The Ups and Downs of Spray Pressure

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Automatic rate controllers are standard equipment on almost all new sprayers. A rate controller allows the applicator to enter a desired application volume and the controller sets the spray pressure that gives the necessary flow for the application volume and sprayer travel speed being used. In practice, this means that higher travel speeds result in higher spray pressure, and vice versa.

But it's not that simple. Rate controllers aren't smart enough to know how pressure affects nozzle performance. Some nozzles don't work well at low pressures. Others do a poor job at high pressures. Some sprayer pumps may even have a problem generating some of the higher pressures a rate controller calls for. What does that mean for the available travel speed range that's possible with any given nozzle? To answer that question, we first have to have a closer look at how pressure affects nozzle performance.

Spray Pressure and Nozzle Performance

Nozzle performance depends on a number of factors. Of these, the most critical is spray pressure. Pressure affects the spray pattern (fan angle) and the spray quality (droplet size range). Both of these affect coverage, overlap, and spray drift, so it's important to get them right. Each nozzle type has a unique spray pressure range and unique spray qualities within that range, so one must obtain information that is specific to the nozzles on the spray boom.

Catalogues Contain Important Information

Nozzle manufacturer catalogues identify the pressure range over which the nozzle should be operated. At low pressures, engineers look for a uniform pattern that meets the advertised fan angle. High pressures are kept low enough to prevent the formation of excessively fine sprays. Manufacturers now publish tables containing "Spray Quality", a broad categorization of droplet size, for their various nozzles and spray pressures in their product line. Common spray qualities for agricultural nozzles are Fine (orange), Medium (yellow), Coarse (blue), Very Coarse (green), and Extremely Coarse (white). An example table from a catalogue is shown in Figure 1. Note that for any given nozzle flow rate (left column), the spray quality

	PSI										
	15	20	25	30	35	40	50	60	70	80	90
TT11001 QJ90-2XTT11001	C	M	M	M	M	M	F	F	F	F	F
TT110015 QJ90-2XTT110015	C	C	M	M	M	M	M	M	F	F	F
TT11002 QJ90-2XTT11002	C	C	C	M	M	M	M	M	M	M	F
TT110025 QJ90-2XTT110025	VC	C	C	C	M	M	M	M	M	M	F
TT11003 QJ90-2XTT11003	VC	VC	C	C	C	C	M	M	M	M	M
TT11004 QJ90-2XTT11004	XC	VC	VC	C	C	C	C	C	M	M	M
TT11005 QJ90-2XTT11005	XC	VC	VC	VC	VC	C	C	C	C	M	M
TT11006 QJ90-2XTT11006	XC	XC	VC	VC	VC	C	C	C	C	C	M
TT11008 QJ90-2XTT11008	XC	XC	VC	VC	VC	VC	C	C	C	C	M

Figure 1: Manufacturer's tables show how spray pressure and nozzle flow rate affects Spray Quality (reproduced from TeeJet catalogue).

changes with spray pressure. For example, the TT110025 nozzle can produce a Very Coarse or a Fine spray, depending on the pressure. Also note that for any given pressure, higher flow rate nozzles produce coarser sprays. At 40 psi, the TT nozzle can produce a Medium, Coarse, or Very Coarse spray. Both of these relationships depend on the nozzle model and manufacturer.

Speed-Pressure-Spray Quality Relationship

As we increase spray pressure, flow rate increases with a square-root relationship.

$$\frac{GPM_1}{GPM_2} = \frac{\sqrt{PSI_1}}{\sqrt{PSI_2}}$$

This means that in order to double the flow rate, we need to increase spray pressure by a factor of four. See Figure 2 to show what would happen if an operator uses a TT11006 to apply 10 US gpa at 18 mph and 40 psi. If the sprayer slows down to 9 mph to initiate a turn, spray pressure will drop to one quarter of 40, or 10 psi. Using the above chart as an example, spray quality would change from Coarse to Extremely Coarse (we don't know for sure because it's outside the lower limit of the chart, which also means that the nozzle would not be guaranteed to produce a wide-enough or uniform spray pattern). Poor pest control performance is likely in this situation).

