GETTING ON TOP OF FLEABANE AND WINDMILL GRASS

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Key words

Windmill Grass, Fleabane, glyphosate resistance, summer fallow, weed control, double knock, integrated weed management, herbicides, WeedSeeker

GRDC code

DAQ000137, UQ00062 and GOA00001

Take Home Message

- Windmill grass and fleabane have been confirmed as glyphosate resistant
- Both species are quickly becoming problematic weeds in zero tillage, summer fallows
- Some effective herbicide control options identified with "Double Knocking" the key to success in fallows. However, apply this tactic is expensive and needs attention to detail.
- An integrated weed management (IWM) approach is required for best long-term management of these weeds.
- A range of herbicides are available with good residual fleabane activity that can be utilized in fallow or in winter crop
- A new WeedSeeker Permit will allow improved control option for these weeds in fallows (NSW only) and could make double knocking more affordable.

Background

Windmill grass (WG) and flaxleaf fleabane have become major weeds of cropping in many parts of Australia. They can be very difficult weeds to control and are thought to have increased for several reasons, namely the:

- increased adoption of no-till farming,
- heavy reliance on glyphosate for fallow weed control,
- the development of glyphosate resistance in both these species,
- both species were allowed to increase steadily as they were not considered problem weeds prior to year 2000

Both weeds can greatly reduce stored water supplies in fallow and can compete well in thin crop crops, reducing yields. Their seeds are spread by wind and seeds of both species are considered surface germinating. Peak emergence of seedling is commonly reported after mild wet springs and autumns. Fleabane and WG have very limited registered herbicides, although there appears to be more un-registered options than registered ones. This is a challenge for industry, regulators, farmers, chemical registrants and researchers.

Although these weeds have many similarities there are some subtle differences:

- Researchers have developed very effective fallow, in-crop and fenceline options for fleabane control as a result of nearly 10 years of investigation. The options for WG control are more restrictive due to much less research time spent on this weed and probably fewer viable options to research.
- Fleabane is an annual weed and WG can be annual to perennial, making WG more persistent.
- Chemical control options are rather different as one is a grass and the other a broad leaf.

- Many ecological studies have been conducted on fleabane and such work on WG is significantly less.

Despite the similarities and differences, an IWM strategy that includes chemical and non-chemical tactics, such as crop competition, for controlling seedlings and preventing seed production on survivors will result in substantially fewer problems and a reduced risk of herbicide resistance.

Lifecycle and management implications

Knowledge of a weed's lifecycle is important in being able to manipulate and better target weed management practices for improved weed control. The germination of both species is largely light and temperature dependant. A larger emergence of weeds in the field is often associated with crop stubble and parts of the topography that enable increased and longer periods of moisture. Monitoring for new emergences is important, as young fleabane and WG is much easier to control and there are many more options available. Seedlings of fleabane will only emerge from the top 1 cm of soil with similar emergence characteristics for WG, explaining partly why these weeds proliferate in no-till systems.

As both weeds are capable of emerging in late autumn they are most likely to be a problem in winter crops and fallows. In crops, pre-plant, in-crop and after harvest control may be required. Both weeds are easily controlled when it is small and young. Once elongation or multi-tillering begins, there are few effective herbicide options available.

The majority of fleabane seeds in the soil lose their viability within 12-18 months. However a small percentage can persist for several years and the quantity is influenced by burial depth. A pot study on the Darling Downs showed that after 3 years of burial 1%, 10% and 8% of viable seed remained at depths of 0-2, 5 and 10 cm respectively. A tillage trial on the Darling Downs (near Dalby) found that the emergence of fleabane was generally reduced under tillage, but that a light harrow increased emergence, possibly as a result of an increased number of seeds being exposed to light (Figure 1). While seed burial through cultivation may be seen as a possible option for fleabane control, buried seeds can remain viable and be brought back to the soil surface by subsequent tillage events.

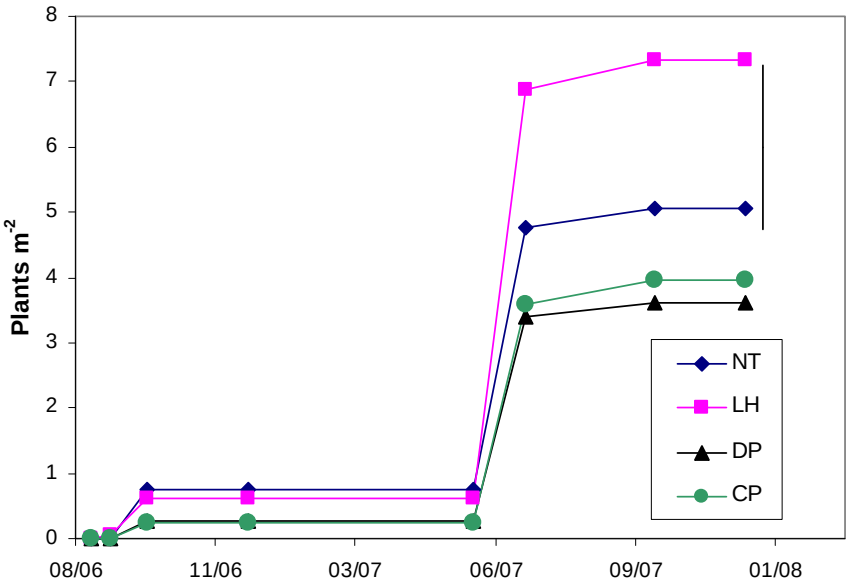

Figure 1: Fleabane cumulative emergence following no soil disturbance (NT) or tillage with light harrow (LH), disk plough (DP), and chisel plough (CP). (Source: DEEDI)

