



SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 1

The need for planning

A spray operator's perspective

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Key points

- **Know your current capacity and identify areas for improvement**
- **Start with efficiency gains before upgrading the sprayer**
- **Plan ahead – for the next job, next crop and changes to the farming system**
- **Do your research before upgrading your sprayer**

1. Importance of planning for spray operations

Pesticide application can be a complex operation that requires knowledge of the weather, mechanics, logistics, chemistry and biology, as well as effective communication skills and good technique.

Successful spray operators plan and review all inputs and outcomes to maximise use of the products purchased, while at the same time doing everything possible to reduce the risks and hazards associated with that use.

Planning successful spraying operations often requires research and consultation, but the benefit of good plans is that they can save a lot of time, money and effort in the long run.

All plans require knowledge of your starting point. If you are looking to make improvements to your spraying operations, you need to have a clear idea of what you hope to achieve, the steps you need to take to get there, and most importantly, know when you have reached your goal. For any plan it is important to identify what success would look like – spraying is no different.

Whether you are performing a single spray operation, upgrading your sprayer or undertaking a major change to your farming system, there are always several steps to take before you get to where you want to be.

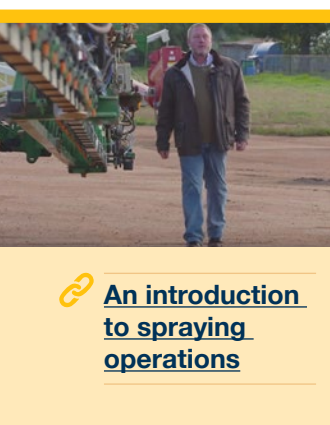
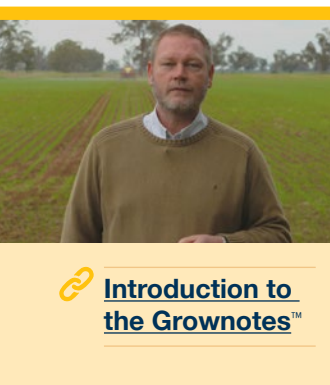
1.1 Know your starting point – what is your current capacity?

Successful spraying is about placing the correct dose of chemical in the right place at the right time. It can involve several parties providing information on any component of the process, although ultimately relies on the spray operator to achieve a successful result.

Timing is one of the most important factors in achieving the best possible spray outcome and planning allows the operator to be efficient throughout the process.

If we want to improve our ability to get the spray out on time we should consider what our current capacity is, how long we have to get the best results from each product and how much time it takes to cover the amount of country we have.

Knowing our starting point helps to identify areas where we may be able to improve.



1.2 Establish a starting point

Ask yourself some questions to help establish a starting point for your spray operation.

- **What products do I use and how do they need to be applied?**
- **How can I make the products I use more effective?**
- **What equipment or set-up(s) do I need to apply to those products?**
- **How many hectares per hour/day can I spray?**
- **How long does it take to complete most spraying operations?**
- **How long do I have to get the products out (before they are less effective)?**
- **How much time do I spend out of the paddock (filling, mixing, or on maintenance)?**
- **How do I manage the weather conditions and sensitive areas?**
- **How much does it cost to operate the sprayer?**
- **What can I do to reduce the need for spraying (rotations, crop competition, cultivation, green manure crops, utilising residual herbicides in place of multiple knockdown applications)?**

2. Identify ways of increasing your capacity and efficiency

Although the time spent spraying is usually only a fraction (often less than 50 per cent) of the total engine hours on the machine, this is not always considered by operators.

There are many things that can be done to change this ratio and to increase your ability to cover the country in a timely manner before buying a bigger, wider or faster sprayer.

The most obvious place to start is to reduce the time spent out of the paddock. Some considerations include improved facilities for filling; mobile mixing plants to take water and pesticides to the field rather than needing to drive back to the shed and front filling points on the spray rig so that booms do not need to be folded before refilling.

