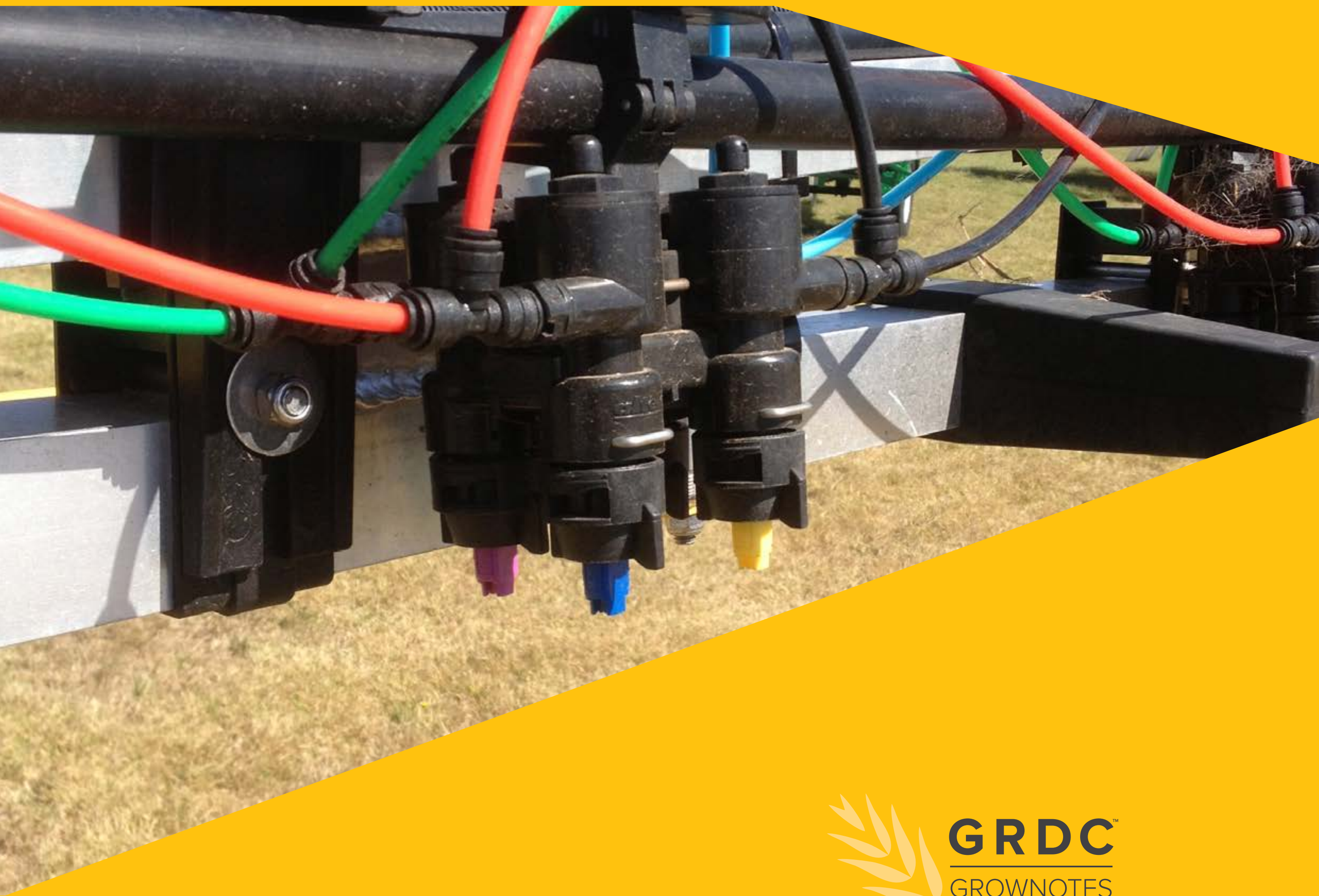

GROWNOTES

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 18
Single line and multi-step systems
How they work and set-up considerations

Graham Betts and Bill Gordon

Key points

- Multi-step systems can allow the operator to greatly increase the range of spraying speeds or application volumes when compared to a standard single line sprayer
- Nozzle selection for a multi-step sprayer requires careful consideration, as the nozzle choices available to operate the spray system with a single brand or model of nozzles may be limited
- Determining the speed, flow rate or pressure at which the system should transition between one nozzle orifice size to another must take into account the minimum pressure required to operate each nozzle effectively and the spray quality that each nozzle will produce
- It may be possible to operate a multi-step system without having to change nozzle types simply by changing the rate controller settings for when transitions occur and operating it at specific speed and application volume combinations

1. The operating principle for multi-step systems

The basic principle of multi-step systems is to be able to switch from one nozzle orifice size to another (usually larger) to increase the useful range of spraying speeds or application volumes.

To achieve this, the automatic rate controller needs to be programmed to know when the operator requires the switch or transition between particular nozzles to occur.