Controlling the problem

Current herbicide registrations for control of WG and fleabane in summer fallow are limited to Touchdown Hi Tech (glyphosate 500g/L). Spray.Seed and paraquat (eg Gramoxone) labels are worded such that they are registered for most annual weeds. This would include fleabane and possibly WG as it occasionally is referred as an annual weed in response to dry seasons. There are only two other selective products registered for control of each weed species in various situations as listed in the table below.

Table 1 Registered herbicide for Windmill or *Chloris sp*. and fleabane control

Windmill grass		
Product Name	**Active Ingredient**	**Use situation**
Dacthal 900™	900g/L Chlorthal-Dimethyl	Various brassica and vegetable crops, cotton, lucerne and lawns
Factor™	250g/L Butoxydim	Various summer crops- e.g. mungbeans, cotton, sunflowers
Fleabane		
Product Name	**Active Ingredient**	**Use situation**
Amicide Advance	700g/L 2,4-D amine	Various winter cereals and fallows
Tordon 75-D	300g/L 2,4-D amine + 75g/L picloram	Fallows prior to winter cereal

Crucial research findings – Windmill grass

The Grain Orana Alliance have highlighted the importance of double knocking WG, as shown below in Figure 2.

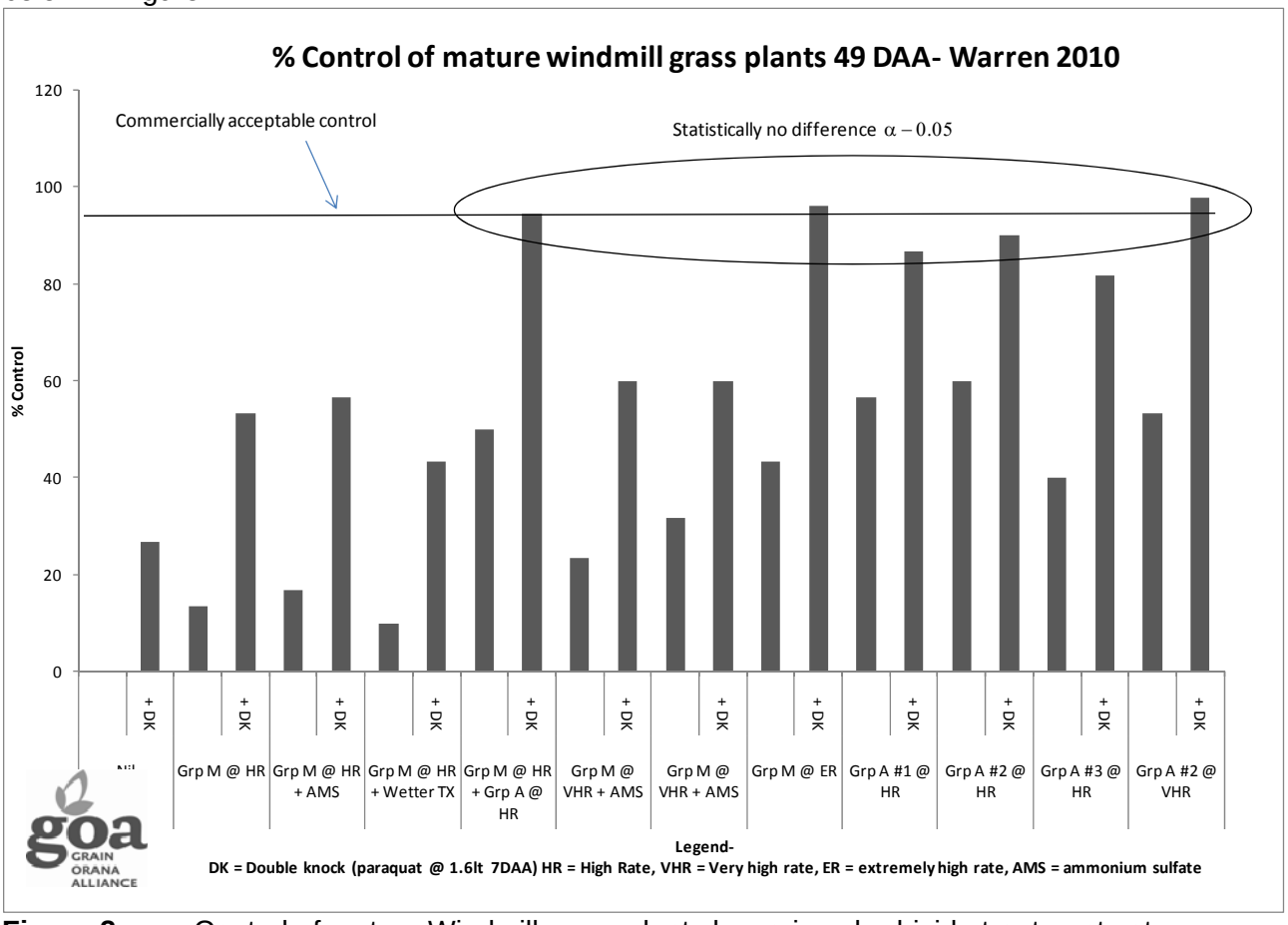

Figure 2 Control of mature Windmill grass plants by various herbicide treatments at 49DAA- Source; GOA

