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Seminar Papers
**NEW ADVANCES IN
HERBICIDE USE**
Wednesday
16 September 2009
Narrabri Bowling Club

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Collated / Edited by
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THE WEED SOCIETY
OF NEW SOUTH WALES INC.

New Advances in Herbicide Use

Date: 16 September 2009

Venue: Narrabri Bowling Club

0945 – 1015	REGISTRATION & MORNING TEA	
1015 – 1030	Rex Stanton President, Weed Society of NSW	Welcome and Introduction
1030 – 1100	Adrian Harris CropLife Australia	Herbicide mode of action groups and resistance management strategies
1100 – 1130	Michael Widderick QDPI&F	Glyphosate resistance and management in weeds
1130 – 1145	Tony Cook NSW DII	Management of glyphosate resistant awnless barnyard grass
1145 – 1215	David Thompson NSW DECCW	Pesticides legislation NSW
1215 – 1315	LUNCH	
1315 – 1415	David Loschke APVMA	The importance of managing spray drift
1415 – 1445	John Kent CSU	Spray drift management
1445 – 1500	AFTERNOON TEA	
1500 – 1530	Scott Jameson Crop Optics Australia	Spot spraying: Now a commercial reality
1530 – 1600	Graham Charles NSW DII	Herbicide use in Genetically Modified (GM) crops

New Advances in Herbicide Use

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HERBICIDE MODE OF ACTION GROUPS AND RESISTANCE MANAGEMENT STRATEGIES

**Dr Adrian Harris,
Assistant Director – Regulatory and Technical,
CropLife Australia**

Importance of herbicide resistance

Australia has the biggest herbicide resistance problem in the world. Repeated use of the same few herbicides for weed control in grain crops, often at low rates, has caused much of the resistance development. Herbicide resistance has increased rapidly since it was first reported in annual ryegrass in 1982 and has become a key constraint to crop production in all states with a history of intensive herbicide use. Resistant annual ryegrass is now very widespread across the grain belt and resistance in this weed has been detected to six different herbicide chemical groups, including common cases of multiple resistant populations resistant to two or more chemical groups. Resistance has now been confirmed in 34 weed species in Australia, and, even more worrying, resistance has developed to 11 different herbicide chemical groups. Selection of resistant weeds can occur in as little as 3-4 years. If the resistance problem is not managed, many herbicides will become ineffective and resistance will develop in new weeds and situations. Ultimately, minimum till systems could be threatened because few herbicides will be effective. Farmers should not expect that new herbicides will continue to be developed and released regularly enough to overcome the resistance problem.

Herbicide Mode of Action (MOA) Groups

In order to manage herbicide resistant weeds, all herbicides sold in Australia are grouped by biochemical MOA of the active constituent against weeds and the MOA is indicated by a letter code on the product label. Australia was the first country to introduce compulsory MOA labelling on products, but other countries have since adopted MOA classification systems.

CropLife Australia completely revised the herbicide MOA grouping and labelling system in February 2008 to better align it with the international system and to incorporate new information on many herbicides. Six new herbicide MOA groups (H, O, P, Q, R and Z) were created to more accurately group herbicides, and titles describing some of the groups were also improved. Most herbicides have not changed group, but 24 active constituents from the old groups E, F and K were moved to a different group. Some affected herbicide product labels may not be updated to show the new MOA letters until 2011. Meanwhile, farmers should read the active constituent on the product label, then check the current MOA letter on the CropLife Australia website, which may be more up-to-date than the letter on the product label. The website also contains a table that shows which active constituents have changed MOA letter. Where there is a temporary difference in MOA group on labels, the new MOA group on the CropLife website should be used.

Herbicide resistance management strategies

By using the new MOA letter for each herbicide, farmers can choose an appropriate resistance management strategy to minimise the risk of resistance developing to that herbicide. CropLife regularly updates and publishes the current modes of action and resistance management strategies on its website. Always follow the product label for application rates and specific use instructions.

Herbicides in Group A (mostly targeted at annual ryegrass and wild oats) and Group B (broadleaf and grass weeds) are high risk herbicides. Not all MOA groups carry the same risk for resistance development, therefore specific guidelines for Groups E, G, H, K, N, O, P and R have not been

developed to date because there are no records of weeds resistant to these groups in Australia. Further information on the modes of action for all herbicide active constituents and the causes of herbicide resistance is available on the CropLife Australia website at www.croplifeaustralia.org.au under “Resistance Management”.

GLYPHOSATE RESISTANCE AND MANAGEMENT IN WEEDS

Dr Michael Widderick
Queensland Primary Industries and Fisheries

What is herbicide resistance?

Herbicide resistance is the inherited ability of a weed to survive and reproduce after exposure to a dose of herbicide lethal to normal individuals of that species. Resistance differs from tolerance, which is the natural and normal variability within a species to tolerate application of herbicides (Heap and LeBaron 2001).

The incidence of herbicide resistance in a weed population is the result of an increase in frequency of a pre-existing gene due to the selection pressure exerted by repeated herbicide applications (Betts *et al.* 1991). Therefore it is dependant on two factors; a) genetic variation, or likelihood to find a resistance gene in a given weed population; and b) the selection pressure or the herbicide use pattern applied to that population (Maxwell and Mortimer 1994).

