GRDC GROWNOTES™

TIPS & TACTICS

REDUCING HERBICIDE DAMAGE

Australian Government
Cotton Research and Development Corporation

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

Spraying only during suitable conditions is key to reducing off-target drift from summer fallow spraying

Every year, broadleaf and cotton crops are damaged and money lost due to herbicide spray drift. Growers must respond to crucial weather factors, including wind and temperature, and choose the correct boom and nozzle configurations to reduce the risks.

KEY POINTS

- Managing weeds in summer fallows conserves soil water for subsequent crops and reduces the weed seedbank for subsequent seasons.
- Drift from the application of herbicides (and from Group I phenoxy herbicides in particular) has caused significant damage to crops in recent years.
- Improved spraying practices are needed along with better understanding of and response to weather and other environmental conditions.
- During summer across the northern grains region, there are only a limited number of hours when conditions are conducive for spraying with low drift risk.
- 2,4-D amine formulations have relatively low volatility, meaning they are effectively non-volatile when used in accordance with label requirements. As such, the large majority of damage is likely to arise from spraying during local surface temperature inversion conditions and from incorrect boom setups.
- In some cases symptoms and damage may be from roots taking up residual 2,4-D in the soil from previous applications.
- While cotton is less sensitive to some other Group I herbicides when compared to 2,4-D, simply switching to these alternate Group I herbicides is unlikely to significantly mitigate risk. Attention must be given to the weather and other application factors involved.
- Alternate herbicide options exist for key weed species (such as fleabane) where 2,4-D is currently being used. These include a range of pre- and post-emergent herbicides.

Figure 1. Around 60 000 ha of the 2015/16 Australian cotton crop was damaged by drift from phenoxy herbicides such as 2,4-D amine. Note damage indicated by leaf rolling, distortion and cupping, particularly on younger leaves. (Photo: Graham Charles, NSW DPI)

Manage better for drift risk

Spray drift from glyphosate, paraquat and a range of Group I herbicides (including the phenoxycarboxylic acids: 'phenoxys') is a problem in the northern growing region. These herbicides form the basis of most spring/summer knockdown fallow spray applications and poor practice on some properties is leading to spray drift onto sensitive crops.

TOP 10 TIPS FOR REDUCING SPRAY DRIFT RISKS

1. Ensure wind direction is away from sensitive crops/areas.
2. Never spray if a surface inversion is present or there are still wind conditions.
3. Daytime spraying: Stop spraying when wind conditions are <4 km/h or >15 km/h or 20 km/h depending on the label.
4. Nighttime spraying: Only spray when there is definitely no surface temperature inversion present. Temperature inversions are less likely to be present with wind speeds >11–12 km/h. However, later at night and near sunrise as the ground has cooled, the risk of spray drift greatly increases, regardless of wind speed.
5. Stop spraying when the Delta T exceeds 8°C unless steps have been taken to mitigate against the production of fine droplets and target weeds are not stressed.
6. Use a coarse spray quality or larger, with emphasis on ensuring there are minimal driftable fines produced.
7. Minimise boom height. Reducing the boom height from 70 cm to 50 cm above the target has been shown to reduce drift by 4 times, while reducing from 1 m to 50 cm above the target reduces drift tenfold.
8. Read product labels and adhere to spray application requirements and downwind buffer zones.
9. Always refer to the manufacturer's information on specific nozzle types, adjuvant concentrations required and whether spray additives can assist in reducing the number of driftable fines produced.
10. Consider if a different knockdown herbicide is more suitable.

Growers need to consider a range of factors, including weather and their equipment, when applying Group I herbicides, particularly 2,4-D. They should also consider if the product they are using is appropriate and consider alternative herbicides and non-herbicide strategies.

Why 2,4-D and other Group I herbicides are used in spring and summer fallow

The primary objective of most fallow spraying is to kill weeds to conserve soil water for use by subsequent crops and to reduce the weed seedbank for subsequent seasons. Even very low weed densities can quickly use highly valuable soil water stored deep in the profile.

GRDC's Water Use Efficiency Project http://www.grdc.com.au/GRDC-Manual-SummerFallowWeedManagement showed that water stored deep in the soil profile that is available to grain crops in the yield critical periods of stem elongation and grain fill, can have a water use efficiency of up to 60 kg of grain per mm of stored water. This same research also showed that for every additional mm of soil water stored in a fallow period, this equated to an additional 0.7 kg of nitrogen (on average) available to the following crop.

