CROP SCIENCE SOCIETY OF S.A. INCORPORATED

C/- WAITE CAMPUS
P.M.B No 1, GLEN OSMOND, SOUTH AUSTRALIA 5064
INCORPORATING THE WEED SCIENCE SOCIETY
ABN: 68 746 893 290

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EDITOR – articles welcome; fax: (08) 8303 6735 Ph: 0408 816 533
email: cropsssa@yahoo.com

TREASURER – Subscriptions
Susan Fuss
gsfuss@bigpond.com
Ph: 0407 900 055

SECRETARY
Neil Wittwer

Next Meeting	**'Mythbusting Biochar**
Venue	**Richardson Theatre, Roseworthy Campus**
Date	**WEDNESDAY 15th OCTOBER**
Time	**7.30 pm**

Dr Rob Norton - IPNI via Skype

Rob will talk on the issues of Potassium and micronutrients. This should be very interesting given our often high nutrient removal systems and varied opinions on how to manage them. Mind you if this warm dry weather keeps up we will reduce our nutrient removal by default!

Dr Lynne MacDonald - CSIRO

'Beyond Carbon: the functional role of biochar in farming systems'
Lynne's talk will cover what biochar is a how it varies depending on feedstock; how it can be used to address specific soil constraints; and how biochar can be used to bring benefit across both animal production and cropping sectors through integrated use.
This should be interesting, usually when I hear 'biochar' I become very sceptical, after many years of baseless spin from 'witch doctor companies' selling a whimsical dream to growers, with/no science to back up. However, Lynne talks science and discusses the possible benefits and shortfalls of biochar in modern farming systems.

Apologies for the late newsletter

Editors will endeavour to produce timely and error-free newsletters in the New Year.
Best wishes for harvest and the Christmas Season!

Canola tolerance to clethodim

Michael Zerner

Take home messages

- Significant grain yield losses can be caused by clethodim.
- Rates exceeding 500mL/ha significantly increases the risk of losses to yield.
- Applications at early growth stages of canola appear the best to avoid crop damage.
- Variation does exist between varieties across all crop types in their level of sensitivity to clethodim.
- Visual damage symptoms observed throughout development following application. Flower distortion being the most distinguishable.

Background

Clethodim has become a very important herbicide in the control of annual ryegrass in southern Australia. In recent times, label rate changes have occurred to enable higher rates of up to 500mL/ha to be used for increased levels of weed control. This rate increase applies to canola, pulse crops and pasture legumes. Since the use of this higher rate of clethodim, a number of crop effects have been reported, particularly in canola. Observed symptoms include, delayed flowering, distorted flower buds and possible grain yield suppression. Symptoms appear to be more severe from later application timings. Other factors that may influence crop effects include herbicide rate, crop stress at herbicide application and possible varietal differences in tolerance.

Given the widespread importance of the use of clethodim in the farming rotation and increased application rates to achieve acceptable levels of control of herbicide resistant annual ryegrass, it is important to identify the level of crop tolerance to these rates in canola. The level of actual yield losses that may occur from the use of high clethodim rates is relatively unknown.

Trial objectives

This current SAGIT funded project aims to address a series of issues related to the use of clethodim in canola. The first of these objectives is to quantify the impact of clethodim use on grain yield and quality in canola. It is also possible that Clearfield, triazine-tolerant and conventional canola cultivars may respond differently to the herbicide and cultivars within these groups may also have differing levels of crop tolerance. Hence, as part of this project a number of recently released canola cultivars are being screened to identify any differences in varietal tolerance (Trial located at Roseworthy, SA). The influence of crop stage at application and crop stresses such as moisture and temperature are also important factors that need to be investigated. Trials conducted at Hart and Yeelanna are currently underway to examine these factors.

Effect on crop

Applications of clethodim to canola can cause distinct visual symptoms. Observations have included a change in colour of the crop canopy causing the leaves to become paler green in appearance. This colour change was confirmed from SPAD readings showing chlorophyll/leaf greenness became significantly lower as higher rates of clethodim were applied (Figure 1). This symptom was consistent across all varieties tested and generally becomes apparent approximately two-three weeks after application.

