Chapter 8
Herbicide Use

Compiled by Annie Johnson, Tim McNee and Bob Thompson

Photo: A. Johnson

Self propelled spray rig.

Herbicide selection may appear to be a complex choice. Plan your use of herbicides as part of your IWM strategy and rotations. Planning and farm records can prevent 'emergencies' and last minute decisions. Economics are a major factor and the cost of the choice can vary greatly depending on yield potential and the timing of application as well as product choice.

This chapter looks at herbicide selection and timing, as well as environmental conditions and how they affect herbicide application.

Herbicides vary in price but the most expensive herbicide is an application failure due to a wrong choice.

Herbicide selection and timing

Weed identification

Correct weed identification is essential when using herbicides. Weed growth stages determine the herbicide rate; weed and crop species the type of herbicide(s) as well as application factors such as water volume, adjuvant and droplet size. Labour availability can also determine herbicide choice.

Herbicides and herbicide mixes

If a single herbicide will not control all the weeds present consider a second application or a mix of herbicides.

Choose mixtures carefully and consider two separate applications if in doubt. Some mixtures are synergistic, that is, when combined they give better control than each individually. Many, however, can antagonise and reduce the efficacy of the application. Check the label of each product to see if the tank mix is chemically compatible. Product compatibility does not determine efficacy.

Rotating herbicides

Rotating herbicides can be more costly than using a single cheap reliable herbicide. Imagine the cost of weed control if resistance meant that the cheap products could not be used. Using a more expensive product every second or third year can save a lot of money in the long term.

Pre-emergent herbicides

Pre-emergent herbicides are a preventative control. Paddock records are important for keeping track of the number and types of weed seeds that may be present in the weed seed bank. Pre-emergent herbicides work best when there is high weed pressure or there is no post-emergent herbicide available.

Most pre-emergent herbicides are residual and are effective against weeds that germinate over a long period of time e.g. annual ryegrass. Residual herbicides protect the yield potential of the crop if herbicide application is expected to be delayed or difficult later on. Pre-emergents are often cheaper than post-emergent herbicides and some can be tank mixed with a knockdown herbicide prior to sowing.

There are several types of pre-emergent herbicide available. Some pre-emergents require incorporation, others are applied post-sowing pre-emergent with no incorporation, others still need to be incorporated.

Incorporated herbicides

Some of the herbicides that require incorporation are highly volatile (e.g. trifluralin) or act as fumigants. Poor weed control by incorporated herbicides can be a result of poor incorporation due to high stubble loads, cloddy seed beds, low soil moisture or equipment problems. The labels for incorporated products give several options for incorporation.

Post-emergent herbicides

Paddock records that track weed densities can help indicate when a post-emergent herbicide would be a better option than a pre-emergent.

Post-emergent herbicides are important when there are no pre-emergents available or are used to control weeds that were missed by pre-emergent applications.

Timing is important for post-emergent herbicides. The crop stages when the herbicide can be applied are outlined on the label example shown in Figure 8.1.

Herbicides with grazing or cultivation

If grazing or cultivation are combined with herbicides for weed control then herbicide selection and timing is also important.

After grazing or cultivating weeds or lucerne, allow time (labels will give directions) for the plants to put on fresh regrowth before spraying. The fresh foliage is what takes up the most post-emergent herbicides.

There may also be withholding periods before stock can graze a paddock after it has been sprayed. Check the product label before application and grazing.

If cultivating or planting a crop after a herbicide application allow sufficient time for the herbicide to be absorbed and translocated within the plant. Some herbicides such as paraquat and diquat work by "scorching" the plant tissue and do not require long times. Check the product label before sowing.

Figure 8.1 Example label: Post-emergent herbicide labels will give weed control periods for when weeds are most susceptible and when crops are most tolerant in the critical comment section

Crop	Weeds Controlled	State	Rate/ha	Critical comments
Wheat, barley and certain oat varieties	Capeweed, Fumitory-red, Fumitory-white, Indian hedge mustard, Paterson's curse, Rough Poppy, Turnip	NSW, Vic, SA only	1L	Spray actively growing weeds at the 2 to 6 leaf stage when cereals have 3 to 5 leaves on the main stem. Do not spray weeds after the 12 leaf stage.

NB: This is not a real label. Always read the label of the product being applied.

