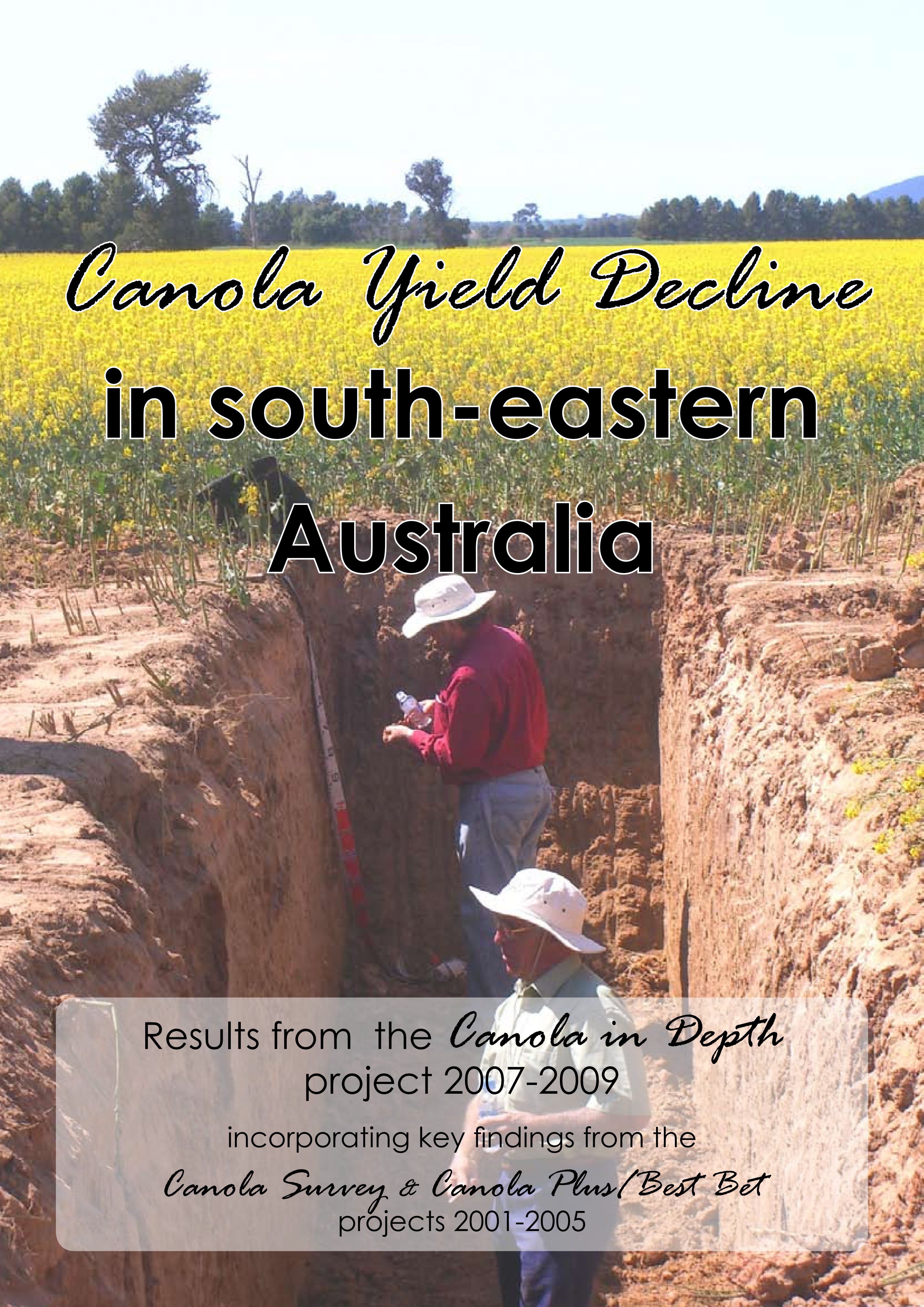

Canola Yield Decline in south-eastern Australia

Results from the *Canola in Depth* project 2007-2009

incorporating key findings from the

Canola Survey & Canola Plus/Best Bet projects 2001-2005

The projects...

Canola yields have been declining in parts of southern NSW and Victoria for the past 15 to 20 years. With Canola Crop Check records showing a 9% yield decline from 1991 to 2001, supported by data from the Australian Bureau of Statistics, poor canola performance has been a major focus of research in and around the FarmLink region since 2001.

From 2001 to 2005, canola disease management, which growers and advisers had identified as a significant limiting factor, was the focus of several research projects including **Canola Plus** and **Canola Best Bet** (p. 10). The **Canola Survey** project was conducted from 2003 to 2005 to identify other potential causes of poor performance. The extensive paddock survey found that subsoil constraints and late season moisture stress (p. 11) were the most common causes of under-performance during the survey period.

