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GROWNOTES

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 9
Mixing, filling and transfer systems
Techniques and tips to increase efficiency

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Key Points

- Time out of the paddock during spraying operations reduces productivity and reduces the timeliness of the application
- Increasing tank size and improving mixing, filling and transfer operations has the potential to double the hectares sprayed per day
- Improved mixing and handling can reduce the risk to the operator and improve efficacy
- Reducing the engine hours on the sprayer will increase its value at trade or useful life

PLAY VIDEO

Mixing & handling - custom trailer

1. Introduction

The purchase and set-up of mixing, filling and transfer systems should receive as much time and attention as the purchase and set-up of the sprayer itself.

Correctly mixing all the products that are included in a tank mix is essential to allowing the products to work as they were intended to. Dissolving and dispersing solid products can take time, unless procedures are introduced to improve their measurement, dilution and dispersion, along with the transfer of the products and water to the sprayer.

Systems that allow the operator to reduce the time taken to accurately measure and transfer products and water to the sprayer will increase efficiency by reducing time out of the paddock. Closed systems can also reduce the risk to the operator and may reduce the need for some items of personal protective equipment (PPE) during the mixing operation.

The greatest gain in productivity will come from reducing time spent out of the paddock, reducing the frequency of fills, not having to fold and unfold the boom, and reducing the distance to fill points.

Any practices that allow the operator to spray more hectares per hour (without increasing the spraying speed) should improve the overall level of control (efficacy), by improving the timeliness of the spraying operation.

2. Establish your current spraying efficiency

Increasing the number of hectares per hour the sprayer can cover while it is in the paddock is not the only way to increase productivity. While spraying speed and boom width determine the spraying rate (hectares per hour) when you are in the paddock, reducing time spent out of the paddock will usually have the biggest impact on spraying efficiency and productivity.

If you have never done so, time how long various operations take. Work out how long it takes to complete a load at various application volumes, from the time you start spraying the paddock until the tank needs to be refilled. Compare this to the time spent out of the paddock, from when you start, ready to spray the next load. Often during a spray job the applicator can spend as much time out of the paddock as they do in the paddock actually spraying.

Operations that reduce overall spraying efficiency and productivity include:

- **time spent folding and unfolding the boom;**
- **time spent travelling to and from mixing points;**
- **time spent measuring, mixing and transferring product; and**
- **time spent filling the main spray tank with water**

Another useful exercise for any spray operator is to compare the engine hours to the actual sprayed hours. Often the sprayed hours are less than 50 per cent of the total engine hours. This is a useful guide to efficiency, as well as a factor affecting the value of the sprayer when it comes time to sell or trade.

3. Considerations before upgrading the mixing, filling and transfer systems

To design a good mixing and transfer system it is important to know what products are likely to be used, the quantities that will be required and the total water volume that will be needed for each job and for the entire season.

Things to consider before upgrading the filling, mixing and transfer set-up should include:

For more information refer to Module 7: Mixing and decontamination

- **product container sizes, ease of handling, transport and storage requirements;**
- **water quality requirements for each product to be used, along with how and when water will be treated;**
- **the solubility of various products, which will determine vat or mixing-vessel sizes;**
- **the tank size of the sprayer, if considering 'batching' entire loads in a mixing vat or vessel;**
- **cleaning and decontamination requirements for each product and the equipment used; and**
- **the quality of internal roads and tracks for determining the transport speeds and vehicle options.**

4. Tips and techniques that can increase mixing and transfer efficiency

Every farming operation is different, so the things that can increase efficiency the most may also differ for each enterprise. This section will discuss some of the areas where efficiency can be improved. Later sections of this module will look at practical examples of how to achieve this, along with examples of how some growers have put many of the ideas discussed into practice.

4.1 Increase the hectares per tank load to reduce number of fills required

Tank size and application volume are the main drivers of hectares per tank load.

4.1.1 Application volume

Reducing application volumes (litres per hectare) will increase the number of hectares per tank, but may also reduce efficacy. For every application, the application volume (L/ha) must be adequate to produce enough coverage of the target for the products being used. Before adjusting the application volume, the operator must take into account the spray quality (droplet size) required and how the product translocates within the target (particularly with herbicides). For many products it may be useful to assess the spray deposits and efficacy achieved in small strips or trials before changing application volumes.

For more information on assessing deposition refer to Module 21: Assessing spray deposits

4.1.2 Tank size

Increasing the tank size can enhance productivity by reducing the number of fills required to complete a job. As a simplified example we will compare a 3000-litre tank to a 6000L tank for a spray job to cover 300 hectares with a pre-emergent herbicide at an application volume of 100L/ha.

If we assume a spraying rate of 60ha/hour while in the paddock, this job requires five hours of actual spraying time.

If we assume the turnaround time for mixing and filling for both tank sizes is around 30 minutes, then:

- **the 3000L tank at 100L/ha will spray 30ha before refilling and will require nine refills to complete the job = 5 hours spraying time + 4.5 hours of filling (efficiency = 5/9.5 x 100 = 52.6%); and**
- **the 6000L tank at 100L/ha will spray 60ha before refilling and will require five refills to complete the job = five hours of spraying time + 2.5 hours of filling (efficiency = 5/7.5 x 100 = 66.7%).**

Before increasing the tank size, either by purchasing a new sprayer or modifying an existing one, carefully consider factors such as the sprayer pump size and agitation requirements for the tank. Also consider the weight, balance and tyre constraints of the sprayer, achievable and safe transport speeds, stability and possible compaction issues.