Table 8.1 The cost of spraying can significantly vary depending on the timing of spraying and weeds present.

Chemical fallow	Early Control 2–4 leaf or <3 cm diameter two weeks after germination		Late Control 6– 10 leaf or > 3 cm diameter one month after germination	
Herbicide	glyphosate (450 g/L) @ $5/L			
Weeds Controlled	Annual grasses	Sowthistle	Annual grasses	Sowthistle
Recommended rate	0.4 L/ha	0.8 L/ha	0.8 L/ha	1.6 L/ha
Cost chemical per hectare	$2	$4	$4	$8
Cost chemical 50 ha paddock	$100	$200	$200	$400
NB: These prices and rates are a guide only. Always check the label before using a product. Prices vary according to area and quantity.				

Timing of in crop herbicides

The timing of herbicide application is important to reduce weed competition and limit the effect of herbicides on the crop to maximise yield potential. Weeds begin to compete with the crop from emergence. Control weeds as soon as possible to give the crop a longer period to compensate for any competition. Later emerging weeds have less impact on yield potential as the crop is more competitive.

Most crops are only tolerant to post-emergent herbicides for a limited time.

Many products also have withholding periods before harvest, always check the label for details.

To avoid damage to the crops yield potential follow the label directions for crop growth stages when the herbicide can be applied (Figure 8.1).

Timing of weed control in fallow

To prevent soil moisture loss in the fallow, multiple emergence 'flushes' are better controlled with a residual herbicide or two to three timely applications of a knockdown herbicide rather than a single delayed high rate of herbicide to large weeds.

Herbicides are most effective when weeds are at the two- to four-leaf stage. In warm temperatures this can be within two to three weeks of rainfall. Delays often result in inadequate control of large weeds and a greater use of soil moisture.

Timing is especially important for weeds like heliotrope and fleabane which are very herbicide tolerant once past the small seedling stage. Product labels are required to indicate at what growth stages the weeds will be controlled (Figure 8.1).

Plant back periods

The plant back period is the recommended time after the use of herbicides that crops can be safely sown to avoid damage. Herbicide break down can be very slow and requires the right moisture and temperature conditions. The breakdown time of the herbicide may vary depending on soil type (especially pH) and seasonal conditions. For some herbicides applied on dry soil 15 mm of rain is required before the herbicide starts to breakdown. Problems with residual herbicides are mostly found following drought as dry conditions lengthen the time taken for herbicides to breakdown. Always check the label for plant back conditions such as soil type, rainfall required or other seasonal conditions.

Photo: K. Roberts

Herbicide damage in wheat.

Rate

Variable application rates are often listed on the product label (Figure 8.2). The choice of rate varies depending on some of the following factors

- Weed species present
- Weed and crop growth stage
- Weather conditions before and at time of spraying
- Application equipment
- Water rates
- Stubble load or tillage system.
- Soil type.

Incorrect rate and/or water volume can frequently result in poor weed control and crop damage. This results in a waste of time and money.

Higher and lower than label herbicide rates

Rates are set at the point where they will be most effective and not exceed the maximum residue limits. Higher than label rates are illegal and may damage crops and increase plant back periods.

A higher than label rate will not necessarily give better control. Excessive concentrations, especially of herbicides such as 2,4-D can cause localised cell damage in the weed which then restricts further herbicide translocation. Thus, higher than recommended rates can be counterproductive.

Lower than label rates while legal in NSW must be treated with care. The product manufacturer has no liability for failures when lower than label rates are applied. Trials over several locations have shown less consistent weed control over the years with reduced rates. A certain level of control may be achieved using lower rates but only with an increase in application efficiency. Using a lower rate could result in weed escapes, decreased yield of crops and pastures and increases in weeds the following year.

Lowering the herbicide rate to reduce costs can end up being a waste of money when it gives unsatisfactory control.

Efficacy is reduced by plant stress which can be brought on by adverse weather conditions, disease or insect attack. Herbicide and water rates may be adjusted to compensate for certain conditions. Follow the label, seek advice from an agronomist or chemical manufacturers, and if necessary, plan an alternate form of weed control.