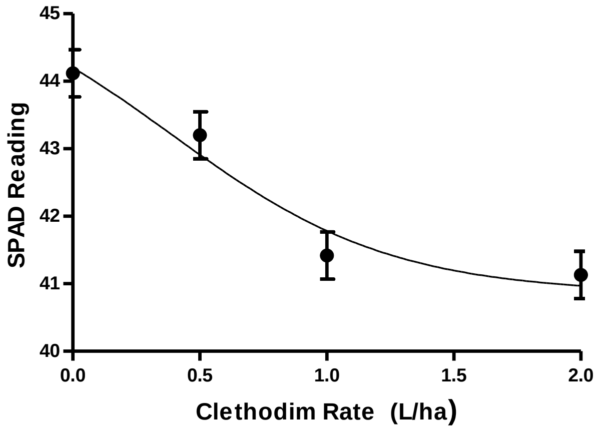

Figure 1. Chlorophyll content (SPAD) of youngest open leaf during stem elongation, following applications of clethodim at the 6-8 leaf growth stage at Roseworthy, SA during 2013.

Flowering and pod development were also severely affected by applications of clethodim. Typically flower buds appear to not fully open which then also impedes pod development. Results from 2013 showed the level of severity of these symptoms varied between herbicide rates and varieties which were reflected in grain yields. Of the varieties tested in this trial AV Garnet appears more tolerant to clethodim than both Hyola 474CL and ATR Gem (Table 1). A larger set of varieties were trialled at Roseworthy, SA during 2013, showing significant variation in clethodim damage across varieties (Figure 2). Some varieties such as AV Garnet showed no yield reduction compared to less tolerant varieties such as CB Tango with its yield reduced by over 20%. Results supported data obtained from the Hart trial with AV Garnet again expressing a higher level of herbicide tolerance. Varieties, Crusher TT and Pioneer 44Y84 also expressed higher levels of tolerance. These trials have been repeated during 2014 to provide confirmation to these initial findings. Clethodim treatments had no impact on biomass production (NDVI), plant height or maturity.

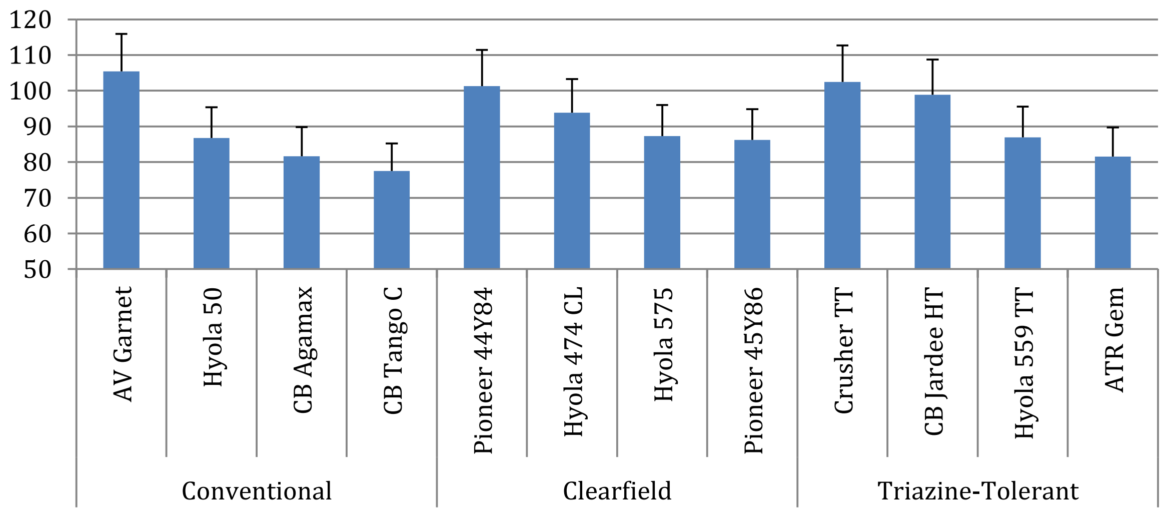

Figure 2. Average grain yields of canola sprayed with 1L/ha of clethodim at Roseworthy, SA during 2013. Yields expressed as a percentage of untreated controls.

Influence of timing

The timing of application has a strong influence on the level of damage that can occur from clethodim. Trials conducted last year showed that earlier applications of clethodim were much safer (Table 1). Results showed significant yield losses at the latest timing (buds just becoming visible), causing up to 40% yield loss depending on variety and rate. The 4-leaf and 8-leaf timings at the label recommended rate of 500mL/ha were relatively safe, but rates exceeding this caused significant yield reductions. Splitting the higher 1L/ha application over two timings resulted in reduced levels of crop damage. From a grower's perspective, a compromise of rates and timings must be taken into account to best control the target weeds. As rates/timings for optimum weed efficacy may increase the risk of crop damage.