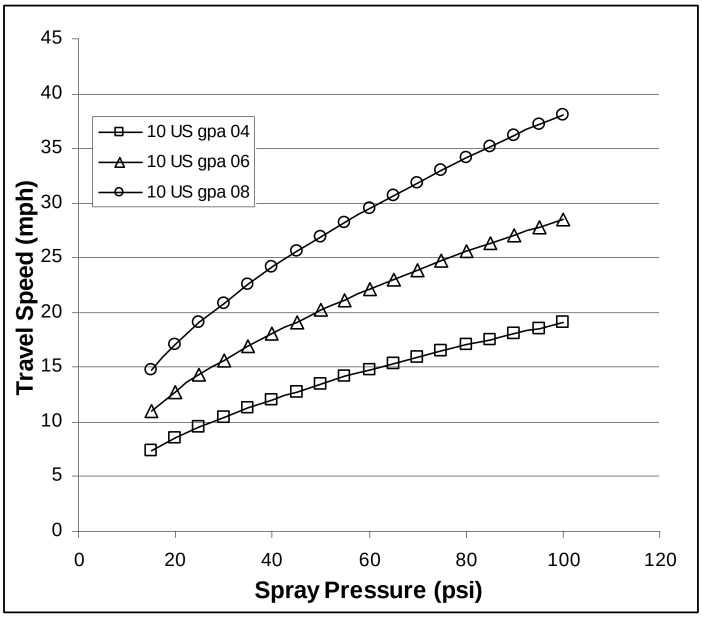

Figure 2: Relationship between spray pressure and travel speed for three tips applying 10 US gpa.

The lesson from this exercise is three-fold: (a) operate the nozzle at a slightly higher pressure at 18 mph (to avoid dropping the pressure too low at 9 mph), (b) avoid going as slow as 9 mph to prevent the pressure from dropping below 15 psi (some operators compromise by setting a minimum spray pressure on their rate controller, in which case they'd over-apply if their speed dropped too low), and (c) consider slower travel speeds. At 14 mph it's easier to maintain a reasonable pressure when you need to slow down. According to Figure 2, perhaps a TT11004 operated at 50 to 55 psi would provide the right pressure flexibility. A Coarse spray is maintained down to 30 psi, which allows a travel speed as low as 10 mph. Even lower speeds (pressures) can be used temporarily without the spray's pattern becoming too narrow or too coarse. Faster speeds than 14 mph are possible as long as spray drift can be managed – if wind conditions or proximity to sensitive areas allows.

Spray Pattern Overlap

Flat fan nozzle patterns need the correct overlap in order to achieve a uniform spray pattern under the boom. Research has shown that the amount of overlap for low-drift nozzles needs to be at least 100% to achieve optimum nozzle performance. In other words, the edge of a fan should reach into the centre of the adjacent fan (Figure 3). This amount of overlap assures that not only the spray volume is uniformly distributed, but that the droplet density is equally uniform. Less overlap may result in fewer droplets depositing in the overlap region, resulting in poor coverage and reduced pesticide performance.

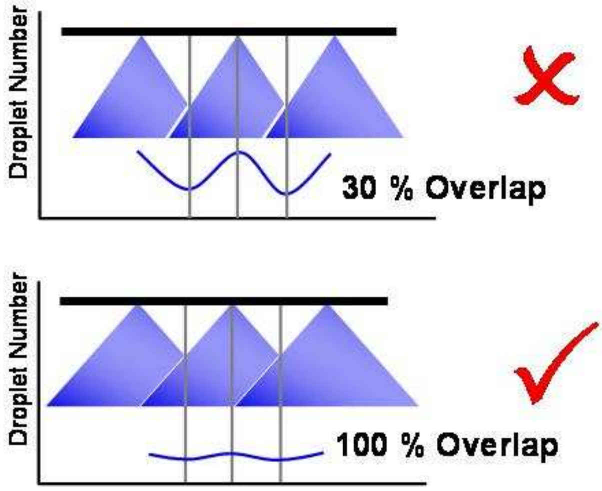

Figure 3: Spray pattern overlaps required for uniform coverage.