For more information see Module 15: Weight, balance and tyres

4.2 Reduce time travelling to and from mixing sites and fill points

Once the tank size and boom width have been optimised for the enterprise, the greatest increase in overall spraying efficiency will come from having the mixing and filling facilities as close as practical to the area to be sprayed.

Having a portable mixing and transfer set-up, along with a suitable size water cart that can be moved to wherever the sprayer is located, will save transfer time out of the paddock and engine hours on the sprayer.

Taking water and product to the paddock can be done in many different ways.

PLAY VIDEO

Mixing and handling water – tankers

Large operations may consider a road-train set-up, with something like a drop- deck torque-liner rear trailer with all the product, mixing, batching and safety equipment and spare parts required for the spray job, along with a lead trailer fitted with the water tanker or tanks. The torque liner keeps the products and equipment out of the weather and everything is covered during transport.

Having the water on the lead trailer means that the rear mixing set-up can be disconnected easily so the water can be refilled easily. This type of set-up can also work as a B-double set-up.

If conditions are not suitable for a prime mover, have a 'bogie dolly' so the trailer(s) can be moved to the paddock using a tractor.

Filling sprayer in-paddock using tanker with 'bogie dolly'.

Photo: Graham Betts

Everything required for mixing and transfer on the one truck.

Photo: Graham Betts

For **medium-sized operations** a similar set-up may be fitted onto a single trailer or body truck.

There is no 'one-size-fits-all' solution to creating a portable mixing-and-transfer set-up; the idea is to develop something that works for your operation. This could be done in several steps provided that things are carefully planned before you start; to avoid duplication or reduced efficiency.

PLAY VIDEO

Mixing and handling – rig features

Where to start?

A useful place to start is with a water cart and portable batching set-up to help improve the mixing and measurement process, particularly for granules and solids.

Ideally, the water cart would hold enough water for the entire day of spraying, but even having enough for two loads will halve the number of trips to the fill point.

Left: Batching set-up.

Right: Fully enclosed mixing vat and transfer pump.

Photos: Graham Betts

Over time, batching plants can be incorporated into an integrated portable set-up, such as a mixing trailer, which can be moved to the spraying site ahead of time.

A purpose built mixing and transfer set-up, able to carry enough product for a full day of spraying. This is used in conjunction with a water tanker.

Photo: Graham Betts

Some operators also include a rack or hoist for a motorbike, or a hitch for a quad bike, to avoid having to move the mixing and transfer set-up for minor tasks or returning to base. This is particularly useful when one person is operating the system.

Bike behind trailer.

Photo: Graham Betts

4.3 Increase the number of fill points around the farm

Even if your average travel speed to and from the fill point is 20 kilometres per hour, a round trip of just 4km would take about 12 minutes per load. Doing this four to five times in a day of spraying, would add up to 45 to 60 minutes out of the paddock. This is the equivalent to spraying one less tankful per day.

Using the sprayer to transport water is an expensive exercise when you consider the impact on engine hours and wear and tear, particularly on tyres and wheel motors for hydrostatically driven self-propelled sprayers.

Where it is not possible or practical to use a large tanker for transporting all the water you require for a job, increasing the number of fill points around the farm will reduce the time taken to access water and return to the paddock to be sprayed. This can be achieved by either plumbing permanent water outlets or installing several storage tanks and fill points that can be regularly topped up. Tanks have the advantage that they can be pre-treated with water conditioners before spraying activities.

When considering the location of storage tanks and fill points, carefully consider access to each of them in all weather conditions. Also consider the quality of internal roads or tracks and achievable travel speeds, both full and empty – especially the full weight of the sprayer and the tyre capacity, as well as any vehicles that may be used to fill storage tanks when you are not spraying.

When establishing fill points, it also helps to think about the pump requirements to fill each load in a reasonable timeframe. Using the sprayer's own pump to fill the sprayer may be too slow for large volumes and will unnecessarily increase the engine hours of the sprayer.

For large spray tanks it is a good idea to have an external fill and transfer system to increase the speed and accuracy of the filling operation.

4.4 Eliminate folding and unfolding

The ability to mix and fill the sprayer close to the paddock, preferably at the end of a paddock, eliminates the need to fold and unfold the boom until you have finished spraying that paddock.

On average it takes about six minutes to fold and unfold most large booms, by the time you ensure it is level and the height is correct. If this is done four to five times in a day of spraying, it would result in 25 to 30 minutes of lost spraying time per day, which, over several days of spraying, would add up to several loads that could have otherwise been completed.

Eliminating folding and unfolding in the paddock can only be achieved by having portable mixing equipment and a water cart, or alternatively 'batching' an entire load in an equivalent-sized tank close to each sprayed paddock. It will be important to consider where the fill point is located on the sprayer: having them mounted at the front of the sprayer can make it simple to approach and exit the mixing and filling equipment.

Front-mounted fill points allow the sprayer to be pulled into the mixing site. They simplify mixing and filling for a single operator.

Photo: Graham Betts

4.5 Examples of productivity gains through changes to equipment or practices

By increasing tank size, eliminating folding, and reducing turnaround times, the hectares sprayed can be substantially increased.

The following is is an example of potential lost productivity as a result of tank size, folding and unfolding, and travel to and from mixing points, as compared to mixing at the application site.