Table 1. Effect of clethodim applied at different timings and rates on the grain yield of canola at Hart during 2013. Highlighted values indicate significantly less than untreated ($p<0.05$).

Application timing	Clethodim rate	ATR Gem	AV Garnet	Hyola 474
Untreated		1.11 t/ha	1.37 t/ha	1.69 t/ha
		-----------grain yield % of control-----------		
4 leaf	0.5L/ha	98	99	100
	1L/ha	94	106	96
8 leaf	0.5L/ha	99	104	96
	1L/ha	**87**	106	**87**
4 leaf & 8 leaf split	0.25L/ha + 0.25L/ha	91	102	92
	0.5L/ha + 0.5L/ha	95	103	**91**
Bud initiation	0.5L/ha	**80**	97	**87**
	1L/ha	**61**	**90**	**61**

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Contact details

Michael Zerner, Waite Campus
michael.zerner@adelaide.edu.au

Weed Resistance in the Mid-North region of South Australia in 2013

Peter Boutsalis, Christopher Preston, Gurjeet Gill

Summary: A random weed survey was conducted in the Mid-North region of SA in 2013. Ryegrass, brome, wild oats, barley grass, wild radish, Indian hedge mustard (IHM) and milk thistle seeds were collected. Changes in herbicide resistance between previous surveys in this region to the current survey conducted in 2013 are presented. The most notable change in ryegrass was the doubling of resistance to Intervix and the large increase in resistance to trifluralin. Resistance to the Group B herbicide Atlantis in brome and wild oats increased from 2% to 51% and 0% to 28%, respectively. In barley grass, surveyed for the first time in this region, the incidence of resistance to Atlantis was identified at 53%. These findings suggest that controlling grass weeds with cereal selective Group B herbicides will become increasingly difficult. In broadleaf weeds, resistance to Glean was identified in 25% and 89% of fields that contained IHM and sowthistle, respectively. Wild radish was encountered in two paddocks with both samples also exhibiting resistance to Glean.

Since 2005, the GRDC has funded the University of Adelaide's Weed Science team to conduct random weed surveys across SA and Vic. Different regions are surveyed every year (Figure 1). Each region is surveyed on a 5 year rotation. In the 2013 survey, paddocks were randomly surveyed for weeds every 10 km in mid-November. At each location, the weeds and the crop present were identified and samples of ryegrass, brome, wild oats, barley grass, sowthistle and Indian hedge mustard were collected at least 10m from fence lines. Wild radish was found in four fields; however, seed only two samples germinated.

Seeds from plants that were present at sampling were collected in the surveys. These seeds can originate from resistant survivors, herbicide misses, or late germinators. If resistance is detected, it indicates that that paddock contained resistant individuals. The survey does not provide information on the entire paddock.

Figure 1: Regions surveyed across south-eastern Australia since 2005

Resistance in ryegrass

In 2013, 150 paddocks were surveyed in the Mid-North and Yorke Peninsula. Weeds established from these seed samples were tested in a pot trial in May and June 2014. A weed sample was scored as resistant if 20% or greater survival was detected in the pot test. Where 0 to 19% survival was recorded, this was not scored as resistant.

A significant increase in resistance to trifluralin occurred from 40 to 66% between 2008 and 2013, respectively was identified (Table 1). Continued selection with trifluralin is the most likely cause of the increase in resistance. In comparison no resistance to Sakura or Boxer Gold was detected although a small number of samples are being re-tested.

Changes to the incidence of resistance in ryegrass to the cereal selective Group A herbicides Hoegrass and Axial and sulfonylurea herbicides was minor. However the incidence of resistance to the imidazolinone (IMI) herbicide Intervix almost doubled. This is most likely due to increased selection with IMI herbicides in Clearfield wheat, barley and canola crops that have become increasingly common in the past 5 years, often being used to target other species such as brome. In 2008, 40% of ryegrass samples screened with 250ml/ha of clethodim survived whereas in the 2013 collection only 17% survived the same rate of herbicide with 13% of samples surviving the double rate of 500ml/ha. The greatest incidence of resistance to 250ml/ha clethodim was detected in the lower north in both the 2013 survey (30% survival) and the 2008 survey (61% survival). It is known that a significant increase in control can be achieved with higher rates of clethodim even on clethodim-resistant populations.