2.1 Things that can speed up mixing, transfer and filling the water tanker/water cart

The ability to transport enough water for a full day's spraying close to the sprayed paddocks can save a lot of time and reduce engine hours on the sprayer.

Mixing trailer (portable set-up)

A mixing trailer that allows you to transport chemical to the site and has all the equipment required to safely mix your chemical and transfer it efficiently to the sprayer will also save time. Whatever system you use, there are many off-the-shelf products to make it easier to set up.



Chemical mixing vat mounted onto a spray trailer. ►

Photo: David Gooden



Chemical vats

Chemical vats can speed up mixing, particularly of powders. The vats can help dissolve products before they go into the tank and can get product into the sprayer more quickly. To reduce the risk of compatibility issues, it is important to fully dissolve/suspend each product before the next is added. Mixing vats with high agitation are good for this task and then can be quickly pumped into the main tank before the next product is added to the mixing vat. Be particularly careful if attempting to add multiple products to the mixing vat. Water volume is limited and mixtures will be concentrated, increasing the risk of product incompatibility occurring.



► For more information, go to **Module 9: Mixing and transfer systems**

Closed mixing systems and chemical transfer pumps



Chemical trailer with everything required for mixing and transfer. ►

Photo: David Gooden



Chemical transfer pumps can increase the accuracy of measurements. Using closed mixing systems, such as Envirodrum® or shuttles, can reduce the risk of operator exposure to chemicals.



Chemical fill points moved to the front of the sprayer often speed up transfer of water and chemicals. ▶

Photo: David Gooden



Easier access to fill points on the sprayer (using an external pump)

Front fill points make it easier to drive to the mixing area, and are easier to access to improve fill times. Using an external pump to fill the sprayer will also help to reduce engine hours.



Mixing and handling – custom trailer

2.2 Making use of weather-forecasting tools

Where possible, make use of weather-forecasting tools to help define your spraying windows over the coming week; knowing which days, and hours within the day, are likely to be suitable for spraying and which are not can help you to plan your week.

Several websites make weather forecasts of up to seven days available. Some of these websites are specifically designed for spray operators and indicate factors such as Delta T (a measure of evaporation potential), rainfall, frost and inversion risk.

www.bom.gov.au/australia/radar

www.spraywisedecisions.com.au

www.eldersweather.com.au

<https://www.syngenta.com.au/weather>

<https://www.goannaag.com.au/wand-network>

<https://cotl.com.au/about.html>

2.3 Improve maintenance to reduce downtime

Service availability is critical to sprayer ownership. Choosing the right dealer is just as important as selecting the type of sprayer you will use. Before purchase make sure you are confident the dealer can provide the services you will require:

- **regular inspection of the sprayer – regular checks can prevent bigger problems later on;**
- **a plan for maintenance out of and during the season;**
- **keeping commonly needed spare parts on hand – whether it is a filter, o-rings, spare nozzles or nozzle bodies, a replacement flow meter or even a main pump, it can be useful to have replacements available to minimise downtime; and**
- **keeping things clean and calibrated – including nozzles, flow meter and components. Even new sprayers should have their nozzles removed and the tank flushed before the first use. Calibrating and checking major components (tank levels, flow meters and controller settings) should also be done before the first use and should continue throughout the sprayer's life. Always flush the sprayer after use and do a full decontamination before changing product type or situation.**

If you have done as much as you practically can to reduce the time spent out of the paddock the next step is to look at improving the efficiency of your spraying operations in the paddock.

3. Maximise your productivity in the paddock

It helps to review your farm inputs and outputs to identify areas to maximise your productivity in the paddock.

Knowing what inputs you make (for example, chemicals, fuel, fertilisers and maintenance costs) and their impact on your output (yield) is an important first step in identifying areas for improvement and for knowing what things can produce real gains in productivity.

