CROP SCIENCE SOCIETY OF S.A. INCORPORATED

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INCORPORATING THE WEED SCIENCE SOCIETY

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Next Meeting	**'The Coming Season'**
Venue	**Richardson Theatre, Roseworthy Campus**
Date	**WEDNESDAY 27th JUNE**
Time	**7.30 pm**

Speakers

Darren Ray – Bureau of Meterology

'Long Range Weather Forecasting'
What are the long term weather indicators for the rest of the season? Darren will tell us what is happening with long range weather patterns and what this means for the season finish.

TBA by SMS later in the week

Strong Alkalinity in South Australian Soils

James Hall, Principal Soil Scientist, SA Government

Background

A long-term South Australian Government program – the 'State Land & Soil Mapping Program' (1986–2012) – has mapped the characteristics of landscapes and soils comprehensively and consistently across the whole of South Australia's non-arid or temperate zone (traditionally known as the 'agricultural areas'). Over 70 characteristics (or attributes) have been mapped, including the severity of 'watertable-induced salinity', the depth to 'toxic levels of boron', 'surface soil texture', 'plant-available waterholding capacity', 'inherent fertility', 'water erosion potential', 'soil organic carbon' content, 'susceptibility to waterlogging' and soil type. The scale of mapping is 1:50,000 or 1:100,000. This information is documented in the recently released book, *The Soils of Southern SA* [1], and also in the DVD, 'Regional Land Resource Information for Southern SA' [2].

Soil pH has also been mapped. This has been done on the basis of pH categories or classes, viz:

pH Category	pH_{CaCl2}	pH_{H2O}
strongly acid	<4.5	<5.5
acid	4.5–5.4	5.5–6.4
neutral	5.5–6.9	6.5–7.9
alkaline	7.0–8.5	8.0–9.2
strongly alkaline	>8.5	>9.2

These classes take account of important thresholds, namely that of <5.5 pH_{WATER} , at which aluminium derived from the decomposition of clay minerals comes into solution and creates toxicity problems for plants, and that of $>9.2_{WATER}$, where very low root density has been observed at numerous soil description sites across South Australia. Note that two main methods of measuring soil pH are used in Australia, and that these have no known direct correlation. The table above gives a correlation guide.

A pH of >9.2 (strong alkalinity) commonly occurs in subsoils of agricultural soils in the low to moderate rainfall areas, and is typically associated with high levels of boron (>15 mg/kg), very high levels of sodium (ESP >25), abundant finely divided soil calcium carbonate (often >50%), as well as raised levels of salts (ECe >2 dS/m). In general, however, a subsoil pH of >9.2 occurs at the same depth or somewhat higher in the soil profile as an ESP of >25; a boron content of >15 mg/kg occurs at a depth coincident with an ESP of >25 or often lower in the profile; while elevated salinity with an ECe >4 dS/m usually occurs lower again (in the lower subsoil or below). Note that abundant fine carbonate, while always associated with alkaline conditions, is not always associated with strong alkalinity: this is particularly the case in moderate to higher rainfall cropping lands with non-mallee soils, and in upper to mid subsoils. Soil pH tends to increase with depth in SA cropping soils containing fine carbonate. See Figure 2 for an example of a 'mallee' soil with a strongly alkaline subsoil and related toxicities.

The salt (sodium chloride), sodium, boron and carbonate in our soils are largely derived from marine sources, having been deposited with wind-blown soil-forming materials and dust, as dissolved substances within rainfall, and as aerosols. Such substances have largely been leached out of soil profiles in the high rainfall areas. Low to moderate average rainfall conditions and restricted soil drainage (e.g. where a subsoil has formed from Blanchetown Clay or a similar material – see Figure 2) favour the development of strongly alkaline subsoil conditions and the accumulation of toxic levels of associated substances.