Although glyphosate resistance in ryegrass has been confirmed in numerous farmer samples where resistance was suspected, in the random survey resistance was detected in only 1% of paddocks. Detecting glyphosate resistance in a random survey is nevertheless concerning due to the importance of this herbicide.

Table 1. Percent of resistant samples identified in the Mid-North SA region in cropping regions in between the first survey in 1998 and the final survey in 2013. 136 ryegrass samples were collected in 2013 and 246 in 2013. Resistance is represented by samples with ≥ 20% plant survival in pot trials.

Ryegrass	2013	2008	2003	1998
Trifluralin 1500 ml/ha	66	40	49	9
Boxer Gold (2500 ml/ha)	0	-	-	-
Sakura (118 g/ha)	0	-	-	-
Hoegrass 1000 ml/ha	74	76	77	38
Glean 30g/ha	#	73	75	15
Oust 20g/ha	71	-	-	-
Intervix 600ml/ha	83	44	-	-
Achieve 380g/ha	-	64	45	-
Axial 300ml/ha	65	59	36	-
Select 250ml/ha	17	40	31	19
Select 500ml/ha	13	-	-	-
Glyphosate 1000ml/ha	1	0	-	-

A dash represents no testing with this herbicide.

previous studies have shown that ryegrass samples resistant to Oust are resistant to Glean. Additionally a small number of samples can be resistant to Glean and not Oust. For this reason the percentage of ryegrass resistant to Glean would be greater than 71%.

Resistance in brome

Group B resistance in Brome is now prevalent across south-eastern Australia. It was confirmed in 51% of paddocks whereas in 2008 it was only present in 2%. A contributing factor to this large increase in Group B resistance is increased use of Atlantis, Crusader and Monza. The increase in no-till seeding has increased the incidence of brome. Control of brome in conventional wheat is only possible with Atlantis, Crusader and Monza. Continued Group B selection with these latter three herbicides has most likely played a major role in the significant resistance identified to Atlantis in the 2013 collection.

No resistance to Group A herbicides was detected, which was similar to the 2% resistance detected in 2008. This indicates that resistance to Group A herbicides is not likely to increase rapidly as these herbicides can only be used in non-cereal crops. Although three cases of brome resistant to glyphosate have been detected in SA through complaints of poor control, the incidence of resistance remains low and is confirmed by the fact that no resistance was detected in the random survey.

Table 2: Percent resistance in brome (dominated by *B. diandrus*) collected in 2008 and 2013 in the Mid-North SA. 60 brome samples were collected in the 2008 survey and 49 in the 2013 survey. Resistance represented by the percent of individuals with ≥ 20 % survival in pot trials.

BROME	2008	2013
Verdict (75ml/ha)	2	-
Targa (150ml/ha)	-	0
Select (250ml/ha)	0	0
Atlantis (330ml/ha)	2	51
Intervix (600ml/ha)	-	0
Glyphosate (1000ml/ha)	-	0

A dash represents no testing with this herbicide.

Resistance in wild oats

Wild oats were often encountered in both the 2008 and 2013 surveys. However the incidence of resistance to Group A herbicides such as Topik has only been increasing slowly. Possible reasons include being self-pollinating, less seed production per plant and reduced distribution within fields compared to ryegrass are likely contributing factors.

In contrast, where no resistance to Group B herbicides was detected in 2008, 28% of wild oat samples exhibited resistance to Atlantis. The reasons discussed above for the increased Group B resistance in brome are also relevant for wild oats. In situations where resistance to Group A and B resistance occurs, weed control in cereal crops becomes increasingly difficult.

Table 3: Percent resistance in *Avena fatua* & *Avena sterilis* (wild oats) collected in 2008 and 2013 in the Mid-North SA. 107 wild oat samples were collected in the 2008 survey and 71 in the 2013 survey. Resistance represented by the percent of individuals with ≥ 20 % survival in pot trials.

Wild Oats	2008	2013
Topik (85ml/ha)	9	12
Atlantis (330ml/ha)	0	28

Resistance in barley grass

Although barley grass was less prevalent than the three other grass weed species in the 2013 survey, the percentage of samples resistant to Atlantis was 53%. This is the first indication that Group B resistance in barley grass is widespread in the Mid North. These resistant samples exhibited strong resistance with survivors being largely unaffected by the herbicide. In contrast, the Group B resistant brome and wild oats were stunted by the herbicide.

