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Next Meeting	**'Agriculture with an international flavour'**
Venue	**Richardson Theatre, Roseworthy Campus**
Date	**WEDNESDAY 21st AUGUST**
Time	**7.30 pm**

Speakers

Hermann Leithold: Agri Con (Germany)

Agri Con specialize in precision agriculture products, N sensors, guidance and machine control, prescription mapping products and a new product H sensor, which identifies different weeds within a growing crop.

Second Speaker TBA

We are most grateful to Peter Boutsalis and Kenton Porker for agreeing to join the panel producing our newsletter. With their backgrounds it will be possible to present a more comprehensive coverage to the weeds and crop adaptation articles,which are really the most important continuing topics that we cover. Both have been consistent supporters and contributors so we delighted that they have agreed to take responsibility for these sections!

SMS DISASTER!!! Sorry if you failed to receive your SMS reminder this week, we have lost most of the numbers. If you want to continue receiving SMS from CSS then give your number to Tony or Susan…PLEASE!!

Pulse Varietal Herbicide Tolerance – 2012 Results

Michael Zerner, SARDI, (08) 8303 9479, michael.zerner@sa.gov.au, Rob Wheeler, SARDI, (08) 83039480, rob.wheeler@sa.gov.au, Larn McMurray, SARDI, Clare, (08) 8842 6265, larn.mcmurray@sa.gov.au

Key Outcomes from 2012

- Group C post-sowing pre-emergent herbicides were the most damaging herbicides in lentils and Nipper was the most sensitive variety.
- Chickpea variety, CICA0857 was found to be more sensitive to Broadstrike (flumetsulam) than the other varieties tested, incurring an 11% yield loss when applied at the label recommended rate and timing.
- No significant yield reductions were found from any herbicide treatment in all field pea varieties evaluated.

Treatments

A series of trials were conducted in 2012 to assess the herbicide tolerance of six varieties of field pea, three varieties of chickpea, and six lentil varieties at the Minlaton central YPASG site. A range of commonly used herbicides and tank mixes were applied at label recommended and higher than recommended rates to provide information on varietal tolerances and safety margins. This was achieved through observing differential responses between the two rates and an unsprayed control. Field plots were also assessed for biomass and phytotoxicity symptoms using a Greenseeker to measure the NDVI (Normalised Difference Vegetative Index). Grain yield was also recorded and results were analysed using spatial analysis techniques (REML).

Lentil

Table 1: *2012 Lentil yields under common in-crop herbicide applications, expressed as a % of control. Highlighted values represent significant yield reductions (P<0.05).*

		PBA Ace	PBA Blitz	PBA Flash	PBA Herald XT	PBA Jumbo	Nipper
Control	**(t/ha)**	2.76	2.35	2.46	2.11	2.43	2.31
Broadstrike®	**25 g/ha**	98	97	100	101	101	94
(4 leaf)	**50 g/ha**	98	98	103	105	101	98
Brodal®	**150 mL/ha**	101	96	99	101	96	99
(4 leaf)	**300 mL/ha**	97	96	**90**	105	101	98
Diuron	**1 L/ha**	98	99	106	97	104	99
(PSPE)	**2 L/ha**	100	103	103	97	99	96
Metribuzin	**280 g/ha**	99	92	93	98	97	94
(PSPE)	**560 g/ha**	**59**	**57**	**51**	**62**	**68**	**42**
Simazine	**1.5 L/ha**	95	103	95	98	93	**87**
(PSPE)	**3 L/ha**	**85**	**82**	**87**	**82**	**80**	**60**
Terbyne®	**1 kg/ha**	99	100	102	94	102	91
(PSPE)	**2 kg/ha**	**87**	**84**	**85**	**74**	93	**69**

Newly released cultivars PBA Herald XT and PBA Ace (CIPAL803) were introduced in 2012 herbicide tolerance trials, whilst cultivars PBA Blitz, PBA Jumbo, PBA Flash and Nipper remained from the previous year.

Of the cultivars tested during 2012, very few showed any significant grain yield loss at recommended label rates (Table 1). Only Nipper appeared sensitive to simazine, incurring a 13% yield when applied at a rate of 1.5 L/ha. Despite simazine not being registered for use in lentils, no other cultivars suffered any significant yield loss at this rate. All Group C herbicides tested including, metribuzin, simazine and Terbyne, caused significant reductions in yields of all cultivars at higher rates, indicating a narrow safety margin for the use of this group of herbicides in lentils. Of these herbicides metribuzin was the most damaging with up to 58% yield reduction in Nipper at twice the recommended rate. Nipper is known for its sensitivity to Group C herbicides and this field experiment supports this, as in most of these herbicide treatments Nipper incurred the greatest yield penalty. Amongst the other cultivars evaluated there is no clear trend in their level of sensitivity to the Group C chemistry.

All cultivars except PBA Herald XT had significant levels of visual damage through phytotoxicity and/or biomass reductions in response to application of Brodal (diflufenican). All cultivars recovered without sustaining significant yield reductions except PBA Flash, where it was found to be sensitive at twice the recommended rate. Interestingly, Broadstrike (Flumetsulam) was found to be safe on all cultivars tested during 2012. PBA Herald XT has improved tolerance to Broadstrike than other cultivars (as shown in trials by the Southern Region Pulse Agronomy program) but this was not evident here due to the lack of plant damage observed in these particular trials.

Chickpea

In 2012, the small kabuli variety Genesis 090 was tested as in previous years as well as the newly released desi variety, PBA Striker (CICA0603) and CICA0857 (early flowering medium sized kabuli), which is scheduled for release in 2014. Genesis 090 has now been evaluated in herbicide tolerance experiments for nine years. In the 2012 trial it was found to suffer an 8% and 11% significant yield reduction in response to the recommended label application of Outlook (di-methenamid) and simazine respectively (Table 2). This was the first time either of these herbicides have resulted in significant yield losses at label recommended rates.