It is demonstrated that the addition of a double knock (+DK) to any of the above treatments has significantly increased the level of control of the mature WG plants. Despite this none of the group M treatments with the exception of the extreme rate (ER) have not reached acceptable control levels. It is also demonstrated that group A herbicides with double knocking treatments have performed well, a number of products actually achieving commercially acceptable control.

Another experiment investigated the effect of delayed application had on herbicide efficacy. Three treatments were applied at 4 different timings. Two rates of Group M herbicide (HR- high rate, and VHR- very high rate) and a very high rate (VHR) of a Group A were applied to separate plots, each was followed by a double knock at 7 days after initial treatment. Results are shown in Figure 3.

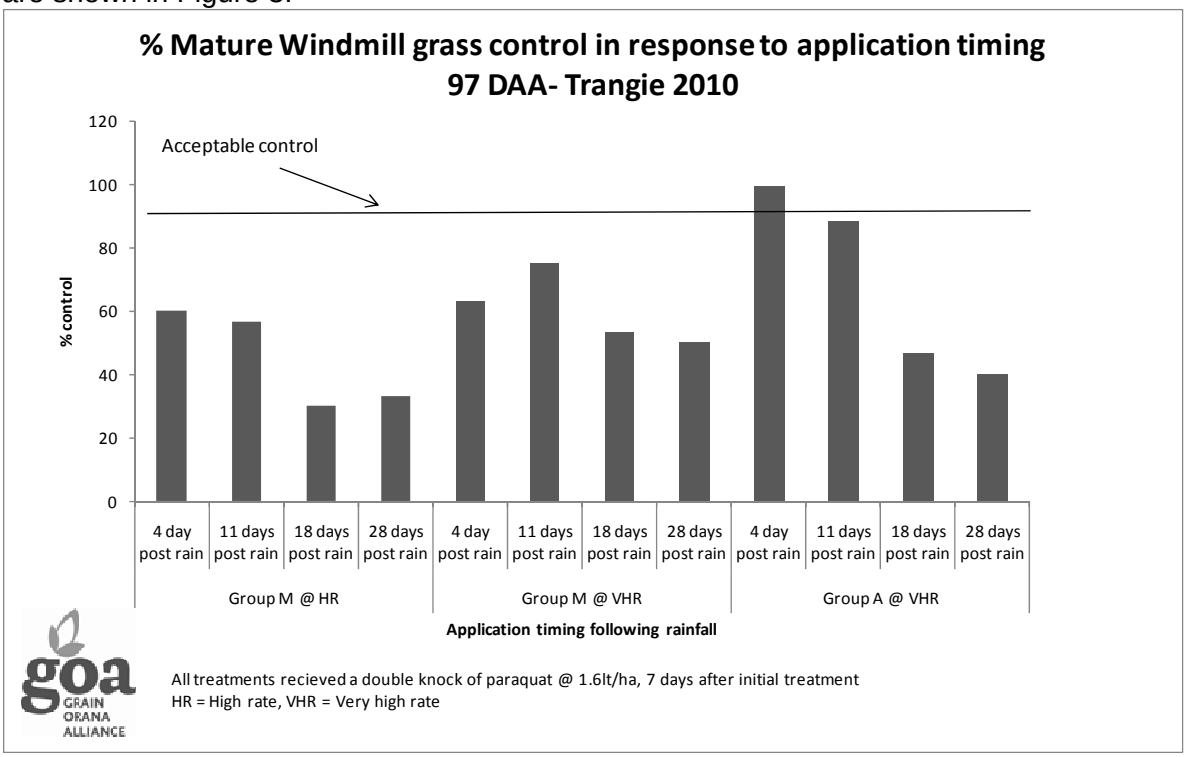

Figure 3 Mature windmill grass control in response to delayed herbicide application at 97 DAA. Source; GOA

The results suggest that regardless of the product choice, control drops off sharply between 11- 18 days post rainfall. All group M herbicide treatments resulted in unsatisfactory levels of control. In the case of the VHR of the group A, the first two timings either exceed what is considered acceptable control or performed close to. However with increasing moisture stress and larger plants, control levels declined and were un-acceptable.