Figure 2. A rubbly calcareous gradational sandy loam on Northern Yorke Peninsula (Soil Characterisation site CY038). This is a 'mallee' soil formed from wind-deposited carbonate-rich loess, overlying unrelated Blanchetown Clay equivalent substrate material. (According to *The Soils of Southern SA*, it is an A5 soil). The low permeability substrate restricts deep drainage and increases the likelihood of an abundant accumulation of fine carbonate (causing the whiteish colouration), strong alkalinity and toxicities in the subsoil. Soil pH reaches 9.1 in the 23–38 cm layer and 9.9 in the 68–115 cm layer. Fine carbonate levels reach 27% in the 11–23 cm layer and 60% in the 68–115 cm layer, but decline below this. Boron levels are at 11 mg/kg in the 23–38 cm layer and reach 34 below 100 cm. The exchangeable sodium percentage (ESP) reaches 8 in the 23–38 cm layer and 52 in the 68–115 cm layer (causing both toxicity and structural issues). On the positive side, owing to its restricted drainage and significant clay content, the movement of water and soluble nutrients below the rootzone is minimised. Root growth was observed to 75 cm in the soil pit. Extractable aluminium was not analysed as, at the time, it was thought only to be an issue in strongly acidic soils. However, samples stored in the State Soil Archive are available for reanalysis.

Discussion

A recent article in the Crop Science Society Newsletter (No. 278, May 2012) by Rengasamy and Brautigan described the previously overlooked phenomenon of aluminium toxicity in strongly alkaline soils, which adversely affects plant and crop growth. In soils used for agriculture in South Australia, strongly alkaline conditions only occur in subsoils.

Mapping Information

Below are presented results on the distribution of strongly alkaline soils (pH >9.2) as mapped by the 'State Land & Soil Mapping Program'. Figure 1 shows the distribution and depth to strongly alkaline soil conditions across South Australia's agricultural lands. Lands mapped as native vegetation are shown in dark green. It can be clearly seen from the map that strongly alkaline subsoils are associated with low to moderate rainfall 'mallee' lands and soils.