Table 2: *2012 Chickpea yields under common in-crop herbicide applications, expressed as a % of control. Highlighted values represent significant yield reductions (P<0.05).*

		Genesis 090	**PBA Striker**	**CICA0857**
Control	**(t/ha)**	2.05	2.36	2.31
Balance® (PSPE)	**100 g/ha**	104	102	102
	200 g/ha	100	101	100
Broadstrike® (4 branches)	**25 g/ha**	98	96	**89**
	50 g/ha	98	96	**89**
Metribuzin (PSPE)	**280 g/ha**	98	104	103
	560 g/ha	98	**89**	98
Outlook® (IBS)	**1 L/ha**	**92**	102	96
	2 L/ha	92	94	99
Simazine (PSPE)	**1.5 L/ha**	**89**	104	102
	3 L/ha	**85**	94	98
Terbyne® (PSPE)	**1 kg/ha**	100	100	102
	2 kg/ha	92	**88**	91

The newly released variety, PBA Striker was found to slightly more sensitive to metribuzin and Terbyne (terbuthylazine) than the other varieties tested but not the other Group C herbicide Simazine. PBA Striker incurred significant yield reductions at higher than recommended rates of these herbicides, but yield was unaffected at label rates. Therefore care should be taken when using high rates of metribuzin and Terbyne applied to PBA Striker however further data is required to confirm these interactions.

The unreleased variety, CICA0857 was identified as having a significantly lower tolerance to Broadstrike (flumetsulam) than Genesis 090. An 11% yield loss was found when Broadstrike was applied at the label recommended and higher rates in this line. Broadstrike can be damaging in chickpeas and as both other cultivars tested showed no grain yield effects at either herbicide rate, it would suggest CICA0857 is less tolerant. Visual symptoms and NDVI readings support the yield data, as more severe plant stunting was observed in this cultivar and it had a significant reduction in biomass compared to the control. As this is the first year of testing of this variety further testing is required to confirm these findings.

Field Pea

During 2012, six field pea varieties were assessed for herbicide tolerance. This included PBA Gunyah, PBA Oura and Kaspa as tested in previous years. Newly released variety, PBA Pearl (OZP0819) and potential new releases OZP0805 and OZP1101 were assessed for the first time during 2012. Unfortunately no significant herbicide*cultivar interaction was found, therefore there is no statistical significant difference between any of the cultivars and herbicides evaluated. Despite this, the grain yields in Table 3 can be used to identify the degree of safety of the herbicides tested but is difficult to draw conclusions on varietal sensitivity. Therefore the long-term summary should be used to identify any specific herbicide and variety interactions.

Table 3: *2012 Field pea yields under common in-crop herbicide applications, expressed as a % of control. Highlighted values represent significant yield reductions (P<0.05).*

		PBA Gunyah	Kaspa	PBA Pearl	PBA Oura	OZP0805	OZP1101
Control	**(t/ha)**	3.31	3.15	3.61	3.14	3.22	3.47
Broadstrike®	**25 g/ha**	96	99	95	98	99	102
(4 node)	**50 g/ha**	96	97	88	99	98	99
Brodal® + MCPA	**125 + 125 mL/ha**	97	98	98	95	97	103
Amine (4 node)	**250 + 250 mL/ha**	98	88	99	91	95	102
Diuron	**1 L/ha**	95	93	104	95	104	100
(PSPE)	**2 L/ha**	96	96	95	96	101	100
Metribuzin	**280 g/ha**	93	97	99	100	94	92
(3 node)	**560 g/ha**	88	87	95	99	78	97
Outlook®	**1 L/ha**	101	99	93	93	93	98
(IBS)	**2 L/ha**	98	99	94	91	88	99
Raptor®	**45 g/ha**	100	103	93	103	101	106
(3 node)	**90 g/ha**	97	99	89	91	96	102
Simazine	**1.5 L/ha**	94	96	91	95	92	86
(PSPE)	**3 L/ha**	83	89	80	96	88	79
Terbyne®	**1 kg/ha**	101	100	97	105	102	102
(PSPE)	**2 kg/ha**	91	99	90	99	98	95

Of the herbicides tested simazine (applied PSPE) and metribuzin (applied 3-node) were the most damaging during 2012. Across all cultivars simazine significantly reduced yields at both rates used in this study. The average grain yield loss was 8% at 1.5 L/ha and 14% at 3 L/ha. Simazine also caused significant levels of biomass reduction, hence this herbicide is not registered for use in field peas. Metribuzin caused significant reductions in crop biomass at both rates, but through crop recovery only the high rate caused a significant 9% yield loss across all cultivars. Although no statistical differences between varieties, PBA Oura showed a trend of increased tolerance to metribuzin, which supports previous year's results.

Conclusion and into the paddock

This research has shown pulse varieties can differ substantially in their sensitivity to important selective herbicides when applied at registered label rates and timings. Therefore it becomes important to check the safety of various herbicide and variety combinations prior to sowing and spraying. Long-term summaries should also be used to identify herbicide and crop varietal combinations for potential grain yield penalties, as herbicide tolerance is strongly influenced by seasonal conditions. Information pertaining to varieties, which have been tested in one year only, should be treated with caution pending further trials over multiple growing seasons. Long-term summaries of herbicide tolerance testing for all crops can be found online from the NVT website (www.nvtonline.com.au).