Glyphosate has been in widespread use for several decades but certain weeds are not well-controlled by glyphosate alone. It is these weeds that drive the need to add a tank mix partner such as 2,4-D to glyphosate in summer fallow. Examples of such broadleaved weeds are fleabane (*Conyza bonariensis*), cowvine/peachvine (*Ipomoea lonchophylla*) and red pigweed (*Portulaca oleracea*).

While all herbicides can lead to drift and cause damage to non-target crops, 2,4-D and other phenoxy herbicides are a key focus because:

- 2,4-D ethyl ester formulations used in the past were more volatile during the prevailing conditions over summer. However, with volatile 2,4-D ester formulations not used in cotton growing areas, much of the recent spray drift that has been attributed to phenoxy herbicides is more than likely related to poor application timing and technique resulting in droplet drift, rather than volatility.
- 2,4-D, like other Group I products, can be very damaging to sensitive crops like cotton, pulse crops and grapes, even when very low amounts of spray drift comes into contact with the crop at a particularly sensitive growth stage. This can lead to visible symptoms, delays in maturity and yield impacts.
- There is widespread use of 2,4-D and other Group I products in northern no-till fallows, often in close proximity to highly sensitive crops.

Managing risk when using 2,4-D and other Group I herbicides

The main risks associated with the addition of 2,4-D amine and other Group I herbicides to fallow sprays is with off-target droplet movement to non-target species.

Figure 2. Under a surface temperature inversion air can separate into very stable layers (laminates) that can concentrate and transport airborne pesticides away from the target. (Source: Bill Gordon)

Secondary risks include:

- soil residuals that affect following crops
- the potential for loss of efficacy from a glyphosate tank mix partner on some fallow weeds, such as grasses and sowthistle
- possible carryover of residues in spraying and mixing equipment.

Main factors affecting off-target drift

The risk of off-target drift from a particular herbicide is affected by many factors. The main ones are:

- volatility of the herbicide
- area and dose rate applied
- proximity and sensitivity of off-target crops
- prevailing weather conditions at the time of and after application
- spray equipment setup, herbicide application and, in particular, the volume of driftable fine droplets produced.

Volatility of the herbicide and dose rates

In agriculture, volatility generally refers to the process of a chemical applied as a spray converting to gaseous form and moving into the surrounding atmosphere.

2,4-D ethyl ester (Ester 800) is highly volatile and is only permitted to be used in Western Australia, under certain application parameters. Other Group I herbicides are classified as having relatively low volatility or as 'non-volatile' (Table 1). When spraying products with relatively low volatility, the risk of off-target drift is more often associated with direct droplet or particulate drift than from volatility. Therefore, damage is not caused by product volatilising off the sprayed surface sometime after application, but is coming from herbicide not reaching the target, remaining suspended in the air and drifting away to later be deposited on a non-target area. Thus, for most situations, the emphasis to manage drift risk comes back to spray conditions, proximity to sensitive crops, boom set-up and avoiding production of driftable fines.

Spraying large areas near crops that are sensitive to very low dose rates of the herbicides being used creates risks that need to be managed carefully. Conditions are often less than perfect and spraying without producing any driftable fines is rarely achieved.

2,4-D ethyl ester has high volatility and should not be used in proximity to sensitive crops. It is only registered for use in Western Australia. Lower volatility formulations are available.

Low volatile ester formulations (LVE) of 2,4-D sold in Australia are mostly the ethylhexyl form. While LVE formulations are still capable of producing small quantities of vapour, they are far less volatile than high volatility esters.

Volatility indicator: Saturated Vapour Pressure

Typically, herbicide volatility is measured in a laboratory and expressed as the saturated vapour pressure (SVP) (in a closed vessel), in units of mPa at a temperature of 25°C. Herbicides with an SVP less than 0.1 mPa @ 25°C are often regarded as having a negligible risk of volatility movement under suitable conditions for spraying. However, in some situations, products with similar vapour pressures can still volatilise at different rates under field conditions.

Saturated vapour pressure is only one indicator of relative volatility and only considers the interactions that occur between pesticide molecules, while in a closed system. Products applied in an open system can react with the environment, where they may interact with soil, water and vegetation. For example imazapic, paraquat and fluroxypyr meptyl all have the same value for SVP, yet when applied in the field they can have very different potentials to volatilise.