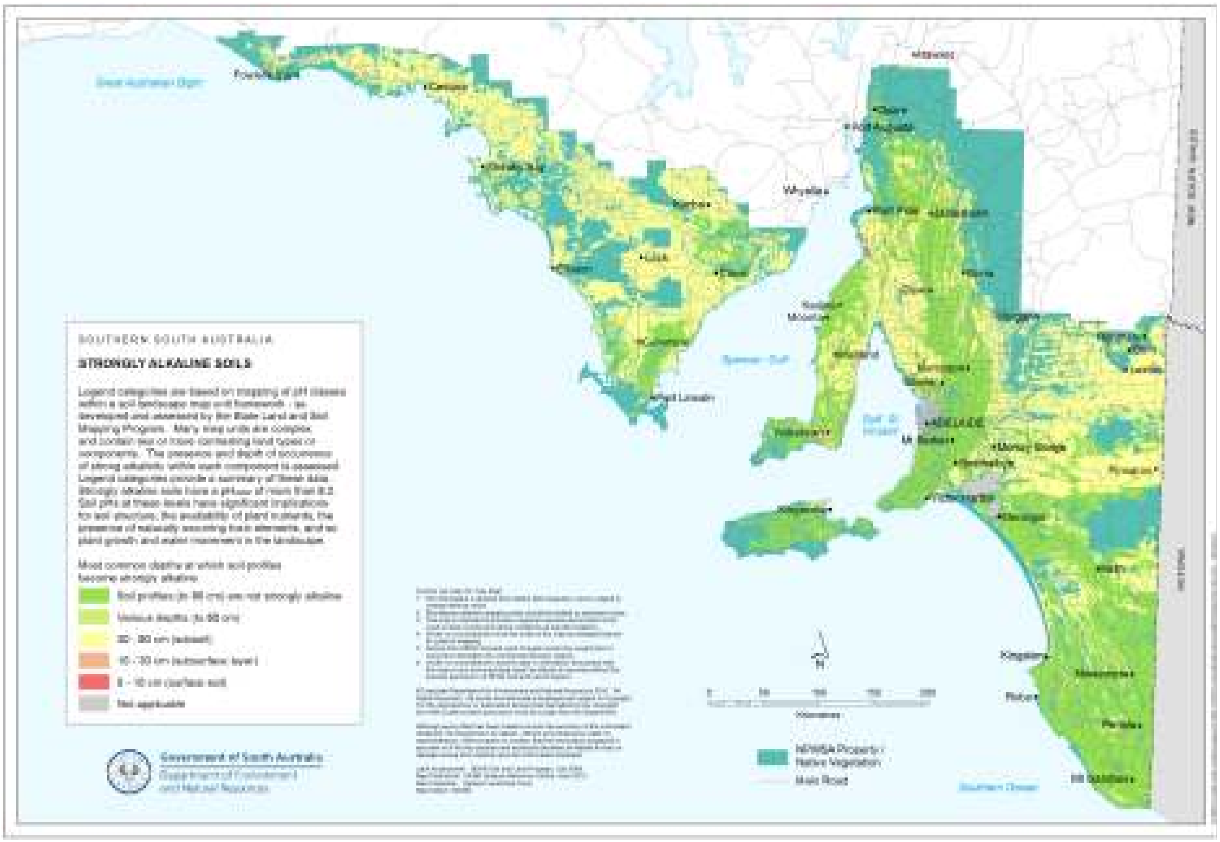

Figure 1. Strongly alkaline soils on agricultural lands in SA: showing distribution and depth to strongly alkaline conditions (highlighting the most common condition in each soil landscape map unit). Green = soil profiles not strongly alkaline above 80 cm; light green = strong alkalinity occurs at various depths to 80 cm; yellow = strong alkalinity between 30 and 80 cm; orange = strong alkalinity between 10 and 30 cm; red = strong alkalinity at <10 cm (saline areas). Dark green = native vegetation. Grey = not applicable areas (e.g. waterbodies).

Data statistics for strongly alkaline soil conditions on agricultural lands are given by NRM Region in Table 1. (A map of South Australian NRM regions can be viewed at www.nrm.sa.gov.au.) Note that areas mapped as native vegetation are not included in these calculations. Two of the regions shown in the table are largely arid (Alinytjara Wilurara and SA Arid Lands), and so have only small extents within the mapped areas. The regions with the greatest occurrence of alkaline agricultural soils are Eyre Peninsula, SA Murray-Darling Basin and Northern & Yorke. On affected lands, the depth to strongly alkaline conditions is mostly between 30 and 80 cm. The roots of most annual crop and pasture plants in most soils do not extend beyond a depth of 80 cm. (The main exception being the deep sands, which generally do not have strong alkalinity, at least in the top 100 cm, owing to rapid drainage and leaching capacity). Strongly alkaline conditions at shallow depths between 10 and 30 cm are uncommon in agricultural soils, while such conditions in the top 10 cm indicate saline land.

NRM Region	Depth to strongly alkaline soil conditions (cm) – hectares of land affected				
	0–10	10–30	30–80	>80	Not applicable
Eyre Peninsula	0	5,880	2,160,600	575,700	110
SA Murray-Darling Basin	0	1,990	1,381,740	1,128,210	99,840
Northern & Yorke	10,900	18,740	785,110	1,287,210	7,320
South East	3,430	7,690	300,510	1,883,070	2,220
Adelaide & Mt Lofty Ranges	0	130	108,210	397,580	64,880
Kangaroo Island	240	2,400	11,130	191,230	3,240
Alinytjara Wilurara	0	0	1,210	0	0
SA Arid Lands	0	0	60	20	0
Totals (hectares)	**14,570**	**36,820**	**4,748,580**	**5,463,020**	**177,600**

Table 1. Data statistics for depth to strongly alkaline conditions on agricultural lands in SA in hectares (figures have been rounded to the nearest 10 hectares). Areas mapped as native vegetation have been excluded from these calculations. Not applicable includes non-soil areas (e.g. waterbodies) and areas not mapped (e.g. the central Adelaide metropolitan area).

Conclusion

As can be seen from these spatial data, strongly alkaline subsoils are common in South Australia's cropping lands. They are associated with a range of toxicities, including aluminium (as has been recently demonstrated by Rengasamy and Brautigan) and, therefore, have significant impact on the water-use efficiency and productivity of agricultural pursuits in South Australia. The newly available data on aluminium toxicity at high pH, in conjunction with the mapping information available through the 'State Land & Soil Information Framework', will help inform the future direction of crop breeding efforts targeting South Australian soils.

Acknowledgements

Thanks to Jan Rowland for extracting the spatial information on strong alkalinity from the attribute datasets stored within the 'State Land & Soil Information Framework'.

Improving the understanding of changes in wheat cost of production and whole farm return on capital across different locations and season types

Barry Mudge, Senior Consultant, Rural Solutions SA

This work was completed under a DAFF project studying resilience of mixed farming businesses under climate change.