3.1 Carefully consider your product choices and their application requirements

It is important to have regular discussions with advisers and consultants about what products are available to you, what works well in your area and what recent research suggests. Always try to make evidence-based decisions: do your own homework on what you have been told. Try to simplify spray mixtures where possible and only mix products which are both physically and biologically compatible. Avoid unnecessary use of adjuvants (typically where needed they will be stated on the product label).



► For more information go to **Module 6: Pre-operational checks**

Consider the things you should know or understand about the products you want to apply.

- **Their modes of action, translocation and uptake of the products you use.**
- **What are the volume/coverage requirements and recommended adjuvants for each product.**
- **Water quality requirements for each product.**
- **Compatibility and mixing requirements, as well as mixing order.**
- **Agitation and solubility requirements (especially for powders, water-dispersible granules, water conditioners).**
- **Filtration requirements of the various products and their impact on some components of the sprayer.**
- **Spray quality (water volume and droplet size) required for the product or tank mix.**
- **Label restraints (no-spray zones) and sensitive areas for each product.**
- **Economics (short-term cost versus longer-term goals, for example, resistance management).**
- **Operator and farm occupant safety.**



► For more information go to Module 2: Product requirements

When a compromise is made, understand how this may impact product performance.

For example, assuming adequate coverage, glyphosate efficacy is optimised when using a large (e.g. VC spray quality) and concentrated droplet (e.g. 50-60 L/ha spray volume), with a non-spreading water based adjuvant which will be included in a quality formulation.

By comparison, Group 14 herbicides work best with good coverage (e.g. M-C spray quality and 80-100L/ha spray volume) and an oil-based adjuvant system.

Any tank mixing of these modes of action will therefore require one product to be compromised.

4. Make use of spray plans and mixing plans

Knowing the application volumes and spray quality requirements for all the products you plan to use is critical to developing spray plans.

Make lists of products with similar application requirements (volume and spray quality) and make sure you have the nozzles to do each type of job.

Products with similar application requirements may include: knockdown herbicides in fallow, pre-emergent herbicides, liquid fertilisers, contact herbicides (double-knocks), early season broadleaf control, grass-selective sprays in crop, in-crop fungicide and insecticide applications, and pre-harvest desiccation.

Each of these groups of products may require different application volumes and spray qualities, so planning how you need to apply each group makes sense.

4.1 Spray plans

Knowing how you want to apply each product (or group of products), in terms of the application volume and spray quality, requires working out which nozzles to have available and at what pressure they should be run.

Completing a spray plan helps to identify the nozzles, controller settings, calibration figures and machine set-up for each group of products, as well as situations where 'mixtures' may lead to one or more products being compromised. This will then allow an informed decision to be made if operational efficiency of making the mixture outweighs product performance considerations of a compromised mixture.

A useful spray plan should identify the target flow rate and nozzle operating pressure at your chosen average speed so that they can be checked 'on the go' to show that things are running well in the paddock. The spray plan should also identify when to adjust settings, such as the minimum hold (pressure, flow or speed), to ensure nozzles perform correctly or to minimise overdosing.

4.2 Mixing plans

A mixing plan is a simple way of recording mixing calculations and requirements. For example, how much of each product will go into the tank, how much of each product (and water volume) is required for the job, and in what order the products should be mixed. Many operators use Excel spreadsheets to do the calculations for them. Using tools such as Excel can help to avoid making easy mistakes.

Figure 1 Spray load calculator.