Glyphosate resistance – the problem

Weed management in broadacre cropping systems relies heavily on glyphosate; an effective, broad spectrum, low cost and safe herbicide. However, widespread and constant use of glyphosate, particularly in fallows and now in glyphosate tolerant crops, has increased the risk of glyphosate resistance through constant selection of existing resistant individuals.

In Australia, several populations of awnless barnyard grass (*Echinochloa colona*) and liverseed grass (*Urochloa panicoides*) and many populations of annual ryegrass (*Lolium rigidum*) are confirmed as resistant to glyphosate. In all cases, the over-reliance of glyphosate has been the major factor in causing this problem.

Weed populations that are resistant to glyphosate can no longer be controlled with glyphosate at field rates. Therefore, more expensive and less convenient weed control options need to be used to control such populations.

Preventing glyphosate resistance

The best way to protect glyphosate is through Integrated Weed Management (IWM). Below are some things to consider:

- Do not rely on glyphosate all the time, but rotate chemistry and use other control methods.
- Control survivors of glyphosate application with a non-glyphosate product or tactic to prevent seed set.
- Monitor regularly and keep good up-to-date field records. If glyphosate has been relied on for a number of years, it is time to change.

Double knock and residuals

An effective option to rotate chemistry and control survivors is “double knock”. A more recent advance for weedy and high risk situations is to add residual herbicides to double knock to minimise subsequent emergences. Preliminary results from 2 field trials conducted near Dalby on barnyard grass, liverseed grass and feathertop Rhodes grass showed that:

- Glyphosate followed by paraquat gave above 99.5% control on all species in most cases. There was still a need for control of a few survivors.
- Glyphosate mixed with atrazine resulted in poor control of barnyard grass.
- Feathertop appears less susceptible to paraquat than the other species.

- The addition of residual herbicides greatly reduced the subsequent emergence of new plants.
- Metolachlor appears to have performed the best, followed by imazapic.
- Paraquat mixed with atrazine was not successful at preventing emergences in barnyard grass or feathertop Rhodes grass.

Although using residuals in fallow increases weed management costs, they will minimise future germinations and thus save one or two knockdown sprays with glyphosate. Applying double knock with the aim of preventing seed set, particularly in problem fields, will have long term benefits and prolong the effectiveness of glyphosate.

Computer modelling

Computer modelling has confirmed that IWM strategies are able to prevent or significantly slow the development of glyphosate resistance in summer grass weeds. Modelling of barnyard grass in northern Australian grains farming predicted that paddock risk levels for glyphosate resistance are reduced where methods of controlling glyphosate survivors are used annually even after several years of complete reliance on glyphosate (Figure 1). This research also suggests that a program of controlling seed set on glyphosate survivors, such as the use of double knock, is an effective way to manage resistant weed seed banks, particularly where seed banks are kept low at the time resistant plants start to dominate the population.

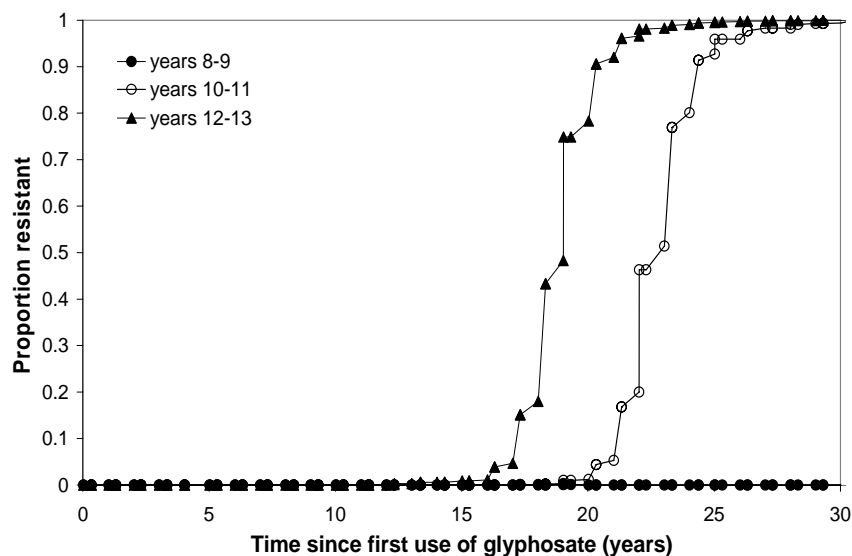


Figure 1. Predicted evolution of glyphosate resistance in barnyard grass under zero-till summer fallows with reliance on glyphosate plus three double knock regimes: two years of double knock on every weed flush in the years specified, followed by double knock annually on the largest flush.