Depending on the type of rate controller used, the transition points may need to be entered into the rate controller as one of the following:

- **pressure in the spray line, or pressure at the nozzle;**
- **flow rate of the nozzle, or flow rate through the whole boom (and accurate section widths); or**
- **spraying speeds for each transition.**

The transition point that must be programmed into the rate controller for each nozzle will vary according to: the range of operating pressures for the specific nozzles chosen; the spray quality each produces; and the minimum pressure requirements of the next nozzle in the sequence of transitions.

Nozzle selection and the transition points between them are probably the most critical aspects in ensuring a multi-step nozzle system operates efficiently and effectively.

1.1 Nozzle shut-off systems to turn nozzles on and off for the transitions

The commercially available multi-step systems utilise nozzle valves to turn the nozzles on and off. These are available as either electric nozzle shut-off valves, or air shut-off valves controlled by air solenoids. In both cases they offer almost instant switching and a positive shut-off. Switching the spray 'on' and 'off' at the nozzle provides the opportunity for boom recirculation systems to be used. This can prevent the operator from having to prime the boom in the paddock before he/she commences spraying.

Electric nozzle valves can also allow for nozzles to be controlled individually, which allows for single nozzle section control to be used. Typically, systems that use air shut-off valves have groups of nozzles plumbed together (the group is controlled by a single air solenoid) and are less likely to offer single nozzle section control.

When comparing the multi-step systems that use electric nozzle shut-off valves, it is important to consider the total current draw of the system that will occur for the width of the boom it is to be fitted to. Wider booms may present a problem for some nozzle shut-off valve types, particularly where multiple nozzles per outlet are fitted to the boom, or where half nozzle spacings are used.

2. Modern versions of the multi-step system

For more information on plumbing requirements for boom recirculation and nozzle shut-off valves go to Module 11: Pumps, plumbing and components

Typically, multi-step nozzle systems are available as a two-nozzle system or a four-nozzle system.

A two-nozzle system may be set up by having two nozzles per outlet across the boom at the standard nozzle spacing (e.g. 0.5 metres) or by having a single nozzle per outlet at a half spacing (e.g. 0.25m). Both set-ups allow for three steps to occur.

A four-nozzle system generally allows for up to 12 steps to occur as the system transitions between individual nozzles (or combinations of two, three or all four of the nozzles operating at the same time).

A four-nozzle set-up may be plumbed by having four nozzles per outlet at the standard nozzle spacing (e.g. 0.5m), or by having two nozzles per outlet using half the normal nozzle spacing (e.g. 0.25m).

Multi-step set-up at 0.25-metre nozzle spacing

Arag Seletron® set up at 0.25m spacing. This set-up can allow for increased overlap when nozzles at each spacing are engaged.

Source: Graham Betts

A four-nozzle multi-step system set up at 0.5m nozzle spacing

A four-nozzle system can provide a range of application volumes or spraying speeds equivalent to 12 or more individual nozzle sizes.

Source: Graham Betts

PLAY VIDEO

Spray systems – three tier

2.1 An example of a two-nozzle system – three-step system

When selecting nozzles for a two-nozzle, three-step system, it is useful to consider what the largest nozzle orifice size that the operator would normally use on a standard single line sprayer would be. If the largest nozzle normally used on a standard single line was an 03 orifice, then the total flow of the two nozzles for a three-step system should be similar to this, e.g. using an 015 and an 02 orifice together produces a combined flow rate equivalent to the flow rate of an 035 orifice size.

However, by using two nozzles operated in the sequence of the 015, then the 02, the operator can gain a greater range of spraying speeds or application volumes (see Table 1).

Table 1 The nozzles engaged and equivalent flow rate for a three-step system fitted with 015 and 02 nozzles.

Steps available with a 2-nozzle system	015	02	Equivalent orifice size
Step 1	✓		015
Step 2		✓	02
Step 3	✓	✓	035

By using the combination of 015 and 02 nozzle sizes in a three-step system to apply a tank mix at 100 litres per hectare this would allow the effective range of spraying speeds to be from about 6.0 kilometres per hour to 23.4km/h (depending on the spray quality required). When compared to a standard single line sprayer fitted with an 03 orifice, which would provide an effective speed range of 13.0km/h to 20.1km/h, this three-step system provides a significant improvement, particularly by reducing the lowest speed the sprayer can effectively operate at.

A reduction in the minimum effective spraying speed minimises overdosing and has the potential to reduce the size of headlands required. An added advantage to some operators may be that the spray quality produced by the combination of the 015 and the 02 orifice sizes would not be as coarse as using a single 03 orifice size, which may be useful for many applications where a medium spray quality may be required.

Care needs to be exercised by the operator when deciding on preferred spraying speed and application volume. The increase in flow rate required to transition from operating an 02 orifice size to operating the equivalent of an 035 orifice (when both nozzles are operated together) can result in the nozzles operating at a lower than anticipated pressure.

The operator should not select a spraying speed close to the point where a transition has been programmed to occur. If the preferred application volume is likely to occur at a spraying speed where a transition will happen, the operator should increase the application volume to ensure that there will be enough pressure to operate the nozzles and the system and not having to constantly switch between nozzles.