Additives

A spray additive (adjuvant) can be part of the formulation or added to the spray tank at time of application. Additives can have a significant influence on the success of a herbicide application. They can be used to improve spray delivery and retention on the target and enhance uptake of the herbicide. They can buffer the solution to ensure the most efficient pH for the herbicide to be active.

For more information on spray additives refer to the book ***Weed Control in Winter Crops*** (NSW DPI).

Water rates

The mode of action of a herbicide can determine the water rate. Many pre-emergent products require low water rates. High water rates are needed for post-emergent products that 'scorch' the plant in order to maximise coverage. Correct water rates also can minimise crop damage with some post-emergent herbicides (e.g. terbutryn).

Increased water rates are used in less than favourable conditions such as increased temperatures and low humidity. Seek advice before altering rates.

Figure 8.2 An example label. Rates are based on weed types, growth stage and spraying conditions.

Crop/ Situation	Weeds Controlled	Growth stage	Rate L/ha	Critical comments
Fallow	Seedling grasses	2 to 3 leaf	1.0 to 1.2	Apply to young or well grazed weeds. In a mixed weed situation use the rate recommended for the growth stage of the hardest to kill weed species. Under less favourable conditions, or where spraying is delayed, or under dense weed stands, use higher rates. Apply in 50 to 100 L of clean water/ha. If vulpia is present add a wetter at 100 mL/100L water.
		4 leaf to early tiller	1.2 to 2.4	
		mid to fully tillered	2.4 to 3.2	
	Seedling brassica weeds	1 to 5 cm diam.	1.2 to 1.8	
		5 to 10 cm diam,	1.8 to 2.4	
		10 to 20 cm diam.	2.4 to 3.2	
	Other seedling broadleaf weeds	1 to 4 leaf, or 1 to 4 cm diam.	1.8 to 2.8	
		4 to 8 leaf, or 4 to 8 cm diam.	1.8 to 3.2	

NB: This is not a real label. Always read the label of the product being applied.

Figure 8.3 Example label. Rate recommendations may vary according to tillage system.

Crop/Situation	Rate/ha	Critical comments
Prior to sowing a crop or pasture with full soil disturbance by cultivation or sowing with a tyned implement.	400–800 mL/ha pre-tillering 800 mL–1 L/ha post-tillering	Full disturbance with cultivation or sowing with a tyned implement may start one day after treatment (seven days if certain listed weeds are present).
Prior to establishing a crop or pasture with an implement that gives minimal or no soil disturbance.	800 mL – 1.2 L/ha	Use lower rate on young weeds, increase to the higher rate where grasses reach full tillering.

NB: This is not a real label. Always read the label of the product being applied.

Tillage system

Some labels have varied rates according to the tillage system (Figure 8.3).

Equipment

Ensure the spray equipment is calibrated to deliver the required rate. A common cause of uneven weed control occurs when the required rate was not evenly applied. Speed or rough ground can cause the spray boom to 'bounce' resulting in uneven spray coverage. Calibrate the boom spray using measuring jugs and a stop watch to ensure the spray is delivering the required amount. See ***Weed Control in Winter Crops*** (NSW DPI).

Soil type

The product rate for soil incorporated herbicides such as trifluralin is dependant on the soil texture. Using the wrong rate for the soil texture could result in poor weed control or damage to the establishing crop or pasture.

Photo: T. McNee

Weeds sprayed in wheat.

Application Failure

If a treatment fails to control the weeds adequately the initial thought is to assume the herbicide lacked efficacy or that the weeds have 'resistance!' Often the reality is the failure can be attributed to

- Equipment calibration mistakes.
- Incorrect weed identification and/or growth stage.
- Incorrect product and/or rate.
- Application when the weeds are stressed.
- Using lower than the label rate. Under normal weather conditions, a below label rate will not give adequate control.
- Chemical may not have been stored under the recommended conditions or may be too old and may have lost efficacy (this happens more often with animal health products than herbicides). Some products if stored for too long may separate and 'settle' and can not be properly re-mixed.

In the event of an application failure look at the situation carefully and establish the reason(s). Take corrective action if possible.

➢ See page 77 for guidelines on when herbicide resistance is suspected.

Environmental conditions

This section will first describe how environmental conditions determine how much of the spray reaches the target. Second, it will show how environmental conditions affect crops and weed interactions with herbicides.

Environmental factors include wind speed, temperature, humidity, soil moisture, rainfall, dew and frost.