Background

Grain production in South Australia occurs over a wide range of climatic zones. This results in wide ranging crop yields with average cereal yields in the more climatically favoured areas ranging up to 4-5 tonne/Ha while more marginal farming country can see average yields down to 1.0 tonne/Ha.

This raises the question of whether the higher yields available to businesses producing wheat in the more favoured regions actually allow these businesses to produce wheat at a lower cost of production (COP) (per tonne) than the less favoured areas. Or are there other compensating factors which allow less favoured areas to compete and how does the ratio of the various costs which make up COP vary across different production zones?

It is also of interest to study COP and, more importantly, return on capital for businesses over a range of season types to establish the different risk profiles applicable to businesses operating in a range of production settings.

At the same time, productivity of different regions changes over time. Climate change is just one of a number of forces which can drive these changes in productivity- technology, variety adaptations, changing input/ output pricing ratios are other potential variations. How, then, does this change in productivity and subsequent adaptation responses reflect in the outcomes for these businesses?

Methodology

Five wheat producing businesses were studied across a production transect varying from highly productive land on Yorke Peninsula (average wheat yield 4.5 tonne/Ha) to marginal cereal growing area in a low rainfall district of the Upper North (average yield 1.3 tonne/Ha). All the businesses studied were selected as being of a size sufficient to achieve good economies of scale and were all regarded as being soundly managed using good agronomic practices. Three of the businesses incorporated livestock into their program with the other two were cropping only.

The two parameters being studied were the cost of production of wheat and return on total assets employed. These were calculated for a range of season types (very poor, below average, average, above average and very good) using yields and input levels as supplied by the participating farmers. Output pricing and input costs were based on February, 2012 levels.

Qualifications and Assumptions

The majority of the businesses operated land in addition to that owned by the operators (either leased or sharefarmed). For the purpose of this exercise, all land was amalgamated irrespective of ownership. The study focussed on the input requirements for the parcel of land under management (labour requirements, machinery etc) and the profitability of that land parcel but had no interest in who actually received the profits.

In calculating cost of production for wheat, certain assumptions and judgements are required in allocating cost items such as overhead costs to the various enterprises. These will always be subject to interpretation. The calculated cost of production for wheat included an allowance for capital tied up in land and machinery. Opportunity cost of capital in machinery was included at 10%, while the current market lease value has been used as the return for land.

Results

It is widely recognised that farmers are effectively operating two businesses- in this case, one business is based on wheat growing (and making a profit from that enterprise) and the other business is based on land ownership and is largely concerned with capital growth of the land asset.

1. *The business of growing wheat*

Given that farmers in the studied regions are almost exclusively aiming their grain output at world markets, their requirement is to keep their cost of production to as low a figure as possible, and hopefully less than what the world market will pay.

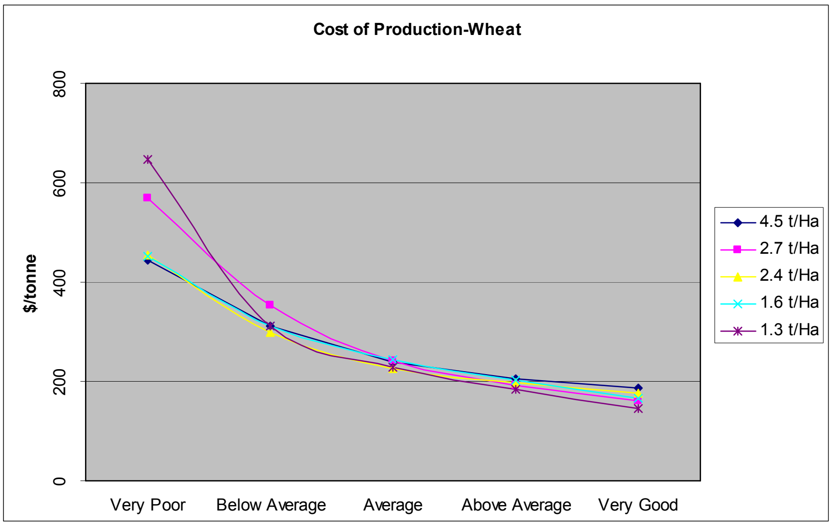

Figure 1. Cost of Production for wheat over different season types for businesses with different average yield expectations

The analysis shows a remarkable consistency in the cost of producing wheat, irrespective of average productivity of the land. COP of wheat at average yields across the various properties varied from $229/ tonne to $244/tonne. However, the ratio of the various costs showed significant change. For the highest yielding farm, the proportion of costs attributable to capital return was markedly higher (31%) with this showing a steady decline across the production zones until only representing 16% on the lower yielding farm.