In light of these results, further research is anticipated with the following research questions to answer:

- Can the good levels of efficacy of Group A herbicide be improved significantly?
- With greater detail, what is the link between moisture stress and herbicide efficacy?
- What is the optimal timing (growth stage and days between knocks) for a double knock?
- Can residual herbicide play a crucial role with WG management? Should they be used in combination with cultivation? Can in-crop WG be achieved?

Crucial research findings – Flaxleaf fleabane

Fleabane density and seed production can be substantially manipulated using crop competition in the absence of herbicides. For wheat, there were trends to lower fleabane numbers with increasing crop population and narrower row spacing (Figure 4). On average, weed density decreased by 26% as crop population increased from 50 to 100 plants per m^2, and by 44% as row spacing decreased from 50 to 25cm. These treatments also had impacts on seed production, as indicated by seed head counts (Figure 5). Row spacing tended to have a much larger affect than crop population. A similar experiment at Trangie, courtesy of Rohan Brill District agronomist at Coonamble discovered similar trends. The 2011 experiment had shown that a 66 cm row space resulted in 120 % more fleabane in fallow than the 33 cm row space. The data indicate that durum wheat responded very similar to bread wheat.

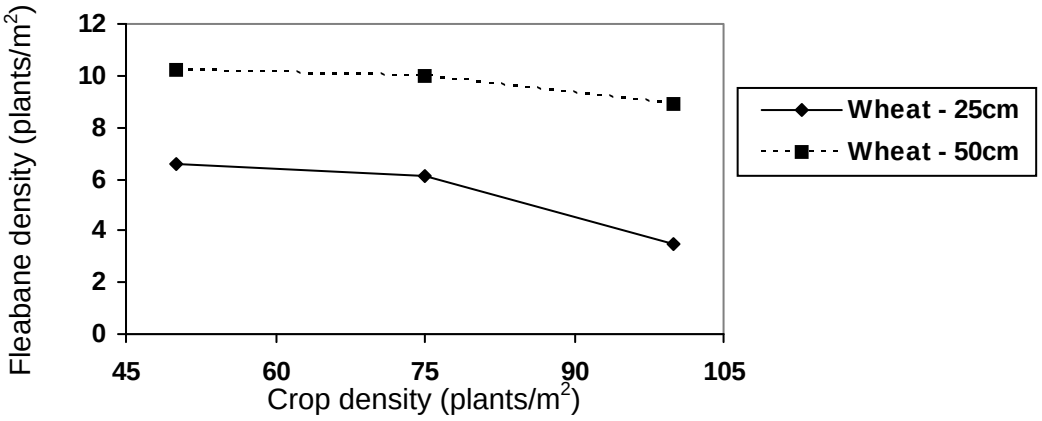

Figure 4: Fleabane density (/m^2) in wheat of different row spacing and plant density (DEEDI)

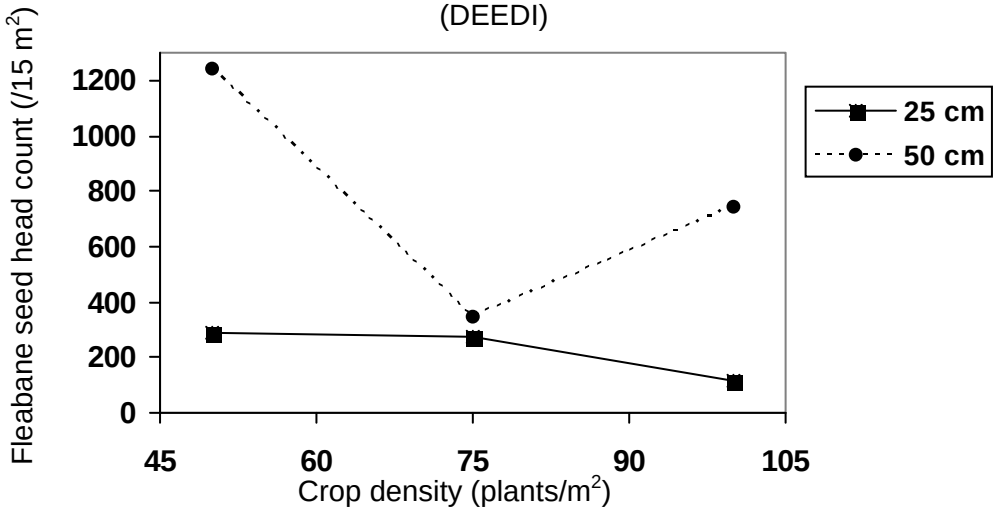

Figure 5: Average fleabane seed head counts (/15m^2) in wheat, durum and barley across different row spacing and plant density (DEEDI)

In-crop herbicides

Amicide Advance® is the only in-crop (cereal) option registered for fleabane control. However, there is a suite of herbicides commonly used in-crop that can be effective on young fleabane.