Worked examples of lost productivity

Assumptions used in this example:

- **the enterprise has 3000 hectares to spray (either in a single job, or over a given period or season);**
- **the application volumes used by the enterprise are 50 litres/ha for well-translocated knockdown herbicides, 80L/ha for grass selective herbicides and 100L/ha for in-crop fungicide applications and pre-emergent applications;**
- **the average distance to the filling point is 8 kilometres from the paddocks (a 16km round trip) and the average travel speed is 40km/hour (50km/h empty and 30km/h loaded). The round trip of 16km at an average speed of 40km/h would take 24 minutes of travel time (0.4h);**
- **either a 4000 or 6000L main tank are used;**
- **a 36-metre boom width is used at an average spray speed of 22km/h (the average spray speed includes 25km/h actual spray speed and the slower speeds at the headland and obstacles).**

At an average spraying speed of 22km/h, with a 36m boom width, the sprayer could complete 79.2ha/h while spraying.

Comparing the two tank sizes and the three application volumes we can calculate lost productivity through travel to and from the fill point and folding and unfolding the boom.

Example 1: Spraying at 50L/ha with 3000ha to spray
Using a 4000L main spray tank: 50L/ha x 3000ha to spray = 150,000L of mixed product:

- 150,000L ÷ 4000L per tank = 37.5 loads;
- travel time to and from fill point = 0.4 of an hour x 37.5 loads = 15 hours @ 79.2ha/h = 1188ha lost productivity travelling to and from fill point;
- time taken to fold and unfold boom = 0.1 of an hour x 37.5 loads = 3.75 hours @ 79.2ha/h = 297ha lost productivity folding and unfolding the boom; and
- spray productivity lost is 1188ha + 297ha = 1485ha.

Using a 6000L main spray tank: 50L/ha x 3000ha to spray = 150,000 litres of mixed product:

- 150,000L ÷ 6000L per tank = 25 loads;
- travel time to and from fill point = 0.4 of an hour x 25 loads = 10 hours @ 79.2ha/h = 792ha lost productivity travelling to and from fill point;
- time taken to fold and unfold boom = 0.1 of an hour x 25 loads = 2.5 hours @ 79.2ha/h = 198 hectares lost productivity folding and unfolding the boom; and
- spray productivity lost is 792ha + 198ha = 990ha.

Example 2: Spraying at 80L/ha with 3000ha to spray
Using a 4000L main spray tank: 80L/ha x 3000ha = 240,000L of mixed product:

- 240,000L ÷ 4000L per tank = 60 loads;
- travel time to and from fill point = 0.4 of an hour x 60 loads = 24 hours @ 79.2ha/h = 1901ha lost productivity travelling to and from fill point;
- time taken to fold and unfold boom = 0.1 of an hour x 60 loads = 6 hours @ 79.2ha/h = 475ha lost productivity folding and unfolding the boom; and
- spray productivity lost is 1901ha + 475ha = 2376ha.

Using a 6000L spray tank: 80L/ha x 3000ha = 240,000L of mixed product:

- 240,000L ÷ 6000L per tank = 40 loads;
- travel time to and from fill point = 0.4 of an hour x 40 loads = 16 hours @ 79.2ha/h = 1267ha lost productivity travelling to and from fill point;
- time taken to fold and unfold boom = 0.1 of an hour x 40 loads = 4 hours @ 79.2ha/h = 317ha lost productivity folding and unfolding the boom; and
- spray productivity lost is 1267ha + 317ha = 1584ha.

Example 3: Spraying at 100L/ha with 3000ha to spray:
Using a 4000L main spray tank: 100L/ha x 3000ha = 300,000L of mixed product:

- 300,000L ÷ 4000L per tank = 75 loads;
- travel time to and from fill point = 0.4 of an hour x 75 loads = 30 hours @ 79.2ha/h = 2376ha lost productivity travelling to and from fill point;
- time taken to fold and unfold boom = 0.1 of an hour x 75 loads = 7.5 hours @ 79.2ha/h = 594ha lost productivity folding and unfolding the boom; and
- spray productivity lost is 2376ha + 594ha = 2970ha.

Using a 6000L main spray tank: 100L/ha x 3000ha = 300,000L of mixed product:

- 300,000L ÷ 6000L per tank = 50 loads;
- travel time to and from fill point = 0.4 of an hour x 50 loads = 20 hours @ 79.2ha/h = 1584ha lost productivity travelling to and from fill point;
- time taken to fold and unfold boom = 0.1 of an hour x 50 loads = 5 hours @ 79.2ha/h = 396ha lost productivity folding and unfolding the boom; and
- spray productivity lost is 1584ha + 396ha = 1980ha.

From the previous example, if spraying a total area of 3000ha at 100L/ha, increasing the tank size from 4000L to 6000L can increase efficiency from about 50 per cent of total time spent spraying to about 60 per cent of total time spent spraying (e.g. equivalent to increasing from 500ha per day to 600ha per day if spraying for about 6.5 hours).

By eliminating the folding and unfolding operation and the travel time to and from the fill point, the 4000L sprayer at 100L/ha will **almost double** its work rate per day, and would increase the work rate per day for the 6000L sprayer by about 50 per cent at 100L/ha.

Table 1 Worked examples of lost productivity for a 400ha spray job applied at 60L/ha comparing various tank sizes due to travel to the mixing and fill point away from the sprayed paddock.

