Application Technique – Considerations for Minimum Tillage.

Comments on Nozzle Selection, Drift Management and Machinery Set up

Bill Gordon Consulting

PO Box 4197 Lawrence NSW 2460

Bill.gordon@bigpond.com

Bill Gordon Consulting is funded by GRDC to discuss application and drift management techniques in the Northern and Southern GRDC regions.

Introduction

Advances in farming practices (e.g. minimum tillage), sprayer technology and guidance systems have all meant that we can apply farm chemicals more efficiently and with greater precision than ever before. However, with increased capacity of machines comes an increased risk of off target loss of product. More hectares per hour means more chemical left in the air per hour, unless we optimise the setup, monitor environmental conditions closely and get our nozzle selections right.

Factors that influence drift potential

How you operate the machine.

Speed

Increasing speed has many effects on how much chemical can arrive at the target, generally speaking the faster you go, the more chemical you will leave in the air, which means less available to land on the intended target. This is due to effects at the nozzle itself, and aerodynamic effects around the machine. Increasing relative wind speed past the nozzle leads to detrainment (escape) of fine droplets from the spray pattern. Increased travel speed, or relative wind speed past the chassis of the machine also increases the lift that occurs directly behind the machine and air movement around the wheels, carrying fine droplets high into the air.

Typically speeds above 16 km/h will impact on the nozzle and increase lift behind the chassis. Hence if you are considering operating at speeds above 16 km/h then using nozzles that cut down the fraction of droplets able move with the wind help to minimise drift potential. Increased speeds also increase wheel track issues in dusty situations, where in most cases additional nozzles around the wheels can improve results with knock down products, but should be avoided with residual products and in situations where the plant back period may be increased.

Boom Height, width and stability

Increased boom height is often associated with increased boom width, increased travel speeds or rough paddocks. Boom height can have a large effect on how much chemical can land on the target. At greater release heights small droplets tend to slow down very quickly and can remain in the air, while larger droplets can accelerate, resulting in more bounce and shattering and less deposition.

An increase in height from 50 cm above the target area or top of stubble to 70cm can result in up to 4 times more chemical staying in the air. While raising boom height from 50 cm to 1m above the target can increase the amount of chemical staying in the air by up to 8 to 10 times.

Increased width also increases the potential for boom instability, that is bounce (up and down movement) and yawing (forward and backward movement). Boom height can be managed by fitting auto boom height control, which will often limit the maximum travel speed to around 27 -28 km/h. Yawing should be of greater concern as it results in under and over dosing, and is much harder to minimise without reducing speed. Yawing is greatly increased when booms exceed around 24 m wide, hence wider booms (greater than 24 m) should generally be operated at lower speeds than narrower booms.

Nozzle Spacing

Nozzle spacing obviously impacts on overlap between nozzles and influences boom height. Generally speaking the closer together the nozzles are, the lower the boom can be above the target (provided boom height is able to be maintained). As mentioned already, reducing boom height means more chemical on the target and less left in the air.

But there are other potential benefits from using a narrower nozzle spacing (less than 50 cm). A narrower nozzle spacing may reduce effects such as shadowing in heavy stubble, where smaller weeds may not be adequately controlled, especially with coarser spray qualities. In other instances, such as controlled traffic with accurate guidance it opens up the opportunity for banded applications and shielded spraying in the inter-row.

However, there are practical limits to how narrow the spacing should be, which will usually relate to required nozzle orifice size to achieve a practical application volume (L/Ha), filtration issues, water quality, mixing order and the ability to meet legal requirements for spray quality with small orifice sizes.

Nozzle Selection

It has been my policy for a long time to make sure that regardless of the machines capacity, we should have enough flexibility with the nozzles we select to allow us to achieve the desired application volumes, without having to unnecessarily sacrifice speed and still meet all legal requirements for nozzle type and spray quality.

Basic Process for Selecting Nozzles and Questions to Ask

STEP 1: Determine the required application volume (L/Ha) and the required spray quality (check the label or manufacturers recommendation) and identify your average operating speed (must ensure boom stability). e.g. Coarse Droplets or Larger at 70 L/ha using a 50cm nozzle spacing on a single spray line, at a travel speed of 16 km/h.

STEP 2: Use a nozzle chart to determine the range of nozzles sizes and operating pressures that will give you the desired L/Ha at your average operating speed (km/h) e.g 70L/ha at 16 km/h

e.g. Using the nozzle chart below for a 50cm nozzle spacing, move across the top row until you reach your average operating speed. Then work your way down the column until you reach the L/ha you were hoping to achieve, finding which orifice sizes and pressures will match you situation.