Volatility is complicated, and is often better assessed under field conditions, rather than solely relying on individual measures such as saturated vapour pressure (SVP) to estimate risk.

Sensitivity of the off-target crop

The tolerance of a crop to different herbicides also affects the risk posed by spray drift. Sensitivity of cotton and other broadleaf crops to various active ingredients is not only dependent on the characteristics of the active ingredient, but the rate of product used and the growth stage of the crop. This is another factor making it difficult to rank active ingredients for drift risk based on volatility data alone.

Prevailing weather conditions

The single biggest issue leading to off-target drift is spraying under the wrong conditions.

Table 1. Relative volatility of products based on saturated vapour pressure (SVP), listed in decreasing order. (Source: University of Hertfordshire PPPD database unless stated)

Product	Relative volatility numbers mPa (at 25°C)
2,4-D ethyl ester (Ester 800 SDS)	41**
MCPA LVE (2EHE) (570 LVE MCPA Selective Herbicide SDS)	5.7**
Dicamba	1.67
2,4-D ethylhexyl ester (2EHE) (Estercide 680 SDS)	0.48
Triclopyr butxyethyl ester (FMC Triclopyr 600 Herbicide SDS)	0.48
MCPA acid	0.4
Flumioxazin	0.32
Oxyfluorfen (Goal®)	0.026
Glyphosate acid	0.0131
Imazapic	0.01
Fluroxypyr-meptyl	0.01
Paraquat	0.01
2,4-D acid 2,4-D salts (amines) dissociate to acid in spray solution	0.009 0.0133
Carfentrazone-ethyl (Hammer®)	0.0072
Picloram	8.0×10^{-5}
Pyraflufen-ethyl (Ecopar®)	4.3×10^{-6}
Metsulfuron methyl	1.4×10^{-8}
Aminopyralid	2.6×10^{-9}
Saflufenacil (Sharpen®)	4.5×10^{-12}

**Nufarm data

The key factors to consider before spraying fallows near sensitive crops include:

- surface temperature inversion
- wind speed and direction
- combination of Delta T and droplet size.

Surface temperature inversion and wind

Spraying under surface temperature inversion conditions can potentially lead to widespread drift events (Figures 2 and 3).

Surface temperature inversions typically occur overnight and persist until sometime after sunrise, when the wind speed usually picks up to start mixing the air. Surface temperature inversions (stable air conditions) occur most nights, making nighttime spraying a very high risk activity for spray drift of any product. (See feature box: 'A trial: day versus night spraying' on page 6.)

Temperature inversions, at their worst, can be identified when dust or smoke tends to hang in the air. For example, in windless conditions in the late afternoon, evening or early morning when dust hangs over a dusty road, or when smoke from a fire rises vertically and then starts heading off in a certain direction.

Like small dust and smoke particles, small 'driftable fine' herbicide droplets can travel many kilometres under inversion conditions. There is high risk spraying in these conditions and all spraying operations should stop before inversion conditions occur.

Temperature and Delta T

Temperature, and more importantly Delta T, are also important considerations for drift risk. Delta T is calculated by subtracting the wet bulb temperature (Celsius) from the dry bulb temperature.

A Delta T between 2°C and 8°C is ideal for spraying but does not overcome the hazard posed by inversion conditions.

Where Delta T is less than 2°C, survival of small droplets is increased and drift risk greatly increases.

Where the Delta T is above 8°C, the air is very dry and droplets will rapidly lose water to evaporation. Under these conditions, droplet size will diminish, increasing the associated drift risk. Small droplets lose relatively more water than larger droplets due to their higher surface area to volume ratio, so become even smaller and are more prone to being held in an inversion and then drift.

DAMAGE TO COTTON CROPS IN 2015/16

In the 2015/16 cotton season, it is estimated that 20% of the crop (60,000 ha) was affected by spray drift, causing an estimated A$20 million in damage.

The main factors leading to the damage were:

1. High reliance on zero-till and the associated use of herbicides for fallow weed management.
2. Widespread rain in November, which led to significant weed emergence requiring spraying throughout cotton growing regions.
3. High daytime Delta T (relationship between temperature and relative humidity used to determine when to spray) conditions in conjunction with growers using auto steer, which has led to more night spraying.
4. Surface temperature inversions were commonplace, especially at night and in the early morning.
5. Many spray operations were not terminated when conditions dictated they should have been.