PLAY VIDEO

A grower's view on multi-step systems

2.2 Operating range for a four-nozzle multi-step system

The four-nozzle multi-step system may be set up by using four nozzles per outlet across the boom (e.g. at 0.5m), or by having two nozzles per outlet, using half the normal nozzle spacing (e.g. 0.25m). Table 2 provides an example of the equivalent flow rates that can be achieved using a four-nozzle multi-step system.

Table 2 The nozzles engaged and equivalent flow rates for a four-nozzle multi-step system fitted with 01, 015, 02 and 03 nozzles.

Steps available with a 4-nozzle system	01	015	02	025	Equivalent orifice size
Step 1	✓				01
Step 2		✓			015
Step 3			✓		02
Step 4				✓	025
Step 5	✓		✓		03
Step 6		✓	✓		035
Step 7		✓		✓	04
Step 8			✓	✓	045
Step 9	✓	✓		✓	05
Step 10	✓		✓	✓	055
Step 11		✓	✓	✓	06
Step 12	✓	✓	✓	✓	07

Depending on the nozzle orifice sizes chosen, a four-nozzle system can offer 12 or more steps, which can provide flow rates ranging from the equivalent of an 01 orifice through to the equivalent of an 07 orifice.

For the example included in Table 2, when operating with 01, 015, 02 and 025 orifices fitted to a four-nozzle system and applying a rate of 100L/ha, this system could operate from about 4.3km/h up to more than 40km/h (although while possible, spraying at 40km/h is not recommended). Alternatively, this system could apply more than 200L/ha at spraying speeds of up to 21km/h.

TIPS

- **When using a half nozzle spacing where different nozzle orifice sizes are operating at the same time (e.g. 01 and 015, or 015 and 02 at a 0.25m nozzle spacing), set the boom height to achieve a double overlap for each orifice size, which would be equivalent to using a 0.5m nozzle spacing.**

3. Nozzle type and transition points for multi-step systems

The hydraulic nozzles available fall into four general categories: extended range flat-fan nozzles, pre-orifice nozzles, low-pressure air-induction nozzles and high-pressure air-induction nozzles.

Generally, extended range flat-fan nozzles produce fine to medium spray qualities in the smaller orifice sizes (01 to 03) which are likely to be most suitable for a multi-step system. This means they are not able to meet the legal requirements for a coarse spray quality common on many product labels. Air-induction nozzles (either high-pressure or low-pressure) or pre-orifice nozzles are the most useful types for multi-step systems.

When considering which nozzle type to choose for each step, from smallest orifice to largest orifice (or combinations of two or more nozzles at once), the operator must carefully look at the minimum pressure required to operate each nozzle and the maximum operating pressure of each nozzle to maintain the required spray quality.

3.1 Required flow rate per nozzle for the transitions

With many of the pre-orifice and low-pressure air-induction nozzles, the minimum operating pressure will need to be at least 2 bar to allow the nozzles to produce an effective spray pattern. When planning the transitions between nozzles, the operator needs to consider what the minimum flow rate of the next nozzle in the desired sequence will be, and to ensure that the spraying system has reached that flow rate before the transition occurs. At the same time, the operator also needs to select a nozzle type that will produce the desired spray quality through the range of operating pressures the nozzle will go through before the transition occurs.

For example, if an operator has selected to use a multi-step system fitted with four low-pressure air-induction nozzles per outlet (a four-nozzle body and each outlet is fitted with 01, 015, 02 and 025 orifice sizes), then the transition from the 01 orifice to the 015 orifice should not occur before the 01 orifice has a flow rate of 0.48 litres per minute per nozzle (equivalent to the flow rate of a 015 orifice at 2 bar). This means that the 01 orifice needs to reach approximately 4.5 bar (0.5L/min per nozzle) before the transition from the 01 orifice to the 015 orifice occurs (refer to Table 3 for examples).

Similarly, the transition from the 015 to the 02 should not occur until the flow rate of the 015 has reached at least 0.65L/min per nozzle (equivalent to the flow rate of an 02 orifice at 2 bar). This process should be followed for each transition between orifice sizes or combinations of the orifice sizes.

Table 3 shows the pressure and flow rate in litres per minute per nozzle for 01, 015, 02 and 025 orifice sizes, along with the spray quality produced for the Lechler IDK-120 (low-pressure air-induction) nozzle for each of the four orifice sizes.