The significance is that the high productivity is being reflected in land value which then demands a financial return. Low yielding country can compensate up to a point by allowing other cost centres to increase (at the expense of capital return) and still keep COP competitive with higher yielding farms. This effectively reflects in a depressed effect on land values. Eventually, however, if yield continues to drop, there is insufficient margin left in the capital allocation and overall COP will rise. In this case, wheat production is unlikely to continue to be profitable (or competitive) and an alternative use for the land tends to occur (eg broad acre grazing).

All the businesses studied showed a profitable outcome at average yields (refer Figure 2- only the highest and lowest yielding farms included). Return on capital across all studied farms varied from 1.4% to 4.8% at average yields and based on 2012 pricing. The analysis shows just how risky it is to operate in the lower producing farming areas. A series of poor years needs to be countered by a rigorous risk management process.

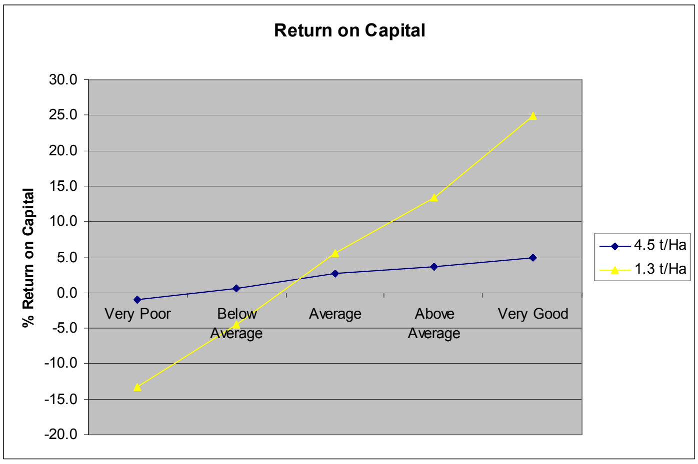

Figure 2. Return on Capital across season types for businesses with different average yield expectations.

2. *The business of owning land*

Table 1 Estimated Change in productivity and land value of different locations since 1990.

Location	Representative Hundred	10 year Wheat Hd av to 90/91	Farmer Estimated Wheat Av 2012	Change	Est Land Value 1990	Est Land Value 2012	Change
Arthurton	Maitland	2.42	4.5	+85%	2200	10400	370%
Snowtown	Barunga	1.83	2.7	+47%	1000	3500	250%
Port Pirie	Pirie	1.46	2.4	+64%	900	3000	230%
Baroota	Baroota	1.07	1.6	+49%	500	1000	100%
Willowie	Willowie	1.60	1.3	-19%	750	750	0%

There have been significant changes in productivity of the study farms over the past 20 years as shown in Table 1.

In general, the higher producing land has increased substantially in productivity, while the lower rainfall land appears to have declined in productivity. Reasons for this are many and are a subject for separate discussion. Importantly though, as shown in the earlier discussion, each of these farms have adjusted to changing circumstances over time and are now operating businesses which are producing wheat at a very similar COP.

- A relatively small climate change induced productivity change is easily overshadowed by other recent changes
- The productivity changes are being captured in land values. The Arthurton farmer has become extremely wealthy just through capital gain. The Willowie farmer's land has not increased in value. The primary effect of a change in productivity is not on profitability, but on wealth creation (within limits)
- There may be increased opportunity for the lower rainfall farmer to expand, due to affordability of land

Conclusions

Summarising the results

- Profitability in lower rainfall areas can be still satisfactory at average yields and is competitive with higher producing regions
- Capital gains from land ownership may be poor if productivity gains remain poor
- Farmers see advantages in land values being held down by lower productivity levels in allowing them to expand their businesses
- Farming systems are very adaptable to change

Risk management focus is very different between higher and lower yielding regions. In high yielding regions, the focus is firmly on productivity and good agronomy. In the lower rainfall areas the risk focus needs to be firmly on methods to limit downside losses in poor seasons without substantially compromising system gains in better years. Flexibility remains the key requirement.