Not all the cotton damage seen in 2015/16 was due to spray drift. Some damage appeared to have been caused by soil residuals from winter/spring fallow sprays of Group I herbicides. Not paying sufficient attention to plant back periods, or allowing for increased plant back periods when using high rates of product via camera sprayers were contributing factors in some situations. It should be noted that plant back periods for some products only start once a significant single rainfall event of 15 mm or more has occurred after application.

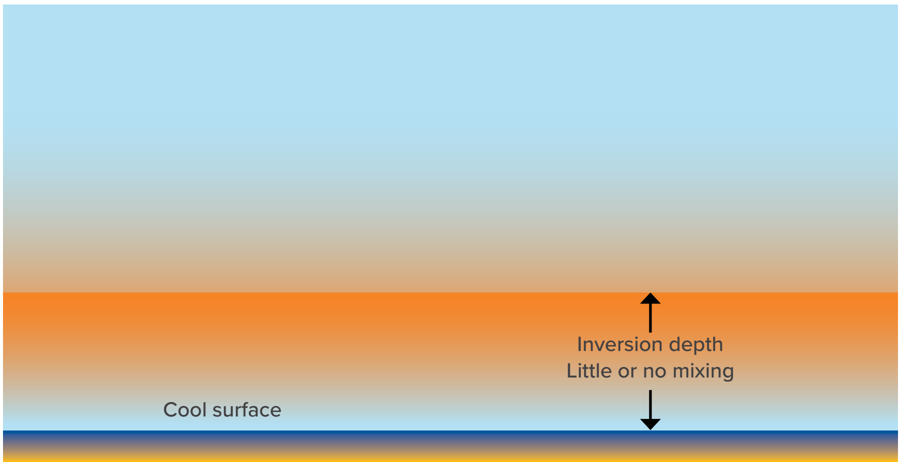

Figure 3. With surface cooling at night, an unmixed layer of cool air develops. Inversion conditions occur most nights. The depth of the inversion is often at its greatest just before sunrise. Nighttime inversion layers need much higher wind speeds to break up and mix air layers, than daytime inversions. (Source: Graham Tepper, 2015)

IF IT'S STILL; STOP SPRAYING!

During the day, stop all spraying if the wind speed drops below 4 km/h.

At night, if the wind speed drops below 11–12 km/h, do not spray!

At night (when the soil surface has started to cool) higher wind speeds are needed to ensure the air is mixing and droplets can return to the surface than would be required during the day while the sun is heating the ground surface.

While less than ideal, using increased carrier volumes and nozzles producing extremely coarse droplets and no/negligible driftable fines may be an option to extend spraying into Delta T conditions in excess of 8°C. Growers who continue to spray when Delta T is above 8°C, must be aware that their risk of drift is far higher than for Delta T values between 2°C and 8°C (other conditions being equal). The more evaporative conditions at high Delta T values can reduce droplet size and increase the proportion of spray resulting in driftable fines, particularly if boom height is higher than ideal (usually 0.5 m above the top of the crop or stubble; whichever is highest).

The risk of reduced efficacy increases when Delta T values are above 10–12°C. Poor droplet survival and deposition, weed stress and changes to the leaf cuticle can all reduce herbicide efficacy under high Delta T conditions.

Spray equipment setup and application

Most spray drift results from the proportion of applied herbicide contained in driftable fine/small droplets. Very few boom and nozzle configurations have zero driftable fine droplets.

In Australia, it is a legal requirement specified on product labels for glyphosate and phenoxy products to be applied using a minimum of a coarse spray quality.