Main spray tank litres capacity	4000 litres	6000 litres	8000 litres
Hectares per load @ 60L/ha for each main spray tank capacity	66.6	100.0	133.3
400 ha x 60L/ha = total litres	24,000	24,000	24,000
Number of loads for each main spray tank capacity	6.00	4.00	3.00
Hectares that could have been sprayed if the operator didn't have to fold and unfold the boom	0.1 hour x 5.0 loads = 0.5 hour x 79.2ha/hour = 39.6ha	0.1 hour x 3.0 loads = 0.30 hour x 79.2ha/hour = 23.76ha	0.1 hour x 2.0 loads = 0.2 hour x 79.2ha/hour = 15.84ha
% hectares not sprayed due to folding and unfolding	(39.60 / 400.00) = 9.9%	(23.76 / 400.00) = 5.94%	(15.84 / 400.00) = 3.96%
Hectares not being sprayed while travelling 4.0 km to fill point	0.2 hour x 5.0 loads x 79.2ha/hour = 79.20ha	0.2 hour x 3.0 loads x 79.2ha/hour = 47.52ha	0.2 hour x 2.0 loads x 79.2ha/hour = 31.68ha
% hectares not being sprayed while travelling 4.0 km to fill point	(79.20 / 400.00) = 19.80%	(47.52 / 400.00) = 11.88%	(31.68 / 400.00) = 7.92%
Total hectares that could have been sprayed if the boom didn't have to be folded and travel 4km	**(39.60 + 79.20) = 118.80ha**	**(23.76 + 47.52) = 71.28ha**	**(15.84 + 31.68) = 47.52ha**
Total % hectares that could have been sprayed if the boom didn't have to be folded and travel 4km	(118.80 / 400.00) = 29.70%	(71.28 / 400.00) = 17.82%	(47.52 / 400.00) = 11.88%
% increase in productivity using 4000L main spray tank as comparison	-	(71.28 / 118.80) = 60.00%	(47.52 / 118.80) = 40.00%
% increase in productivity using 6000L main spray tank as comparison	-	-	(47.52 / 71.28) = 66.66%
Hectares that could have been sprayed if the boom didn't have to travel 8km	0.4 x 5.0 x 79.2 = 158.40ha	0.4 x 3.0 x 79.2 = 95.04ha	0.4 x 2.00 x 79.2 = 63.36ha
% hectares that could have been sprayed if the boom didn't have to travel 8km	(158.40 / 400.00) = 39.60%	(95.04 / 400.00) = 23.76%	(63.36 / 400.00) = 15.84%
Total hectares that could have been sprayed if the boom didn't have to be folded and travel 8km	(39.60 + 158.40) = 198.00ha	(23.76 + 95.40) = 119.16ha	(15.84 + 63.36) = 79.20ha
Total % hectares that could have been sprayed if the boom didn't have to be folded and travel 8km	(198.00 / 400.00) = 49.50%	(119.16 / 400.00) = 29.79%	(79.20 / 400.00) = 19.80%

4.6 Improve the efficiency of mixing and transfer operations

4.6.1 Use mixing vats for solid products

The results of poor mixing, particularly of solid products, can be seen by the operator as blocked filter screens, residues in the bottom of the batching or main spray tank or at the end of boom lines. It is important to fill the spray tank as quickly as possible, but not so quickly that the mixing process and products could be compromised.

Using a mixing vat with a cone-shaped bottom to pre-dissolve solid products and to ensure they are fully dispersed in the water before they are transferred to the main spray tank can eliminate many problems. Having water already in the main tank and the agitation running, will help to disperse the product as it is transferred from the vat.

TIP

Have a tank fitting in the side of the mixing vat and an anti-vortex fitting in the vat outlet. Arrange the plumbing so liquid can be sucked from the side of the vat and returned to the vat from the bottom. This can greatly assist with dissolving solid products quickly

PLAY VIDEO

Mixing and handling water quality

4.6.2 Pre-treat poor-quality water where required

It takes time to fully dissolve products such as crystalline ammonium sulfate (CAMS), especially if the water temperature is low e.g. during winter. Spray operators should allow at least 10 minutes to fully dissolve the CAMS before adding other products. Waiting for products such as CAMS to fully dissolve while you are mixing a load in the middle of a spray job can seem to waste valuable time, but if it is not done properly the tank mix may be compromised.

There are two general approaches to reducing mixing times when using CAMS, one is to pre-treat the entire water volume required for a load or the day by batch mixing, the other is to pre-dissolve a known quantity per litre, and to use the pre-dissolved liquid in place of the crystalline solid.

Where large volumes of water are required for a particular spray job, consider treating enough water for several loads in a batching tank before you start the spraying operation.

If pre-dissolving the CAMS, carefully identify the solubility of the product; this information can be found on the Safety Data Sheet (SDS). Different CAMS products may specify different solubility rates (grams per litre that can be dissolved). Many crystalline products can be dissolved at 500 grams per litre (g/L), which would allow the operator to use 2 litres of the pre-dissolved product in place of 1 kilogram of the crystalline form.

Always check the solubility of any solid product you intend to use.

4.6.3 Improve transfer systems

Reducing the fill time will not increase productivity if it results in a poorly mixed load that affects the overall efficacy of the job. While the rate at which we can transfer water to fill the main tank reduces time out of the paddock, using the same system to ‘suck’ chemicals from ‘shuttles’ or ‘envirodrums’ may not be appropriate for measuring or transferring smaller volumes.

Transfer pump alternatives

There are many approaches to the mixing and transfer pump set-up, but generally there are two common set-ups growers have used to improve efficiency.

The first option is to have a single 3-inch (7.62cm) poly pump for transferring water only, and a 2-inch (5.08cm) pump for transferring products and the contents of the vat. While the 3-inch pump can fill the sprayer quickly, it is generally too fast for sucking product directly from shuttles or envirodrums.