To further investigate the impact of subsoil constraints on canola yields, the **Canola in Depth** project was undertaken from 2007 to 2009. The project consisted of replicated trials in southern NSW and Victoria (Figure 1) which encompassed a range of subsoil constraints including:

- subsurface compaction (hardpans)
- subsurface acidity
- subsoil sodicity
- subsoil salinity

Treatments were generally a combination of surface and/or deep applied lime or gypsum. Where possible, common treatments were used to allow comparison between sites, including:

- control (nil treatment)
- deep rip to 25-30cm
- deep rip + injected lime or gypsum

Deep ripping/injecting was carried out using a Yeomans deep ripper modified with a trailing cart, from which lime or gypsum was blown down tubes located behind the ripper tynes (Figure 2).

Figure 1 - Canola in Depth trial locations

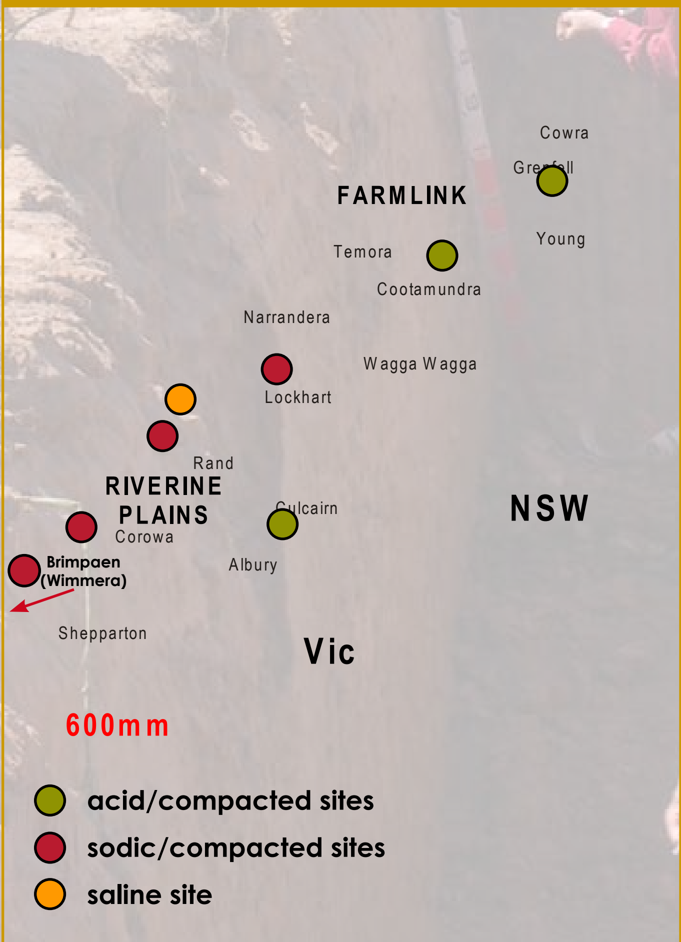

Figure 2 - FarmLink 'ripper/injector'* used in the trials

Photo: F. Gummer

**Funded by National Landcare Program, Yeomans Plow Co & Hart Bros Seeds*

Definitions used in site selection

- **compacted subsurface**[1] = penetrometer resistance > 2 MPa at field capacity
- **acidic subsurface**[1] = pH_{Ca} < 5.0
- **sodic subsoil**[2] = ESP (exchangeable sodium %) > 15%
- **saline subsoil**[2] = EC_e (electrical conductivity) > 2 dS/m

[1]**subsurface -** A horizon, either below plough layer or below 10cm depth

[2]**subsoil -** B horizon, usually below 20cm depth

Table 1 - Canola in Depth treatment responses

Location	Canola response to lime injection	Canola response to deep ripping
Acidic & compacted subsurface		
Culcairn	nil (but dry matter response in barley '09)	nil (but dry matter response in barley '09)
Greenethorpe	nil	dry matter only '07
Milvale	nil	nil
Sodic & compacted subsoil		
Location	**Canola response to gypsum injection**	**Canola response to deep ripping**
Rand	nil	negative yield response '08
Corowa	nil	nil
Lockhart	nil	nil
Brimpaen (Vic)	nil	nil
Saline subsoil		
Yuluma	• negative rooting depth response to salinity in '08 & '09 • negative dry matter and yield response to salinity in '08 only (drier season)	

Project Conclusions:

- **Subsurface compaction:** Canola is not expected to respond to deep ripping where compaction (penetrometer resistance) is less than 3MPa. Above 3MPa, a response to deep ripping is possible but the economic viability depends on its residual value. The use of tap-rooted species (including canola) over a number of years may be preferable.
- **Subsurface acidity:** Canola appears to be relatively tolerant of subsurface acidity, except where exchangeable aluminium exceeds 20%, manganese is toxic, or where the acid 'throttle' is greater than 20cm deep. Typical subsurface acidity can be managed by liming the surface to pH_{ca} 5.5 and by using acid tolerant varieties.
- **Subsoil sodicity:** Canola is not expected to respond to deep placement of gypsum unless subsoil exchangeable sodium levels are above 15% and growing season rainfall exceeds 400mm.
- **Subsoil salinity:** Canola appears relatively sensitive to subsoil salinity, although effects can be masked in a favourable season. EM surveys combined with strategic soil sampling can identify saline paddocks that may be better suited to a more tolerant species, eg. barley.
- ***Overall, canola appears to be generally tolerant of subsoil constraints. Other than late-season water stress, disease remains the major limiting factor to canola yields.***

Acknowledgements - Canola in Depth:

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Research Team:

- I&I NSW: Mark Conyers, Albert Oates, Graeme Poile, Richard Lowrie, Sergio Moroni (CSU)
- CSIRO: John Kirkegaard, Tony Swan, John Angus, Mark Peoples
- Vic DPI: James Nuttall, Roger Armstrong
- FarmLink: Kirrily Condon, Katrina Durham

Steering Committee:

- Tim Condon, Delta Agribusiness
- Chris Duff, Delta Agribusiness
- Peter Hamblin, AgriTech
- Michael Sinclair, FarmLink
- John Sykes, John Sykes Rural Consulting

Co-operators:

- Roy Hamilton, Rand
- Geoff Lane, Lockhart
- David Davidson, Milvale
- Rob Taylor, Greenethorpe
- Warwick Hodge, Greenethorpe
- Hugh Hearn, Culcairn
- John Stevenson, Yuluma
- Peter McGennisen, Brimpaen

FarmLink Ripper/Injector:

- Yeomans Plow Co
- Hart Bros Seeds
- National Landcare Program (DAFF)

This document was produced by Kirrily Condon, Grassroots Agronomy on behalf of FarmLink and the Canola in Depth research team, June 2010.

Further information is available from the Project Supervisor, Mark Conyers (I&I NSW):

P: (02) 6938 1830 E: mark.conyers@industry.nsw.gov.au
or on the FarmLink website: www.farmlink.com.au

Subsurface... compaction

- Canola is not expected to respond to deep ripping in south-eastern Australia where compaction (penetrometer resistance) is less than 3MPa at field capacity.
- In these instances, canola roots are able to penetrate the compacted layer of the region's relatively permeable soils through structural cracks and pores (Figure 3).
- Above 3MPa, a response to deep ripping is possible, but the economic viability depends on its residual value. The use of tap-rooted species (including canola) over a number of years may be preferable.

A series of dry years has highlighted the importance of crop roots being able to access subsoil moisture. Consequently, there has been renewed interest in managing subsoil compaction, which has in part contributed to the recent increase in adoption of tramlining or controlled traffic farming. However the extent to which compaction really does impact on plant growth in southern NSW is often questioned.

A canola paddock survey conducted across soil types in southern NSW in 2004/05 showed that **37 out of 39 paddocks had compacted subsurface layers** (soil strength 2MPa or greater), with 40% greater than 3MPa. Of the paddocks south of Wagga Wagga, more than 60% showed severe root distortion (less than 10% north of Wagga Wagga), which suggested that canola was sensitive to compaction.

However a recent review of deep ripping trials conducted in south-eastern Australia over the last 25 years[1] has shown variable responses to removal of the compacted layer in both wheat and canola. The review, which included results from year one of the Canola in Depth project, found:

- **Yield responses to deep ripping only occurred on sodic/clay soils in wet years**, with no yield responses on these soils in an average season. Unfortunately half the trials, the majority of which were on clay loams, were conducted in very dry years with limited potential for yield responses.

Photo: J. Kirkegaard

Figure 3. At a field day at the Greenethorpe site in 2007, visiting Professor Gordon Spoor noted that canola roots had been slowed by the compacted layer, but had been able to penetrate it using the many structural cracks and pores to proliferate in the subsoil. This explains why crops grown in these relatively permeable soils tend to 'catch up' by the end of the season to areas where the compacted layer has been removed through deep ripping.

Photo: S. Moroni

Figure 4. A deep ripper supplied by Yeomans Plow Co. was used to break up subsurface compaction at seven Canola in Depth trial sites. The tynes ripped to a depth of 30cm, at a row spacing of 45cm. Despite reducing compaction, no canola yield responses to deep ripping were recorded at any of the sites, suggesting canola is more tolerant of subsurface compaction than previously believed.

- Early dry matter responses to deep ripping were more prevalent in canola compared with wheat, but these rarely persisted to yield. Although dry matter responses were greatest on the two most compacted trials (4.0 to 4.2MPa), only a few responses were recorded at sites of 2.75 to 3.5MPa and **no responses were recorded on sites of less than 2.75MPa**.