Table 3 Flow rate and spray quality for Lechler IDK-120 nozzles at various pressures

Size	Bar	L/min / nozzle	Spray quality	Transition for medium	Transition for coarse
01 ORANGE	1.5	0.28	C		
	2.0	0.32	C		
	3.0	0.40	C		
	4.0	0.46	M		
	5.0	0.51	M		C
	6.0	0.56	F	M	
	7.0	0.60			
	8.0	0.65			
015 GREEN	1.5	0.42	C		
	2.0	0.48	C		
	3.0	0.59	C		
	4.0	0.68	M		C
	5.0	0.76	M		
	6.0	0.84	F	M	
	7.0	0.91			
	8.0	0.96			
02 YELLOW	1.5	0.56	VC		
	2.0	0.65	C		
	3.0	0.79	C		
	4.0	0.91	M		C
	5.0	1.02	M		
	6.0	1.12	M		
	7.0	1.21		M	
	8.0	1.29			
025 LILAC	1.5	0.70	VC		
	2.0	0.81	VC		
	3.0	0.99	C		
	4.0	1.14	C		
	5.0	1.27	M		C
	6.0	1.40	M		
	7.0	1.51		M	
	8.0	1.61			

Note, the red box indicates that the transitions should be programmed before this pressure or flow rate is reached at the nozzle. For a Medium quality, transition before the red box with the YELLOW 'M' inside. For a Coarse spray quality, transition before the red box with a BLUE 'C' inside The operator should always chose spraying speeds and application volumes that align with the desired spray quality, e.g. 5 bar to achieve a Medium spray quality and 3 bar to achieve a Coarse spray quality.

Note that with small increases in the orifice size between each step, it is possible to transition between nozzles (or combinations of nozzles) before the maximum pressure of each nozzle is reached. This allows for greater control of the pressure at the nozzle to achieve the desired spray quality, provided the flow rate per nozzle is sufficient to operate the next nozzle (or combination of nozzles) in the programmed sequence.

3.2 Achieving the desired spray quality

Most product labels require the operator to produce either a medium spray quality or a coarse spray quality. The ideal nozzles to fit to a multi-step system would allow both spray qualities to be produced without having to change the nozzles fitted to the sprayer.

Table 3 shows that the Lechler IDK-120 nozzles between 01 orifice and 025 orifice sizes can all produce a coarse spray quality at 3 bar, and all orifice sizes can produce a medium spray quality 5.0 bar. Selecting this nozzle type would allow the operator to change spray quality simply by changing the nozzles when the transitions occur to match the required operating pressure. For coarse spray qualities the transition should occur before the nozzles reach 3.5 bar (red box), and for a medium spray quality the transitions should occur just before the nozzles exceed 5.0 bar.

The ideal rate controller for a multi-step system would allow the operator to ‘save’ or ‘store’ a programmed sequence for a coarse spray quality and another sequence for medium droplets. Where such a function is not available, the operator should produce a spray plan and record where the transition points should be programmed when changing between spray qualities (e.g. from coarse to medium). While it may take several minutes to enter the information into the controller to tell the system when new transitions should occur to change the spray quality, this will still be much faster than changing a complete set of nozzles.

3.3 Steps and transitions for a four-nozzle multi-step system to achieve coarse or medium spray qualities from a single set of nozzles

When using a four-nozzle multi-step system, to provide for the lowest practical spraying speed it is useful to consider starting with an 01 orifice nozzle. However, there are only a few low-pressure air-induction nozzles available in an 01 orifice size, and currently only two brands that can produce a coarse spray quality with this orifice size (see Table 4 for an example). If the operator requires either coarse or medium droplets from the same low-pressure air-induction nozzle type, only the Lechler IDK nozzles can achieve this in all orifice sizes from 01 to 025.

When using nozzles produced by other manufacturers, the operator needs to select more than one brand or model of nozzle to cover all of the orifice sizes that would be required to produce either a coarse spray quality or a medium spray quality from each of the nozzle orifice sizes used.

Table 4 Spray qualities produced by various low-pressure air-induction nozzles from 01 to 03 orifice sizes.

		Low-pressure air-induction (run above 2-3 bar)										
BRAND		**Agrotop**	**Lechler**	**Hardi**	**Hardi**	**Lechler**	**Hypro**	**Hypro**	**Teejet**	**Belle-ricay**	**Albuz**	**Hypro/ Spray-master**
MODEL		**Airmix**	**IDK-120**	Minidrift Duo twinjet	Minidrift	IDKT twinjet	Guardian Air	Guardian Twin Air	**AIXR**	**Bubble-jet**	**CVI**	**Drift Beta / ULD**
Nozzle size	Bar											
01 ORANGE	1.5											
	2.0	M	C	not available in this size	not available in this size	not available in this size	not available in this size	not available in this size	not available in this size	VC	not available in this size	not available in this size
	3.0	M	C							C		
	4.0	F	M							C		
	5.0	F	M							C		
	6.0	F	F							C		
	7.0									M		
	8.0											
015 GREEN	1.5		C		C		UC	not available in this size	VC			
	2.0	XC	C	not available in this size	C	not available in this size	XC		C	XC	C	C
	3.0	C	C		C		C		C	VC	C	C
	4.0	C	M		M		M		C	C	C	M
	5.0	C	M		M		M		M	C	C	M
	6.0	M	F		M		M		M	C		M
	7.0						M			C		F
	8.0						M					F
02 YELLOW	1.5		VC	VC	VC		XC		XC	VC		
	2.0	C	C	C	C	not available in this size	VC	C	VC	C	C	C
	3.0	C	C	C	C		M	M	C	C	C	C
	4.0	M	M	C	C		M	M	C	M	C	C
	5.0	M	M	M	M		M	M	C	M	M	M
	6.0	M	M	M	M		M	M	M	M		M
	7.0	M					M	F		M		M
	8.0						M	F				F
025 LILAC	1.5		VC	VC	VC	not available in this size	XC		XC	XC		
	2.0	VC	VC	VC	VC		VC	VC	XC	XC	C	VC
	3.0	C	C	C	C		C	C	VC	VC	C	C
	4.0	C	C	C	C		M	M	C	C	C	C
	5.0	M	M	M	M		M	M	C	C	M	C
	6.0	M	M	M	M		M	M	C	C		M
	7.0						M	M		C		M
	8.0						M	M	M			M
03 BLUE	1.5		VC	VC	VC	C	UC		XC	XC		
	2.0	VC	VC	VC	VC	C	XC	VC	XC	XC	C	VC
	3.0	C	C	C	C	C	VC	C	VC	VC	C	C
	4.0	C	C	M	C	M	C	M	C	C	C	C
	5.0	C	M	M	C	M	M	M	C	C	M	C
	6.0	M	M	M	M	F	M	M	C	C		M
	7.0	M					M	M		C		M
	8.0						M					M