Acknowledgements

SARDI New Variety Agronomy Groups based at Clare and Waite are greatly acknowledged for their support in management of the trials. This project is jointly funded by GRDC and the South Australian Government and is supported by cooperating farmers (Bruce Cook and Michael Richards, Minlaton).

Scattered Trees
(acknowledgement to Ron Bird of Hamilton, Vic)

In previous newsletters we have been following the debate around water usage and erosion, contrasting seeding with discs into tall standing stubbles, and the Indigenous land management techniques involving the creation and preservation of swamps and pools.

At the time of European settlement, significant areas in Australia were dominated by large scattered trees, eg the valleys of the Mt Lofty Ranges and surroundings. Extensive examples of this type of landscape still persist in the Eden Valley area and eastern hills and in the SE. These trees can be massive, maybe 40m in height and many have been 'hollowed out by fire'. Elsewhere there were open plains, hence the Grace and Pinkerton Plains.

Gammage, defining the term plain, p8 quotes Govett (1832),
"the park-like forests of this country are relieved in many parts by plains, ... entirely destitute of timber. ...... some are hilly and undulating, while others appear a mere flat, ... and the generality of them possess a good soil."

Whether we are considering either tall standing stubble or large trees in a Kangaroo Grass sward, the effect of these on wind speed and thereby evapotranspiration becomes a matter of interest. While there have been quite extensive investigations of the effects of shelter belts on stock and plant growth, reports on the wind speeds modified by large trees are uncommon. My interest in this topic was heightened by a conversation with Nicholas Van Den Berg, current President of the Agricultural Science students association, who remarked that in his region, pastures growing between interspersed trees remained green for longer than those in open paddocks. Ian Nuberg suggested that Rod Bird, previously at Horsham Research Station was the expert, and he not only confirmed Nicholas's observation, but has supplied key information for this article.

An issue of the Aust. J. Expt. Agr. vol 42 was devoted to a comprehensive documentation of investigations on the effects of shelter belts. Animals are the clearest beneficiaries of shelter, especially lambs, and Bird has elsewhere described the advantages of a strip of tall wheat grass in sheltering lambing ewes.
Pasture growth is suppressed, especially in dry seasons at a distance from the base of the shelter belt equal to its height, and, in at least some circumstances, improved pasture growth has been measured for some distance further away. Reductions in wind speed can be measured at many times (eg 20x) the belt's height. Also, there is the observation that maybe half of the evapotranspiration in that area is actually evaporation from the soil surface. No doubt this figure may not be relevant to current seeding into standing stubbles!

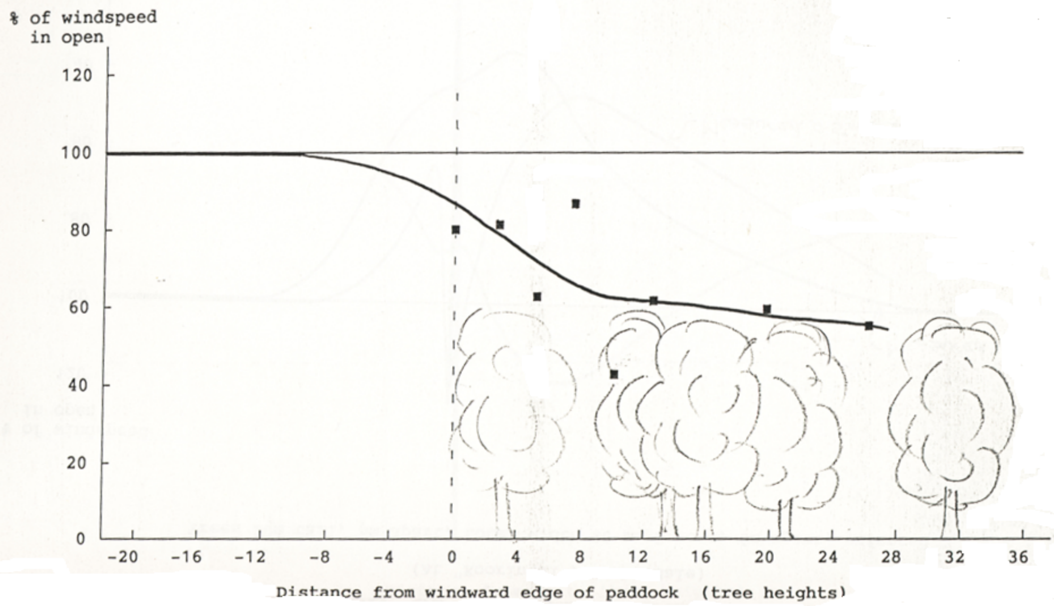
The accompanying diagram comes from a short report 'Preliminary Shelter Belt Wind test results in existing mature random spaced open Woodlands' by M Knight (of RMIT) presented at a 'Land Care Futures' seminar in 1989. It suggests that a fairly dense stand with only 21% tree canopy cover may decrease wind speed by half.

Generally the effects of windbreaks have been measured by strategically located anemometers, adequate for strong winds, but their predictive value may be inadequate for catastrophic winds. On June 6, 2003 on the Murray Plains, an atmospheric inversion layer directed the wind down, not only on a landscape scale causing maximum damage some 6 to 8 km from the range, but also on a local scale. On a NS fence, sand and debris accumulated up to the second lowest wire. About 4m on the east side (lee) in the crop was a gouge line where the wind had again been directed downwards by the inversion layer. Events such as that in 2003 occur maybe only decades apart, but cause important erosional events in the longer term. These are not, however, subject to current scientific analysis despite their importance in longer term productivity of the land.