Since the review, a further two years of deep ripping trials have been carried out on clay loam soils through the Canola in Depth project (Table 1). Although yields have been compromised by continued dry conditions, early crop responses, combined with the review findings, have highlighted a number of outcomes relating to soil compaction in south-eastern Australia:

- **The commonly accepted soil strength threshold of 2MPa (at which root growth becomes restricted) may not apply to the relatively permeable soils in south-eastern Australia.** In these instances, cracks and pores in the soil enable root penetration through the compacted layer, allowing roots to access water and nutrients in (non-sodic) subsoils.
- There is little current evidence to suggest that deep ripping of soils in south-eastern Australia is beneficial, except in combination with gypsum on sodic clay soils where the growing season rainfall is greater than 400mm.
- Although the benefits of controlled traffic farming are numerous, current evidence suggests its role in compaction management is not as critical on clay loam soils in south-eastern Australia. However early adopters of controlled traffic in the region have observed noticeable improvements in soil strength and structure. This is being further investigated in the current FarmLink/CSIRO project focused on improving crop water use efficiency across the farming system.

'Ripping yarns, 25 years of variable responses to ripping clay soils in south-eastern Australia.' www.regional.org.au/au/asa/2008/concurrent/managing_subsoils/5934_kirkegaardja.htm

Resistance?

Resistance is a measure of soil strength, typically measured using a 'cone penetrometer' (pictured). A soil with penetrometer resistance of 2MPa or greater has generally been considered compacted and restrictive to root growth. However research now shows that 3MPa at field capacity may be a more appropriate threshhold for canola in south-eastern Australia.

Deep ripping at the Canola in Depth trials

Deep ripping treatments were applied to seven Canola in Depth trial sites with a compacted subsurface (Table 1) using a Yeomans Plow (Figure 4). The tynes ripped to a depth of approximately 30cm at a row spacing of 45cm.

Penetrometer profiles taken across the plots after sowing at the Culcairn site in 2007 showed the penetration depth of the deep ripping tynes (Figure 5) compared to the knife points in the direct drilled plots (Figure 6).

The red areas represent low soil strength where the tynes have broken through the compacted layer to a depth of approximately 7cm in the direct drilled plot and 30cm in the deep ripped plot.

There is some reduction in soil strength (yellow areas) directly below the tyne depth due to shattering. Undisturbed soil further below the tyne depth remains compacted, indicated by soil strength values of greater than 2Mpa (green and blue areas).

Despite reducing compaction to a depth of 30cm, deep ripping resulted in a canola dry matter response at one trial only (Table 1), although no yield responses were recorded.

Figure 5. *Effects of deep ripping on compaction, Culcairn 2007.*

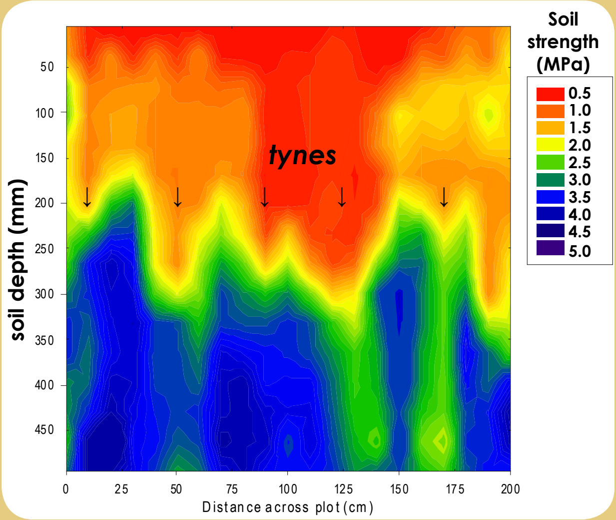
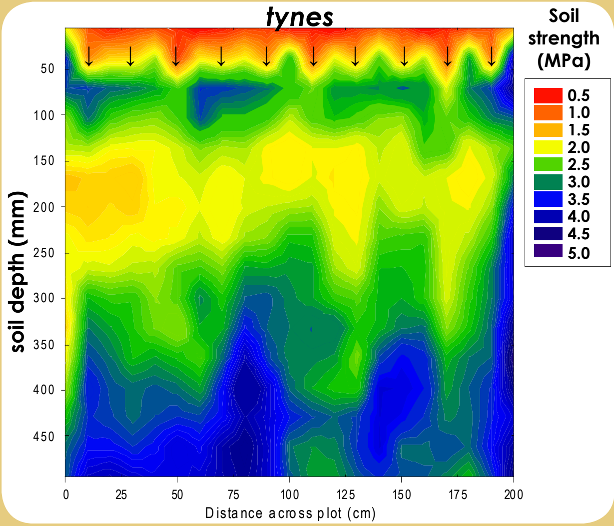