Adjust the boom height so that at the lowest expected spray pressure (slowest planned travel speed), the nozzles still achieve 100% overlap. There is no disadvantage with greater than 100% overlap, except that higher booms will lead to greater drift. When a choice exists, choose 110º fan angle nozzles. Most air-induced nozzles are produced at one (usually wide) fan angle only, but actual angles usually differ from those advertised. It is important to visually check the overlap before spraying.

Recommendations

What does this mean in practice? Spray operators need to know the right spray quality for the job at hand. They also need to use manufacturers' charts to identify the spray quality their nozzle will likely produce at their expected application volume and travel speed. If it's a poor match, a different nozzle may need to be found. Here are some rules of thumb:

1. Choose a nozzle that produces a Coarse spray over most of the operating pressures you expect to use. Although Very Coarse sprays can work in most situations, avoid them when using lower water volumes, controlling grassy weeds, or using contact modes of action.
2. Minimize spray drift by avoiding pressures that produce Medium or Fine spray qualities.
3. Choose a pressure that is in the middle of the nozzle's recommended operating range. If the range is 15 to 90 psi, select 50 psi. If it's 40 to 100 psi, select 70 psi. This allows you slow down or speed up somewhat without breaching the nozzle's capabilities.
4. Identify the travel speeds that are possible without creating spray qualities that could compromise your application goals.
5. Visually inspect the spray pattern at the pressure extremes you expect to spray at. At the lowest pressure, your nozzle should still produce 100% overlap (the edge of the spray fan should come to the middle of the next nozzle at target height). If it doesn't, choose a wider fan angle nozzle, increase spray pressure or elevate the boom.

6. Make sure your pump can produce the higher spray pressures you expect to need. Pressure limitations are greatest at high flow rates (fast travel speeds applying large water volumes).
7. Be prepared to compromise. It's rarely possible to travel at the exact speed, obtain the perfect pressure, and apply the desired water volume that's been worked out in the office or using manufacturer's charts. If in doubt, choose slower speeds or higher water volumes to make things work out.

Nozzle manufacturers are getting much better at producing information that helps applicators produce good spraying outcomes. Learning how to use this information is the first step.

Drop Size Classification

Nozzle selection is often based upon droplet size. The droplet size from a nozzle becomes very important when the efficacy of a particular plant protection chemical is dependent on coverage, or the prevention of spray leaving the target area is a priority.

The majority of the nozzles used in agriculture can be classified as producing either fine, medium, coarse, or very coarse droplets. Nozzles that produce fine droplets are usually recommended for post-emergence applications, which require excellent coverage on the intended target area. The most common nozzles used in agriculture are those that produce medium-sized droplets. Nozzles producing medium- and coarse-sized droplets can be used for contact and systemic herbicides, pre-emergence surface-applied herbicides, insecticides and fungicides.

An important point to remember when choosing a spray nozzle that produces a droplet size in one of the six categories is that one nozzle can produce different droplet size classifications at different pressures. A nozzle might produce medium droplets at low pressures, while producing fine droplets as pressure is increased.

Droplet size classes are shown in the following tables to assist in choosing an appropriate spray tip.

VF Very Fine	F Fine
M Medium	C Coarse
VC Very Coarse	XC Extremely Coarse

Droplet size classifications are based on BCPC specifications and in accordance with ASAE Standard S-572 at the date of printing. Classifications are subject to change.