Resources on boom setup and spraying:

- Spray Application GrowNotes™ Manual, Module 14 https://grdc.com.au/GrowNotesSprayApplication
- Pesticide input efficiency http://www.cottoninfo.com.au/pesticide-input-efficiency
- NuFarm SprayWise® Decisions http://www.spraywisedecisions.com.au
- Reducing herbicide spray drift (includes a table of product volatility) http://www.dpi.nsw.gov.au/biosecurity/weeds/weed-control/herbicides/spray-drift#table1
- The SnapCard app assists spray operators to measure spray deposition. It is available for Android and Apple devices (Download from Google Play and the App Store) https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-122-Spray-application/App-provides-snappy-spray-assessment
- Spray drift is in the operator's hands https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-122-Spray-application/Spray-drift-is-in-operators-hands
- The Australian Spray Performance Calculator https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/Ground-Cover-Issue-122-Spray-application/The-operators-toolbox-just-got-bigger
- Weather monitoring equipment for agricultural spraying operations https://grdc.com.au/GRDC-FS-SprayEquipment
- Surface temperature inversions and spraying https://grdc.com.au/GRDC-FS-SprayInversions
- Practical tips for spraying https://grdc.com.au/GRDC-FS-SprayPracticalTips
- Summer fallow spraying https://grdc.com.au/GRDC-FS-SummerFallowSpraying

Spray equipment decontamination

Spray drift is not the only cause of crop damage and attention must be given to boom decontamination processes before in-crop spraying commences. Different types of herbicides require different techniques and boom cleaning agents. Read and follow directions on specific product labels. Further information:

- Spray Application GrowNotes™ Manual, Module 7 https://grdc.com.au/GrowNotesSprayApplication
- Cleaning spray equipment http://www.dpi.nsw.gov.au/biosecurity/weeds/weed-control/herbicides/cleaning-spray-equipment
- Decontaminating spray booms https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/weed-management-in-field-crops/using-herbicides

CottonMap tool helping reduce the risks of spray drift

The cotton industry's CottonMap (Figure 4) is a tool to help mitigate risk associated with spray drift by allowing spray operators to understand where cotton fields are located in proximity to their fallow spray operation. The CottonMap tool is an industry initiative developed by Cotton Australia, Cotton Research and Development Corporation (CRDC), Grains Research and Development Corporation (GRDC) and Nufarm Australia Limited.

Growers or their advisers can log in and plot out the location of fields that they have planted to cotton each season. Other farmers and spray contractors can check the site to see the location of neighbouring cotton crops when planning spray applications. This, coupled with vigilance around spray conditions, wind directions and application, helps to reduce adverse effects from spray drift.

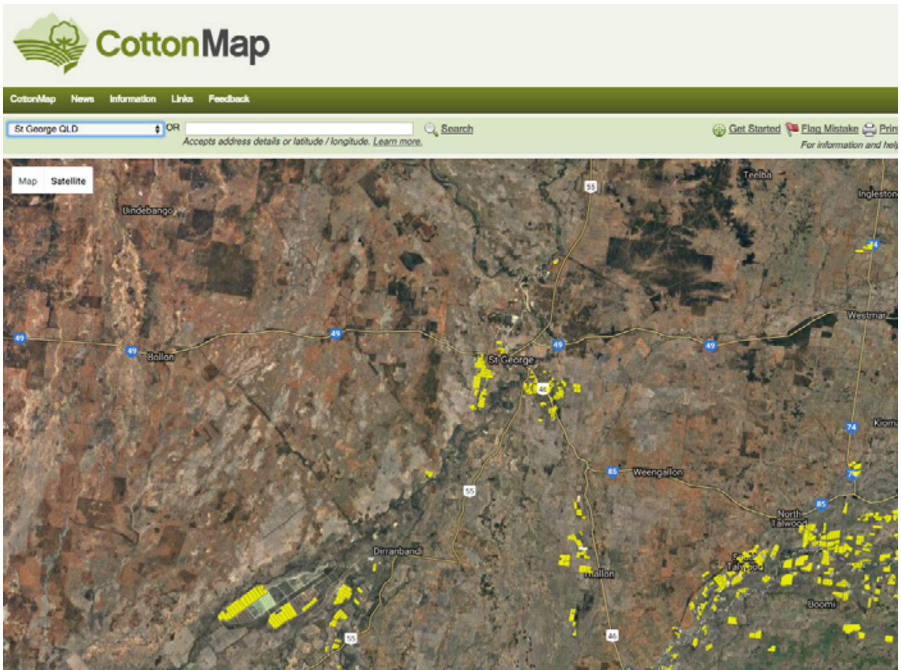

Figure 4. CottonMap website (http://www.cottonmap.com.au) provides a map and information to help growers plan their spraying.

Knockdown alternatives to 2,4-D amine

While the 2,4-D amine formulation (and volatility) is unlikely to be the direct source of the problem, inappropriate application and poor use practices continue to result in drift issues.