In a 2010 trial near Warwick, in-crop herbicides were applied in wheat at 2 different times, 2 weeks apart. At the first spray the majority of fleabane were small (<5cm) and at the latter spray there were more plants that were >10cm. The results (Table 2) show that there are a range of treatments which provided >85% control when applied to young fleabane. A delay

of 2 weeks in application resulted in an average 40% reduction in control. The Group I phenoxy herbicides provided the greatest control of both young and older fleabane.

Table 2: Fleabane biomass reduction (% of untreated) 4 weeks after in-crop herbicide treatment 2 weeks apart

Herbicide	Biomass reduction (%) 4 weeks after treatment	
	First time of spraying	Second time of spraying (2 weeks after 1st)
Untreated	0	0
Group B sulfonylurea	76	4
Group I phenoxy	98	91
Group I pyridine	95	0
Group I pyridine	85	6
Group I phenoxy	87	92
Group I phenoxy	77	44
Group B sulfonylurea + Group I phenoxy	86	35
Group I pyridine + Group I phenoxy	93	50
Group I pyridine + Group I phenoxy	77	57
Group I phenoxy + Group B sulfonylurea	84	73
Group I phenoxy + Group I phenoxy	86	28
MEAN	86	44

Specifics of rate and product have been deleted from the above table as NONE of the herbicides listed are registered for the control of fleabane.

No treatment provided 100% control of fleabane and there were new flushes of emergence after herbicide application. Products containing picloram (eg Tordon) reduced subsequent emergences by more than 50%.

Many researchers has found that sulfonyl urea herbicides to be of moderate benefit. They would play a role as a pre-em or early post-em and if applied post-em, should be mixed with a Group I herbicide. Further to this, evidence suggests that Group H chemistry may have good efficacy and could be a critical herbicide mode of action rotation option. All the above listed treatments in Table 2 would not be suitable for winter cereal under-sown with lucerne. However, one experiment (data not presented) investigated lucerne compatible treatments in wheat. As a result, there appears two suitable treatments, one a Group I herbicide and the other from Group C. These treatments should be applied to weeds less than 5mm in diameter.

Fallow herbicides

Fallow management of fleabane with a single herbicide application has been extremely inconsistent. Although good results have been obtained with specific treatments in some situations, NO CONSISTENT robust option has been identified to cover a wide range of situations. This is typified by research undertaken by Barry Haskins, District Agronomist Hillston, who found the best three single pass treatments only attained between 90 and 95% control. Higher levels of control are required as fleabane can easily replenish the seed bank with its large seed production potential. As a result the industry has needed to look at more involved (and much more expensive) techniques such as double-knocks but also is now seriously looking at the fit and value of residual herbicides in an overall management program.

1. Double-knock approaches

The most consistent and widely adopted double-knock for fleabane is a mix of glyphosate and 2,4-D as the first application, or knock, followed by a paraquat or paraquat & diquat based option as the second-knock.

Figure 6 clearly shows the value of the second knock. This trial was established to compare the effectiveness of double-knocks on fleabane at different ages. The timings was when fleabane was ~ 1, 2 and 3 months old. The inclusion of a second knock of Sprayseed resulted in excellent levels of control of fleabane at the two earlier stages. However, not at 3 months old, even a double-knock approach only resulted in ~90% control.

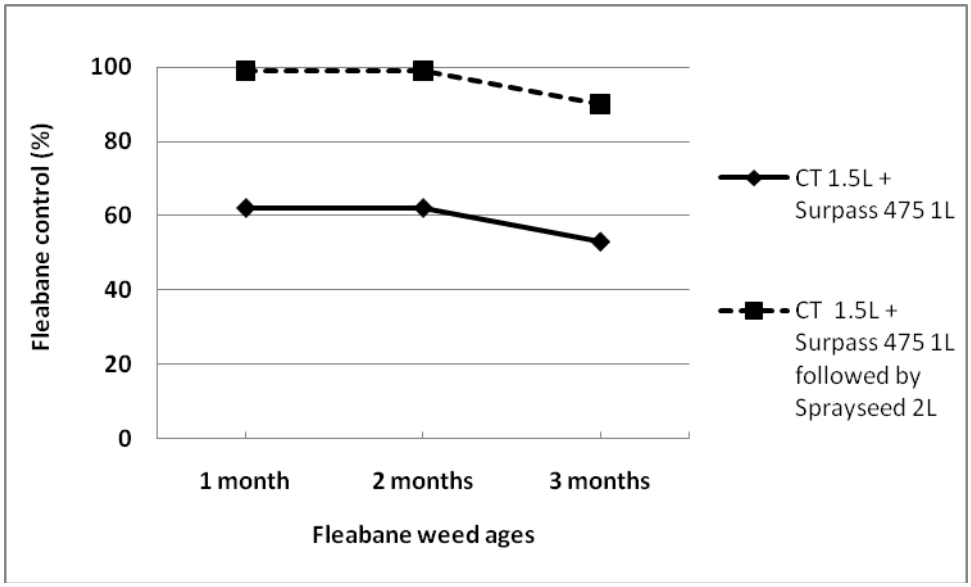

Figure 6: Benefit of double-knock over single herbicide applications on fleabane control – knocks 7 days apart (DEEDI 2009)

An additional range of single and double-knock treatments have been evaluated for fallow control of fleabane across Qld and NSW. The evaluation took place across 2009 and 2010 seasons and examined the impact of fleabane age on herbicide efficacy. Results show that the double-knock approach is more consistently reliable than single knock treatments, across seasons and especially on older fleabane (Table 3). Even when applied to older fleabane, the efficacy of the double-knock treatment is reduced as seen in the 2009 data. To maintain the efficacy of the double-knock treatment on larger fleabane, the rate of herbicide applied needs to be increased (2010 data – age 3 months). The 2010 results have been averaged across Qld and NSW as they did not differ significantly.