Alternative herbicide control of glyphosate resistant annual ryegrass (*Lolium rigidum*) on fence lines

Patricia Adu-Yeboah, Peter Boutsalis, Gurjeet Gill, Jenna Malone & Christopher Preston

Introduction

Weeds growing freely on fence lines can move into cropping fields and contaminate harvest. They can also serve as alternative hosts to various pests. As a result crop producers prefer to control weeds and other vegetation on their fence lines. Annual ryegrass is one of the weeds that can dominate fence lines of many South Australian cropping fields. Many farmers employ the use of glyphosate in controlling weeds on fence lines, because it is easy to use and costs less than most other herbicides. A consequence of the continuous use of glyphosate has been the evolution of glyphosate resistant annual ryegrass on many fence lines in South Australia, with 53 out of the documented 189 sites with glyphosate resistant annual ryegrass in Australia being fence line situations.

Management of glyphosate resistant weeds on fence lines is important to prevent the resistant plants from moving into cropping fields. In order to identify alternative herbicide controls for growers who prefer a herbicide option to other management practices, the University of Adelaide conducted two field trials to assess the effect of glyphosate mixtures and other herbicide mixtures in controlling glyphosate resistant annual ryegrass on fence lines in South Australia. We also determined how far these resistant weeds had moved into cropping fields from the fence lines.

Methods

Fence line trials were conducted at two sites; Ungarra on the Eyre Peninsula and Hilltown, near Clare. Ungarra had a larger population of annual ryegrass, however both sites had a history of intensive glyphosate use for many years.

The fence lines were divided into subplots and 19 different mixes and rates of herbicides were applied to each subplot using a two metre hand held boom sprayer in a replicated trial. Control was assessed by counting the number of seed heads per square metre.

To determine how far resistant weeds had dispersed into fields, actively growing annual ryegrass were collected at distances of 0, 15, 30 and 50 metres into the fields. They were tested for resistance to glyphosate using a Syngenta Quick Test method. Briefly, the roots and shoots of the plants were trimmed to about 2 cm, planted in pots containing potting mix and new growth treated with glyphosate after 14 days using a laboratory boom sprayer. Survival was assessed 21 days after herbicide treatment.

Results

- The annual ryegrass was more resistant to glyphosate and weed populations were larger at Hilltown compared with Ungarra

- Mixtures containing Roundup PowerMax were not effective in fully controlling annual ryegrass on the fence lines at either site.

- Mixtures containing Spray.Seed, Alliance or Basta were most effective, with less than 10 seed heads m^{-2} recorded at Ungarra. Spray.Seed was more effective where the annual ryegrass population was lower at Ungarra than at Hilltown.

- The double knock application of two treatments of Spray.Seed 14 days apart was the most effective of the currently registered options.

- There are alternative herbicide products available to control glyphosate-resistant annual ryegrass on fence lines. However, these are more expensive than and not as easy to use as glyphosate.

Control of glyphosate-resistant annual ryegrass with alternative herbicides at the Hilltown and Ungarra sites.

Treatment	Ryegrass heads per square metre	
	Hilltown	Ungarra
Untreated	1111 ± 422	271 ± 51
Roundup PowerMax (1L/ha)	1002 ± 191	78 ± 1
Roundup PowerMax (2L/ha)	919 ± 157	61 ± 37
Roundup Power Max (1L/ha) + Amitrole T (6L/ha)	367 ± 76	86 ± 67
RPM Mix A	333 ± 145	71 ± 29
RPM Mix B	642 ± 91	88 ± 54
RPM Mix C	433 ± 10	58 ± 21
Spray.Seed (3.2 L/ha)	172 ± 57	3 ± 3
Alliance (4L/ha)	76 ± 46	3 ± 0
SS Mix A	3 ± 2	1 ± 1
SS Mix B	14 ± 2	5 ± 3
SS Mix C	0 ± 0	3 ± 3
SS Mix D	123 ± 27	15 ± 9
Basta (6L/ha) + Amitrole T (6L/ha)	138 ± 15	1 ± 1
Basta Mix A	33 ± 10	0
Basta Mix B	107 ± 9	0
Basta Mix C	0	0
Basta Mix D	52 ± 26	0
Basta Mix E	23 ± 17	1 ± 1
Spray.Seed (3.2 L/ha) fb Spray.Seed (3.2 L/ha)	27 ± 17	3 ± 3