Table 5: WIND REDUCTION OF MATURE RANDOM RED GUM PADDOCK

(At "Vasey Farm", Balmoral)

Mature trees approx. 20m tall, random spaced. Average 17 stems/hectare, canopy cover 21%



Alkaline Soils Workshop
Ehsan Tavakkoli

The workshop was held at the Waite campus of The University of Adelaide, on Thursday 27 June 2013 with 65 people attending which included consultants, researchers and students. The workshop received support from Australian Society of Soil Science and was co-sponsored by the Waite Research Institute and GRDC. The purpose of the workshop was to review the current knowledge about alkaline soils and their limitations as a means of identifying ways of improving productivity on these soils. The program covered soil chemistry, soil pedology, soil biology, plant nutrition, breeding and agronomy. This article summarises the proceedings of the workshop at each category and highlights the knowledge gap and recommended future research.

Summary and general recommendations from the workshop

Soil mapping and pedology

Soil types can change quickly over relatively short distances. There are problems with the current system of soil classification that hinder their use by agronomists and land managers. The formation of alkaline sodic soils may occur more rapidly than is commonly thought: under the right conditions irreversible change to alkaline, sodic soils can occur rapidly over relatively short distances. These changes occur on localised 'reaction zones'.

<u>Gaps and further work</u>

- Further work to understand the chemistry of the reaction zones where soil degradation occurs
- There is need to improve the existing pedological classification of the major kinds of sodic alkaline soils in Australia and develop a non-pedological soil classification systems (simpler and more accessible) for use by land managers and agronomists
- There is a need for an accurate map of sodic alkaline soils.

Breeding

While cereal breeders do not currently select for yield on alkaline soils specifically, there was a general recognition that overcoming many of the constraints of alkaline will require a breeding solution. Genetic variation for a number of traits such as bicarbonate tolerance, tolerance to Al at high pH, is still unknown and the agronomic value of greater tolerance the soil limitations still has to be assessed.

Diagnosis of micronutrient limitations

Alkaline soils have a range of nutritional problems but the reliability of many of the diagnostic tools (soil and plant tests) is still far from satisfactory. It was generally felt that plant testing was more satisfactory that either grain or the current soil tests for most micronutrient deficiencies. Data are available through ASRIS on the micronutrient concentrations in soils at a 250m resolution which could be used to produce maps of soil properties and which could assist with risk management on alkaline soils.

<u>Gaps and further work</u>

- Critical evaluation of the published critical levels and the effects of other stresses on critical levels
- Training and education of practitioners on understanding and interpretation of tissue analyses
- Extending the risk analysis approach currently being conducted by IPNI and funded by GRDC by mapping the micronutrient levels in soils using the ASRIS data base.
- What are the top elemental toxicities that might give robust tolerance to a range of alkaline soils? HCO^{-}_{3}/CO^{-2}_{3}, B or Al?
- Multiple stress tolerance is poorly understood in alkaline soils. There is often combined ionic stresses (deficiencies and/or toxicities) as well as drought and heat stress, future breeding should incorporate the interaction of multiple stresses

Agronomy

The response of crops to the constraints of alkaline soils varies spatially and seasonally which can make empirical research difficult. Genetic solutions to some of the problems are considered important but there is debate as to the most appropriate traits to target. The importance of subsoil amelioration to improve productivity is well established. Significant and sustainable yield improvements are possible by improvements in the nutrient and organic matter levels in the subsoil. The challenge is to translate these into commercial practice.

Gaps and further work

- A better understanding of the GxExM interaction on alkaline soils
- The use of simulation modelling of root growth to assess effects of environmental conditions and management
- Development of economically viable means of subsoil amelioration
- Genetic solutions shows promise but the current knowledge is poor

Summary of presentations

1. Rengasamy

   While soils with a pH >7 are classified as alkaline, the problems of alkaline soils do not develop until much higher pH values (>8.5). pH of alkaline soils is affected by the ionic composition of the dominant salts in the soil and the type of anion can have important influences on soil pH and subsequently on the chemical and physical properties of soils. The presence of sodium bicarbonate can drive pH above 8.5 and sodium carbonate above 9.5. These high pH values affect the speciation of ions which influences their phyto-availability leading to both nutrient deficiencies and toxicities. At pH > 9 Ca^{2+} and Zn^{2+} concentrations decline to deficient levels, and $Al(OH)_4^-$ increases leading to aluminium toxicity. As well dissolved organic C increases and becomes increasing mobile in the soil.

   Areas of further research

   - Speciation and chemistry of Zn and Al at high pH and their effects on plant growth
   - The importance and effects of Ca and Mg deficiencies at high pH (>9)

2. Rob Fitzpatrick

   About 30% of Australia's cropping land has alkaline soils. Characterising soil catenary sequences has highlighted that soil properties can change quickly over short distances in the landscape. Contrary to widespread belief, the formation of sodic alkaline can occur quite rapidly (within years) and the formation of these soils is associated with the flow of water and salts through the landscape. The formation of sodic alkaline soils can be irreversible. Changes in soil properties that lead to the formation of alkaline sodic soils occurs in localised reaction zones where the potential for erosion increases and the development of a hostile soil environment reduces productivity. The formation of these zones are associated with drainage through the landscape and are present in valleys in the mid North, through the Adelaide Hills and in the South east.