Paddock	Sample paddock			Total area	200
Task	Summer knock-down				Total spray tank loads
Recommendation		Rate	Unit	Total req	
Carrier	Water	50	L	10,000	2.00
Adjuvant*	Water conditioner	1 kg/100L	kg	100	
Adjuvant*	Wetter	0.2L/100L	L	20	
Chemical	Knock-down	1.5	L	300	
Chemical	Spike	0.3	L	60	
Chemical					
Chemical					
*Rate based on volume %					
Full tank loads		Tank volume	Hectares per tank load	Number of full tank loads	
		5000	100.00	2.00	
		Rate		Amount/load	Mixing order
Adjuvant*	Water conditioner	1L/100L	kg	50.00	1
Adjuvant*	Wetter	0.2L/100L	L	10.00	4
Chemical	Knockdown	1.5	L	150.00	2
Chemical	Spike	0.3	L	30.00	3
Chemical					
Chemical					
Part tank load		Number part tank volume	Hectares per part tank load	Tank water Volume to ADD	
		0	0	0	
Adjuvant*	Water conditioner		kg	0	
Adjuvant*	Wetter		L	0	
Chemical	Knockdown		L	0	
Chemical	Spike		L	0	
Chemical	0		0	0	
Chemical	0		0	0	

► For more information go to Module 5: Spray plans

Simple spreadsheets for calculating mixing requirements can save time. ►

5. Plan to make the most of good weather conditions

5.1 Identify acceptable weather conditions for each product you use

Some product labels will indicate environmental requirements for wind speed, hazardous inversion conditions, rainfall events and no-spray zones (downwind buffers). Also consider wind direction in relation to sensitive areas, the likelihood of dew or frost, and delta T conditions at and following application, as these will affect how and when you apply many products.

It is a good idea to identify a couple of spray set-ups (spray quality and application volumes) suitable for each product or tank mix to be ready to manage what is in front of you, especially as environmental conditions change.

Know when to stop. Regardless of the product used, at some point spraying should not take place.

5.2 Make better decisions – monitor and assess conditions as you go

Regularly monitoring and recording the weather provides real data on which to base decisions.

Experienced operators learn to read visual clues, but these observations still need to be supported by measurements in the paddock where you are spraying.

Handheld weather meters are good but are only practical when you stop to fill or mix. Many operators should consider having onboard weather stations, particularly if they have large tanks or long periods between filling operations. Where phone/internet coverage permits, remote weather monitoring base stations may be able to be accessed in real time to inform prevailing and forecast weather conditions.



Monitoring and recording weather conditions will help you to make better decisions. ►

Photo: Graham Betts

6. Think about how you will spray each paddock (driving technique)

It is worth planning your sprays on a paddock-by-paddock basis. Take into account likely conditions and spray run direction.

Consider what challenges each paddock presents in terms of obstacles and ground conditions (wet or dusty) as these will determine a comfortable speed range for that paddock.

If they are not already fitted to your sprayer, think about the value that systems such as auto-swath/auto-section control, height control, boom recirculation/boom prime or multi-step spray could make to improve your spraying efficiency.

Identify downwind sensitive areas and ideally plan to spray when the wind is blowing away from these areas. If spraying must be undertaken in proximity to these areas and the wind is blowing towards them, consider what drift reduction techniques can be employed (i.e. reduce boom height, choose coarser spray quality, slow down), while complying with any buffer zones on the product label.

6.1 Managing and maintaining an appropriate speed range

Unless you have a spraying system that can cope with large variations in speed, it may be necessary in some paddocks to increase application volumes to ensure your nozzles are operating effectively when travelling at lower-than-normal speeds.

Ensure that boom height is as low as possible, while maintaining double overlap at the top of the target. Raising boom height, to allow for faster travel speed, is one of the leading causes of spray drift.

6.2 Headlands

One way to reduce the speed range during spraying operations is to include sufficiently large headlands. Wide headlands can help to avoid operating at lower speeds (reduced pressure) at the ends of runs and minimises operating with the sprays on during turns. A practical headland matches the seeder width so that crop direction is the same as the spray runs.

