GENERAL ARTICLES

J. H. Combellack

Marcus Lury

Guide to the successful use of boom sprayers

J. H. Combellack
Keith Turnbull Research Institute, Frankston, Victoria, Australia 3199

Marcus Lury
Lurmark Limited, Cambridge, United Kingdom

Summary

This guide has been prepared to answer the questions that are often asked about sprayer maintenance and operation. It is intended to help the operator obtain the best possible results from the herbicides used.

Preparing the sprayer

Checking

It is advisable to check the sprayer well in advance of any spraying operation as spare parts may have to be ordered. The following parts should be examined carefully for damage or wear and replaced if necessary.

TANK Any sign of leaks around pipework connections, drainpipes or lid?

PUMP Does the shaft rotate freely without excessive play? Was the oil drained out after storage?

FILTERS Are they clean and intact?

PRESSURE REGULATOR Can it be adjusted easily?

PRESSURE GAUGE Reading zero?

CONTROL VALVES Do they operate freely?

BOOM Any sign of damage? Can height be adjusted easily?

HOSES and PIPEWORK Are they all in good condition? Any sign of leaks or loose connections?

Cleaning

The sprayer should have been thoroughly cleaned immediately after it was last used. If not, the following procedure should be applied.

1 Scrub out the tank with a stiff brush and fill the tank with a mixture of 400 to 500 g 100 L^{-1} of washing soda in water and leave overnight. Next morning pump the mixture through the nozzles, then fill the tank with clean water. Remove the drain plug and flush out the tank. Refit the drain plug.
2 Remove the main filter, line strainers, nozzle and nozzle filters. Leave them to soak for a while in clean water, wash them in a solution of washing soda (40 g 10 L^{-1}) and blow through filters and nozzles with compressed air.
3 Check that the air vent is clear.
4 Making sure that pump shaft turns freely, attach the sprayer to the tractor and where necessary couple up the p.t.o. shaft.
5 Refill the tank with clean water and pump through all pressure lines before refitting the filters and nozzles. Tap any metal pipes with a piece of wood to dislodge scale while the water is flowing, before refitting the nozzles.

Testing

1 Fill the tank with clean water and operate the sprayer at working pressure (around 200 to 300 kPa).
2 Make sure that the recirculating/jet agitation system operates effectively.
3 Examine the spray pattern from each nozzle against a dark background. Clean or replace any nozzles that show streaks or signs of blockage.
4 Compare the output of the nozzles by placing containers of equal size under each nozzle and running the sprayer for a minute, The water level in each container should be the same and any tips showing too much or too little output should be replaced. This test should be repeated until all nozzle outputs are matched within plus or minus 5% of the average.
5 Make sure that fan spray nozzles (if fitted) are off-set 10° to 15° to the spray boom.
6 For overall spraying, adjust the boom height to the height recommended for the nozzles that are fitted. Run the sprayer and check again that the spray patterns have no obvious streaks. Also ensure that the width of the pattern from each nozzle on the ground is at least 1.5 times the distance between nozzles. For 500 mm spaced nozzles a boom height of 450 to 500 mm above the ground should provide such a coverage for 80 to 110 nozzles.
7 Drive the sprayer out over clean concrete or tarmac and watch the sprayed area dry out. If stripes appear the boom is set too low and it should be raised and retested until even drying is achieved. A stripe associated with one particular nozzle means that it is faulty and needs replacing.

Once an even drying pattern is established, the boom height should be measured and used to set the boom height above the spray target in the field.

Accuracy is important

The flowrate from a given nozzle is proportional to the square root of the pressure at the nozzle, and whilst increases or decreases in pressure are not dramatically obvious, even small variations in pressure can result in widely differing application rates.