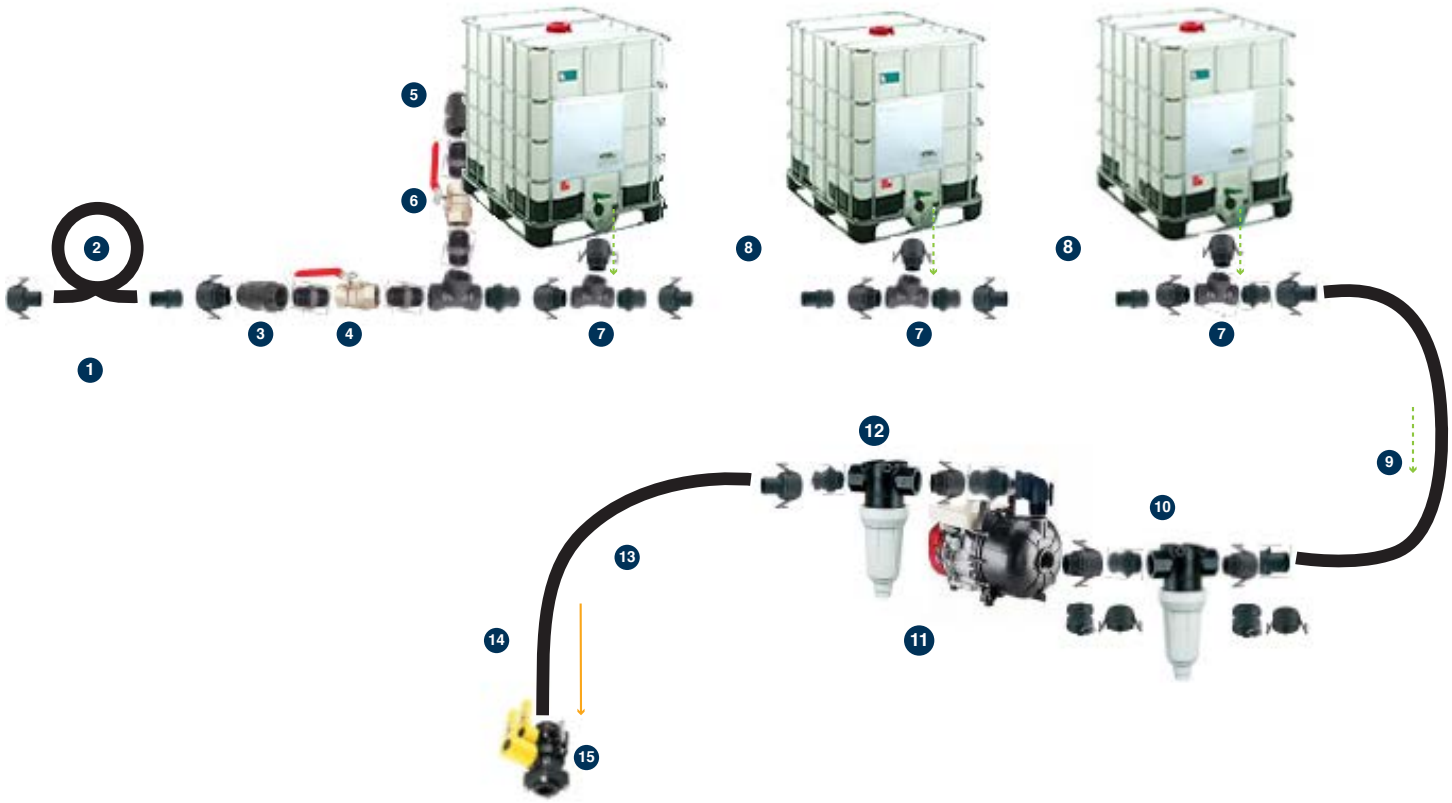
For many operations it is useful to match the pumps so that parts and fittings are identical, such as having two separate 2-inch poly pumps. One of the 2-inch pumps for water only, and the other 2-inch pump for operating the mixing vat, water flushes, sucking product from the shuttle and/or envirodrum directly to the mixing vat, batching tank or the main spray tank.

Where the pump set-ups are identical (e.g. both 2-inch), it is useful to spray-paint the clean water fittings all one colour (e.g. blue) and to have different coloured hoses for the clean water system and the product transfer system.

Figure 1 Example of a set-up for transferring water only using a 2-inch auxiliary pump.

1. Flow from water source
2. 2-inch camlock plug
3. 2-inch chemical suction hose, length to suit each situation
4. 2-inch camlock dust cap and plug
5. 2-inch suction filter with the coarsest screen available e.g. 16 mesh screen
6. 2-inch poly centrifugal pump
7. 2-inch pressure filter with e.g. 30, 50 mesh screen
8. 2-inch chemical suction hose, length to suit each situation
9. low going to the batching or main spray tank
10. 2-inch dry connect fittings

Figure 2 Sample plumbing layout for multiple shuttles.