There are some potential alternative chemistries and control strategies for the key weeds being targeted by 2,4-D amine.

Outside of glyphosate and 2,4-D amine, the main herbicide knockdown options for problem broadleaf weed control in spring and summer are:

- Paraquat
- Group G herbicides (e.g. flumioxazin, saflufenacil and carfentrazone)
- Group I herbicides (e.g. dicamba, fluroxypyr, triclopyr, picloram, aminopyralid)
- Group B herbicides (e.g. tribenuron methyl, metsulfuron-methyl).

Paraquat

Paraquat has low volatility and high activity on many of the problem fallow weeds targeted by 2,4-D amine. Much of the current use of paraquat is usually as a double knock option for fleabane, where it is applied after the application of a first spray (usually glyphosate plus a phenoxy or another Group I herbicide).

As a contact herbicide that is not readily translocated in the plant, paraquat works best on small weeds where high levels of spray coverage can be achieved. Where drift occurs, damage is often evident within a day and can appear severe in the short term; however, often plants with a low level of damage will grow out of the damage symptoms, with less impact on longer term plant growth than results from more translocated products.

Sequential applications of paraquat can be useful when targeting plants that are slightly too large for control with a single spray of paraquat.

Paraquat does not rely on translocation for its activity and its efficacy is less affected by minor levels of heat and moisture stress than glyphosate.

Paraquat can be a useful fallow spray option to use near 2,4-D sensitive crops. Remember that if paraquat is causing drift damage to sensitive crops, other herbicides will be drifting just as far; however, symptoms may take considerably more time to present and

A TRIAL: DAY VERSUS NIGHT SPRAYING

Airborne droplets are brought back to the ground by the mixing of the air close to the surface. This is often referred to as turbulence. Mixing of the air close to the surface is increased with increases in the wind speed, roughness of the surface (ground cover) and the heat of the ground surface.

As heat from the ground is lost through the evening, mixing of the air decreases, so wind speed must increase to return droplets to the ground. At some point in the evening the mixing stops and the airflows become parallel to the ground. This is often associated with surface temperature inversions, which keep small droplets in the air for very long periods of time.

The increased risks associated with night spraying were clearly highlighted in a 2011 trial at Millee (Figure 4). Two 55 ha plots were sprayed and the downwind drift was measured on a 20 m high tower located 80 m downwind from the treated area. A nighttime spray (2:30 a.m.) was compared to a daytime spray (7:30 a.m.).

The amount of drift was far higher for the nighttime spray. The difference in the level of air stability was the main reason for the increased downwind drift at night in 11.6 km/h wind, compared to a daytime spray in 18.3 km/h wind (Table 2).

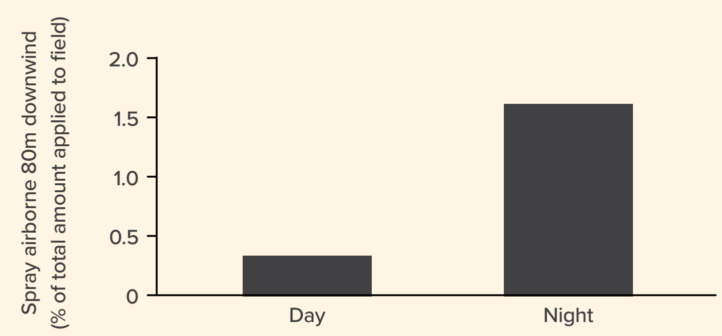

Figure 5. Amount of spray deposited on a tower 80 m downwind from sprayed field during night and day sprays (expressed as a percentage of total airborne fraction). Application details: Coarse spray quality: 36 M boom, 22 km/h, AIXR-02 nozzles @ 4 bar and 50L/ha. (Source: Bill Gordon Consulting and the Centre for Pesticide Application and Safety (UQ) in CRDC BGC1001 project)

Table 2. Environmental conditions during trial at Millee.

	Wind Speed (km/hr)	Wind Direction (°)	Temperature (°C)	Relative Humidity (%)	Stability Ratio
Night	11.6	19	25.5	64	0.26
Day	18.3	4	28.7	61	-0.29

cotton is more sensitive to drift damage from translocated phenoxy herbicides.