For example, when setting a pressure of 300 kPa, a rise to 325 kPa will give an overdose of 4% while a fall to 275 kPa will result in a 4% underdose. Variations in tractor speed are even more dramatic. By dropping from 7 km h^{-1} to 6 km h^{-1} a 16% overdose will occur. Combine the drop in speed (16% overdose) with a small increase in pressure (4% overdose) and the result is a 20% overdose. This could easily mean increased herbicide costs, damaged crops, unnecessary wear and tear on equipment, and additional time, transport and labour costs. It is easy to understand why an accurate speedometer and pressure gauge are essentials in crop spraying.

Setting up the sprayer

It is not difficult to calibrate and adjust the sprayer to achieve the manufacturer's recommended application rate. Simply bear in mind that the four basic factors that govern sprayer output are **tractor speed, nozzle flowrate,** the **swath width being sprayed** and the **number of nozzles.** These factors provide an enormous range of application rates.

It should be remembered that nozzles are designed to operate efficiently within an optimum pressure range (approximately 200 to 500 kPa for fan spray nozzles). It is inadvisable to operate outside these limits since the spray pattern can alter dramatically, resulting in uneven herbicide application. Nozzles are cheap compared to the cost of the herbicides passing through them, so be sure to carry enough spare sets of nozzles of different sizes to cover the different application rates that you may require. The following simple methods can be used to calculate each of the factors that influence the final application rate.

Calculation of rates and quantities

Speed/application rate
The application rate of a sprayer is directly proportional to the speed of the tractor. As nozzle output charts may not cover all possible variations in speed, a formula must be used to calculate the effect of changes in speed on the application rate. Formula (i).

Nozzle flowrate in relation to pressure
The flowrate of liquid through a nozzle, or series of nozzles, is proportional to the square root of the pressure at the nozzle. Therefore, to double the flowrate for any given nozzle the pressure must be increased four-fold. To check any sprayer output it is advisable to measure the volume of water passing through each nozzle for a specific time at a fixed pressure. Knowing such information, it is possible to calculate the flowrate at a different pressure or the pressure needed to increase the flowrate by a set amount. Formula (ii).

Volume rate of application
Volume rate of application of a sprayer depends on the number of nozzles on the boom, the output per nozzle, the swath width and the speed of the sprayer. Since these are all connected by a simple equation, with any four factors available the fifth can be calculated. Formula (iii).

Required sprayer speed
The required sprayer speed can be calculated if the number of nozzles, the output of each nozzle, the swath width and application rate per hectare are known. Formula (iv).

Boom output
Boom output in litres per minute is calculated by multiplying the output per nozzle by the number of nozzles, at any given sprayer speed.

Individual nozzle output
Individual nozzle output, for any given sprayer speed, swath width and application rate can be calculated. Formula (v).

Hectares sprayed per load
Hectares sprayed per load can be calculated by dividing the sprayer capacity by the volume rate per hectare or by relating sprayer capacity, spray width, sprayer speed with boom output in litres per minute. Formula (vi).

Area sprayed per hour
Area sprayed per hour can be calculated by dividing litres per hour through the boom by the application rate in litres per hectare, or by relating swath width and sprayer speed.

Amount of herbicide concentrate per tank
This can be calculated on the basis of the sprayer tank capacity, the volume rate of application and the herbicide dose rate. Formula (vii).

In the field

Before setting out, make sure that the herbicides you are using have been measured accurately and mixed thoroughly according to the manufacturer's recommendations.

Overall spraying
At the edge of the field adjust the boom to the correct height above the spray target and check that all nozzles are spraying properly.

Spray two swaths around the outer perimeter of the field to establish a wide headland on which to turn.

Make subsequent passes across the field following the direction of drilling. Wherever possible, spray up-wind of the last run to prevent running into any remaining spray cloud. Turn the sprayer on and off as the boom passes over the headland that you have already sprayed. Make sure that you do not spray into the headland as this will result in wastage and overdosing.

Topping up
A flickering pressure gauge is often the first sign that the tank is almost empty. As soon as air starts to pass through the nozzles switch off the sprayer and mark the place where spraying stopped. It is then possible to pick up again in the correct position after refilling on the headland.