The herbicide application

The environmental conditions at the time of application determine how much of the spray reaches the target.

Low Temperatures

Plant growth is slow to dormant below 5°C so it is unlikely that weed control would be required at low temperatures. As the temperature drops herbicides become more viscous, creating problems with equipment and it is physically difficult to apply the correct rate. Some herbicides are more likely to cause crop damage at low temperatures, this will be specified on the label.

In water temperatures below 10°C some products will form a gel.

High temperatures

High temperatures during the application impact on the rate of evaporation of the spray droplets and the rate of volatilisation of the herbicide. Application during high temperatures may substantially reduce the quantity of the herbicide reaching the intended target.

Humidity and Delta T

Delta T indicates the drying ability of the air. Humidity affects the rate of evaporation and volatilisation of the spray droplets.

Low humidity increases, and high humidity reduces the risk of evaporation.

The relative humidity and/or Delta T are easily measured in the field using handheld electronic relative humidity meters or whirling psychrometers. Delta T is calculated by subtracting the wet bulb temperature from the dry bulb temperature.

Rain

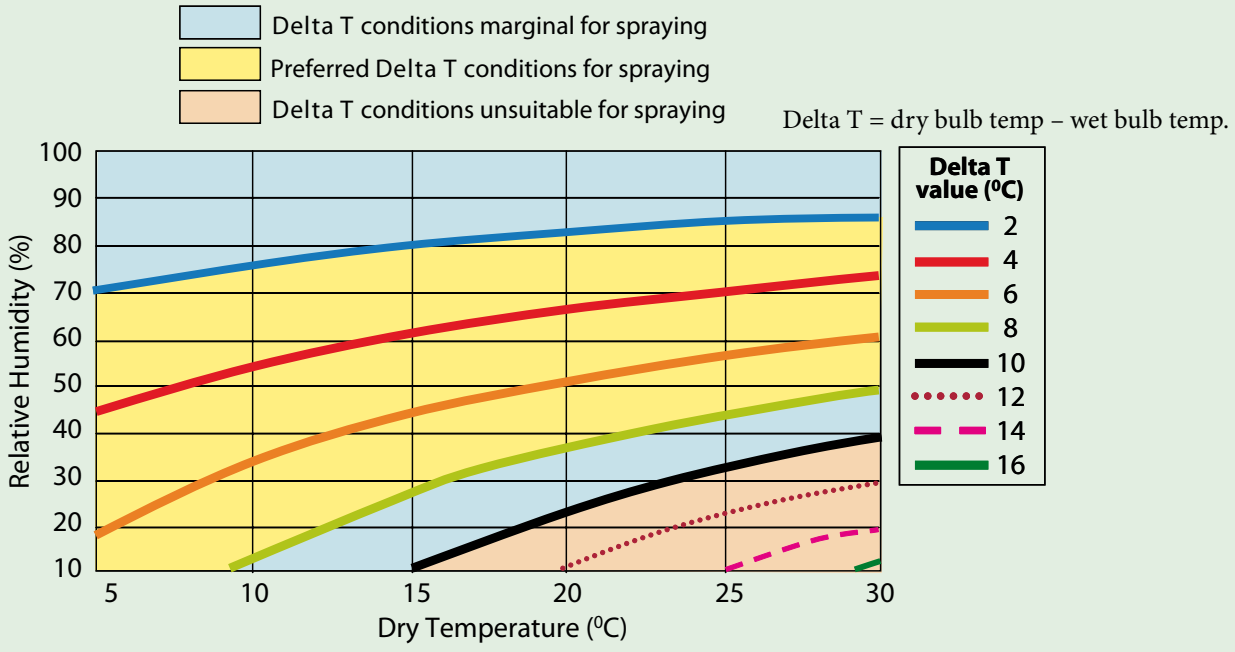
The herbicide label indicates the rain fastness of the product. The interval between spraying and rain is most important. The intensity and volume of rain also determines the degree to which the application is affected. Water soluble compounds are more vulnerable to rain than oil based products. Some adjuvants can decrease the interval between spraying and rain by increasing the rate of leaf penetration or binding to the leaf.

Dew

Some labels recommend against spraying when leaves are wet with dew e.g. dicamba.