All data sourced from manufacturer's websites in January 2015 except for Airmix data (sourced from 2012 Nufarm Spraywise publications). Source: Bill Gordon

Typical steps when operating a four-nozzle multi-step system

Tables 5 to 14 show the first 10 steps for a four-nozzle multi-step system. The tables highlight the spraying speed and application volume to achieve either a coarse spray quality (highlighted in blue) or a medium spray quality (highlighted in yellow) for an application volume of 100L/ha.

Spraying speeds highlighted with a red background show the nozzle will be outside its optimum range of operating pressures. Spraying speeds with an orange background shows the nozzle is approaching the limits of its optimum operating pressure range limit. Spraying speeds with a green background show the nozzle is operating within its ideal pressure range.

Table 5 Step 1 for a four-nozzle multi-step system fitted with 01, 015, 02 and 025 orifice sizes to deliver 100L/ha.

Nozzle size & colour	Bar pressure at the nozzle	Litres per minute per nozzle water only	Spraying speeds to achieve coarse (blue) or medium (yellow) spray qualities at 100 litres per hectare using Lechler IDK 120 nozzles at 0.5-metre (19.68-inch) nozzle spacing								
01 ORANGE	Step 1										
	Bar	L/min/nozz	Spraying speed (km/h)								
			3.9	4.3	4.7	5.1	5.5	5.8	6.1	6.4	6.7
	2.0	0.322	100	89	82	76	71	67	63	60	58
	2.5	0.360	112	100	91	85	79	75	71	67	65
	3.0	0.395	123	110	100	93	87	82	77	74	71
	3.5	0.426	132	118	108	100	93	88	84	80	76
	4.0	0.456	142	127	115	107	100	94	89	85	82
	4.5	0.483	150	134	122	113	106	100	95	90	87
	5.0	0.510	158	142	129	120	112	106	100	95	91
	5.5	0.535	166	149	135	126	100	111	105	100	96
	6.0	0.558	173	155	141	131	100	116	109	104	100

Note: changing the nozzle type (brand, fan angle and orifice size) would change the spray quality produced.

From Table 5, showing step 1 for an application volume of 100L/ha, the operator can determine a suitable minimum spraying speed to achieve a coarse spray quality (blue highlight) would be 4.7km/h. The minimum spraying speed for a medium spray quality at 100L/ha would occur at 6.1km/h.

For each step thereafter (refer to Tables 6 to 14), the operator should select a spraying speed that aligns with either 3 bar for a coarse spray quality, or 5 bar for a medium spray quality. However, the operator must remember to change the transition points in the rate controller when they wish to change between spray qualities.

By carefully evaluating the range of operating pressures, spray quality produced and spraying speeds that align with these pressures, the transition points can be determined. This information should be recorded in a spray plan, as well as in the rate controller. Tables 6 to 14 show the next 9 steps for a four-nozzle multi-step system applying a rate of 100L/ha.

Table 6 Step 2 for a four-nozzle multi-step system fitted with 01, 015, 02 and 025 orifice sizes to deliver 100L/ha.

Nozzle size & colour	Bar pressure at the nozzle	Litres per minute per nozzle water only	Spraying speeds to achieve coarse (blue) or medium (yellow) spray qualities at 100 litres per hectare using Lechler IDK 120 nozzles at 0.5-metre (19.68-inch) nozzle spacing								
015 GREEN	Step 2										
	Bar	L/min/ nozz.	Spraying speed (km/h)								
			5.0	6.0	7.1	7.7	8.2	8.7	9.2	9.6	10.0
	2.0	0.483	100	89	82	75	71	67	63	60	58
	2.5	0.541	130	100	91	85	79	75	71	67	65
	3.0	0.592	142	118	100	92	87	82	77	74	71
	3.5	0.640	154	128	108	100	94	88	84	80	76
	4.0	0.684	164	137	116	107	100	94	90	85	82
	4.5	0.725	174	145	122	113	106	100	95	90	87
	5.0	0.764	183	153	129	119	112	105	100	95	91
	5.5	0.802	192	160	135	125	117	111	105	100	96
	6.0	0.837	201	167	141	131	122	115	110	104	100

Note: changing the nozzle type (brand, fan angle and orifice size) would change the spray quality produced.