References

- Betts, K.J., Ehlke, N.J., Wyse, D.L., Gronwald, J.W. and Somers, D.A. (1991). Mechanism of inheritance of diclofop resistance in Italian ryegrass (*Lolium multiflorum*). *Weed Science* **40**, 184-189.
- Heap, I. and Le Baron, H. (2001). Introduction and overview of resistance. In 'Herbicide Resistance and World Grains.' (Eds. S.B. Powles, D.L. Shaner). (CRC Press: Boca Raton, Florida)
- Maxwell, B.D. and Mortimer, A.M. (1994). Selection for herbicide resistance. In 'Herbicide resistance in plants: biology and biochemistry.' (Eds. S.B. Powles and J.A.M. Holtum). pp. 1-26. (Lewis Publishers: Boca Raton, Florida)

MANAGEMENT OF GLYPHOSATE RESISTANT AWNLESS BARNYARD GRASS

Tony Cook
NSW Department of Industry and Investment,
Tamworth Agricultural Institute

Abstract

Confirmation of glyphosate resistant barnyard grass (*Echinochloa colona* (L.) Link) in northern NSW resulted in surge of research activity aimed at investigating alternative control options. It served as a grim reminder that the most widely used and effective herbicide, glyphosate, was under threat of being obsolete. Furthermore, its discovery has highlighted to other growers that their use of glyphosate should be scrutinised and the principles of integrated weed management must be promoted into their cropping systems.

Introduction

Inquiries or reviews are often undertaken after any major crisis. This also should apply after significant agricultural threats such as the discovery of glyphosate resistant awnless barnyard grass. After the confirmation of glyphosate resistance in 2007, Cook *et al.* (2008) investigated many alternative herbicidal alternatives. Since then, research was targeted at fine tuning the better options, and investigations were also aimed at looking at novel ways of applying herbicides along with cultural techniques. These findings will be summarised in this paper.

As a part of Grains Research and Development Corporation funded project, awnless barnyard grass was identified as one of several weeds that had the potential of developing glyphosate resistance in the northern grain belt a year before its discovery (Storrie *et al.* 2006). This conclusion was made after considering the various risk factors. Over-use of glyphosate in summer fallows (no-till farming) and the dependency on continuous winter crops were the two main factors that led to this conclusion. An alarming issue is the dominance of winter crops/summer fallows in the western and southern parts of the northern grain region. Despite this, Queensland has recently discovered two cases of glyphosate awnless barnyard grass.

Summary of results

Pre-emergence control

Many pre-emergence herbicides have high levels of efficacy against awnless barnyard grass. They provide excellent long-term control provided that rainfall patterns favour activation of herbicides soon after application. The use of pre-emergence herbicides for barnyard grass control in the past was limited mostly to atrazine and metolachlor based products for the growing of sorghum.

The list of herbicides that achieved very high levels of control (> 95%) from two replicated experiments were; metolachlor (Dual[®]), imazapic (Flame[®]), imazethapyr (Spinnaker[®]) and rates of atrazine $\geq 3\text{ kg a.i. ha}^{-1}$. The dinitroaniline herbicides, pendimethalin (Stomp[®]) and trifluralin (Treflan[®]) resulted in 60 to 80% control. These herbicides may allow the growing of some summer crops, whilst attaining excellent levels of control.

A light cultivation that disturbs the top 2 to 4 cm of soil appeared to stimulate high levels of awnless barnyard grass germination. This practice was undertaken prior to pre-emergence herbicide application to allow a greater proportion of the seed bank to be affected by herbicides.

Selective post-emergence herbicides

Two herbicides from a wide range of Group A and B selective herbicides were deemed as highly efficacious. They were haloxyfop (Verdict[®]) and fluazifop-p-butyl (Fusilade[®]) when applied at two growth stages (1 to 4 leaf and early tillering). Only one experiment has investigated these options and may need additional investigation at later growth stages to measure consistency of results over a wider range of growth stages.

Non-selective post-emergence herbicides

Despite glasshouse experiments confirming one population was classified as moderately resistant to glyphosate, applications of glyphosate can be used judiciously to control a great proportion of the population.

Resistance to glyphosate is strongly related to growth stage. Once plants are beyond the early tillering stage, the expression of resistance is develops rapidly. Although standard rates of glyphosate have been applied to 1 to 2 leaf awnless barnyard grass, as much as 85 to 95% control can be obtained. The survivors need to be treated with an alternative herbicide such as paraquat. This is one example of the double knock technique.

Much effort has been directed at double knocking awnless barnyard grass. Generally levels of control are near 100% and applications slightly outside the optimum timing window still achieve over 99% control. It is recommended that the first knock (glyphosate) be applied no later than the early tillering stage to maximise the efficacy of this herbicide. An application of paraquat is preferred soon afterwards, within a seven days of the first knock. Paraquat was consistently and slightly better than the other bipyridyl herbicide (Spray.seed[®]) - paraquat + diquat.

The double knock technique has some logistical issues. It needs to be done soon after rainfall events to prevent weeds from developing beyond the optimal early tillering stage and requires a second application soon afterwards. Rainfall may fall between first and second knocks, delaying entry onto paddocks and hindering herbicide application/efficacy. Work undertaken by NSW DPI (now NSW DII) proved that incorporation of a residual herbicide with the second knock will improve control slightly over a similar treatment without the residual herbicide. More importantly, the residual herbicide will be activated by the next rain event and prevent the need to repeatedly use the double knock technique. The double knock technique is a vital integrated weed management option but should only be used on the first big flush of weeds and not used throughout the fallow season.