   Areas of further research

- An improved understanding of the chemistry of the reaction zones
- The existing method of pedological classification has limitations for land managers. There is a need to develop a non-pedological method of soil classification for land managers and agronomists. This has been done successfully in for the wine industry and could be extended to broadacre farming

3. Tang

   There is a variety of potential nutritional problems in alkaline soils including the direct effect of high pH as well as deficiencies of phosphorus and many micronutrients as well as toxicities of boron. While a number of plants can tolerate high pH (~8), the presence of bicarbonate can have a marked effect on plant growth over and above than of pH alone. However there has been relatively work done on the effects of bicarbonate. The form of N (nitrate, ammonium) can also influence how plants respond to high pH. There is considerable diversity among plant species in their ability to grow and access nutrients on alkaline soils. The different strategies that plants possess to cope with the nutritional problems of alkaline soils can be exploited by practices such as intercropping to overcome the low availability of some nutrients

Areas of future research

- The effects of bicarbonate on plant growth
- The use of cropping systems (rotations, relay cropping and intercropping) to improve nutrient availability on alkaline soils
- Genetic diversity in adaptation to alkaline soils
- N management and pH changes on alkaline soils
- Fe*P interactions deserve further study

4. Gupta

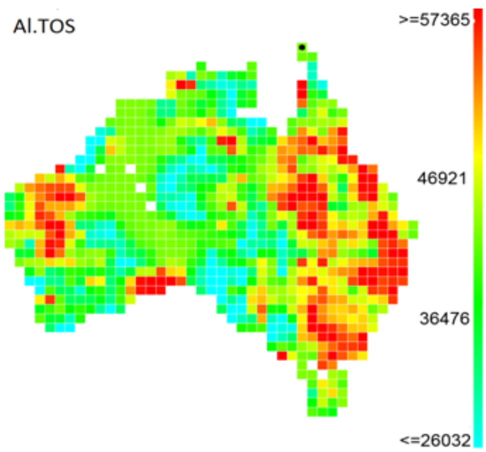
Productivity on alkaline soils is limited by a number of interacting chemical and biological limitations. Removing the microbial constraints to growth can improve yield, but the full benefit of this will only be achieved if there is an adequate supply of nutrients. Alkaline soils have a number of characteristics, such as high pH, high bicarbonate and high salinity that are hostile to microbial communities. Consequently in many soils microbial communities that are adapted to these soils have developed and the genetic and functional diversity found in alkaline and calcareous soils are frequently lower than in less constrained soils. This is often associated with greater susceptibility to soil borne disease: fungal diversity may be high but there is a high proportion of fungal pathogens. Management practices that can alleviate some of these constraints, even in the short term, can help to improve soil biological activity and benefit plant growth.

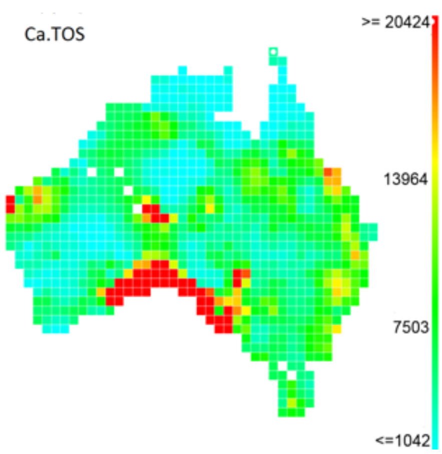
Areas for future research

- What is the level of genetic and functional diversity among soil microbial population
- What are the major factors in alkaline soils that influence community diversity

5. Norton

Surveys of grain nutrient concentrations, soil tests and soil mapping have been used to identify potential micronutrient problems in major soil types and crops. On the alkaline and calcareous soils, the main risks are deficiencies of zinc, manganese (on highly calcareous soils). While there were some concerns about the value of grain analysis (as opposed to leaf analysis) the general consensus was that within the limitations of time and resources the results of the project were useful to help assess risks of micronutrient deficiencies. Data on soil micronutrient concentrations (B, Cu, Zn and Mn) are presently available in the ASRIS data base and there is the possibility of producing fine resolution maps of these nutrients which could be used in conjunction with soil pH maps to develop risk assessment maps. Examples of such maps for aluminium and calcium are shown below.





6. Setter

Waterlogging can occur on poorly structured sodic soils as well as duplex soils. The importance of confounding factors and understanding the target environment in developing varieties tolerant to properties such as salinity, waterlogging and tolerance to nutrient deficiencies and toxicities was stressed. With regards to waterlogging tolerance there is evidence to show that waterlogging not only affects growth through anaerobiosis, but by the effects of waterlogging on nutrient availability and toxicity. Therefore tolerance to waterlogging depends on BOTH tolerance to anaerobiosis AND micronutrient toxicity. Therefore selection for micronutrient toxicity is an essential component in breeding for waterlogging tolerance.

7. Coventry/Phillips

Currently wheat and barley breeders are not actively selecting for tolerance to alkaline soils. A notable exception is B tolerance but even in this case there is debate among wheat breeders about its value. While salinity and sodicity on alkaline soils is recognised cereal breeders are unconvinced about the benefit of salinity exclusion are the major mechanisms of salt tolerance in SA. In South Australia, most breeding trials are conducted on alkaline soils and so tolerance is probably being selected for passively by selecting for high yields. It was pointed out that one of the foundation varieties for the Waite barley breeding program (CI3578) originated from a region of alkaline soils in the Middle East, suggesting that adaptation to alkaline soils has been an important adaptive characteristic of varieties for the region. Tolerance to bicarbonate has been used in the durum breeding program but not on the barley breeding program. Environmental variation can be high and the effects of different constraints are not expressed consistently in all soils and in all seasons. There is a need to understand the target environment and the value of traits in these environments.