Table 7 Step 3 for a four-nozzle multi-step system fitted with 01, 015, 02 and 025 orifice sizes to deliver 100L/ha.

Nozzle size & colour	Bar pressure at the nozzle	Litres per minute per nozzle water only	Spraying speeds to achieve coarse (blue) or medium (yellow) spray qualities at 100 litres per hectare using Lechler IDK 120 nozzles at 0.5 metre (19.68 inch) nozzle spacing								
02 YELLOW	Step 3										
	Bar	L/min/ nozzle	Spraying speed (km/h)								
			7.7	8.7	9.5	10.2	10.9	11.6	12.2	12.8	13.4
	2.0	0.645	100	89	82	76	71	67	63	60	58
	2.5	0.721	112	100	91	85	79	75	71	67	65
	3.0	0.790	122	110	100	93	87	82	78	74	71
	3.5	0.853	132	118	108	100	94	88	84	80	76
	4.0	0.912	141	126	115	107	100	94	89	85	82
	4.5	0.967	150	134	122	113	106	100	95	90	87
	5.0	1.019	158	141	129	119	112	105	100	95	91
	5.5	1.069	166	148	135	125	117	111	105	100	96
	6.0	1.117	173	155	141	131	122	116	110	104	100

Note: changing the nozzle type (brand, fan angle and orifice size) would change the spray quality produced.

Table 8 Step 4 for a four-nozzle multi-step system fitted with 01,015,02 and 025 orifice sizes to deliver 100L/ha.

Nozzle size & colour	Bar pressure at the nozzle	Litres per minute per nozzle water only	Spraying speeds to achieve coarse (blue) or medium (yellow) spray qualities at 100 litres per hectare using Lechler IDK 120 nozzles at 0.5-metre (19.68-inch) nozzle spacing								
025 LILAC	Step 4										
	Bar	L/min/ nozz	Spraying speed (km/h)								
			9.7	10.8	11.8	12.8	13.7	14.5	15.3	16.0	16.8
	2.0	0.806	100	89	82	76	71	67	63	60	58
	2.5	0.901	112	100	91	85	79	75	71	67	65
	3.0	0.987	122	110	100	93	87	82	77	74	71
	3.5	1.066	132	118	108	100	94	88	84	80	76
	4.0	1.140	141	127	116	107	100	94	89	85	82
	4.5	1.209	150	134	122	113	106	100	95	90	87
	5.0	1.274	158	141	129	120	112	105	100	95	91
	5.5	1.336	166	148	135	125	117	111	105	100	96
	6.0	1.396	173	155	141	131	122	115	110	104	100

Note: changing the nozzle type (brand, fan angle and orifice size) would change the spray quality produced.

Table 9 Step 5 for a four-nozzle multi-step system fitted with 01, 015, 02 and 025 orifice sizes to deliver 100L/ha.

Nozzle size & colour	Bar pressure at the nozzle	Litres per minute per nozzle water only	Spraying speeds to achieve coarse (blue) or medium (yellow) spray qualities at 100 litres per hectare using Lechler IDK 120 nozzles at 0.5 metre (19.68 inch) nozzle spacing								
03 BLUE Using the 01 and 02 nozzles together	Step 5										
	Bar	L/min/ nozzle	Spraying speed (km/h)								
			11.6	13.0	14.2	15.3	16.4	17.4	18.3	19.2	20.1
	2.0	0.967	100	89	82	76	71	67	63	60	58
	2.5	1.081	112	100	91	85	79	75	71	67	65
	3.0	1.184	122	110	100	93	87	82	77	74	71
	3.5	1.279	132	118	108	100	94	88	84	80	76
	4.0	1.367	141	126	115	107	100	94	89	85	82
	4.5	1.450	150	134	122	113	106	100	95	90	87
	5.0	1.529	158	141	129	120	112	105	100	95	91
	5.5	1.604	166	148	135	125	117	111	105	100	96
	6.0	1.675	173	155	141	131	123	116	110	104	100

Note: changing the nozzle type (brand, fan angle and orifice size) would change the spray quality produced.

Table 10 Step 6 for a four-nozzle multi-step system fitted with 01, 015, 02 and 025 orifice sizes to deliver 100L/ha.

Nozzle size & colour	Bar pressure at the nozzle	Litres per minute per nozzle water only	Spraying speeds to achieve coarse (blue) or medium (yellow) spray qualities at 100 litres per hectare using Lechler IDK 120 nozzles at 0.5 metre (19.68 inch) nozzle spacing								
035 Using the 015 and 02 nozzles together	Step 6										
	Bar	L/min/ nozzle	Spraying Speed (km/h)								
			13.5	15.1	16.6	17.9	19.1	20.3	21.4	22.5	23.4
	2.0	1.128	100	89	82	76	71	67	63	60	58
	2.5	1.261	112	100	91	85	79	75	71	67	65
	3.0	1.382	123	110	100	93	87	82	77	74	71
	3.5	1.492	132	118	108	100	94	88	84	80	76
	4.0	1.595	141	126	115	107	100	94	89	85	82
	4.5	1.692	150	134	122	113	106	100	95	90	87
	5.0	1.784	158	141	129	120	112	105	100	95	91
	5.5	1.871	166	148	135	125	117	111	105	100	96
	6.0	1.954	173	155	141	131	123	115	110	104	100

Note: changing the nozzle type (brand, fan angle and orifice size) would change the spray quality produced.