Cultural control options

A long term cropping rotational experiment commenced in late 2008. Its aims are to reduce the glyphosate resistant barnyard grass seed bank over time. As the experiment is only one year old, there is insufficient data to conclusively make specific claims. However, from observation and fecundity measurements made in the summer of 2008/9, it appears that using pre-emergence herbicides in sorghum crops will not lead to reductions of seed banks. Although the effective herbicides, atrazine and metolachlor were used along with inter-row cultivation or paraquat applications, a few plants in the intra-row regions survived. These plants were estimated to have 50 to 70 panicles and assuming that an average panicle may produce 50 viable seeds, approximately 2500 to 3500 seeds will be produced per plant. This should be sufficient to reset the seed bank. If time and labour is adequate, the need to hand chip the few surviving plants may have some merit, providing weed densities are very low.

The second part of the rotational experiment had a summer fallow. Higher levels of weed control were reported, as the entire area could be treated uniformly as opposed to the directed treatments in sorghum.

The use of summer fallows appears to be best suited to most growers for best control of awnless barnyard grass. Some reasons (culturally and chemically) why a seed bank depletion strategy should be based on fallows include;

- The ability to use the widest range of herbicides without immediate crop phytotoxicity implications
- Using blanket applications of knockdown herbicides
- No protection from crop sowing lines or shielding from herbicides due to crop canopy
- Cultivation over the entire paddock
- Easier to inspect fallows for low weed densities
- Crops utilise moisture allowing surviving weeds to stress faster than what would happen in fallows.

As mentioned previously, experience suggests that a shallow disturbance to the seed bank will encourage awnless barnyard grass to germinate, accelerating seed bank decline. Other potentially useful strategies include the use of summer active green manure crops, provided that effective pre-emergence herbicide can be used. Strategic cultivation should be considered, particularly if plants develop into large well-tillered plants, as often happens when growth rates in summer are rapid. At this stage, most herbicide options are useless and the use of cultivation may be the only one that will completely prevent seed set.

Using stock to graze this weed is not recommended, as grazing pressures are usually not high enough to achieve high levels of control. Furthermore, it is likely that using stock will spread resistant plants to other paddocks by passing viable seed through the digestive tract or seed adhering to muddy hooves.

Conclusions

Since the discovery of glyphosate resistant awnless barnyard grass 2 ½ years ago, a major investigation of all the available options was investigated. Despite losing efficacy from glyphosate, many alternative control options remain. These generally need to be

applied pre- or early post-emergence to awnless barnyard grass. Difficulties arise once plants grow beyond the mid tillering stage because the selection of effective options diminishes greatly. The partial loss of glyphosate is a serious threat to agriculture. The promotion of an integrated management approach is required to take selection pressure off the remaining chemical options. A balanced approach that relies upon cultural and existing herbicidal options is recommended.

Acknowledgements

Most of this work could not have been possible if not for the funding provided by the Grains Research and Development Corporation. Particular thanks go to Graeme Constance for allowing his property to be used for experimental work.

References

Cook, T., Storrie, A.M., Moylan, P.D. and Adams, W. (2008). Field testing of glyphosate-resistant awnless barnyard grass (*Echinochloa colona*) in northern NSW. *Proceedings of the 16th Australian Weeds Conference*, eds. R.D. van Klinken, V.A. Osten, F.D. Panetta and J.C. Scanlan, p. 93. (Queensland Weeds Society, Brisbane)

Storrie, A.M., Cook, T., Moylan, P.D., Maguire, A., Walker, S.R. and Widderick, M. (2006). Managing herbicide resistance in northern NSW. (NSW Department of Primary Industries, Tamworth).

PESTICIDES LEGISLATION NSW

David Thompson
Pesticides Inspector, Metro Region
NSW Department Environment, Climate Change and Water

Brief overview

Pesticides Act 1999 obliges user to:

- gain registered products only, or those made available by Permit
- read label or Permit prior to each use
- follow all relevant label instructions, with particular attention to:
 - DO and DO NOT statements above Table of Use
 - ensuring target pest and use in NSW is identified on label
 - mixing rates and rates of application
 - Withholding or Re-Entry periods; compatibility; water quality
 - Safety Instructions for other people
 - oncoming weather conditions
 - nearby sensitivities: drift (also Threatened Species)

The “Due diligence” defence

Establish (to the Court):

(a) that the commission of the offence was due to causes over which the person had no control, and

(b) that the person took all reasonable precautions and exercised all due diligence to prevent the commission of the offence.

- Identify the risks:
 - adverse weather
 - equipment failure, spillage at mixing, vehicle instability
 - overspray waterways
 - threatened species impacted
 - off-target drift
 - bystander effects
 - incorrect mixing/application/location
- Address the risks
 - gain forecast – document it, save it
 - maintenance program – planned, documented & signed
 - check product appropriateness – alternatives?
 - gain professional advice – document surveys
 - right equipment, right weather
 - notify neighbours
 - check label thoroughly
 - operator trained
 - complete records kept
 - product and equipment updates – documented
 - works manual
 - safety equipment maintenance and replacement – documented
 - occasional unannounced work inspections/audits

Shared liability S 112

A corporation contravenes whether by act or omission

- each director taken also to have contravened, UNLESS
 - court satisfied that:
 - the person not in a position to influence, OR
 - used all due diligence to prevent the contravention
 - Directors to keep detailed records, use only trained workers, ensure a 'diligent' degree of oversight,

Pesticides Regulation includes

- Notification by Public Authorities of pesticide applications to come (e.g. from a Pesticide Notification Plan) as found on Councils'/Public Authorities' websites.
- Training for commercial pesticide users
- Record keeping for each application