When drilling and spraying at the same time, it is usually impractical to drive back to the headland if spraying stops in the middle of a bout. It is, therefore, sensible to keep a spare drum of ready-mixed solution in the field and top-up at the headlands to avoid stopping in mid-bout. Make sure that the topping up solution is well mixed before adding it to the sprayer tank.

Left-over spray
Liquids should not be left in the sprayer if there is any risk of overnight frost, as freezing may damage pumps, filters and spray-lines.

Non-toxic herbicides can be sprayed out over weed patches that are not accessible to livestock.

Other herbicides should be drained out and disposed of safely, well away from livestock and water sources, preferably on a ploughed area which is not to be used for cropping purposes.

Cleaning and storing the sprayer

Cleaning
If you plan to continue spraying with the same type of herbicide, it is sufficient to wash down the sprayer thoroughly with clean water paying particular attention to the inside of the tank.

Remove the nozzles, filters and boom end caps (if detachable) and leave them

to soak in clean water. Blow through the nozzles and filters with compressed air before refitting.

If a different type of herbicide or another pesticide is used, it is essential to remove all traces of the previous solution.

First, remove the drain plug and hose down the sprayer inside and out with clean water. Scrub inside the tank thoroughly with a stiff brush and then refit the drain plug.

Fill the tank with clean water and add detergent or washing soda according to the type of spray last used. For oil-based sprays add 50 mL of liquid detergent per 100 L of water. For other sprays add 400 to 500 g of washing soda per 100 L of water. Leave overnight, then agitate the mix and flush out through the complete system. Use the same solution to wash down the outside of the sprayer.

Refill the tank with cleaning solution and leave to stand overnight unless there is a risk of frost. Drain the tank the following morning and flush through complete system twice with clean water.

Storing

Clean the sprayer as above.

Remove the hoses and store them in a dark place.

Remove the nozzles, filters and drain plug. Store them in the basket strainer at the top of the tank, being careful not to damage the mesh, but make sure that the lid is left at an angle to allow all the parts to dry out completely.

Fill the pump with oil.

Lubricate the moving parts of the sprayer and store under cover until next required.

Appendix

Formula (i)

$$\frac{\text{speed 1}}{\text{speed 2}} \times \text{known rate per hectare at speed 1} = \text{application rate at speed 2}$$

Examples

$$\frac{7 \text{ km h}^{-1} \text{ speed 1}}{6 \text{ km h}^{-1} \text{ speed 2}} \times 100 \text{ L ha}^{-1} \text{ at speed 1} = 116 \text{ L ha}^{-1} \text{ at speed 2}$$

Thus a decrease in speed of 1 km h^{-1} will lead to a 16% increase in the application rate. If one travels 1 km h^{-1} faster, then there will be a decrease of 12.5% in the application rate, *viz:*

$$\frac{7 \text{ km h}^{-1} \text{ speed 1}}{8 \text{ km h}^{-1} \text{ speed 2}} \times 100 \text{ L ha}^{-1} \text{ at speed 1} = 87.5 \text{ L ha}^{-1} \text{ at speed 2}$$

Formula (ii)

Example (a)

A nozzle flows at 1 L per minute (Q_1) at 200 kPa pressure (P_1): what will be its flow rate (Q_2) at 800 kPa (P_2)?

As the flow rate of liquid through a nozzle is proportional to the square root of the pressure at the nozzle,

$$\text{then } Q_1 = Q_2\sqrt{\frac{P_1}{P_2}}$$

$$\text{then } Q_2 = Q_1 \div \sqrt{\frac{P_1}{P_2}}$$

$$\text{i.e. } Q_2 = 1 \div \sqrt{\frac{200}{800}} = 2 \text{ L per minute}$$

Example (b)

What pressure (P_2) will be required to increase the flow rate of a nozzle from 0.4 L per minute (Q_1) at 100 kPa (P_1) to 0.8 L per minute (Q_2)?