Spraying is not usually affected by light dew. In some situations it can improve coverage and efficacy. Do not spray if weeds are covered in heavy dew, as dew may roll off the leaf carrying the applied herbicide with it.

Figure 8.4 Delta T is one of the standard indicators for acceptable spray conditions. When applying pesticides Delta T should ideally be between 2 and 8 and not greater than 10.



Source: Modified from Bureau of Meteorology, 2004.

Case Study 8.1 Inversions and herbicide drift

Inversions

Temperature inversions are layers of air where temperature increases with height (normally they decrease with height) (Figure 8.5). Inversions frequently form in the late evening and strengthen overnight (being strongest near sunrise) before being eroded by mid morning as the air near the ground heats up. Inversion layers are stable and are characterised by calm, light or variable winds, that make it difficult to predict the movement, both vertically and horizontally, of spray droplets. Do not spray when inversion conditions exist.

When thre is an inversion layer droplets may rise and be trapped before being carried away from the target area.

Herbicide drift

All foliar herbicides are capable of drift. When using a herbicide you have a legal liability for injury to persons or damage to property and a legal liability for harm to non target animals and plants. This means that you are lawfully obligated to prevent any pesticide from drifting, contaminating or damaging neighbours' crops and sensitive areas.

Particle drift

At high temperatures and low humidity the water in the spray droplets evaporates. Smaller droplets remain airborne longer and are carried by air currents away from the intended target. Avoid variable or gusty wind conditions (Table 8.2). Avoid calm conditions as small droplets may remain suspended for long periods. Spray when the wind is blowing away from sensitive areas.