Table 11 Step 7 for a four-nozzle multi-step system fitted with 01, 015, 02 and 025 orifice sizes to deliver 100L/ha.

Nozzle size & colour	Bar pressure at the nozzle	Litres per minute per nozzle water only	Spraying speeds to achieve coarse (blue) or medium (yellow) spray qualities at 100 litres per hectare using Lechler IDK 120 nozzles at 0.5-metre (19.68-inch) nozzle spacing								
04 Using the 015 and 025 nozzles together	Step 7										
	Bar	L/min/ nozzle	Spraying speed (km/h)								
			15.5	17.3	18.9	20.5	21.9	23.2	24.5	25.7	26.8
	2.0	1.289	100	89	82	76	71	67	63	60	58
	2.5	1.441	112	100	91	84	79	75	71	67	65
	3.0	1.579	122	110	100	93	87	82	77	74	71
	3.5	1.706	132	118	108	100	94	88	84	80	76
	4.0	1.823	141	127	115	107	100	94	89	85	82
	4.5	1.934	150	134	122	113	106	100	95	90	87
	5.0	2.039	158	141	129	120	112	105	100	95	91
	5.5	2.138	166	148	135	125	117	111	105	100	96
	6.0	2.233	173	155	141	131	122	115	110	104	100

* Note changing the nozzle type (brand, fan angle and orifice size) would change the spray quality produced.

Table 12 Step 8 for a four-nozzle multi-step system fitted with 01, 015, 02 and 025 orifice sizes to deliver 100L/ha.

Nozzle size & colour	Bar pressure at the nozzle	Litres per minute per nozzle water only	Spraying speeds to acheive coarse (blue) or medium (yellow) spray qualities at 100 litres per hectare using Lechler IDK 120 nozzles at 0.5-metre (19.68-inch) nozzle spacing								
045 Using the 02 and 025 nozzles together	Step 8										
	Bar	L/min/ nozzle	Spraying speed (km/h)								
			17.4	19.5	21.3	23.0	24.6	26.1	27.5	28.9	30.1
	2.0	1.450	100	89	82	76	71	67	63	60	58
	2.5	1.622	112	100	91	85	79	75	31	67	63
	3.0	1.776	122	109	100	93	87	82	69	74	71
	3.5	1.919	132	118	108	100	94	88	33	80	36
	4.0	2.051	141	126	115	107	100	94	74	85	68
	4.5	2.176	150	134	123	113	106	100	35	90	39
	5.0	2.293	158	141	129	119	112	105	100	95	71
	5.5	2.405	166	148	135	125	117	111	29	100	41
	6.0	2.512	173	155	141	131	122	115	104	104	100

* Note changing the nozzle type (brand, fan angle and orifice size) would change the spray quality produced.

Table 13 Step 9 for a four-nozzle multi-step system fitted with 01, 015, 02 and 025 orifice sizes to deliver 100L/ha.

Nozzle size & colour	Bar pressure at the nozzle	Litres per minute per nozzle water only	Spraying speeds to achieve coarse (blue) or medium (yellow) spray qualities at 100 litres per hectare using Lechler IDK 120 nozzles at 0.5-metre (19.68-inch) nozzle spacing								
045 Using the 02 and 025 nozzles together	Step 9										
	Bar	L/min/ nozz.	Spraying speed (km/h)								
			19.3	21.6	23.7	25.6	27.3	29.0	30.6	32.1	33.5
	2.0	1.612	100	89	82	76	71	67	63	60	58
	2.5	1.802	112	100	91	85	79	75	71	67	65
	3.0	1.974	122	110	100	93	87	82	77	74	71
	3.5	2.132	132	118	108	100	94	88	84	80	76
	4.0	2.279	141	126	115	107	100	94	89	85	82
	4.5	2.417	150	134	122	113	106	100	95	90	87
	5.0	2.548	158	141	129	120	112	105	100	95	91
	5.5	2.673	166	148	135	125	117	111	105	100	96
	6.0	2.791	173	155	141	131	122	115	110	104	100

* Note changing the nozzle type (brand, fan angle and orifice size) would change the spray quality produced.

Table 14 Step 10 for a four-nozzle multi-step system fitted with 01, 015, 02 and 025 orifice sizes to deliver 100L/ha.