Figure 6. *Effects of knife points on compaction, Culcairn 2007.*



Subsurface... acidity

- Provided the surface soil is not acid, canola appears to be relatively tolerant of subsurface acidity, except where exchangeable aluminium exceeds 20%, manganese is toxic, or where the acid 'throttle' is greater than 20cm deep.
- Canola's relative tolerance of subsurface acidity is attributed to a combination of:
  a) Canola roots being able to push through the 'acid thottle' into neutral subsoil without damage.
  b) Manganese, which increases in concentration in acid soils and to which canola is particularly sensitive, not being present in sufficiently high levels in some subsurface soils.
- Subsurface acidity can be managed by liming the surface to pH_{ca} 5.5 and by growing acid tolerant varieties.

Canola is widely considered to be sensitive to acid soils and responsive to surface liming, with extensive research showing positive yield responses to lime. Whilst surface liming has become accepted practice when growing canola, the development of subsurface acidity has prompted questions over its impact on canola growth.

On the red and red brown earths of south-eastern Australia with low buffering capacities, farming practices have resulted in a decline in surface pH levels from approximately pH_{Ca}6.0 to less than pH_{Ca}4.5 in the absence of lime. Although the surface soil is limed, an acid throttle remains between the limed surface and the naturally neutral or alkaline subsoil.[1]

As soil pH decreases (becomes more acid), the concentration of toxic forms of aluminium and manganese increases. Research by Moroni et al showed that **canola is particularly sensitive to manganese (Mn^{2+}), but less sensitive to aluminium (Al^{3+}) compared with wheat varieties:**

- High manganese levels resulting from low pH and extreme environmental conditions can affect

Photo: S. Moroni

Figure 7. *Research by Moroni et al. has shown that canola is particularly sensitive to manganese (toxicity symptoms above) which increases in concentration in acid soils. The lack of canola responses to deep lime injection in the Canola in Depth trials suggest that manganese levels were not present in sufficiently high levels in the subsurface to affect canola growth.*

Photo: S. Moroni

Figure 8. *In addition to manganese, aluminium also increases in toxicity as soil pH decreases. Although aluminium levels are generally thought to be the cause of canola root 'pruning' (pictured), laboratory testing has shown canola can tolerate relatively high concentrations of aluminium.*

pH?

pH is a measure of soil acidity, with pH_{Ca} less than 5.0 considered acidic. As pH decreases, aluminium and manganese increase in concentration, potentially affecting plant growth.

Canola appears relatively tolerant of subsurface acidity provided aluminium and manganese are not at highly toxic levels.

While pH is most accurately measured using laboratory analysis (pH_{Ca}), a guide to soil pH can also be achieved using a simple powder test kit (pictured) available from rural suppliers and nurseries.

canola growth through reduced photosynthesis. Manganese toxicity is commonly seen at the seedling stage (Figure 7) and/or flowering time, often in waterlogged soils at the end of winter as soils warm up. Although plants appear to overcome the toxic effects of manganese as the season progresses, the effects of reduced photosynthesis would inevitably reduce the plant's growth potential. Manganese toxicity is difficult to ameliorate and may not even be removed through liming.

- High aluminium levels are generally thought to be the cause of canola root 'pruning' (Figure 8) often seen in soils with an acid throttle. However under laboratory conditions, canola has been shown to tolerate high concentrations of aluminium, similar to aluminium resistant wheat varieties.[2] Aluminium toxicity is removed through liming.

However results from the Canola in Depth project have shown that provided the surface soil is not acid, canola appears to be relatively tolerant of subsurface acidity. This has been attributed to a combination of:

a) Canola roots being able to push through the 'acid thottle' into neutral subsoil without damage.

b) Manganese not being present in sufficiently high levels in some subsurface soils.

The most economic approach to growing canola on soils with an acidic subsurface is therefore likely to be a combination of surface liming and the use of aluminium and manganese tolerant varieties. The previous understanding that subsurface acidity should be managed by surface liming to promote lime movement and amelioration of the subsurface layer is impractical in terms of the number of years required and now seemingly not as critical. However surface liming remains a 'best management practice' for successfully growing canola on soils with topsoil acidity and to prevent further acidification of the subsurface.

Acknowledgements: Mark Conyers & Sergio Moroni, EH Graham Centre for Agricultural Innovation.

[1]Angus J et al. 2008. Canola and the acid throttle. Proc. 2008 NSW GRDC Grains Research Update, Wagga Wagga.

[2]Moroni JS, et al. 2006. Resistance of rapeseed (Brassica napus L.) to aluminium apparent in nutrient solution but not in soils. "Ground-breaking stuff". Proc. 13th Australian Agronomy Conference, Perth. Australian Society of Agronomy.