Nozzle Size	Bar	l/min/ nozzle	Litres per sprayed hectare at 50 centimetre nozzle spacing, water only													
			10	12	14	15	16	17	18	20	22	24	25	26	28	30
01 Orange	1	0.23	28	23	20	18	17	16	15	14	13	12	11	11	10	9
	2	0.32	38	32	27	26	24	23	21	19	17	16	15	15	14	13
	3	0.39	47	39	33	31	29	28	26	23	21	20	19	18	17	16
	4	0.45	54	45	39	36	34	32	30	27	25	23	22	21	20	18
	5	0.50	60	50	43	40	38	35	33	30	27	26	25	24	22	21
	6	0.55	66	55	47	44	41	39	37	33	30	28	27	26	24	23
	7	0.59	71	59	51	47	44	42	39	35	32	30	29	28	26	25
015 Green	1	0.34	41	34	29	27	26	24	23	20	19	17	16	16	15	14
	2	0.48	58	48	41	38	36	34	32	29	26	24	23	22	21	19
	3	0.59	71	59	51	47	44	42	39	35	32	30	28	27	25	24
	4	0.68	82	68	58	54	51	48	45	41l	37	34	33	31	29	27
	5	0.76	91	76	65	61	57	54	51	46	41	38	36	35	33	30
	6	0.83	100	83	71	66	62	59	55	50	45	42	40	38	36	33
	7	0.90	109	90	77	72	68	64	60	54	49	45	43	42	39	36
02 Yellow	1	0.46	55	46	39	37	35	32	31	28	25	23	22	21	20	18
	2	0.65	78	65	56	52	49	46	43	39	35	33	31	30	28	26
	3	0.79	95	79	68	63	59	56	53	47	43	40	38	36	34	32
	4	0.91	109	91	78	73	68	64	61	55	50	46	44	42	39	36
	5	1.02	122	102	87	82	77	72	68	61	56	51	49	47	44	41
	6	1.12	134	112	96	90	84	79	75	67	61	56	54	52	48	45
	7	1.21	145	121	104	97	91	85	81	73	66	61	58	56	52	48
025	1	0.57	68	57	49	46	43	40	38	34	31	29	27	26	24	23
	2	0.81	97	81	69	65	61	57	54	49	44	41	39	37	35	32
	3	0.99	119	99	85	79	74	70	66	59	54	50	48	46	42	40
	4	1.14	137	114	98	91	86	80	76	68	62	57	55	53	49	46

Say I wanted to spray at 16 km/hr @ at 70 L/Ha with a COARSE or larger spray quality which nozzle size & type would you select ?

Using the chart, we find that we could use an 015 orifice at 7 bar, an 02 orifice at 4 bar or an 025 orifice at 2.5 bar. All of these nozzle sizes could give us 70L/ha at 16 km/h.

STEP 3: Identify the types of nozzles based on their operating pressure at the average speed, and identify the most appropriate minimum operating pressure for each nozzle type (the SPRAYWISE charts are useful for evaluating suitable minimum operating pressures for each of the nozzles)

For example:

015 @ 7 bar = *High pressure air induction (minimum pressure = 4 bar)*

02 @ 4 bar = *Low pressure air induction (minimum pressure = 2 bar)*

025 @ 2.5 bar = *pre-orifice e.g. LD or standard TT (minimum pressure > 1.5 bar)*

STEP 4: Use the minimum operating pressure for each nozzle type to identify at what speed the desired L/ha is achieved (Dropping below this pressure means nozzles will not work properly).

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			10	12	14	15	16	17	18	20	22	24	25	26	28	30
01 Orange	1	0.23	28	23	20	18	17	16	15	14	13	12	11	11	10	9
	2	0.32	38	32	27	26	24	23	21	19	17	16	15	15	14	13
	3	0.39	47	39	33	31	29	28	26	23	21	20	19	18	17	16
	4	0.45	54	45	39	36	34	32	30	27	25	23	22	21	19	18
	5	0.50	60	50	43	40	38	35	33	30	27	25	24	23	21	20
	6	0.55	66	55	47	44	41	39	37	33	30	28	26	25	24	22
	7	0.59	71	59	51	47	44	42	39	35	32	30	28	27	25	24
015 Green	1	0.34	41	34	29	27	26	24	23	20	19	17	16	16	15	14
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02 Yellow	1	0.46	55	46	39	37	35	32	31	28	25	23	22	21	20	18
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	5	1.02	122	102	87	82	77	72	68	61	56	51	49	47	44	41
	6	1.12	134	112	96	90	84	79	75	67	61	56	54	52	48	45
	7	1.21	145	121	104	97	91	85	81	73	66	61	58	56	52	48
025 Lilac	1	0.57	68	57	49	46	43	40	38	34	31	29	27	26	24	23
	2	0.81	97	81	69	65	61	57	54	49	44	41	39	37	35	32
	3	0.99	119	99	85	79	74	70	66	59	54	50	48	46	42	40
	4	1.14	137	114	98	91	86	80	76	68	62	57	55	53	49	46

Note: regardless of the nozzle type selected, the speed at which the nozzles no longer perform well is approximately the same for all nozzle types (that is around 11-12 km/h) in this example.