Licensing

- Under POEO Act, use of herbicides in water
- Whether the DECC Region recommends it
- Metro Region considers not necessary in most cases
- Public Register
<http://www.environment.nsw.gov.au/prpoeoapp/searchregister.aspx>

Threatened Species

Pesticides Act S 9/11 Harm to animals or plants

- Strict liability Threatened Species – i.e. if it occurs, deemed to be offence.
- Due diligence defence – for court to decide
- No on-farm defence

NP&W Act S 118A Harm/pick threatened/endangered/vulnerable species

THE IMPORTANCE OF MANAGING SPRAY DRIFT

David Loschke
Australian Pesticides and Veterinary Medicines Authority

Concerns among the public about possible risks from pesticide spray drift have increased dramatically over the last few years as more people become aware of the issue from internet and media reports. The Australian Pesticides and Veterinary Medicines Authority (APVMA), the federal agency that regulates pesticides, uses scientific information to determine the risks when using each pesticide and decides whether the risk can be controlled safely. Some level of spray drift happens with almost every outdoor pesticide spray application, and the APVMA is now placing stronger use restrictions on pesticide labels to reduce spray drift.

The risks that arise from off-target spray drift are caused by the exposure of people and other living things to a chemical that has drifted to a place where it should not be. Each active chemical is different and can create different kinds of risks. When the properties of a specific chemical are compared with the living things it might affect and linked to the way spray drift deposits accumulate downwind, the APVMA can estimate how far spray drift risks can reach from the application area.

The APVMA has recently refined its spray drift risk assessment policy and is now applying a broader range of drift-control restrictions on pesticide labels. This more stringent regulation is already being applied to all new products and will be applied to all existing products as the APVMA works through them dealing with the higher risk pesticides first.

Of all the factors contributing to spray drift that the APVMA can control with label restrictions, spray droplet size is the most important. It is easy to understand that very small droplets are more likely to drift, but the risk is even greater than most realise. During the past 20 years, growers have heard again and again that they need to apply pesticides with very small droplets in order to achieve good coverage on their targets and therefore achieve good efficacy. But many growers have taken this message too far and apply pesticides with spray droplets that are finer than needed to achieve efficacy.

In fact, with fine droplets efficacy can actually be reduced by losing part of the pesticide to off-target drift – pesticide that was intended for the crop. More importantly, other people including other farmers may be harmed by the drifted pesticide and will justifiably call for greater restrictions or even bans to pesticide use. The APVMA is dealing with this by requiring many pesticides to be applied with a “COARSE” droplet size. For example, all 2,4-D products must now be applied with Coarse droplets, and by the 2009-2010 season, the other phenoxy herbicides will have the same requirement. The APVMA will ensure that the droplet size required on the label still provides good efficacy for the product.

The new labels will also limit applications to times when the wind speed is between 3 and 20 km/hr and will forbid applications during times of surface temperature inversions. It is likely that applications of 2,4-D through the night during surface temperature inversion conditions have been one of the biggest factors in the serious damage caused to cotton and vineyard crops during the last several years.

One of the most significant changes that growers must comply with will be new mandatory “no-spray zones” on pesticide labels. These protective no-spray zones (often called buffer zones) are different for each pesticide and are determined from scientific studies that examine each

pesticide's hazards. The no-spray zones will only exist in the downwind direction at the time of application and only when the kind of risk identified on the label is present in that direction. The label will specify the distance from the identified risk where spraying must stop. That area can be treated later when the wind is blowing in a different direction.

Chemical users can find more information on these changes on the APVMA website at www.apvma.gov.au. Look under the heading "Spray Drift" where a number of downloadable documents can be found including the general policy document – APVMA OPERATING PRINCIPLES IN RELATION TO SPRAY DRIFT RISK.

It is important that all pesticide users appreciate that the public is now holding them to a higher standard in relation to spray drift than in the past. Signs of this are clearly evident overseas in recent regulatory decisions and court cases. Public sentiment in Australia is also evident in letters to Ministers and regulators and in many recent media reports. Responsible control of spray drift is a very important issue for the farm community in maintaining access to valuable chemical tools into the future.

SPRAY DRIFT MANAGEMENT

Assoc. Prof. John Kent
Head, School of Agricultural and Wine Sciences
Charles Sturt University

Introduction

The movement of a herbicide, insecticides and fungicides outside of the intended target area can occur through drift of spray droplets, solid or non-volatile particles or volatile vapour. This drift can result in damage to crops etc., contamination and illegal residues in produce, environmental contamination, death of beneficial organisms, loss of chemical and reduced efficacy, adverse publicity and litigation. The extent of the problem depends on the pesticide involved, the quantity of drift, distance travelled, the susceptibility and sensitivity of the affected area and the level of damage tolerated.

Spray applicators have a legal responsibility to avoid drift.

Causes of drift

In order to manage drift it is useful to understand the causes which can be summarised as:

1. Using an inappropriate droplet size for the pesticide, the prevailing weather conditions or the situation.
2. Using inappropriate equipment or set up e.g. boom too high, travelling too fast, wrong nozzles or pressure too high.
3. Using an inappropriate pesticide or formulation e.g. volatile ester vs less volatile amine.
4. Spraying in adverse weather conditions.
5. Failing to identify susceptible non-target areas.