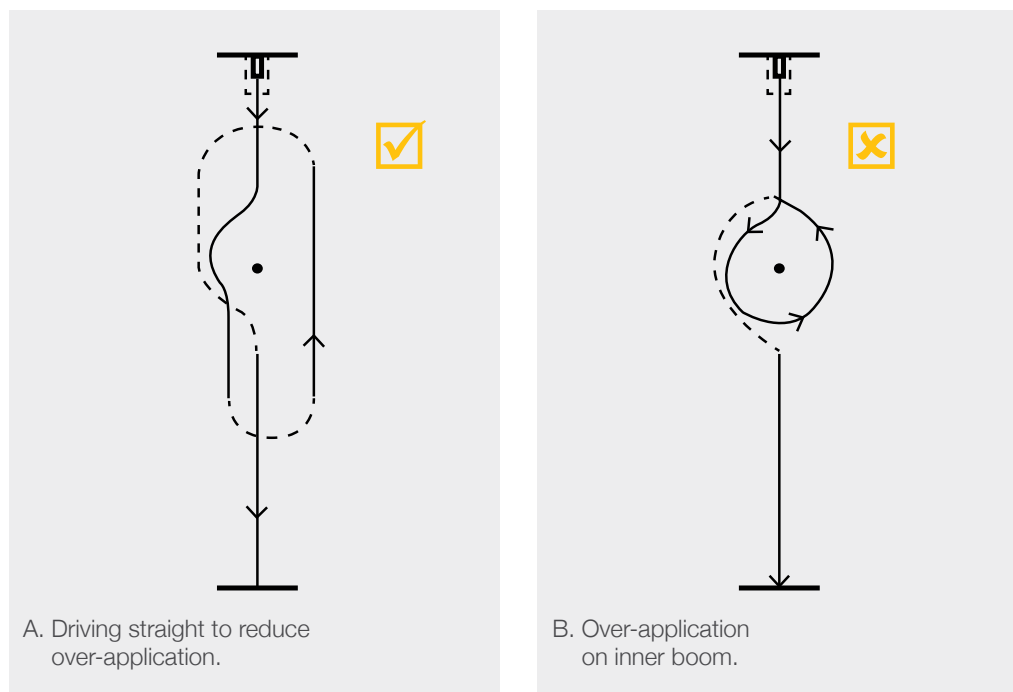
Having auto-section control and an accurate GPS can make this job much easier. Systems that increase your operational speed range, such as multi-step booms or pulse width modulation can reduce the width that headlands may need to be.

6.3 Obstacles and turns

While many spray systems can help to manage variations in straight-line speed, very few can fully compensate for the changes in application rate that occur across the boom if operating with the spray on during a sharp turn.

Planning how you are going to spray around obstacles is important for ensuring good control because of the potential consequences of under and over-application. This is a situation where auto-swath/auto-section control is very useful. However, even with auto-section control, gentle turns are critical.

Figure 2 How to spray around an obstacle



Good driving technique around obstacles can minimise overdosing. ▶

6.4 Corners

It is a good idea to square up the ends of the paddock to minimise operating with the sprays on during turns. It is also important to consider how to deal with corners. Generally, the best approach is to back into corners with a rear-mounted boom (or drive into corners with a front-mounted boom), provided your spraying system can operate effectively at the initially low take-off speeds. Auto-section control can also help to prevent overdosing when backing into corners.



Turning at speed on a corner can result in poor weed control. ▶

Photo : Bill Gordon

6.5 Direction of travel

It is a good idea to mix up your direction of travel. Each time you spray a paddock, start at the opposite end to where you started last time. This helps to overcome some of the effects of shadowing behind standing stubble, particularly if you are doing a double knock with 'contact' herbicides.

6.6 Alternating wheel tracks

In situations where dust is an issue it can be a good idea to alternate the wheel tracks you use for spraying products in fallow situations. Shifting across a planter width each time you spray can help reduce some of the problems associated with poorer weed control adjacent to the wheels and in the centre of the machine.

6.7 Leaving unsprayed buffers

Sometimes you may have to operate close to sensitive crops or other areas where you don't want to risk the product moving off-target. If it is not possible to spray these areas first when conditions are favourable, it can be useful to leave unsprayed areas within a paddock.