Paraquat is activated within the leaf in the presence of light. Night application slows the activation of paraquat and may allow for some increased translocation within the treated leaf; however little herbicide will move outside of the treated leaf even in the dark. However, night spraying substantially increases the risk of herbicide drift.

Complete coverage is essential. To reduce paraquat drift, while maintaining coverage, Syngenta recommends medium/coarse droplets with a minimum carrier volume of 75 L/ha.

Group G

Group G products are traditionally used as 'spikes' added to glyphosate or bipyridyl herbicides (paraquat or paraquat/diquat) to enhance the weed spectrum. When used with glyphosate, they increase the speed of visual symptoms following spray application.

Hammer® (carfentrazone-ethyl) and Valor® (flumioxazin) are used to improve efficacy on volunteer cotton and a range of other broadleaved weeds.

Sharpen® (saflufenacil) is used either as a stand-alone herbicide or in a mix with glyphosate for the control of a range of broadleaved weeds, including volunteer cotton seedlings, small fleabane and sowthistle.

Group G products are typically not considered volatile (for example, Valor® can be applied as a directed spray within the cotton crop, provided foliage is not directly contacted). Valor® and Hammer® are poorly translocated. Low levels of spray drift that may contact sensitive foliage pose a lower risk than the same level of drift from most translocated products.

Sharpen® has utility in northern summer fallow as an alternative to 2,4-D amine used for control of fleabane, when used in a program with a glyphosate tank mix, then double knocked with paraquat. However, activity on larger fleabane is not as robust as 2,4-D when used as a part of a similar double knock program on larger weeds.

Like paraquat, Group G herbicides are largely contact herbicides and require good spray coverage.

Group I

Most Group I herbicides, (with the exception of high volatile esters of 2,4-D which are only registered for use in Western Australia) have relatively similar volatility (triclopyr volatility risk is higher, but cotton is less sensitive at certain growth stages when compared to 2,4-D amine) and are unlikely to cause damage from volatility movement when applied correctly under suitable spraying conditions.

Damage, where caused by spray drift, is a function of the growth stage of the crop and the inherent sensitivity of the crop to the activity of the herbicide in question. Growth stages of cotton where reproductive structures are being formed are particularly sensitive to very low levels of Group I herbicides, and especially 2,4-D.

Relative sensitivity of cotton to different Group I herbicides

There has been much discussion about the relative sensitivity of cotton to different Group I herbicides. In a 1972 study, Smith and Wiese concluded that the order of damage to cotton seedlings was: 2,4-D ester> 2,4-D amine> dicamba> MCPA (Table 3).

Table 3. Percent injury from simulated downwind drift of Group I herbicides to cotton seedlings located 0 m, 3 m and 12 m downwind (mean of three experiments). (Source: Smith and Wiese, 1972)

Herbicide applied at 0.184 kgai/ha	Percent injury on cotton seedlings		
	0 m downwind	3 m downwind	12 m downwind
2,4-D amine	95	44	14
Dicamba	81	22	4
MCPA	59	15	2

In their study, downwind drift was measured in cotton seedlings at downwind distances of 0 m, 3 m and 12 m. This shows that cotton is less sensitive to MCPA than to 2,4-D when exposed to the same level of drift (assuming similar rates of product were applied). This finding supports the unpublished findings of Peter Birch (B&W Rural Moree – Pers. Comm.) that seedling cotton is far more sensitive to drift from 2,4-D than from MCPA.

It is very important to note that all three herbicides still have the potential to cause severe damage to cotton and other sensitive crops.

Group B

Tribenuron is a Group B (acetolactate synthase [ALS] inhibitor) herbicide. It is used either as a stand-alone post-emergent herbicide, or in a tank mix with glyphosate for the control of a range of broadleaved weeds. When used in a mix with glyphosate, it has efficacy on summer weeds such as pigweed (*Portulaca oleracea*), black bindweed, common thornapple and mintweed. Used as a stand-alone, it controls a range of summer weeds including; Boggabri weed (*Amaranthus mitchelli*) and caltrop.

Metsulfuron is a Group B herbicide that has a role in fallow as a mix partner with glyphosate. It improves weed efficacy on a range of broadleaf weeds. Check product labels for details.

Residual options

Where fallow paddocks are in close proximity to sensitive summer crops, drift risk at that time of year may be mitigated by using a residual herbicide to reduce the need for post-emergent herbicides in nearby paddocks over the spring/summer.