Turbo TeeJet® (TT) and Turbo TeeJet® Duo (QJ90-2XTT)

	PSI										
	15	20	25	30	35	40	50	60	70	80	90
TT11001 QJ90-2XTT11001	C	M	M	M	M	M	F	F	F	F	F
TT110015 QJ90-2XTT110015	C	C	M	M	M	M	M	M	F	F	F
TT11002 QJ90-2XTT11002	C	C	C	M	M	M	M	M	M	M	F
TT110025 QJ90-2XTT110025	VC	C	C	C	M	M	M	M	M	M	F
TT11003 QJ90-2XTT11003	VC	VC	C	C	C	C	M	M	M	M	M
TT11004 QJ90-2XTT11004	XC	VC	VC	C	C	C	C	C	M	M	M
TT11005 QJ90-2XTT11005	XC	VC	VC	VC	VC	C	C	C	C	M	M
TT11006 QJ90-2XTT11006	XC	XC	VC	VC	VC	C	C	C	C	C	M
TT11008 QJ90-2XTT11008	XC	XC	VC	VC	VC	VC	C	C	C	C	M

AI TeeJet® (AI) and AIC TeeJet® (AIC)

	PSI											
	30	35	40	45	50	55	60	70	80	90	100	115
AI110015	VC	VC	VC	VC	VC	C	C	C	C	C	C	C
AI11002	VC	VC	VC	VC	VC	VC	VC	C	C	C	C	C
AI110025	VC	VC	VC	VC	VC	VC	VC	VC	C	C	C	C
AI11003	XC	XC	VC	VC	VC	VC	VC	VC	VC	C	C	C
AI11004	XC	XC	XC	VC	VC	VC	VC	VC	VC	C	C	C
AI11005	XC	XC	XC	VC	VC	VC	VC	VC	VC	VC	C	C
AI11006	XC	XC	XC	XC	VC	VC	VC	VC	VC	VC	C	C
AI11008	XC	XC	XC	XC	XC	VC	VC	VC	VC	VC	VC	C
AI11010	XC	XC	XC	XC	XC	VC	VC	VC	VC	VC	VC	C

Turbo TwinJet® (TTJ60)

	PSI										
	15	20	25	30	35	40	50	60	70	80	90
TTJ60-11002	VC	C	C	C	C	C	M	M	M	M	M
TTJ60-110025	XC	VC	C	C	C	C	C	C	M	M	M
TTJ60-11003	XC	VC	C	C	C	C	C	C	C	M	M
TTJ60-11004	XC	VC	C	C	C	C	C	C	C	C	M
TTJ60-11005	XC	VC	C	C	C	C	C	C	C	C	C
TTJ60-11006	XC	XC	VC	VC	C	C	C	C	C	C	C

Turbo TeeJet® Induction (TTI)

	PSI											
	15	20	25	30	35	40	50	60	70	80	90	100
TTI110015	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC
TTI11002	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC
TTI110025	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC
TTI11003	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC
TTI11004	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC
TTI11005	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC
TTI11006	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC	XC

XR TeeJet® (XR) and XRC TeeJet® (XRC)

	PSI						
	15	20	25	30	40	50	60
XR8001	M	F	F	F	F	F	F
XR80015	M	M	M	F	F	F	F
XR8002	M	M	M	M	F	F	F
XR8003	M	M	M	M	M	M	F
XR8004	C	C	M	M	M	M	M
XR8005	C	C	C	C	M	M	M
XR8006	C	C	C	C	C	C	C
XR8008	VC	VC	VC	C	C	C	C
XR11001	F	F	F	F	F	VF	VF
XR110015	F	F	F	F	F	F	F
XR11002	M	F	F	F	F	F	F
XR110025	M	M	F	F	F	F	F
XR11003	M	M	M	F	F	F	F
XR11004	M	M	M	M	M	F	F
XR11005	M	M	M	M	M	M	F
XR11006	C	C	M	M	M	M	M
XR11008	C	C	C	C	C	M	M