Lime injection at the Canola in Depth trials

Lime injection treatments were applied to three Canola in Depth trial sites (Table 1) which had a limed surface above an acid throttle between 5 and 30cm depth. Lime was injected using a Yeomans deep ripper on 45cm tyne spacing, modified with a trailing cart from which lime was blown down tubes located behind the ripper tynes (Figure 2).

pH profiles measured from the plots at the Culcairn site at harvest in 2007 showed lime injection had increased pH of the original acid 'throttle', so that the most acidic depth at approximately 10cm had increased from pH_{Ca} 4.1 to pH_{Ca} 5.0 (Figure 9). Despite this, no canola responses to deep lime injection were recorded at any of the sites over the three years of the project (although an acid sensitive barley sown at the Culcairn site in 2009 did show a significant dry matter response - Figure 10).

Figure 9. *Lime injection increased pH of the 'acid throttle' at Culcairn, 2007.*

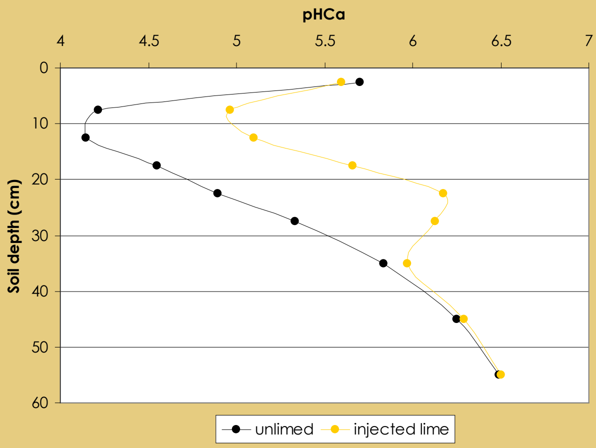


Figure 10. *Only acid sensitive barley, not canola, showed a dry matter response to injected lime at the Culcairn site in 2009 (left: unlimed, right: injected lime).*

Photo: M. Peoples

Subsoil...
sodicity

- Canola is not expected to respond to deep placement of gypsum unless subsoil exchangeable sodium levels are above 15% and growing season rainfall exceeds 400mm.

In Australia, a soil is generally considered sodic if the exchangeable sodium percentage (ESP) is greater than 6% in the topsoil or 15% in the subsoil.

Sodic soils tend to 'disperse' when wet, meaning soil particles separate, blocking soil pores and resulting in a hard, dense structure when dry. This can result in reduced plant emergence due to crusting of the soil surface, as well as restricted root growth due to limited water and air movement through the dense soil profile.

Applying gypsum (and/or lime if the soil is also acid) can improve the structure of sodic soils by preventing the soil from dispersing. Although this may result in improved trafficability, water infiltration and better plant growth, research by I&I NSW[1] and CSIRO[2] has shown that **yield responses to gypsum can vary depending on seasonal conditions, particularly rainfall.** For example:

- A sodic trial site near Temora, NSW had 12% ESP in the topsoil, increasing to 30% at depth. Under the relatively wet conditions of 2000, topdressed gypsum resulted in canola yield increases of 0.5 to 2.0 t/ha. However no yield responses occurred during the dry conditions between 2002 and 2004, despite improvements to soil structure.

Unlike lime, gypsum is able to move down the soil profile relatively easily. In the trial described previously, topdressed gypsum had reduced ESP to a depth of 30cm five years after application. However sodicity often occurs deeper in the soil profile, affecting root growth and consequently yield. Deep placement of gypsum to a depth of approximately 25cm in the Canola in Depth trials resulted in no yield responses for the duration of the project due to below average rainfall. Canola responses to subsoil sodicity may be evident under waterlogged conditions.

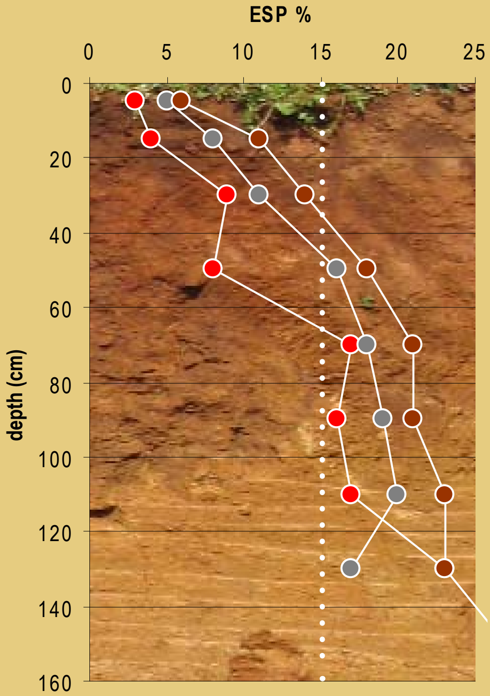
Acknowledgements: [1]Brian Dear & Yin Chan (I&I NSW); [2]Mark Peoples & Tony Swan (CSIRO Plant Industry).