At both sites, resistant ryegrass plants were found at each distance collected, included the furthest distance of 50 metres into the crop. This suggests the possible movement of glyphosate resistant annual ryegrass from the fence lines into the crop. Glyphosate-resistant annual ryegrass on fence lines needs to be managed, as it can easily spread at least 50 metres into cropped areas.

Fence line trial showing different herbicide treatment plots with varying efficacy

GLYPHOSATE RESISTANCE IN NON-CROPPING AREAS OF AUSTRALIA

Jenna Malone, Tony Cook, Hanwen Wu, Abul Hashem, Peter Boutsalis and Christopher Preston

Glyphosate is the most widely used herbicide for weed control in Australia, in both agricultural and non-agricultural situations. While glyphosate resistance has occurred at numerous sites in agricultural systems in Australia, it has also begun to appear in a number of non-agricultural settings including road sides, railway rights-of-way and irrigation channels. Glyphosate resistance in these non-crop areas, in addition to causing immediate impacts, has the ability to spread into other areas and cause management difficulties elsewhere. Herbicide resistance in non-agricultural situations has not been reported often and little is known about the risks of herbicide resistance evolving in these areas.


Glyphosate resistant weeds occur in patches on road sides where glyphosate is the only weed management strategy used. Left: glyphosate resistant annual ryegrass in a water channel along a road. Right: glyphosate resistant windmill grass on the edge of a roadside.

A physical survey of areas likely to be at high risk of glyphosate resistance was conducted across Australia to obtain a better understanding of the extent of glyphosate resistance in non-cropping areas. Surveys were conducted in Western Australia, South Australia, Victoria, New South Wales and Queensland and involved driving along major roads and highways and collecting weed species present on the roadsides, along railway right-of-ways and around buildings or irrigation channels. Four different weed species were targeted in the survey: annual ryegrass (*Lolium rigidum*), fleabane (*Conyza bonariensis*), windmill grass (*Chloris truncata*), and barnyard grass (*Echinochloa colona*).

More than 400 samples of whole plants or seed of the four species were collected from SA, NSW, QLD, VIC and WA. Resistance was identified in all four weed species. High frequencies of glyphosate resistance were identified in annual ryegrass and fleabane, where more than 50% of populations contained high numbers of resistant individuals. Resistance was identified in all states surveyed.

Glyphosate resistance was found to occur in all non-agricultural areas surveyed. Roadsides, often adjacent to crops, were where a majority of the resistant samples were from. However, resistance was also identified along irrigation channels, railway rights-of-way and around buildings, such as silos.

Summary of the location and number of populations collected, and number of qlyphosate resistant populations for each species collected from the non-cropping area survey.

Species	Location	No. collected/ No. resistant	Total	Resistan t (%)
L. rigidum	NSW	75/37	186	50%
	SA	54/41		
	WA	57/15		
C. bonariensis	QLD	9/7	84	52%
	NSW	41/31		
	VIC	14/0		
	SA	12/6		
	WA	8/0		
E. colona	QLD	1/1	9	33%
	NSW	8/2		
C. truncata	Vic	65/6	150	7%
	WA	22/1		
	SA	6/0		
	NSW	55/1		
	QLD	2/0		

Fleabane populations sprayed with glyphosate showing susceptible and resistant individuals

This study has demonstrated there is a large amount of glyphosate resistant weeds in non-cropping areas. These resistant weeds need to be controlled by other weed management techniques. Glyphosate resistant weeds evolve wherever there is intensive reliance on glyphosate for weed control and few or no other weed management practices used. Glyphosate resistant weeds in non-agricultural areas have the potential to spread into nearby agricultural production areas and vice versa. Effective management of glyphosate resistant weeds in non-agricultural areas will reduce this risk.

George Grey, later to become the 3rd Governor of South Australia was wrecked on the Western Australian coast north of Geraldton so he and his party were forced to walk to Perth. Below are extracts from his subsequent publication outlining his observations on of Indigenous Agriculture.