Nozzle size & colour	Bar pressure at the nozzle	Litres per minute per nozzle water only	Spraying speeds to acheive coarse (blue) or medium (yellow) spray qualities at 100 litres per hectare using Lechler IDK 120 nozzles at 0.5-metre (19.68-inch) nozzle spacing								
055 Using the 01, 02 and 025 nozzles together	Step 10										
	Bar	L/min/ nozzle	Spraying speed (km/h)								
			21.3	23.8	26.1	30.1	30.1	31.9	33.6	35.3	36.8
	2.0	1.773	100	89	82	71	71	67	63	60	58
	2.5	1.982	112	100	91	79	79	75	71	67	65
	3.0	2.171	122	110	100	87	87	82	77	74	71
	3.5	2.345	132	118	108	100	94	88	84	80	76
	4.0	2.507	141	126	115	100	100	94	89	85	82
	4.5	2.659	150	134	122	106	106	100	95	90	87
	5.0	2.803	158	141	129	112	112	105	100	95	91
	5.5	2.940	166	148	135	117	117	111	105	100	96
	6.0	3.070	173	155	141	122	122	115	110	104	100

* Note changing the nozzle type (brand, fan angle and orifice size) would change the spray quality produced.

Correctly selecting the nozzles and identifying the transition points are the most critical processes for operating a multi-step system. Once this has been completed operation is relatively simple.

TIP

- **If plumbing the boom sprayer for row crop work or with a half nozzle spacing, the boom should be plumbed with a nozzle body in the centre of the boom then working outwards from there at the selected spacing.**

5. Wheel-track nozzles on multi-step systems

On a standard single line sprayer many operators would normally fit a larger orifice size nozzle behind the wheel to compensate for the impact of dust and lower spray deposits adjacent to the wheels when spraying fallows with knockdown herbicides.

Simply increasing the orifice size of the nozzles on a multi-step system requires that the operator consider the impact on the each of the transitions. The best solution may be for the operator to determine what the spraying speed will be for the fallow application and what nozzles will be engaged at this speed for the chosen application volume (L/ha). Once this has been established, only consider using a larger orifice size for one of the nozzles that will be engaged (e.g. replace the 025 air-induction with an 04 pre-orifice or low-drift nozzle producing a coarse spray quality adjacent to the wheels).

If the orifice size of one of the nozzles in the multi-step system is increased adjacent to the wheels, the operator should calculate the overall increase in flow rate that will occur when these nozzles are operating, and make adjustments to the applied rate to compensate for this.

See the GRDC fact sheet on Summer Fallow Spraying for further information on the positioning of wheel-track nozzles

For example:

The operator is trying to achieve 70L/ha at a spraying speed of 24km/h, using a 36m-wide multi-step on a 0.5m nozzle spacing to spray a fallow with knockdown herbicides.

At this spraying speed and application volume this four-nozzle multi-step system is operating with 72 x 025 orifice nozzles engaged at 3 bar = 72.0L/min.

If four of the 025 orifice nozzles adjacent to the wheel tracks (two per wheel) were replaced with 04 orifice nozzles the flow rate for the nozzles would increase from 1.0L/min for the 025 orifice, to 1.58L/min for the 04 orifice. This would result in an extra 0.58L/min of flow x 4 nozzles, or an additional 2.32L/min of flow for the whole boom.

To maintain 3 bar at all of the nozzles, and deliver 70L/ha across the rest of the boom, the total flow rate for the whole boom should now be 74.32L/min. To achieve this, the applied rate needs to be increased by a factor of 74.32 ÷ 72.0 = 1.032.

1.0322 x 70L/ha = 72.25L/ha to maintain pressure in the spray lines at 3 bar and to achieve the applied rate of 70L/ha across the boom.

Mixing would still be based on the 70L/ha rate, and once the fallow spraying operations have been completed, the original 025 orifice size should be returned to its original position.

An alternative to changing nozzle orifice sizes would be to plumb additional wheel-track nozzles behind each wheel that can be switched on or off independently of the rest of the boom. By doing this the operator still needs to consider the impact of the increased flow rate and adjust the application volume, as indicated in the previous example.

Wheel-track two-nozzle set-up

Plumbing additional wheel-track nozzles for fallow spraying will allow the multi-step system to transition correctly.

Source: Graham Betts

Using wheel-track nozzles does not increase the boom width, so operators should not change the boom-width settings in the controller. Adjust application rate to match the required application rate by determining the change in total flow rate required to maintain the required pressure at the nozzles.

6. Summary

Multi-step systems will increase the level of complexity of the spray system compared to a standard spray system. They can also introduce a new range of things for the operator to consider, such as additional maintenance, additional system checks and additional decontamination.

For many farming enterprises, where a large variation in spraying speeds and application volumes is common, the time saved by operating with a multi-step system far outweighs the additional planning and maintenance the system is likely to require.

The initial planning and nozzle selection are the most critical aspects of operating a multi-step nozzle system effectively and efficiently.

Many multi-step spraying systems are capable of achieving very low spraying speeds (improving deposition and reducing overdosing). This feature, combined with single nozzle section control, can often save more than 5 per cent of the total chemical usage on many farms.

NEXT MODULE

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 19 Shielded sprayers Practical issues and set up considerations

GRDC GROWNOTES

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