Gypsum injection at the Canola in Depth trials

Injected gypsum treatments were applied to four Canola in Depth trial sites with a sodic subsoil (Table 1), where the exchangeable sodium percentage (ESP) was greater than 15%. Gypsum was injected using a Yeomans deep ripper on 45cm tyne spacing, modified with a trailing cart from which gypsum was blown down tubes located behind the ripper tynes (Figure 2).

With below average rainfall recorded for the duration of the project, there were no canola yield responses to injected gypsum at any of the sites.

Figure 11. The Canola in Depth site at Rand consisted of three different soil types, but all had sodic subsoils below ~40-50cm (brown & grey clays) and ~ 70cm (red loam). Canola did not respond to deep application of gypsum in any soil type.



ESP?

ESP (exchangeable sodium percentage) is a measure of soil sodicity. A soil is generally considered sodic, ie. tends to disperse when wet, if the ESP is greater than 6% in the topsoil or 15% in the subsoil.

Although ESP is routinely tested through soil chemical analysis, a simple test can also be conducted by gently placing a few crumbs of soil (3-5mm diameter) in a saucer of rain water. If a cloudy halo develops around the soil crumb in about two hours, the soil is dispersive or sodic (pictured - sodicity increasing to the right).

Subsoil... salinity

- Canola appears relatively sensitive to subsoil salinity with reduced dry matter and yield, although effects can be masked in a favourable season.
- EM surveys combined with strategic soil sampling can identify saline paddocks that may be better suited to a more tolerant species, eg. barley.

A soil is generally considered saline if the electrical conductivity (ECe) is greater than 2 dS/m, but this may depend on the type of salts present (see 'EC' inset).

Subsoil salinity can substantially reduce plant growth and yield, particularly in dry seasons. The presence of salts in the root zone results in reduced water uptake and some salts, eg. sodium and chloride, can have a direct toxic effect on the plant.

Although previous research suggests that **canola is relatively salt tolerant compared with other species** such as wheat, lucerne and chickpeas[1], the Canola in Depth project found that **canola is still relatively sensitive to subsoil salinity under paddock conditions**. In a dry season, rooting depth, dry matter and yield decreased with increasing salinity levels. However the effects were masked in a favourable season with adequate rainfall and surface moisture post-flowering (Figure 12).

Where subsoil salinity is suspected, EM surveys combined with ground-truthing can be used to identify paddocks where canola may not be suitable. A more salt tolerant species such as barley may be considered as an alternative.

Deep rooted 'primer plants' (eg. phalaris, chicory), which potentially provide root channels in hostile subsoils for the next crop to follow[1], may also be a suitable alternative.

Acknowledgements: Tony Swan, John Angus, John Kirkegaard & Mark Peoples (CSIRO Plant Industry); James Nuttall & Roger Armstrong (Vic DPI).

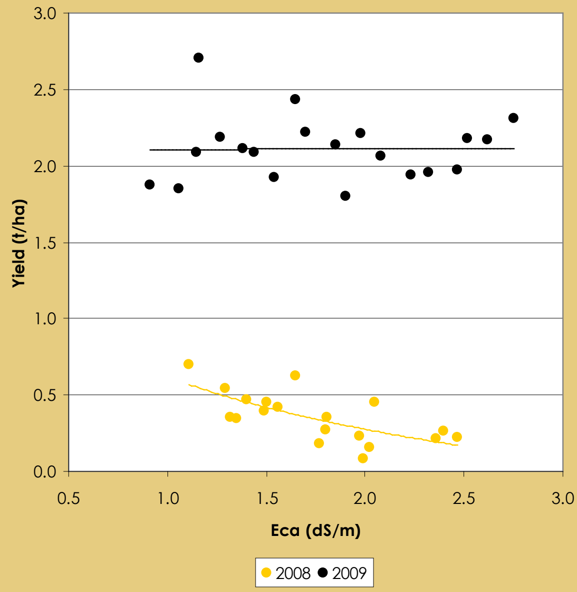
[1]T. Swan, M. Peoples. Primer plants: a new approach to improve cropping on hostile soils (GRDC project CSP343).

Salinity at the Canola in Depth trial

A site at Yuluma in southern NSW was selected for its high subsoil salinity content (EC_a up to 2.8 dS/m).

Over two seasons, variable salinity levels across the paddocks were correlated with canola rooting depth, dry matter and yield. In both seasons, canola rooting depth declined as salinity increased, however this only translated into a dry matter and yield penalty in 2008 when conditions were much drier. Significantly higher rainfall in 2009 (185mm in-crop) masked the effects of the saline subsoil (Figure 12).