Journals of Two Expeditions of Discovery in North-Western and Western Australia,
During the years 1837, 38, and 39,
By George Grey Esq,
Governor of South Australia,
London 1841

The course I pursued was one of 180°, and we soon fell in with the native path which we had quitted yesterday; but it now became wide, well beaten, and differing altogether, by its permanent character, from any I had seen in the southern portion of this continent. For the first five miles we traversed scrubby stony hills, thickly wooded with banksia trees; but the limestone here again cropped out, and we entered a very fertile valley, running north and south, and terminating in a larger one, which drained the country from east to west. This valley is remarkable as containing one Xanthorrhea (grass-tree); being the farthest point to the north at which I have found this tree. In it also was a gigantic ant's nest, being. the most southerly one I had yet seen. All these circumstances convinced me that we were about to enter a very interesting region.

And as we wound along the native path my wonder augmented; the path increased in breadth and in its beaten appearance, whilst along the side of it we found frequent wells, some of which were ten and twelve feet deep, and were altogether executed in a superior manner. We now crossed the dry bed of a stream, and from that emerged upon a tract of light fertile soil, quite overrun with warran plants, [The Warran is a species of *Dioscorea*, a sort of yam like the sweet potatoe. It is known by the same name both on the east and west side of the continent.] the root of which is a favourite article of food with the natives. This was the first time we had yet seen this plant on our journey, and now for three and a half consecutive miles we traversed a fertile piece of land, literally perforated with the holes the natives bad made to dig this root; indeed we could with difficulty walk across it on that account, whilst this tract extended east and west as far as we could see.

It was now evident that we had entered the most thickly-populated district of Australia that I had yet observed, and moreover one which must have been inhabited for a long series of years, for more had here been done to secure a provision from the ground by hard manual labour than I could have believed it in the power of uncivilised man to accomplish. After crossing a low limestone-range, we came down upon another equally fertile warran ground, bounded eastward by a high range of rocky limestone hills, luxuriantly grassed, and westward by a low range of similar formation. The native path, about two miles further on, crossed this latter range, and we found ourselves in a grassy valley, about four miles wide, bounded sea wards by sandy downs. Along its centre lay a chain of reedy fresh water swamps, and native paths ran in from all quarters, to one main line of communication leading to the southward.

In these swamps we first found the *yun-jid*, or flag (a species of *typha*), and the sow-thistle of the southern districts; one we came to was a thick tea tree swamp, extremely picturesque, and producing abundance of these plants, some of which were collected by the men to eat in the evening. …………to obtain a sufficiency of food, even for a native, requires in Australia a great degree of skill and knowledge of the productions of the country; but for a European, utterly unaccustomed to this species of labour, and totally unacquainted with the productions of the land, to obtain enough to support life for any period, whilst, at the same time, he has to search for water, is quite impossible.

We still found many native paths running along the estuary, and saw the natives fishing, but they carefully avoided us making off for the high lands as fast as they could. The estuary became narrower here, and shortly after seeing these natives, we came upon a river running into it from the eastward; its mouth was about forty yards wide, the stream strong, but the water brackish, and it flowed through a very deep ravine, having steep limestone hills on each side: many wild fowls were on the river, but we could not get a shot at them. Being unable to ford the river here, we followed it in a S.E. direction for two miles, and in this distance passed two native villages, or, as the men termed them, towns,- the huts of which they were composed differed from those in the southern districts, in being much larger, more strongly built, and very nicely plastered over the outside with clay, and clods of turf, so that although now uninhabited, they were evidently intended for fixed places of residence. This again shewed a marked difference between the habits of the natives of this part of Australia, and the south-western portions of the continent; for these superior huts, well marked roads, deeply sunk wells, and extensive warran grounds, all spoke of a large and comparatively speaking resident population, and the cause of this undoubtedly must have been, the great facilities for procuring food in so rich a soil.

Finding water in some degree revived their spirits, and I contrived to get them to proceed seven miles' more before night-fall, the way being over sandy open plains very favourable for walking. We passed a large assemblage of native huts, of the same permanent character as those I have before mentioned: there were two groups of those houses close together in a sequestered nook in a wood, which, taken collectively, would have contained at least a hundred and fifty natives.