10 Steps to manage spray drift

1. **Choose appropriate pesticide:** Use a low volatile product or one which will not cause significant damage if it does drift.
2. **Read the label!!** Check for instructions regarding minimising drift.
3. **Identify susceptible areas (Awareness zone):** Do a risk assessment – what might be damaged if there is pesticide movement out of the target area. This should be recorded.
4. **Communicate:** Communicate with those who may be affected. This is compulsory in NSW for public areas. Managers must have a notification plan.
5. **Avoid adverse weather conditions:**
 - a. What is the weather forecast? – Think ahead.
 - b. Wind direction - Make sure wind is blowing away from susceptible areas, if possible work across and into the wind, and be alert to changes during the job.
 - c. Wind speed - For large area spraying the ideal is 3 – 15 km/hr (8 knots or 4 m/sec), not dead calm or light and variable.

- d. Temperature - It is the temperature near ground level that is critical! The ideal temperature range is 10 to 30°C with some humidity. If less than 10°C there may be problems with frost, dew and inactive plants and insects. If more than 30°C then plants are stressed, the operator is stressed, and there may be phytotoxicity, high evaporation and volatilisation. Avoid temperatures above 35°C.
 - e. Humidity - If humidity is low then evaporation is high. If humidity is very high then there is reduced evaporation and this can excessively extend droplet life. The ideal humidity is when the ΔT is between 2 and 8°C. Avoid low relative humidity (ΔT greater than 10°C). The ΔT is the temperature difference between wet and dry bulb thermometers.
 - f. Atmospheric stability - This is the vertical movement of parcels of air. Avoid spraying under very stable atmospheres and DO NOT spray if a temperature inversion is present. Very unstable atmospheres and hot air rising off the ground can carry chemical (vapour and droplets) upwards. Beware of cold air drainage which can carry chemical downhill and into hollows. Neutral atmospheric stability is ideal for spraying.
6. **Control droplet size:** Avoid fine droplets smaller than 100 to 150µm by choosing a suitable nozzle type (e.g. air induction) and size (larger) and correct spray pressure. Use nozzle charts to select droplet type, size and pressure to give the desired spray quality. Spray oils and anti-evaporants can be used to make droplets larger. Surfactants make droplets smaller.
 7. **Control droplet trajectory:** Minimise droplet release height and direct spray (& air) to the target. Do not travel at excessive speeds which propel droplets into the air.
 8. **Modify sprayer:** Hoods, covers and shields may be used to trap droplet droplets underneath but these need to be well designed.
 9. **Use buffers:** A windbreak between a sprayed area and susceptible areas may be a good investment. Vegetative buffers need to be 20 – 30 m deep and comprise fine leafed shrubs and trees. Solid barriers do not work.
 10. **Keep records:** Applicators have a legal obligation to keep records of every job including: weather conditions at the commencement and completion; any wind changes during the job; the equipment used and settings; and the location, date and time of application.

Conclusion

Pesticide application and drift management is a complex process. Every situation is different so it is important to understand the variables and to be able to manipulate these as appropriate. Managers need to take responsibility for practices in their own workplace and take a risk management approach. Use all appropriate drift management techniques, keep records, and remember “*Spraying is nearly always a compromise between what is ideal, and what must be done!*” .

References and further reading

APVMA (2008). Operating principles in relation to spray drift. Accessed from APVMA website: http://www.apvma.gov.au/users/spraydrift_principles.shtml

Kent, J. (2009). Pesticide Management Subject Resources. Charles Sturt University.

Proceedings of the International Conference on Pesticide Application for Drift Management, October 27-29 2004. (Waikoloa, Hawaii).

SPOT SPRAYING: NOW A COMMERCIAL REALITY

Scott Jameson
Business Manager
Crop Optics Australia Pty Ltd

Agricultural producers and contractors are reaping the benefits from sensor technology which can be used to selectively apply herbicides, insecticides, fertilisers and fungicides to plants in an agricultural, horticultural, viticultural and industrial situation.

The WeedSeeker® technology is designed for use on any crop free surface. It is being used in agriculture, along roadsides, railway corridors, airport runways, median strips and more - the possibilities are limitless.

DPI research in Northern NSW has shown that the average weed cover in broadacre fallow paddocks is as low as 20% of the paddock area. This means that often 80% of the herbicide is applied to bare soil or stubble and is wasted. This is inefficient, expensive and environmentally unsustainable.