Areas of future work

- Genetic variation in bicarbonate tolerance in barley
- Genetic variation in tolerance to Al toxicity at high pH
- Interactions between stresses and the need to look at tolerance to multiple stresses

8. Wilhelm

While much of the workshop highlighted the problems associated with alkaline soils, there are nevertheless, a number of advantages of these soils: they do not require liming, they generally have high infiltration rates, they are highly trafficable and they are often not as abrasive as other soils. The technologies and information to correct some of the common nutritional limitations such a poor P nutrition and Zn nutrition are known. The long-term benefits of ameliorating subsoils by deep placement of nutrients and organic matter and the benefits of fluid fertilisers on alkaline soils have been demonstrated by past research: there are no longer a research gap but a ‘commercialisation’ gap. Large areas of alkaline soils have been productive for a long time and famers have adapted their management to some of the unique characteristics of these soils. Consequently they have managed to improve water use efficiencies of crops on these soils within the limitations of these soils, where the ‘bucket size’ is restricted by the presence of hostile subsoils. Moving to the next step of improved water use to improve productivity further will require addressing a number of subsoil constraints that are currently limiting water use.

Areas for future work

- Economic adaptation of methods of subsoil amelioration

<u>Water Repellent Sands: The Problem and How It Was Ameliorated.</u>
A Tribute to Clem Obst of Mundulla.

Max Tate, (max.tate@adelaide.edu.au), Visiting Research Fellow, University of Adelaide,

Background:

In 1981 Prof. Malcolm Oades at the Waite, showed me an excellent PhD thesis (D.A. McGhie) from Western Australia, which was concerned with the water repellent sands problem in that state, and asked my opinion of it. My comment was to the effect, that fifty years had elapsed since the original paper by Professor James **Prescott** and C.S. **Piper** (The Soils of South Australian Mallee. **Trans. Roy. Soc. S. Australia**. 56:118. **1932**.), of the Waite had observed the problem, and I thought it was about time an organic chemist with new instrumentation took a good look at the causal agent. In their paper, Prescott and Piper wrote: ”Soil samples are occasionally received from mallee areas which refuse to wet under rain and in which seeds do not germinate. On one or two occasions this effect has also been traced to the presence of an essential oil. Two decades earlier, Schreiner and Shorey, had published a U.S. paper titled: GLYCERIDES OF FATTY ACID IN SOILS. Oswald **Schreiner**, Edmund C. **Shorey**. . *J. Am. Chem. Soc.* , *1911*, 33 (1), pp78-80. Thus both oils and fats were already known to be present in soils

In contrast to these reports of the presence of oils and fats in soil, a member of the CSIRO Division of Soils, presented a conference paper: [R.D. **Bond** (**1969**). The occurrence of water-repellent soils in Australia. In ‘Water-repellent soils’. Eds L.F. DeBano and J.Letey.) pp.259-263 Proc. Symp. On Water-repellent Soils. University of California, Riverside, California.], in which he stated in his concluding remarks:

“ Water repellence of sand in Australia is attributed to organic films which coat the sand grains and which are produced by fungi growing in the soil. **The composition of these organic films is unknown, but they are not oils nor waxes [MET EMPHASIS]** and their effect is reduced by dilute acid and alkali.

My own view, that Bond’s 1969 conclusion, that oils and waxes were not involved, was totally inadequate, was based upon the fact that on another 1960s project, I too had initially been unable to extract a biologically active phospho-lipid (Lyso-lecithin) from wheat using similar lipid solvents, but later we were readily able to isolate it, by simply using an aqueous butan-1-ol solvent, which was capable of breaking strong hydrogen bonds to the starch hydroxyl (-O-H) groups in the wheat.

A New Approach

In May 1984 I received a new Infrared Spectrometer for a different project from the Australian Research Council (ARC), Malcolm Oades and I also had a new Indonesian PhD student (Mansour Ma’Shum) to work on the water repellent sands problem. Furthermore, a skilled Infrared expert from The MaCaulay Institute in Aberdeen, Scotland (Vic. Farmer) arrived at exactly the same time that I left for a year’s study leave in France. I left a one paragraph note asking Vic to help Mansour to find out what the properties of the water-repellent sand were.

When I returned in May 1985, there was an even briefer note from Vic which said: The instrument works well and I think Mansour is a true scientist! Later a paper by **Ma’shum**, M., and **Farmer** V.C. (**1985**) “Origin and assessment of water-repellency of a sandy South Australian soil.” Aust. J. Soil Res. **23**, 623-626., appeared with the conclusion “ We conclude that the majority of the water repellent substances can be extracted from a sandy soil of this type.” (MET from near Tintinara).

What Exactly are These Hydrophobic Soil Extracts of Ma’Shum and Farmer made of ?