1. Flow from water source
2. 2-inch chemical suction hose
3. 2-inch one-way valve, so product cannot contaminate water supply
4. 2-inch manual ball valve
5. 2-inch one-way valve, so air can be introduced into the suction line and residual product flushed through the piping before fresh water is flushed through and after the shuttle ball valve has been closed
6. 2-inch manual ball valve to introduce air into the system
7. 2-inch shuttle outlet manifold – make all the manifolds the same so they can be interchanged
8. 2-inch chemical suction hose with camlocks – make all the hoses the same so they can be interchanged
9. l2-inch chemical suction hose to suit each situation
10. 2-inch suction filter with the coarsest screen e.g. 16 mesh screen
11. 2-inch poly centrifugal pump
12. 2-inch pressure filter with e.g. 30, 50 mesh screen
13. 2-inch chemical suction hose to suit each situation
14. Flow going to the main spray tank
15. 2-inch dry connect fittings

A portable mixing and transfer system.

Photo: Graham Betts

4.7 Closed measurement and transfer systems for liquids

The best way to reduce risk to the operator and increase efficiency is to use a closed transfer system and avoid pouring from drums or shuttles to measure how much product to add to a vat or tank.

Chemical flow meters and chemical transfer pumps can increase the accuracy of the measurement, but some are also quite slow, while direct measurement from shuttles needs careful consideration.

TIPS

- It is important to maintain hygiene at all times: install dust caps or plugs as soon as the camlock is disconnected from fittings (e.g. mount plug on the side of the chemical transfer system). As soon as the hose is disconnected from the sprayer it can be connected to the dust cap.
- When using camlocks, it is ideal to install the male then female camlock in the direction of flow e.g. CFS plumbing.
- Before installing or using male camlocks, level the face of the camlock until all of the dull or higher points have been removed. You may choose to use wet and dry sandpaper to improve surface.
- You can purchase shims to place under the gasket in the female camlock to help improve sealing.
- Face mounted camlocks downwards at 45° or 90°, not horizontal, this will reduce the pressure/weight of the hose on the seal.
- Triple-rinse shuttles by installing a tank-rinse fitting in a spare lid. When required, the operator can swap lids and connect to fresh water to triple-rinse the shuttle.
- Having shuttles and/or an envirodrum connected to a common suction hose can potentially create product cross-mixing and decontamination issues. A good option is to have a shuttle camlock manifold with one-way valve and manual ball valve manifold so air can enter suction hose and remove most of the product from the line. Close the air manual ball valve and open the manual ball valve on the manifold with one-way valve from water source and flush all the residual product out of the suction line. Obviously, if using products that could affect the next crop, a more through clean would be required.

Shuttle flush nozzle
Photo: Graham Betts

4.7.1 Measurements of product

How accurately you measure products for each load may impact on the outcome of the spray job. The more highly loaded the product is – and the lower the rate of product per hectare is – the greater the need for accuracy.

For products such as water conditioners, the accuracy may only need to be in kilograms per tank load or in bags per tank if the bag weight has been checked.

For some liquid products, or powders where the rate is in millilitres or grams per hectare, accuracy becomes much more critical. Using accurate scales or chemical transfer meters that have been calibrated for the specific product density can improve accuracy.

Where a chemical transfer meter is not suitable for the container type, and larger volumes need to be transferred, you must check the accuracy of anything you use to measure the product with.

Transferring from shuttles and vessels using hoses

Measurements should allow for the volume of product that will be held in the hose itself, particularly when transferring product directly into the spray tank from a shuttle. This is particularly important if the product is not being flushed from the line by clean water. However, it is also important to consider the volume held within the hose when transferring small amounts of mixed products from vats and mixing vessels.

Table 2 Amount of product or spray solution held in various lengths of hose.

Internal hose size in inches (“) and (centimetres)	Internal hose size radius (cm)	Length of hose (cm) to achieve 1 litre	Example of the calculation
½” (1.27)	0.635	789.10	1000 cm^3 (1 litre) ÷ 3.14159 ($2\pi^2$) ÷ $radius^2$ (ID ÷ 2) = centimetres (length of hose)
¾” (1.905)	0.9525	350.70	1,000 ÷ 3.14159 ÷ 0.9525 ÷ 0.9525 = 350.70 cm
1” (2.54)	1.27	197.35	1000 ÷ 3.14159 ÷ 1.27 ÷ 1.27 = 197.35 cm
1 1/4” (3.175)	1.5875	126.30	1000 ÷ 3.14159 ÷ 1.5875 ÷ 1.5875 = 126.30 cm
1 1/2” (3.81)	1.905	87.70	1000 ÷ 3.14159 ÷ 1.8575 ÷ 1.8575 = 92.2 cm
2” (5.08)	2.54	49.34	1000 ÷ 3.14159 ÷ 2.54 ÷ 2.54 = 49.34 cm
3” (7.62)	3.81	21.93	1000 ÷ 3.14159 ÷ 3.81 ÷ 3.81 = 21.93 cm

Liquid height in the shuttle

It is not recommend that spray operators rely on the accuracy of the graduations on a shuttle for measurement of product. However, it may be useful to double-check volumes transferred against the shuttle levels using an accurate ruler.

In theory, for a 1000L shuttle, you could measure the height of the liquid when full, then work out what volume is delivered per centimetre drop in this level. Once this has been established, the reduction in liquid height may be used as a guide to the volume of product that has been transferred from the shuttle.

Using a stainless steel ruler can assist with determining how much product has been used or still remains in the shuttle.

Marking a shuttle with a stainless steel ruler.

Photo: Graham Betts

If the shuttle shape changes over its height, or wall thickness varies, this method will lose accuracy.

Measuring output against changes in the height of volume in the shuttle should only be used when more than 50L of product needs to be transferred to a vat or tank. For smaller volumes, the accuracy must be checked in an accurate measuring vessel.