Confirmation of 11 and 5% of samples resistant to the Group A herbicides Targa and Select is also a significant finding. Resistance to Group A and B herbicides (as was encountered in one sample) can make chemical weed control difficult.

Table 4: Percent resistance of 22 *Hordeum spp.* (barley grass) samples collected in 2013 in the Mid-North SA. Resistance represented by the percent of individuals with ≥ 20 % survival in pot trials.

Barley Grass	**2013**
Targa (150ml/ha)	11
Select (250ml/ha)	5
Atlantis (330ml/ha)	53

Resistance in Indian hedge mustard (IHM)

Less resistance to Group B herbicides was detected in IHM in 2013 compared with 2008. Group I resistance in IHM has only been detected in the Port Broughton to Bute cropping region of the mid-North. . The availability of a greater range of alternative mode of action herbicides containing herbicides such as bromoxynil, pyrasulfotole, difufenican and atrazine are likely to have contributed to the reduced incidence of herbicide resistant IHM.

Table 6: Percent resistance in *Sisymbrium orientale* (Indian hedge mustard) collected in 2008 and 2013 in the Mid-North. 63 samples were collected in the 2008 survey and 18 in the 2013 survey. Resistance represented by samples with ≥ 20 % survival in pot trials.

IHM	**2008**	**2013**
Glean (20g/ha)	54	25
2,4-D (650ml/ha)	45	0

Resistance in sowthistle

Since 2009 sowthistle has been collected in our weed surveys. In these collections Group B resistance has been confirmed in at least 80-90% of fields containing sowthistle. The incidence of resistance detected in the 2013 Mid-North survey was 89%. Factors such as the strong selection imposed by Group B herbicides, large numbers of seeds produced per plant, the lack of dormancy, growth all year round and its efficient aerial distribution system have contributed to the dominance of Group B resistant biotypes. Control of milk thistle with Group B herbicides is therefore likely to be poor due to the ubiquitous distribution of Group B resistance.

Testing with 2,4-D and Glyphosate was first conducted in the current 2013 survey samples. No resistance to either was detected suggesting that use of these herbicides can be effective.

Table 6: Percent resistance in 46 *Sonchus oleraceus* (milk thistle/ sowthistle) samples collected 2013 in the Mid North. Resistance represented by the percent of individuals with ≥ 20 % survival in pot trials.

Milkthistle	**2013**
Glean (20g/ha)	89
2,4-D (650ml/ha)	0
Glyphosate (1000ml/ha)	0

Resistance in wild radish

Wild radish is not widely distributed across the Mid-North region. For this reason only 4 samples were encountered. All tested samples were resistant to Glean but not to 2,4-D or Glyphosate. Growers have been encouraged to use alternative mode of action herbicides containing chemicals such as bromoxynil, pyrasulfotole, picolinafen, difufenican and atrazine to prevent further increases in Group B resistance and prevent the incidence of Group I herbicide resistance increasing as has been detected in farmer complaint samples.

Table 7: Percent resistance in two *Raphanum raphanistrum* (wild radish) samples collected 2013 in the Mid North. Resistance represented by the percent of individuals with ≥ 20 % survival in pot trials.

Wild radish	**2013**
Glean (20g/ha)	100
2,4-D (650ml/ha)	0
Glyphosate (1000ml/ha)	0

Acknowledgement: Funding for this research was provided by the GRDC

Photo 1: Effect of pre-emergent herbicides on ryegrass collected randomly in 2013 from the mid-north SA. Left to right – untreated, trifluralin, Boxer Gold, Sakura, untreated, trifluralin, Boxer Gold, Sakura. Significant trifluralin resistance detected.

Photo 2: Effect of post-emergent herbicides on ryegrass collected randomly in 2013 from the mid-north SA. Left to right double trays Intervix, Hoegrass, Axial, Oust (=Glean). Strong resistance detected to all these herbicides

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Photo 3: Effect of post-emergent herbicides on ryegrass collected randomly in 2013 from the mid-north SA. Left to right Glyphosate, Select. Very low level resistance detected.

Photo 4: - Effect of the Group B herbicide Atlantis on barley grass collected randomly in 2013 from the mid-north SA. Significant Group B resistance detected

Photo 5: - Effect of post-emergent herbicides on sowthistle (milkthistle) collected randomly in 2013 from the mid-north SA. Left to right 2,4-D, Oust (=Glean), Glyphosate. Strong Group B herbicide resistance detected.