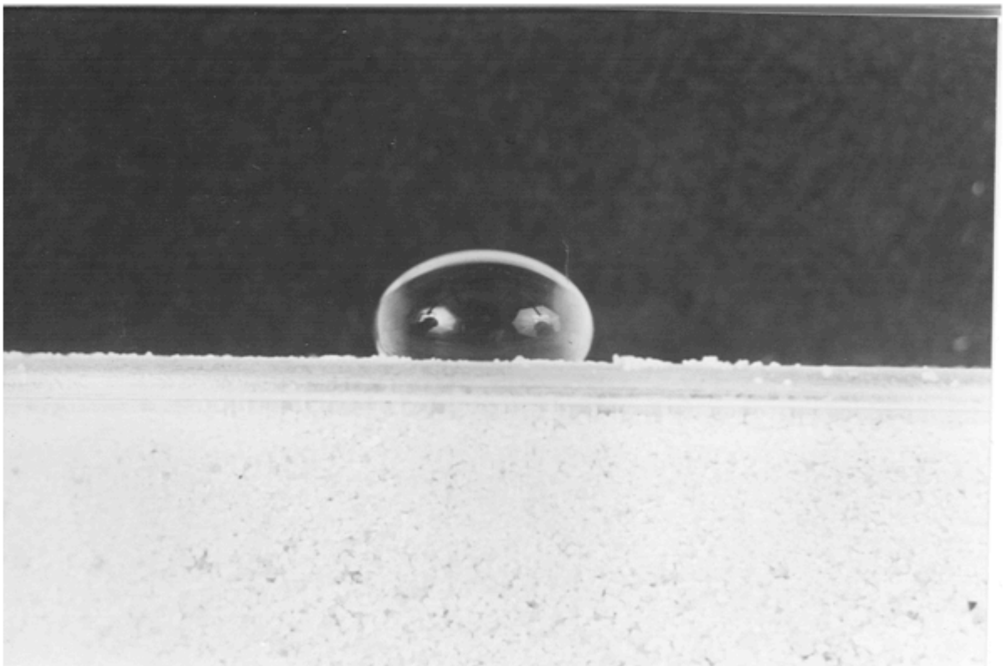
Mansour's next paper : M. **Ma'Shum**, M.E.**Tate**, G.P. **Jones** & J.M. **Oades** (Extraction and characterisation of water-repellent materials from Australian soils.) Journal of Soil Science, **1988,39**,99-110., addressed this question by providing independent physical (IR and 13C NMR) evidence that the 1969 view espoused by Bond that neither oils nor waxes, were involved was completely untenable. The spectroscopic (IR and 13CNMR) and chromatographic fractionation of the material extracted (1880mg/kg) by isopropanol/ammonia (or water) from the water-repellent sand, in order to render it completely wettable, convincingly showed the presence of a mixture of polymethylene oil and wax esters. Importantly it concluded that "the major problem (MET: in the extraction) concerns the disruption of hydrogen bonding links which are strengthened in aprotic solvents (e.g.common lipid solvents such as ether and chloroform which have no hydroxyl groups).

How can we Easily Measure Water-repellency in Soils?

It was also necessary to choose a suitable quantitative-measure of water repellency, to compare how closely our future model would fit the observed, field situation (**Fig. 1**) water-repellency. Fortunately **Peter King** of the then South Australian Dept. of Primary Industries had published a very simple procedure for measuring water repellency in soils as the **M**olarity (a concentration) of an aqueous-**E**thanol **D**roplet, i.e. **MED** (c.f. **King**,P.M. (**1981**) Comparison of methods for measuring severity of water-repellence of sandy soils and assessment of some factors that affect its measurement. Aust. J. Soil Res. **19**, 275-285.).

Soil erosion on a water-repellent sand dune.

Pure water has an **MED** value of zero and will simply sit on a non-wettable soil until it completely evaporates, see **Fig. 2.,** pure alcohol has an **MED** value of close to 17 and will dissolve most waxes and then this undiluted ethanol droplet will immediately penentrate the water-repellent sand. In its simplest form, the method involves first making a reference series of known concentrations (molarities) of pure alcohol in water, then starting with a droplet, of pure water and subsequently adding droplets with successively higher and higher molarities of ethanol to the water-repellent sand until the concentration is reached that will penetrate the sand within ten seconds, and this then provides the necessary **MED** value.



Water-repellent beach sand treated with 0.8g/ kg of cetyl alcohol.

Other more sophisticated laboratory based methods including those developed by CSIRO Soils division were examined, but it was the simplicity, rapidity and field applicability of Peter King's **MED** procedure, which enabled Mansour to make real progress.

How A Model Water-Repellent Sand Was Made.

Once we realised that the notion, that strong hydrogen bonding by the electron-rich oxygen **(-O-)** atoms which are present in the ester **(-C=O.O-)** groups of plant oils, waxes and long chain alcohols, to the hydrogen **(-H)** atoms in the surface Silanol **(= Si-O-H)** groups of the sand might be important, we set about seeing if we could convert a readily wettable beach sand into a water-repellent sand.

Every young child quickly learns that you cannot build sand castles out of dry sand. Water molecules **(H_2O)** can be written as a hydrogen-bonded chain structure: **H-O-H--O-H--O-H--O-H- -** (Here for textual simplicity, I have used just one of the two hydrogen atoms attached to each oxygen atom in water, but in the real world, both hydrogen atoms of water are involved) . It is this hydrogen bonding sequence **H--O-H--** that literally, "glues" the wet sand castle together.

It did not take long to establish that readily-wettable coarse (500 micrometre) beach sand (**MED = 0**), could easily be converted to highly water repellent (**MED > 6**) sand as shown in **Fig 2**, by dissolving just 0.8g of Cetyl alcohol (1-Hexa-decanol , with the following Chemical formula: **CH3-($CH2)_{14}$-CH2-OH)** in chloroform and then drying it onto 1kg of dry beach sand for (17h. at 105C).

This final heat treatment, like our long hot summers, displaced any residual water molecules from being hydrogen bonded to the oxygen atom of the silanol (**Si-O-H**) groups on the surface of the sand and replaced those **H-O-H** water molecules, with the terminal -**CH2-O-H** of the cetyl alcohol. This then left the rest of the long, water-repellent, **C-15** hydrocarbon chain sticking up from the surface and thereby prevented access by new water molecules to the all important surface silanol (Si-O-H) groups. Later work by Mansour in his final paper, included electron microscopy, that showed that more than a simple monomolecular layer of oil or wax was needed on the sand, to provide really high and stable MED value.

Can we Somehow, Just Increase the Number of Hydrophilic Silanol Groups?

At this point, I asked Mansour to take some very fine silica gel used by us organic chemists to separate chemical compounds and which we knew had an enormous surface area and a correspondingly enormous number of hydrophilic (water-loving) silanol groups, which could conceivably make up for the ones already blocked by the cetyl alcohol in our model water-repellent sand.