Table 3: Fleabane visual biomass reduction (% of untreated) 42 days after knockdown treatment across seasons (2009 and 2010) and Qld and NSW (DEEDI and NSW I&I).

Herbicide (first knock fb second knock)	Rate	2009 $		2010 #	
		1 month	3 months	1 month	3 months*
Gly CT + Surpass 300	1.5L + 1.5L	62	53	88	83
Gly CT + Tordon 75D	1.5L + 0.7L	90	45	92	98
Gly CT + Surpass 300 fb Sprayseed	1.5L + 1.5L fb 2.0L	99	90	94	95
Gly CT + Tordon 75D fb Sprayseed	1.5L + 0.7L fb 2.0L	99	93	99	99
Gly CT + Surpass 300 fb Alliance	1.5L+ 1.5L fb 2.0L	98	78	94	93
Amicide 625 fb Sprayseed	1.5L fb 2.0L	99	72	97	96

fb = followed by – second knock 7 days after first knock
$ - Queensland data only
# - averaged for Qld and NSW

2. Residual approaches

The difficulties and expense of controlling fleabane with knockdown sprays, together with early indications of glyphosate resistance in some summer grasses, has resulted in interest in the potential use of residual herbicides as part of an overall management strategy.

Where do residuals fit?

To get the most benefit out of residual herbicides they should be applied **before the largest expected emergence flushes**. There are three key positions where residuals may be of benefit in our system for managing fleabane:

a) Use of a residual in autumn/ winter during the winter fallow
b) Use of a pre-plant or in-crop residual within the winter cropping program
c) Use of a pre-plant or in-crop residual within the summer cropping program

In the winter of 2009, a range of residual herbicides were applied by DEEDI researchers, including members of the following groups and sub groups:

- Group B sulfonyl ureas (eg Glean®)
- Group B imidazolinones (eg Flame)
- Group C substituted ureas (eg diuron)
- Group C triazines (eg atrazine)
- Group H isoxazoles (eg Balance®)
- Group I phenoxy and pyridine mixtures (eg Tordon® 75-D)
- Group K chloroacetamide (eg Dual® Gold)

Figure 7 shows the cumulative control obtained from each treatment over a 5 month period following application. Good levels of residual control were obtained from all products with only the Group I phenoxy and pyridine mixture herbicide providing less than 90% control in this bare fallow situation.