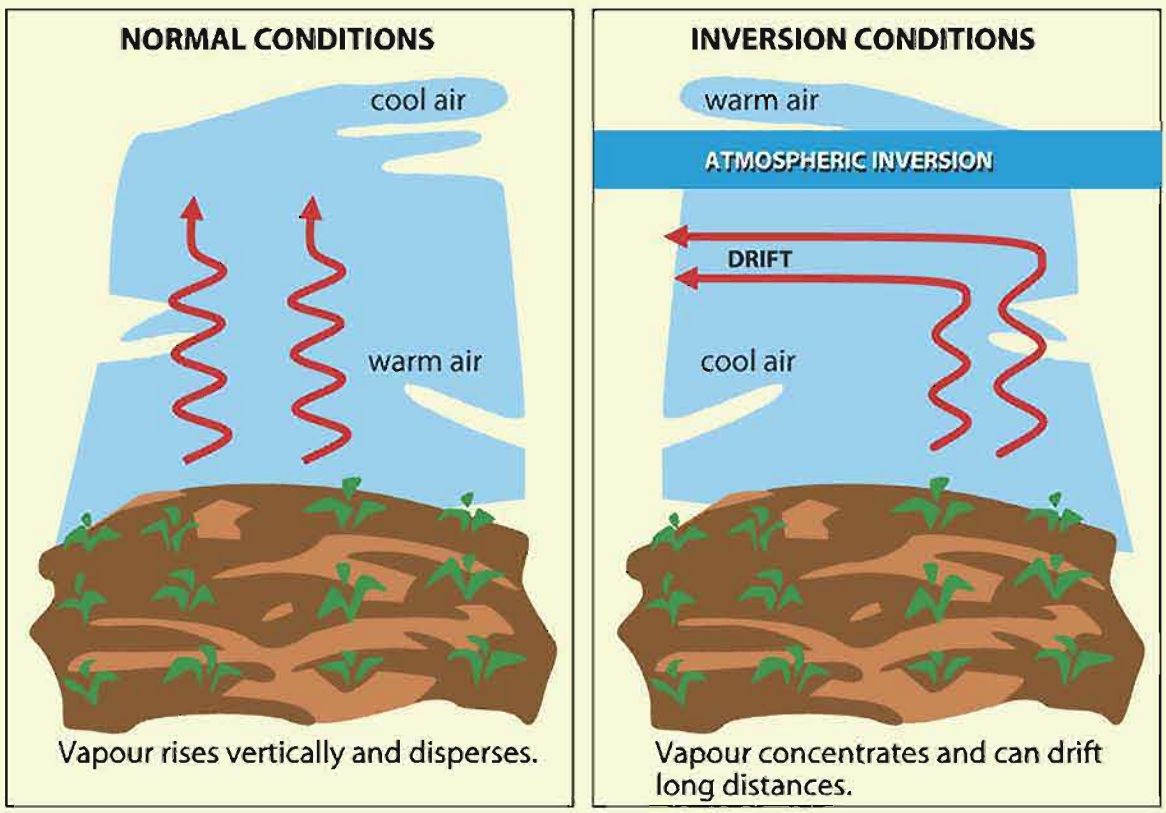
Volatility

Volatility refers to the likelihood that the active ingredient in the herbicide spray will evaporate and become a gas. High temperatures with low humidity inclines herbicides to vaporise, releasing damaging vapour. Volatilisation can occur at the time of spraying, or hours after application if temperatures heat up. Even when the observed air temperature is within acceptable limits for spraying, soil surface temperatures can be higher.

Vapour drift can be avoided by choosing low volatile active ingredients. The ester forms of 2,4-D and MCPA are highly volatile while the amine and salt forms have lower volatility. Low volatility products can still volatilise if conditions are hot and dry enough. Low volatility products are still susceptible to particle drift.

Humidity of greater than 45% is often recommended for spraying to prevent volatilisation.

Figure 8.5 Temperature inversions make it difficult to predict the movement of spray droplets.



Source: Storrie, A. 2004.

Frost

Spraying during frost will reduce herbicide uptake and movement. Spraying 24 hours before or after frost is less likely to have reduced efficacy unless there is damage to the plants. Check the product label for frost and temperature recommendations.

Soil moisture

Labels give directions for soil moisture at time of application. The effect of soil moisture varies depending on the type of herbicide, for example foliar or soil incorporated.

Dusty conditions can reduce the efficacy of glyphosate as it binds to clay particles and becomes inactive. Dust also acts as a physical barrier to the herbicide reaching the leaf surface.

Waterlogged conditions can result in crop damage when some foliar herbicides move through the soil into the crop's root zone (Figure 8.6). The free water causes the active ingredient to be separated from the crop safener and burn the roots.

Figure 8.6 Example label directions

Soil Moisture at Application:

DRY – Weed control may decline.
MOIST – Optimum performance and safety.
WATERLOGGED – May impair crop safety and reduce weed control.

NB: Always read the label of the product being applied.

Wind

Wind speed and direction affects the movement of droplets. Estimates of wind speed can be made (Table 8.2), however, is in your interest to measure wind speed as accurately as possible. Hand held devices can be purchased to measure wind speed.

Crop and weed response to herbicides

The environment influences the growth of the crop and the weeds, which in turn affects the interaction between plants and herbicides.

Plant growth is determined by light, moisture, nutrients and temperature. Plant growth can be affected by too much or too little of these and other factors such as insects and disease. Most herbicides need actively growing plants to be effective. If conditions are unsuitable for spraying and are not forecast to change, reconsider the form of weed control planned.

Temperature

Temperatures during the days before herbicide spraying can influence weed and crop growth rates. Average temperatures will result in actively growing plants, while too hot or too cold will leave stressed slow growing plants. Spraying at low (<15˚C) or high (>30˚) temperatures is not recommended as most herbicides require the plant to be actively growing for the herbicide to work.

Spray failures have occurred when high temperatures have reduced the quantity of herbicide absorbed by the stressed plants.

Post application temperatures may affect the time taken for symptoms to develop. For example low temperatures slow herbicide activity but have little effect on total weed control.

Table 8.2 Guidelines for spraying derived from the Beaufort wind scale.

Description	Approximate wind speed at 0.5–1.0 m above ground level.		Visible signs	Spraying recommendations
Calm	Less than 2 km/h	Less than 0.5 metre/sec	Smoke rises vertically.	Avoid spraying.
Light air	2 to 3 km/h	0.5–1 metre/sec	Direction shown by smoke drift.	Spraying inadvisable.
Light breeze	4 to 6 km/h	1–1.5 metre/sec	Leaves rustle, wind can be felt on face.	Ideal for boom spraying, using high pressures (>400 kPa) and low volumes (i.e. small droplets).
Gentle breeze	7 to 10 km/h	1.5–3 metre/sec	Leaves and twigs in constant motion.	Suitable for boom spraying, using low pressures (200–300 kPa) and larger droplets.
Moderate breeze	11 to 14 km/h	3–4 metre/sec	Small branches moved; raises dust or loose paper.	Suitable for spraying if using low pressure nozzles and high volume application (80–120 L/ha)
Fresh breeze	15 to 20 km/h	4–5 metre/sec	Small trees begin to sway.	Do not spray.
Strong breeze	Above 20 km/h	6 metre/sec	Large branches in motion. Telegraph and power lines whistle.	Do not spray.