TeeJet® (TP)

	PSI				
	30	35	40	50	60
TP8001	F	F	F	F	F
TP80015	F	F	F	F	F
TP8002	M	M	F	F	F
TP8003	M	M	M	M	F
TP8004	M	M	M	M	M
TP8005	C	M	M	M	M
TP8006	C	C	C	C	C
TP8008	C	C	C	C	C
TP11001	F	F	F	VF	VF
TP110015	F	F	F	F	F
TP11002	F	F	F	F	F
TP11003	F	F	F	F	F
TP11004	M	M	M	F	F
TP11005	M	M	M	M	F
TP11006	M	M	M	M	M
TP11008	C	C	C	M	M

TurfJet® (TTJ)

	PSI				
	30	40	50	60	70
1/4TTJ02-VS	XC	XC	XC	XC	XC
1/4TTJ04-VS	XC	XC	XC	XC	XC
1/4TTJ05-VS	XC	XC	XC	XC	XC
1/4TTJ06-VS	XC	XC	XC	XC	XC
1/4TTJ08-VS	XC	XC	XC	XC	XC
1/4TTJ10-VS	XC	XC	XC	XC	XC
1/4TTJ15-VS	XC	XC	XC	XC	XC

Turbo FloodJet® (TF)

	PSI				
	10	15	20	30	40
TF-2	XC	XC	XC	XC	XC
TF-2.5	XC	XC	XC	XC	XC
TF-3	XC	XC	XC	XC	XC
TF-4	XC	XC	XC	XC	XC
TF-5	XC	XC	XC	XC	XC
TF-7.5	XC	XC	XC	XC	XC
TF-10	XC	XC	XC	XC	XC

DG TwinJet® (DG-TJ60)

	PSI				
	30	35	40	50	60
DGTJ60-110015	F	F	F	F	F
DGTJ60-11002	M	M	M	F	F
DGTJ60-11003	C	M	M	M	M
DGTJ60-11004	C	C	C	C	M
DGTJ60-11006	C	C	C	C	C
DGTJ60-11008	C	C	C	C	C

TwinJet® (TJ)

	PSI				
	30	35	40	50	60
TJ60-6501	F	VF	VF	VF	VF
TJ60-650134	F	F	F	VF	VF
TJ60-6502	F	F	F	F	F
TJ60-6503	M	F	F	F	F
TJ60-6504	M	M	M	M	F
TJ60-6506	M	M	M	M	M
TJ60-6508	C	C	C	M	M
TJ60-8001	VF	VF	VF	VF	VF
TJ60-8002	F	F	F	F	F
TJ60-8003	F	F	F	F	F
TJ60-8004	M	M	F	F	F
TJ60-8005	M	M	M	F	F
TJ60-8006	M	M	M	M	M
TJ60-8008	C	M	M	M	M
TJ60-8010	C	C	C	M	M
TJ60-11002	F	VF	VF	VF	VF
TJ60-11003	F	F	F	F	F
TJ60-11004	F	F	F	F	F
TJ60-11005	M	M	M	F	F
TJ60-11006	M	M	M	F	F
TJ60-11008	M	M	M	M	M
TJ60-11010	M	M	M	M	M

DG TeeJet® (DG E)

	PSI				
	30	35	40	50	60
DG95015E	M	M	M	F	F
DG9502E	M	M	M	M	M
DG9503E	C	M	M	M	M
DG9504E	C	C	C	M	M
DG9505E	C	C	C	M	M

DG TeeJet® (DG)

	PSI				
	30	35	40	50	60
DG80015	M	M	M	M	F
DG8002	M	M	M	M	M
DG8003	C	M	M	M	M
DG8004	C	C	C	M	M
DG8005	C	C	C	M	M
DG110015	M	M	F	F	F
DG11002	M	M	M	M	M
DG11003	C	M	M	M	M
DG11004	C	C	M	M	M
DG11005	C	C	C	M	M