The main residual herbicide options for controlling broadleaved weeds in summer fallow are Balance® (isoxaflutole), Flame® (imazapic), Terbyne® (terbuthylazine) and atrazine. Diuron is not registered for use in fallow in NSW or Qld.

Balance® is a Group H soil residual HPPD herbicide. Balance® has very useful residual activity on weeds such as fleabane, sowthistle and feathertop Rhodes grass.

Flame® is a Group B imidazolinone with long residual activity on red pigweed, caltrop, mintweed, Boggabri weed and importantly, cowvine/peachvine. Cowvine is a key weed species driving 2,4-D use in summer fallow.

Terbyne®, a Group C triazine, has residual and some knockdown control of an extensive range of broadleaf weeds in fallow, including fleabane, sowthistle, brassica weeds and others. Terbyne® has shorter persistence than many other residual herbicide options, which allows greater flexibility in following rotational crops.

Atrazine, a Group C triazine, is registered for use in fallow prior to planting sorghum. Atrazine controls a broad spectrum of broadleaved weeds as well as several grass species. Broadleaved weeds on the label include: Amaranthus, ground cherry, blackberry nightshade, bladder ketmia, burrs, caltrop, common thornapple, mintweed, parthenium, red pigweed, prickly paddy melon and sesbania.

If using a residual herbicide to reduce the need for knockdown sprays around sensitive crops, it is important to know which weed species are in the paddock to ensure that the residual herbicide chosen will control the spectrum of weeds that will be encountered.

When using soil residual herbicides, it is always critical to read and understand re-cropping restrictions on the currently-registered product label. These re-crop restrictions place significant limitations on how widely these residual options can be used.

Plant back restrictions for cotton are summarised in tables on pages 98 and 99 in the Cotton Pest Management Guide 2016–17 http://www.crdc.com.au/publications/cotton-pest-management-guide.

Details about the soil behaviour of pre-emergent herbicides including breakdown pathways and DT_{50} (half-life) values, are contained in the GRDC publication: The soil behaviour of pre-emergent herbicides http://www.grdc.com.au/SoilBehaviourPreEmergentHerbicides.

Agronomic actions

Tillage

The number of days and hours per day when conditions are suitable for spraying over summer can often be very limited. When the risk of spray drift to nearby sensitive crops is considered, switching to tillage may be the only viable way to manage the risk.

Tillage may also reduce selection for herbicide resistance and help control larger weeds that have become difficult to manage with herbicides alone, such as established feathertop Rhodes grass.

Unsprayed spray buffers

Unsprayed downwind spray buffer areas are specified on a number of herbicide labels.

Vegetative buffers

Vegetative buffers or other barriers such as netting provide another layer of protection for sensitive crops. See pp. 140–141 of the Cotton Pest Management Guide 2016–17 http://www.crdc.com.au/publications/cotton-pest-management-guide.

Rotation and management

Practices that reduce the weed seedbank of problem weeds may also assist by reducing the need for broadacre application of knockdown herbicides. Weeds with no or low seedbank dormancy can often be significantly reduced through good management and planning.

An example is fleabane, which is a surface germinating weed with little to no seedbank dormancy. As such, if seed set is stopped, populations can be run down significantly in just one or two seasons.

Often the weed seedbank of fleabane blows out in poorly managed winter crops, with the problem in the summer fallow arising out of the winter crop.

A three tier management strategy will quickly run down the weed seedbank of weeds such as fleabane:

1. Use of a highly competitive winter crop with no gaps in the plant stand. A vigorous cereal crop that attains early ground cover helps to outcompete fleabane.
2. Use of knockdown and residual herbicides in the winter crop phase. Products such as Tordon® 242 (picloram), Hotshot® (aminopyralid) or Lontrel® (clopyralid) in wheat provide useful residual to reduce spring germinations of fleabane, while Balance® provides useful levels of residual control in chickpeas (care should be taken with re-cropping intervals).
3. The first flush of weeds in the summer fallow should be treated when small, usually with glyphosate plus a Group I herbicide, then double knocked with paraquat.

By comparison, cowvine/peachvine and bladder ketmia are very hard seeded with high seedbank dormancy. As a result, they are far slower to respond to seedbank reduction strategies than 'low seed dormancy' species like fleabane or sowthistle.

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MORE INFORMATION

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