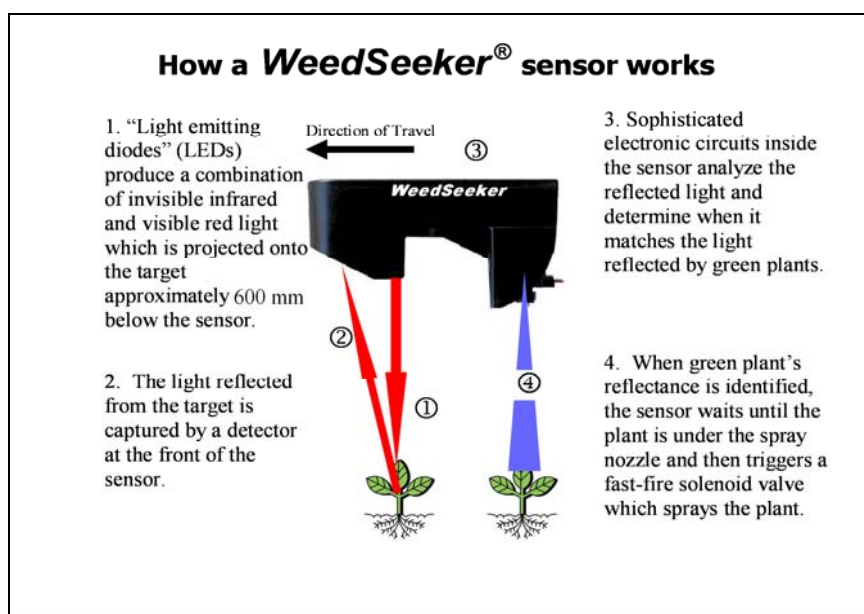


Diagram: How WeedSeeker sensor works.

The WeedSeeker® technology uses sensors and nozzles spaced at 380 mm apart. This spacing, being narrower than the standard 500 mm is used to maximise the vision of the sensor, in heavier stubbles a wider spacing would cause shadowing of the target weeds. The WeedSeeker® will spray only weeds, not bare ground. WeedSeeker® is effective wherever weeds occur intermittently. The technology can be fitted to most boomsprays with many of the major manufactures now designing booms specifically suited for WeedSeeker®.

WeedSeeker® is weather proof and operational both day and night, with speeds of between 15 – 20 km per hour being recommended to achieve best results. Higher speeds of up to 25 km per hour are achievable depending on the size and type of weeds being targeted. These speeds make it very versatile and convenient for operators who are constantly restricted by weather and time. At speeds above 25 km per hour there is usually no problems with the sensors seeing the weeds, getting the chemical to hit the target is the main issue.

As previously mentioned, the WeedSeeker® can be used in a number of applications, including: shielded spraying in row crops; broadacre fallow spraying; tree crop spraying; channel spraying, industrial spraying (e.g. councils, railways, roadways, airports and schools); vineyard spraying; and fungicide, insecticide and fertiliser applications in vegetables.

The benefits of WeedSeeker® are huge. An ever increasing issue in the northern Australia cropping region, the control of hard to kill fallow weeds such as fleabane, peachvine, milkthistle, Roundup Ready cotton and marshmallow is an area where the WeedSeeker® technology shines. The WeedSeeker® allows producers to use mixtures of different herbicide groups, which may be currently too expensive to apply in a blanket application. This method of application will prolong the life of existing herbicides and reduce resistance in weed populations, greatly improving sustainability of cropping systems.

Don Hubbard of Spring Ridge NSW purchased the WeedSeeker in early 2007 and has been using it in many situations. “It has been particularly successful in controlling hard to kill weeds such as ryegrass, fleabane and milkthistle. Depending on the situation and weed population (i.e. spot spraying in fallow) we generally make chemical savings between 75% – 90%. When dual-lining, that is putting on an overall light background spray and spot spraying only the larger weeds in the one pass, we also make significant chemical savings.”



Photo: WeedSeeker in use on broadacre crop

WeedSeeker® use reduces the risk of herbicide drifting onto non-target areas and the surrounding environment due to the amount of chemical being released being substantially lower than conventional spraying methods. The development of reduced tillage and no-till cropping systems can provide environmental benefits in terms of reducing soil erosion by wind and water. Reducing herbicide use improves returns further and allows more producers to adopt the system to the benefit of the whole agricultural landscape, and less chemical load in the environment benefits the whole community. WeedSeeker® also reduces the amount of water used by covering more hectares per tank load.

Producers and contractors who use WeedSeeker® are saving thousands of dollars each year by reducing the amount of herbicide they use, and with the increasing price of herbicides, who knows what the savings could end up being. Their investment is saving them time, money, herbicide, and the environment.

If you would like more information on the WeedSeeker® visit www.cropoptics.com.au or phone Scott Jameson at Crop Optics Australia on +61 428 664 318 or +612 6760 7756.

HERBICIDE USE IN GENETICALLY MODIFIED (GM) CROPS

**Graham Charles
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The Australian cotton industry has been growing genetically modified, herbicide tolerant cotton varieties for the past 10 seasons. Over 85% of the cotton planted in the 2009/10 season will include the glyphosate tolerance, Roundup Ready Flex[®] gene.

The use of the Roundup Ready Flex[®] gene has contributed to improvements in in-crop weed control, with broadcast in-crop applications of glyphosate replacing many pre-planting and in-crop residual herbicide applications, hand-hoeing and some in-crop cultivation passes. Applications of glyphosate have many advantages over these older technologies. Glyphosate requires fewer man hours to apply, is less damaging to the crop than were the residual herbicides and early-season cultivation, the timing of its applications are more flexible, only being applied after weeds have emerged, generally glyphosate has a broader spectrum of control, and it has a reduced environmental footprint, with fewer off-target issues.

Consequently, the introduction of herbicide tolerant GM cotton to Australia has been beneficial to the cotton grower and the environment, with improved weed control, better crop yields, and subsequent reductions in the use of cultivation and residual herbicides and associated environmental problems. The introduction of this technology has also enhanced the ability of cotton growers to develop more flexible farming systems for cotton. These include the adoption of permanent beds and permanent wheel tracks with much reduced levels of cultivation, the opportunity to plant into and retain standing stubble from previous crops, and the flexibility to adopt different planting configurations, including ultra-narrow row cotton.