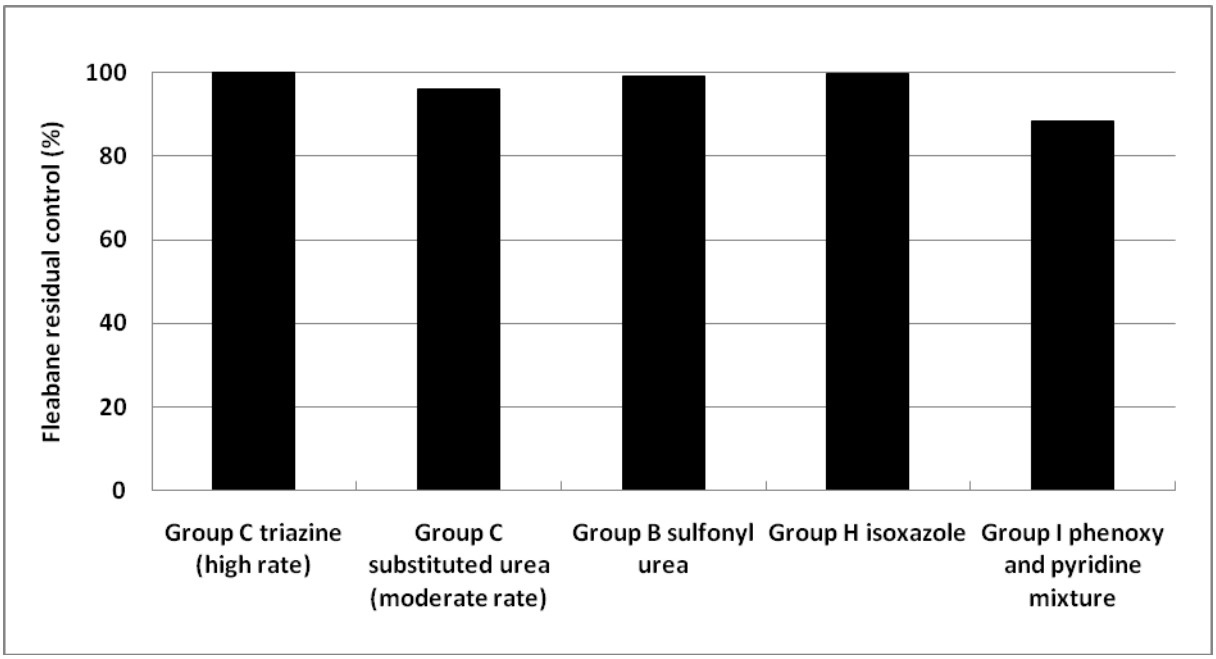

Figure 7: Residual fleabane control in winter fallow following double knock application (DEEDI 2009)

Specifics of rate and product have been deleted from the above figure as NONE of the herbicides listed are registered for the control of fleabane.

Northern Grower Alliance (NGA) established 4 trials in winter 2009 to also examine the effectiveness of a range of common residual herbicides. All were applied in a non-crop situation to investigate the relative efficacy of different active ingredients.

All trials were established in a clean fallow between June 25 and July 6 with only low rainfall received in July, August and September. Fleabane residual control was assessed 32-72 days after application. Fleabane pressure was low in all trials. The results in Figure 8 show the mean level of control of some of the key herbicides over the 4 trials.

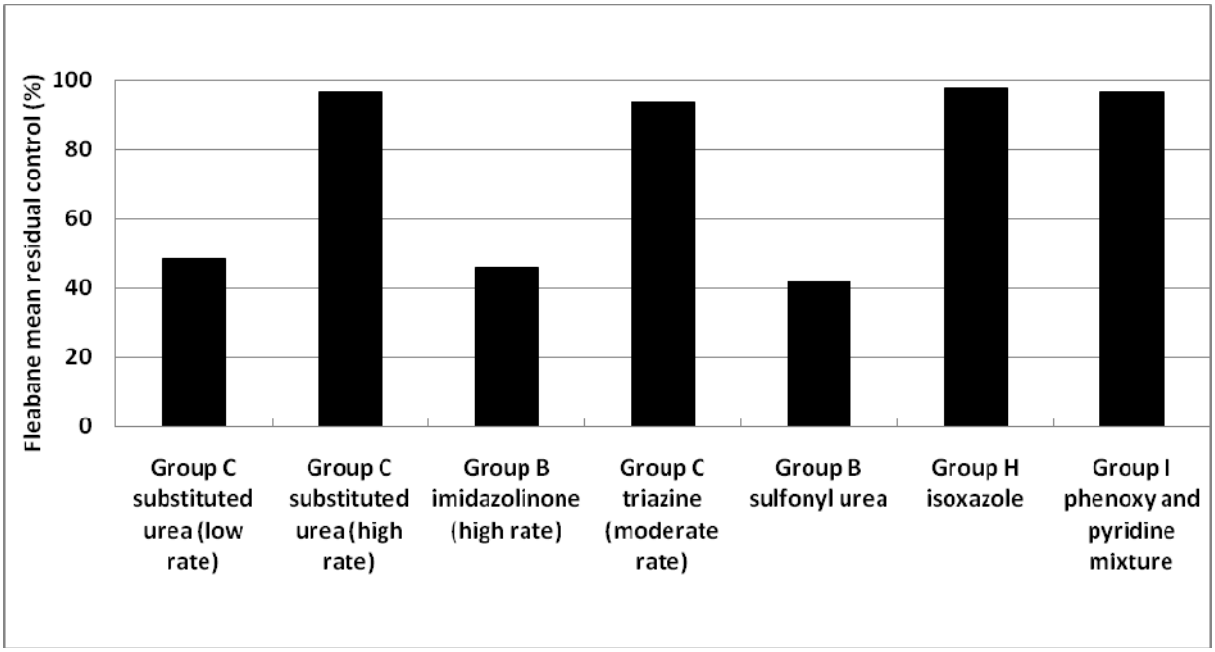

Figure 8: Residual fleabane control in winter fallow (NGA 2009)

Specifics of rate and product have been deleted from the above figure as NONE of the herbicides listed are registered for the control of fleabane.

Key points

1. Good levels of fleabane control were obtained in all 4 trials from a Group C substituted urea herbicide (high rate), a common in-crop rate of Group C triazine herbicide, a common in-crop rate of a Group H isoxazole or a common in-crop rate of a mix of Group I phenoxy and pyridine herbicides. NB some of these products are only registered in-crop but can still be useful residual weed control tools
2. No other option exceeded 90% control in any trial
3. A label rate of a commonly used Group B sulfonyl urea provided useful suppression in 2 trials (~80-85% control) but negligible activity at the other 2 sites (NB no crop competition in these trials).

Recent (2009 and 2010) field trials in Queensland and northern NSW of residual products confirmed that the Group C substituted urea product provided consistently greater than 90% control of new flushes of fleabane emergence for at least 6 months after treatment.