16kph	**nozzle type**	**min pressure**	**min speed**
015 @ 7 bar	high pressure AI	4 bar	12 km/h
02 @ 4 bar	low pressure AI	2 bar	11/12 km/h
025 @ 2.5 bar	pre-orifice	1.5 bar	11/12 km/h

Ask yourself, do you spend much of your spraying time below the minimum speed ?, if you do, there are two possible outcomes

a) If no minimum hold is set in the automatic rate controller, the nozzle may not work as effectively. e.g. fan angle collapse and overlap is poorer, with air induction nozzles the droplets may not have as much air in them and the retention of droplets on foliage may be reduced.

b) If the minimum hold function is set at that pressure and you travel at lower speeds, you will be overdosing those areas. While this may not create immediate problems with some knock down herbicides, it does cost you money, and with some products that have residual activity it may inhibit crops and create greater plant back problems.

To remedy this would require a small increase in the application volume, which will increase the speed range available, or use of large enough headlands so that you reduce the area overdosed (not preferred for controlled traffic situations).

STEP 5: Identify the practical range of the nozzle, this will be based on the manufacturers recommended pressure range, or the limits or your machine.

Ask yourself, what range of volumes can I get out of each nozzle?

nozzle type	**volume range at 16 km/h**
015 high pressure AI	4-8 bar = 70 L/ha to 75 L/ha
02 low pressure AI	2-6 bar = 70 L/ha to 84 L/ha
025 pre-orifice	1.5- 5 bar = 70L/ha to 96 L/ha

STEP 6: Determine which nozzle types provide the greatest flexibility with the pressure range you have available with your machine. You must also remember to consult the product labels to determine if any restrictions on nozzle type exist. Some labels still say not to use pre-orifice or air induction nozzles, however this is slowly changing.

STEP 7: Go to the spray quality charts and select nozzles that meet your requirements.

My suggestion would be to have at least 2 sets, such as a winter set and a summer / pre-emergent set. For example you may choose a nozzle that is coarse at your lower volume range and medium at higher volume to go from fallow to in-crop in winter (such as a pre-orifice nozzle or low pressure air induction), and have another set that stays coarse through your volume range to do summer fallow and pre-emergent spraying (such as a coarser low pressure air induction).

Typical Application Volume	**Medium Spray Quality** **(lower risk areas)**	**Coarse or larger Spray Quality**	**Extremely Coarse Spray Quality** **(higher risk areas)**
Low range **50-70 L/ha**	**Older insecticides, with short residual.** **Translocated herbicides on medium targets,**	**2,4-D and tank mixes, Fully translocated products**	**Fully translocated herbicides, moderate targets, very sensitive areas.**
High range **70-100L/ha**	**Small targets** **In crop spraying, contact type products,** **Penetration and coverage in large broadleaf crops**	**Most products and Most targets.** **Soil Applied's** **Stubble and Cereal penetration** **Some contacts at higher volumes**	**Pre-ems** **Fully translocated herbicides, most targets, very sensitive areas**

What about Narrower Nozzle Spacings?

How does narrower nozzle spacing affect nozzle choice?

Photograph taken by Andrew Newall (provided by Graham Betts)

Consider both benefits and Limitations of using a narrower Nozzle Spacing.

Things to think about when considering a swap to narrower spacings:

Potential Positives

- Less shadowing (in row / stubble line)
- Lower booms = less drift potential
- More Chemical on the target (better droplet retention)
- Potential acceptance as a DRT to reduce label no-spray zones

Possible Negatives

- Cost of modification
- Cost of nozzles and replacing them
- Limited legal nozzle choices without increasing L/Ha
- Value at Re-sale (+ or -)
- Tracking issues
- Lack of validation studies

Other things to consider:

What happens if you offset your planting line next season to retain stubble cover?

You would need to run two spray lines with offset nozzles, or have nozzle spacing at half your row width and blank off every second nozzle when you swap from herbicide to in crop spraying.

Nozzle Selection with Narrower Spacings

- Using modified charts * to identify nozzle sizes and pressures to achieve 50L/ha @ 20 km/h (similar choice for 70 L/ha @ 16 km/h) with narrower spacing's

15"	12"	10"
01 @ 8 bar	01 @ 5 bar	01@ 3.5 bar
015 @ 3.5 bar	015@ 2 bar	
02 @ 2 bar		

- Narrower the spacing = less legal nozzle choice for coarse spray qualities, unless you are prepared to increase application volume.
- Smaller than 01 – no spray quality data

*from ispray.com.au toolbox..create custom spray charts

Hence the decision to swap to a narrower nozzle spacing, requires a lot of careful consideration, and at this point in time we don't have any hard data to support (or reject) this as being good value for money….I guess time will tell.