However, increasing reliance on glyphosate in the farming system has led to other problems, including species shift to weeds which are more tolerant of glyphosate and may be difficult to control with other herbicides, and the emergence of glyphosate resistant weed species. These problems have not been caused by the adoption of a GM crop, but by over-reliance on glyphosate in the whole farming system. A robust crop management plan for resistance management in Roundup Ready cotton was developed for this product and implementation of this plan ensures that weeds are well managed in-crop. The results of this management are monitored and reviewed annually to ensure the system is stable and effective.

Species shift and the emergence of glyphosate resistant weeds are relatively minor issues for cotton production but much larger issues for the farming system and the environment. In practical terms, they can be treated as a single issue, as the causes of their development and the strategies required to manage these issues are the same. In simple terms, resistance and species shift result from over-reliance on a single weed management tool and corresponding under-use of alternative management tools. In this case, the problems are caused by the substitution of glyphosate for cultivation, hand-hoeing and other herbicides.

To date, glyphosate resistant individuals of 3 weed species (ryegrass, awnless barnyard grass and liverseed grass) have emerged in the farming system, with a 4th species, flaxleaf fleabane showing high levels of tolerance to glyphosate. Problems have also emerged from a range of other glyphosate tolerant species, including pig weed and the bindweed complex.

The problems of glyphosate resistant grasses can be readily addressed in cotton, with minimal impact on the system, by reintroducing a residual grass herbicide. This could be applied pre- or post-crop emergence, but mechanical incorporation is problematic in standing stubble and post-emergence in the ultra-narrow row configuration. Control of these weeds is more problematic in fallow and likely to require regular use of a double-knock approach, following glyphosate with either an alternative herbicide, such as paraquat, or a cultivation pass, increasing the number of inputs and the cost of the system. Glyphosate tolerant perennial

weeds, such as bindweed, are very difficult to control with a herbicide once established. Their management will probably require the use of strategic heavy cultivation.

Nevertheless, evidence from the southern farming system suggests that glyphosate resistance can be avoided if weeds are controlled using just one additional effective alternative weed management tool each year. An additional tool needs to be used each year, regardless of whether a GM crop is planted, and over the whole farm area, including irrigation structures and fence lines, where glyphosate may be the only weed management tool currently used.

The introduction of an alternative GM technology, glufosinate tolerant, Liberty Link[®] cotton, and possibly other genes in the future, creates other viable options for managing species shift and herbicide resistance in cotton, but does little to assist with managing these weeds in fallows, as glufosinate is not a cost-effective herbicide for fallow use. The introduction of alternative genes also adds to the complexity of the farming system, increasing the likelihood of accidental herbicide damage from drift, contamination and applications to the wrong fields. Nevertheless, these genes offer cotton growers continuing access to the benefits of GM technology, while expanding the range of weed management tools and increasing the stability and sustainability of the system. This is especially true with Liberty Link cotton, where a residual grass herbicide will necessarily be part of the system on most fields.

The use of these GM technologies in canola in Australia is still in its infancy, but problems with species shift and glyphosate resistant weeds are also inevitable in canola, with glyphosate resistant rye grass already present through much of the canola growing area.

One of the challenges of using these technologies in cotton is that there is no clear signal to trigger the timing of herbicide applications. Multiple applications of glyphosate can be used in Roundup Ready Flex[®] cotton at rates up to 1 kg a.i./ha through most of the crop's life. This rate controls most weeds at small to medium size and many weeds, such as the grasses, through to mature size. Consequently, there is little need to time herbicide applications based on weed size, allowing applications to be delayed, provided weeds are controlled before they set seed. However, delaying weed control can lead to strong competition. Cotton is relatively uncompetitive as a seedling and excessive weed pressure can cause large reductions in yield. Even small numbers of large weeds can be very damaging to a developing cotton crop.

Field experiments over the past 7 years have focused on defining a weed control threshold for cotton based on weed competition (weed pressure), a function of weed size and density. This has been achieved by defining the critical period for weed control for cotton using large field experiments. Experiments typically used 3 model weeds, 6 weed densities, 4 times of weed introduction and 5 times of weed removal, with 4 replicates, giving 1440 plots. Weed and crop growth and development were recorded during crop growth, as well as final crop yields.

This data has been used to develop a weed control threshold model for cotton relating weed size and density to crop development, which has been defined using day degrees. The model has been released to the cotton industry, but uptake has been disappointing, partly due to the difficulty of assessing weed pressure over relatively large field areas, with fields over 100 ha in size not uncommon. The combination of field size and weed patchiness makes it difficult to effectively assess weed pressure over a whole field.

More recently, experiments have been conducted using both physical measurements and a GreenSeeker[™] sensor with mixed weed populations in order to develop a model which is able to integrate results over a field without the need for extensive physical sampling. Adaptation of the control threshold to use a sensor to assess weed pressure should greatly enhance the uptake of this technology by the industry and improve the value of a GM crop.

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*A society promoting the awareness and understanding
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Aims and Objectives

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- To exchange information and ideas.
- To encourage the investigation and study of weeds and weeds management.
- To represent members' interests at State and National levels through appropriate organisations.
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For further information contact:

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