4.8 Direct injection (advantages and limitations)

Direct-injection systems eliminate the need for measuring and mixing for most liquid products and have the capacity to more accurately deliver the required rate than a conventionally mixed tank, where variation in concentration throughout the load can occur due to the tank shape and agitation system.

Direct injection allows the operator to use a fully closed system, which means that the time and potential risks normally associated with mixing operations are eliminated for products that are available in containers such as 'envirodrums' where 'micromatic' fittings are used.

Direct injection also allows the spray operator to stop at any time without having to worry about potential interactions in the tank, as it usually holds clean water, or water and an adjuvant or water conditioner. When spraying has to stop, the spray lines can easily be flushed with clean water, and only the parts of the system where product has actually contacted need to be decontaminated.

Direct injection also opens up the opportunity for variable-rate application, without changing the total application volume.

However, direct injection does present a challenge for dry products and suspension concentrates. Generally, dry products need to be mixed in the tank, as with a conventional sprayer set-up. There are options to pre-dilute and inject suspension concentrates and flowable formulations, although they will add additional expense and require additional room on the sprayer to mount.

Direct injection may not be immediately compatible with some recirculating booms, unless the recirculation system can be turned off when direct injection is used.

5. Mixing vats and batching systems

The ideal batching system would allow for a total tank mix volume equivalent to the main sprayer tank to be mixed, agitated and ready for transfer as the sprayer pulls up. To implement this strategy successfully usually requires two people: one to complete the mixing and batching while the other sprays the load.

Where it is not possible to batch an entire load, consider using vats to simplify the mixing process and to speed up dispersion and transfer of products to the sprayer.

5.1 Considerations for mixing vats

The mixing vat should be of a suitable size to hold and dissolve enough of the product to match the size of the spray tank. This is why it is important to check the product's safety data sheet (SDS) for the solubility of dry products, then compare how much product is required for a full spray tank, and what volume the vat will need to hold to fully dissolve that much product.

For liquid products it is useful to have accurate measurements in the vat to reduce the time required to measure the product, for example, when transferring product directly from a shuttle into the vat.

Measurements in a mixing vat

Measurements in mixing vat.

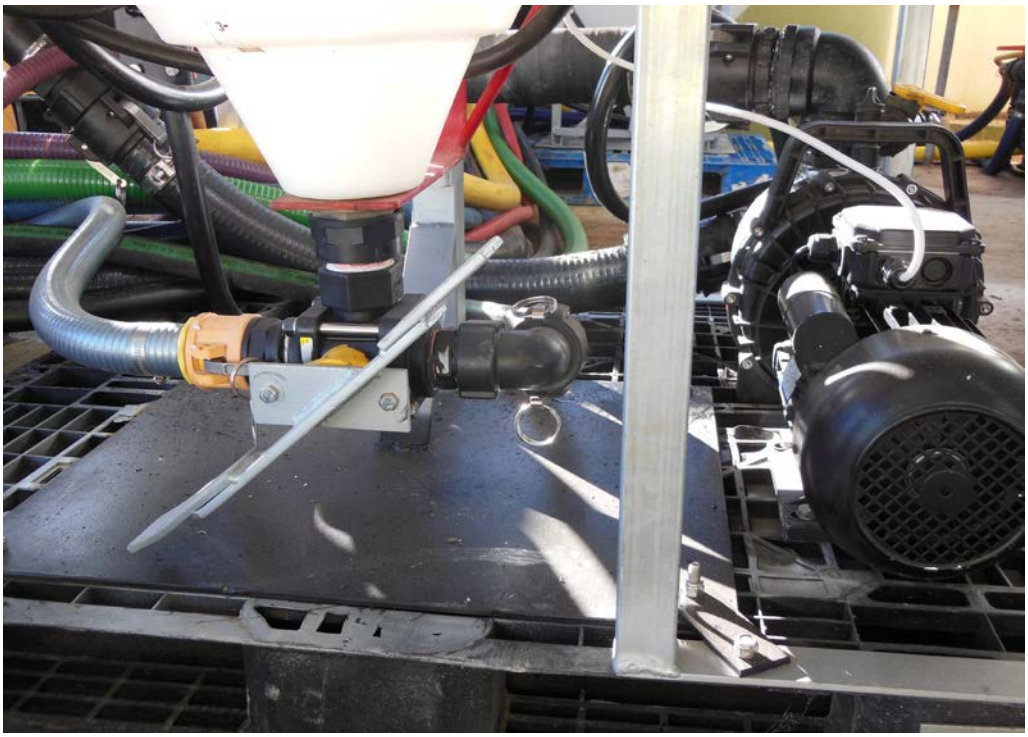
Photo: Graham Betts

Useful mixing vat features:

- made of a durable, UV-stable material that has a smooth internal surface to allow for better decontamination;
- a cone-shaped base with a flat sump, so a tank outlet and anti-vortex fitting can be easily installed into the base, such as a Banjo Bottom Drain™ manifold bolted tank fitting;
- a lid that is large enough to allow drums to be rinsed easily;
- fitted with a drum rinse nozzle;
- no internal ledges that may trap solid products;
- the system should have the ability to isolate the mixing vat from other plumbing;
- the ability to suck out of the side of the mixing vat, and a return to the bottom of the mixing vat;
- a way of preventing debris from entering the spray system, such as a perforated base plate inside the mixing vat; and
- modified handles, such as extensions, or foot pedals to allow for ease of operation.

Perforated stainless steel mesh in the bottom of a mixing vat.