Off he went to the lab, but he rushed back very excitedly about ten minutes later saying: **IT WORKS! IT WORKS!** I naturally said: "Aha, perhaps we need to build a silica gel plant down near Tintinara." Fortunately we decided we should first discuss this fascinating result straight away with Mansour's other supervisor: Malcolm Oades.

Malcolm was not only a fully trained Soil Scientist, but a Yorkshire man as well. In his Yorkshire accent he said: "why don't you try clay additions they have enormous numbers of silanol groups on their surfaces and our cricketers have been "Marling" cricket pitches for decades." So we obtained some clay from Millicent and ball-milled (an energy intensive exercise) it into a powder just like our finely divided silica gel and it too reduced the **MED** value, exactly as Malcolm had predicted. Nevertheless, an even better type of clay which would readily disperse itself in the soil and remained for us to see.

ENTER: One Highly Observant and Successful Farmer: Clem Obst of Mundulla.

One Thursday morning in 1986, Mansour showed me an article in the local Stock Journal. It was headed, in my view rather skeptically and also somewhat impolitely : **"Clem Obst, thinks he has solved the water repellent sands problem."**

In the late 1950s Clem had noticed that his neighbour had dug a dam in the trough (swale) between adjacent dunes and wherever the clay from about 50cm below the surface had been discarded, Clem noticed that the grass grew abundantly.

He then dug a dam himself and instead of just chucking the clay in a heap, beside the dam, he spread the resulting clay on the worst water repellent areas on his property, which happened to be on the top of one of his wind-blown sand dunes and later harrowed it in. A detailed description of exactly how he did all this was published by him as an article: "Water-Repellent Sands Part II", in the Crop Science Society Journal in 1996. My reaction to Mansour was immediate: "BOOK THE CAR TOMORROW! We are going down to see Clem. "

I didn't know where Mundulla was then, but I did know that one of Malcolm Oades' former students: Dale Lewis worked at the S.A. Dept Primary Industries at Naracoorte, and a phone call to Dale quickly arranged a demonstration meeting between Dale, Mansour and I at Nuriootpa. Dale became an instant convert to amelioration of the water repellent sands using clay, once we showed him a test tube demonstration of how our highly repellent model sand formed a column when it was poured into a test tube of water and then by carefully pouring out most of the water and giving a brief shake, the thin surface skin of the residual column would break allowing a stream of dry sand to pour once more from the tube. By repeating the same trick, but adding some of the ball-milled Millicent clay, all the water repellent sand then became wet and settled to the bottom of the tube. The efficacy of clay-amelioration was there for all to see.

At that point in time Dale knew where Clem lived, but had never actually visited him. After contacting Clem, Dale gave us detailed instructions on how to find Clem and so it was that Mansour and I met this truly remarkable farmer. Clem suitably impressed us straight away. He asked how we did our lab experiments with the Millicent clay and after telling him about the time-consuming ball-milling and then mixing it with sand, he said: " Aargh, you don't have to do all that, you just spread the clay on the surface of the repellent sand around October/ November, then wait for the first rains and harrow it in .

He then showed us the remarkable difference in fertility on the sand hill where he had **originally spread the first lot of clay a quarter of a century before**, which was in sharp contrast, to the extremely poor quality of the adjacent pasture which served as an excellent untreated-control area, where the original clay from the dam had run out. For field examples, see **Figs. 3** and **4.**

Untreated and adjacent clay ameliorated water-repellent sands.

Profile of wheat grown on clay treated, water-repellent sand

Publication of the Science of Clay Amelioration of Water Repellent Sand.
Mansour's last PhD publication (M. **Ma'shum**, J.M. **Oades** and M.E. **Tate**. "The use of dispersible Clays to Reduce Water-repellency of Sandy Soils." Aust. J. Soil Res., **1989**, **27**, 797-806.), summarises much of the laboratory science which underlies Clem's real world farming success.
However, its ultimate publication was not without trouble, and even now, two decades later, it still rankles with me, that at the insistence, of the "anonymous" Australian reviewers, that before it could be published, the final paragraph had to be altered to include the statement:
"Further information on the nature of interactions of dispersible clays with hydrophobic sands is required before field testing of appropriate for a complete understanding of the system, before field testing of appropriate dispersible clays as a control measure for water-repellent sands is warranted."
How Common Sense Prevailed!
Fortunately, after inspecting Clem's 26 year old experiment at Mundulla, Dale Lewis and Melissa Cann of the S.A. Dept Primary Industries at Naracoorte, wasted no time attending to the unknown reviewer's strictures, and instead immediately carried out many meticulous and successful field experiments including the fact that Clem's easily dispersible "sodic" clay was far superior to the Millicent clay which we had used in the lab, and thereby laid a firm scientific foundation for clay-amelioration of water repellent soils. Malcolm also had other students following up the many leads that came out of Mansour's publications.
Conclusion:
It was at that moment of our meeting with Clem Obst that I realised that it had been our great good fortune to witness what would soon become a quiet revolution, in how water-repellent sands were managed in Australia and with it, the great improvement in productivity that followed. Of course there was still lots to be done and the invention of machines in the South East, which could scoop the clay up and spread it out at 25km/hour and later innovations involving less energy-intensive procedures such as delving have all made a remarkable story of intelligent farming achievement. Clem has recently had his 90th birthday and now resides in Murray Bridge. These reminiscences are my tribute to Clem Obst and his marvellous influence on the water repellent sands saga. It's been great to know him!

Illustrations: (I am indebted to Peter King for providing some of these photos.)