Frost

Severe frosts can cause plant damage which reduces the weeds ability to uptake and transport herbicides around the plant. The effect of frost depends on the weed species and the herbicide product.

Frost can also damage tissue of crop plant tissue and increased phytotoxicity can occur resulting in yield loss.

Humidity

Humidity interacts with temperature in determining the rate of product uptake and to a certain extent movement of the herbicide around the plant. Under low humidity and high temperature conditions herbicide uptake is reduced as some plants close their stomata to prevent their leaves from drying out.

Soil moisture

Too much or too little soil moisture will cause plant stress. Water stressed plants will have reduced uptake and movement of herbicide. Grasses can be moisture stressed before wilting occurs. Spray adjuvants may be used to increase penetration into the leaf.

Plants can recover from moisture stress within 24 hours of adequate rain. However, as 'adequate' rain is difficult to predict other weed control options should be planned.

Under very wet soil conditions some post-emergent herbicides (Group A) may be root absorbed and can incur crop damage. Using a plane to spray when it is very wet may not be beneficial to the crop.

Photo: A. Johnson

Nozzle selection is important.

Further information the following book and brochure are available from NSW DPI

- **Spray drift managment – principles, strategies and supporting information.**
- **Reducing herbicide spray drift – Agnote.**

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Case study 8.2 Modifying equipment for better weed control By Tim McNee

Name	Judy, Hayden, Stuart, Michael, Nigel Wass and families.
Property	"The Plains", Nyngan (10 360 ha – 2360 ha native vegetation)
Enterprise	Continuous cropping, wheat, barley, pulses, canola.

Building machinery to suit their own system is common for the Wass brothers with two planters and a spray unit built to date. The latest project of which Stuart Wass is the "chief engineer" involves building a self propelled spray rig.

The need to build their own machinery was the result of identifying several factors that were important to their farm management style.

Precision application

Using GPS and auto steer controllers reduces overlap and gaps which results in an estimated 5% saving in chemical costs and a larger reduction in weed escapes.

Timing

To cover the large area of the property on time, the spray rigs need to be light so spraying can start soon after rain without getting stuck in the mud.

Night spraying

The combination of GPS and lighting allows night spraying which provides the opportunity to spray under the best conditions in summer. (There are no herbicide susceptible crops grown in the area.) The lights not only allow the driver to see where they are going but to light up the boom to ensure the spray is running smoothly and there are no blocked nozzles.

Efficient operation

The spray unit (36m width) has been designed to fit the property's 12m tramlines with 3m wheel spacing. The unit is set high off the ground to avoid contact with the crop when spraying.

The unit only has a 2 000 litre tank to decrease the weight. The unit is 2.7 tonne empty.

To ensure quick filling a premixing 35 000 litre 'nurse tanker' is also being built to allow rapid refills in the paddock.

Cost savings

Building the spray unit resulted in a significant cost saving when compared to purchasing a new rig. The unit cost approximately $40 000 in parts to build (labour was not costed). Fuel consumption is significantly less than trailing spray units.

Herbicide application

The fine tuning of equipment for spraying has been done at the same time as experimenting to improve herbicide application. Improving spraying has been a major part of better weed control on "The Plains". Many of the changes have resulted in less money spent on chemical and fuel, less weed escapes and better crop yields.

"We learnt more about the chemicals and the best conditions to apply them. Surfactants and wetters are important. By getting the conditions right we were able to drop the rate and still control the weeds". "If you get bad water, no matter what you do the spray won't work as well".

Weather conditions

Close attention is always paid to the weather when spraying, especially inversions. Spraying in the right conditions gives better results which means less escapes and less need to respray. Slowing down the rig, reducing the pressure and increasing droplet size has also improved coverage and reduced drift.

Photo: T. McNee

Wass's self propelled spray rig.