Residual summary

Several herbicides can provide good residual activity against fleabane.

Products and mixes that have shown useful levels of residual activity on fleabane in trials include:

- High fallow rates of Group C triazines for residual weed control applied in the autumn, prior to a rain event, when sorghum is to be sown in the spring, or in early spring before planting the sorghum crop.
- A Group C substituted urea herbicide used in association with cotton or chickpeas.
- A group H isoxazoles in chickpeas.
- A Group B sulfonyl urea as a pre-plant to a winter cereal, particularly when combined with good crop competition.
- A Group I phenoxy and pyridine mixture in fallow at least 2 months prior to winter cereals as part of a double-knock scenario to assist both knockdown control and provide useful residual control. Products containing the active picloram (eg Tordon

75-D, Tordon 242) may also be useful in-crop tools when combined with good crop competition.

Herbicide resistance – potential threats

Windmill grass: If the current recommendation to use Group A herbicides followed by a bipyridyl is used extensively there are clear risks of developing Group A and/or L resistance. This is likely to present itself within 5 to 10 years, as shown in other case studies (management of glyphosate resistant annual ryegrass developed Group A resistance). The need to incorporate cultivation with residual herbicides is therefore paramont.

Fleabane: Although there appears to be more chemical strategies to combat this weed, the majority rely upon Group I herbicides. Some selection pressure will be on Group L via the use of double knocking. To be proactive in resistance management, development and promotion of alternative mode of action herbicides is required (eg Groups C and H).

A new technology that has a good fit (WeedSeeker)

The APVMA have just issued a permit that enables NSW grower's access to a wider range of herbicides and rates in fallow when using a WeedSeeker®.
Thirty different herbicides are listed on the permit from seven mode of action herbicides, some being non-residual and other with short or longer term activity in the soil. This offers great flexibility for those managing hard to control fallow weeds such as fleabane and windmill grass.
Some herbicide rates have been increased to allow for control of larger, stressed or harder to control weeds. For example the glyphosate 450 rates range from 3 to 4L/ha, which far exceeds the label blanket rate of 400mL to 2.4L/ha. Likewise, similar increases in rate are allowed for paraquat or Spray.Seed®.
Not only is this technology useful for controlling small or scattered light weed patches in fallows, it can be used to effectively manage glyphosate resistant weeds. As stated previously, herbicides such as paraquat or Group A herbicides to be extremely useful options to control windmill grass. The new permit will allow the use of these herbicides and at robust rates.
The key to successful resistance management is killing the last few individuals; this becomes rather difficult on large scale properties. Much time is spent scouting for these small patches and if not controlled will result in significant seed production and re-setting of the weed seed bank. The WeedSeeker® will make the final stages of an eradication campaign more feasible.
Applying Group A herbicides in fallows is widely accepted by many as a risky practice; by selecting for Group A resistant species. Appropriate warnings are listed on the permit to prevent the onset of Group A resistant weeds in fallows. For most situations a follow-up spray with paraquat or Spray.Seed® prevents any survivors producing seed. If all else fails cultivation must be used to ensure survivors do not set seed.

Summary
Windmill grass: although most likely present for some time WG emerged recently as a major threat to efficiencies of zero till systems most likely as a result in evolution of that system. The removal from the system of all other control methods other than herbicides has favoured its survival and proliferation. The use of herbicides which are generally not effective has seen the weed infest paddocks at an ever increasing rate and the recent identification of glyphosate resistance adds further to the difficulties of control.
Research into this problem has been limited with some conflicting data. Common outcomes are:

- Final control is related to moisture availability before, during and after spraying.
- Double knock treatments can increase effectiveness

- Group A herbicides appear promising for control but are unregistered for such use patterns

The recent identification of glyphosate resistance in WG and the problems that it proving to growers has seen the weed attracting attention of such bodies as the Australian Glyphosate Sustainability Working group and other researchers like DEEDI and NSW DPI. It has been recently identified to GRDC as one of the 5 major weeds in the northern cropping region. As such we will see an increased focus on developing our understanding and controlling this problem weed both locally and from a national perspective.

Fleabane: Successful control of fleabane and other weeds will only be achieved by using a combination of management tools. Clearly there are economic and management downsides to using double-knocks or residual herbicides and registrations for these use practices are needed (similarly for potential WG treatments). These options provide the most robust options to manage this key widespread weed. Hopefully the arrival of new products will provide additional effective tools.

One key lesson learnt in fleabane herbicide management is to move the main battle from late spring and summer (when weeds are hardened off and very difficult to completely control) to earlier in the season. This way we can use either very effective double-knocks on smaller weed stages or incorporate residual chemistry into our fallow or in-crop management on a paddock by paddock basis.

Once effective control of both weed species is reached, maintaining excellent levels of control requires excellent patch management of small infestation, keeping non-cropping areas clean and having a focus on preventing weed seed production.

Disclaimer

Please note, some of the herbicides mentioned in this paper are only registered for 'in-crop' use and some do NOT have recommendations for the control of fleabane. **Always read and follow label directions.**

Acknowledgements

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