Unsprayed areas can be left if you are expecting a change in wind direction. This allows those areas to be sprayed later, possibly with a different set-up.

7 Monitoring and recording the outcome of all spray jobs

Keeping records serves many purposes including reviewing product performance and for legal reasons. However, there are many other reasons to keep records that can help to improve your pest and weed management over time.

- **Use record-keeping systems that work for your enterprise and will also be useful in the future.**
- **Always record things that have worked well (we don't do this enough).**
- **Assess the level of control you achieved and how long it took.**
- **Record unexpected results – surviving weeds, diseases and pests – and follow-up on these.**
- **Make notes on how long it takes to complete different types of spray jobs (hectares per hour) to help plan future operations.**

8. Planning for longer-term goals

Consider logistical flow across the whole farm via the various spraying operations. Can you improve how things flow?

Identify areas where equipment design or farm layout may be reducing your efficiency. Ask yourself the following.

- **Where are the typical hold-ups?**
- **What are the spray hours compared to the engine hours?**
- **Where do losses in efficiency occur?**
- **Are there areas of over or under-application?**
- **How can these things be improved?**



► For more information go to **Module 22: Integration of the sprayer with other farm equipment**

8.1 Integration of equipment

It is important to consider how well all of your equipment is integrated. This includes: GPS, auto-steer, wheel centres, total widths of seeders, headers and the sprayer. Integrating all of these things can take time and careful planning but the results can be very rewarding.

8.2 Traffic and machinery movement around the farm

Make sure vehicle movements around the farm make sense. For spraying operations it can often be logical to increase the number of fill points to reduce travel time refilling the sprayer, or employ water carts to take the water to the application site.

8.3 Farm layout

Changes to farm layout are difficult but are sometime necessary to maximise efficiencies and minimise risk to sensitive areas.

Longer spray runs, fewer turns and fewer obstacles can all increase efficiency and reduce running costs.



► For more information go to **Module 4: Drift management strategies**

Fewer wheel tracks in the paddock can often improve yields and reduce running costs, but this generally requires good integration between all of your equipment.

Consider using vegetative barriers to reduce the movement of chemicals from sprayed paddocks towards sensitive areas such as houses, water bodies, pastures and neighbouring crops.

8.4 Crop choice and rotations

The cheapest spray application is the one you don't have to make.

Where it is possible and practical, consider crop types, varieties, tolerance traits and management practices that allow you to:

- **reduce disease build-up;**
- **make use of crop competition to suppress weed growth – consider planting density, row width and operational issues for other machinery;**
- **consider alternative crops that may allow the use of herbicides with different modes of action as a way of controlling hard-to-kill weeds; and**
- **implement alternative control strategies – using residual herbicides to rotate chemistries and reduce the need for additional fallow spray passes, or strategic cultivation.**

8.5 Plan for when you will need to upgrade or replace your sprayer

Planning for your next sprayer should begin when you start operating your current sprayer.

- **Identify the features you found most useful, but also what limits your ability to spray the way you wanted to spray.**
- **Consider what features you may require, and why, well in advance of the purchase or upgrade.**
- **Document your current maintenance requirements and costs.**
- **Know the real cost of operating your current sprayer.**
- **Consider depreciation and when to change.**
- **Know the life you expect out of a replacement sprayer for your operations.**
- **Research and consult as widely as you can.**
- **Make sure service and after-sales support is available.**

Before purchasing a new sprayer, also consider the following.

- **Are there other ways of improving your productivity?**
- **How will the sprayer integrate with other equipment?**
- **What features will contribute to more efficient operations?**
- **How you will get increased productivity without reducing efficacy or increasing risk?**
- **How will it match your future cropping and management practices?**

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 2 Product requirements Thinking about how products work and factors that can affect their performance