Since we know the pressure has to be increased four fold to double the flow rate,

$$\text{then } Q_1 = Q_2\sqrt{\frac{P_1}{P_2}}$$

$$\text{then } P_2 = \frac{Q_2^2}{Q_1^2} \times P_1$$

$$\text{i.e. } P_2 = \frac{0.8 \times 0.8}{0.4 \times 0.4} \times 100 = 400 \text{ kPa}$$

Formula (iii)

$$\text{volume rate of application} = \frac{600^* \times \text{number of nozzles} \times \text{output per nozzle (L min}^{-1})}{\text{swath width (m)} \times \text{speed of sprayer (km h}^{-1})}$$

* 600 is derived from 10 000 m^2 (1 hectare) ÷ 16.66 m per minute (1 km h^{-1}).

Example

A sprayer has 20 nozzles spraying 1.75 L per minute each, a 10 m swath width and a speed of 7 km h^{-1}. What is the rate per hectare?

$$\text{Rate per hectare} = \frac{600 \times 20 \times 1.75}{10 \times 7} = 300 \text{ L ha}^{-1}$$

Formula (iv)

$$\text{required speed (km h}^{-1}) = \frac{600 \times \text{number of nozzles on the boom} \times \text{nozzle output (L min}^{-1})}{\text{swath width (m)} \times \text{volume rate of application (L ha}^{-1})}$$

Example

A sprayer has 20 nozzles each with an output of 1.75 L per minute, a swath width of 10 m and a required application rate of 300 L ha^{-1}. What speed is necessary?

$$\text{required speed} = \frac{600 \times 20 \times 1.75}{10 \times 300} = 7 \text{ km h}^{-1}$$

Formula (v)

$$\text{nozzle output (litres per minute)} = \frac{\text{sprayer speed (km h}^{-1}) \times \text{sprayer width (m)} \times \text{volume of application (L ha}^{-1})}{600 \times \text{number of nozzles}}$$

Example

A sprayer is travelling at 7 km h^{-1}, the swath width is 10 m, the application rate required is 300 L ha^{-1} and the number of nozzles is 20. What is the required output per nozzle?

$$\frac{7 \times 10 \times 300}{600 \times 20} = 1.75 \text{ L per minute per nozzle}$$

Formula (vi)

$$\text{hectares per load} = \frac{\text{tank capacity (L)} \times \text{boom width (m)} \times \text{speed of sprayer (km h}^{-1})}{600 \times \text{boom output (L min}^{-1})}$$

Example

A sprayer has a liquid capacity of 900 L, a swath width of 10 m, a speed of 7 km h^{-1} and a boom output of 35 L per minute.

$$\text{hectares per load} = \frac{900 \times 10 \times 7}{600 \times 35} = 3 \text{ ha}$$

Formula (vii)

Amount of spray per tank is determined by multiplying the dose rate (in litres, grams or kilograms) by the number of hectares sprayed per load (see Formula vi).

Example

Using a 1000-litre tank with a boom width of 20 m, a sprayer speed of 7 km h^{-1} and a boom output of 35 L per minute, how many litres of spray are required to apply 1.5 L ha^{-1}?

$$\text{spray required} = \frac{1000 \times 20 \times 7}{600 \times 35} = 6.67 \text{ L of spray per tank}$$

Further reading

Combellack, J. H., Richardson, R. G. and Andrew, L. (1982). *Efficient Boom Spraying*. Special Technical Bulletin. Keith Turnbull Research Institute, Frankston, Victoria.

Matthews, G. A. (1979). *Pesticide Application Methods*. Longman, New York.

NEW EQUIPMENT

Edited by J. H. Combellack
Keith Turnbull Research Institute, Frankston, Victoria 3199

RC-101 Automatic Sprayer Control System

The system is designed to give the operator better control over variations in application rates. It achieves this by compensating automatically for changes in tractor speed and for the changes in pressure when one section of the boom is closed. Whilst this system does not accommodate the speed range change possible with the most commonly used metered spray system, a piston pump driven by a ground wheel, it does have the advantages that (a) it can be used on conventional (non-metered) sprayers and (b) it does allow sectionalized booms.