Photo: Graham Betts



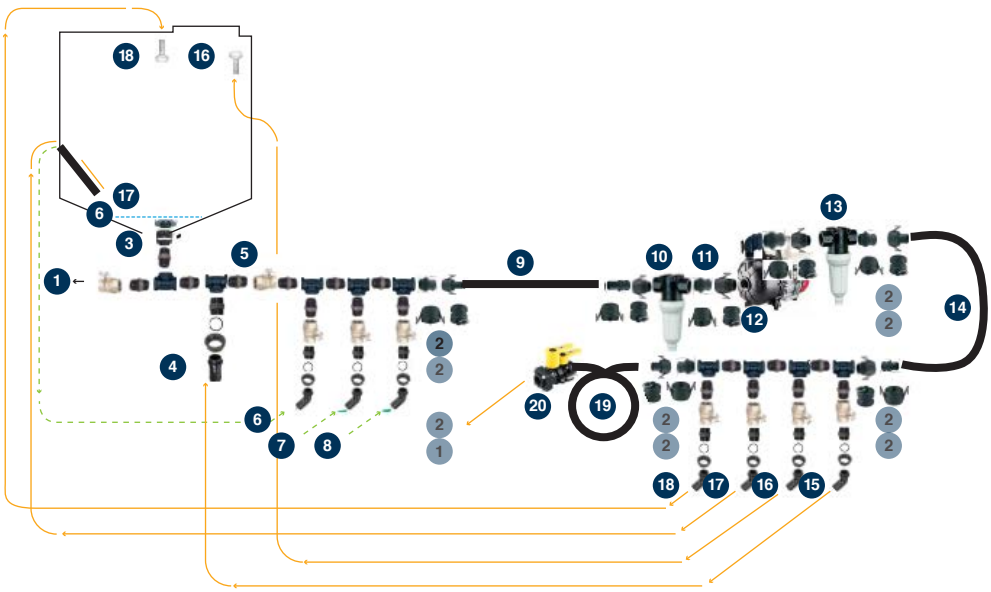
An anti-vortex fitting added to the outlet of the mixing vat.

Photo: Graham Betts

An extended tap handle fitted to the tap of the mixing vat to improve operator access and safety.

Photo: Graham Betts

Figure 3 Example of potential mixing vat and transfer system.



1. 2-inch mixing vat drain manual ball valve
2. Stainless steel perforated mesh to catch product that has not been dissolved and to catch any contaminates e.g. plastic rings out of drum lids, pieces of bag etc.
3. 2-inch anti-vortex outlet. This fitting is very important to reduce air getting into the system that can create foaming, and to help with mixing product when pumping from the side of the mixing vat (position 6) to the bottom of the mixing vat
4. 2-inch fittings to push product/water into the bottom of the mixing vat from the side of the mixing vat and water source
5. 2-inch manual ball valve to close suction from the mixing vat
6. 2-inch manual ball valve and fittings to suck product/water out of the side of the mixing vat
7. 2-inch manual ball valve and fittings to suction probe, shuttle(s), envirodrum, probe etc.
8. 2-inch manual ball valve and fittings to suction probe, shuttle(s), envirodrum, probe etc.
9. 2-inch chemical suction hose, length to suit each situation
10. 2-inch suction filter with the coarsest screen e.g. 16 mesh screen
11. 2-inch camlock fittings with dust cap and plug
12. 2-inch poly centrifugal pump
13. 2-inch pressure filter with e.g. 30, 50 mesh screen
14. 2-inch chemical suction hose, length to suit each situation
15. Pressure, 2-inch manual ball valve to shuttle cap rinse nozzle
16. Pressure, 2-inch manual ball valve and fittings to push product/water into the bottom of the mixing vat
17. Pressure, 2-inch manual ball valve and fittings to drum rinse nozzle
18. Pressure 2-inch manual ball valve and fittings to side of mixing vat to help with mixing product
19. 2-inch manual ball valve and fittings to mixing vat rinse nozzle
20. 2-inch chemical suction hose, length to suit each situation
21. 2-inch dry connect fittings
22. Product going to the batching or main spray tank
23. 2-inch camlock dust cap and plug

TIPS

- Solid products and suspension concentrates (flowables) will dissolve and disperse more easily if the vat is as full with water as practical before introducing these products. When adding these products into the vat, add them as though you are pouring liquid out of a 20L drum – slowly. Another good option is to pump water into the bottom of the vat as this will dissolve the products more easily.
- Install and use a tank rinse nozzle in the mixing vat to enable flushing of the vat and potentially settle any foam.
- Use an anti-vortex fitting on the tank outlet to reduce the possibility of sucking air.
- Use an outlet that enables the mixing vat to be totally drained without any residue being left in the mixing vat e.g. Banjo Bottom Drain™, manifold bolted tank fitting.

6. Summary: The benefits of an integrated, portable mixing and transfer system

Having a portable system can eliminate the need for a permanent mixing site. When designing the system, you must take into account the same things as you would for a permanent mixing site. This includes how you will contain and manage spills, provide access to PPE, first aid, clean water, SDSs and record-keeping requirements.

Once they are fully operational, portable mixing and transfer systems can reduce time spent out of the paddock. This will increase productivity and the effective life of the sprayer, and will help to retain its value for longer.

An investment in the mixing, filling and transfer system can provide a greater return on investment than buying a larger sprayer.

NEXT MODULE

SPRAY APPLICATION MANUAL FOR GRAIN GROWERS

Module 10 Weather monitoring for spraying operations

How to assess if conditions are suitable for spraying

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