Figure 12. Canola yield decreased as subsoil salinity levels increased in the dry season of 2008, but not in the 2009 season when effects were masked by significantly higher rainfall post-flowering.



EC?

EC (electrical conductivity) is a measure of soil salinity, commonly meaured using either:

- saturated paste extract (EC_e or EC_{se})
- 1:5 soil water extract ($EC_{1:5}$) - needs to be adjusted for soil texture to compare with EC_e
- EM38 meters which record apparent EC (EC_a)

While the use of EM38 meters (pictured) are a practical means of recording EC across paddocks, results should be ground-truthed through soil testing to determine the source of high EC_a readings, eg. sodium chloride salts or the less damaging gypsum salts. Chloride testing is also a good indicator of potential salinity damage, with high chloride levels having a direct toxic effect on plants. Chloride is considered marginal at 300-600 mg/kg and toxic at greater than 600 mg/kg.

Disease management

- Disease remains a major factor limiting canola yields, particularly blackleg and sclerotinia.
- Blackleg is a consistent problem in high rainfall regions or seasons with above average rainfall. Although sclerotinia is sporadic, it can be devastating in favourable springs.
- Blackleg can be managed through varietal resistance, fungicides and segregation from canola stubbles. Sclerotinia can also be managed with fungicides, although yield responses can be inconsistent.

The intensification of canola cropping in southern NSW during the 1990s is a likely cause of the increase in blackleg and sclerotinia stem rot experienced in favourable seasons or in higher rainfall areas over the past 15 to 20 years.

Although blackleg is the most significant canola disease, its severity can be reduced through the use of more resistant varieties, segregation from canola stubbles and fungicide use. Research in the higher rainfall area of southern NSW suggests that, **for each 1% reduction in blackleg lodging, yield can increase by 5%[1].**

However yield responses do not always correspond with a decrease in blackleg lodging. In some cases, blackleg impacts on yield through an internal root rot (Figure 13), where plants appear 'normal' on the outside but senesce prematurely. In other instances, crops can compensate for lodged plants if infected early and conditions are favourable.

Although less research has been conducted on sclerotinia, a survey undertaken in southern NSW from 1998 to 2000 showed up to 38% stem infection with an average of 10% plants infected[2]. In high rainfall areas, research showed that, **for each 1% reduction in sclerotinia infected plants, yield increased by 1.3%[1].** Although fungicides are available, optimal conditions for yield responses remain unclear. There are no resistant varieties.

[1]J. Kirkegaard et al (2006). Effect of blackleg and sclerotinia stem rot on canola yield in the high rainfall zone of southern NSW. Australian Journal of Agricultural Research 57, 201-212.

[2]T. Hind et al (2003). Prevalence of sclerotinina stem rot of canola in NSW. Australian Journal of Experimental Agriculture 43, 163-168.

Disease management at the Canola Plus and Best Bet Canola trials*

*(*Incorporating FarmLink's Canola Plus project funded by GRDC and the Harden District Rural Advisory Service's Best Bet Canola project funded by Grain Growers Association, 2001-2005.)*

From 2001 to 2005, trials were conducted across nine sites in southern NSW to determine the efficacy of seed/fertiliser applied fungicides in managing blackleg in canola.

In general, the seed treatment Jockey® and fertiliser treated Impact-in-Furrow® increased canola yields if plants were infected by blackleg at the early seedling stage. Across all sites, the average yield increase due to Jockey® and Impact® was 0.09 t/ha and 0.14 t/ha respectively (Jockey® outperformed Impact® only once). The seed treatment Maxim® only occasionally reduced blackleg and rarely increased yield.

Varieties with improved blackleg resistance experienced reduced lodging and higher yields, with additional yield responses to fungicides in high disease situations, even on varieties with blackleg resistance rating greater than 7.0 (*Blackleg resistance ratings are now rated on a scale of 'Resistant - R' to 'Very Susceptible - VS').*

Sclerotinia management was also investigated in the trials. Although prevalent from 1998 to 2001, sclerotinia only occurred sporadically from 2001 to 2005 when the trials were conducted. In 2001, yield responses to fungicides ranged from 0.2 to 0.9 t/ha. Responses were absent in 2002 and 2004, uneconomic in 2003 and inconsistent in 2005 (late infection resulted in a significant but uneconomic response).

Although sclerotinia fungicides (Rovral® and Sumisclex®) gave good control of stem infection in the trials when applied at 20% to 50% flowering, the conditions that result in yield responses are still unclear.

Figure 13. Blackleg infected plants can appear 'normal' on the outside but rotten on the inside (left), causing premature death.

Photo: C. Duff

S. Sprague et al (2007). Responses to blackleg fungicides in southern NSW. Proc. 15th Australian Research Assembly on Brassicas, Geraldton WA, p 192-196.

J. Kirkegaard et al (2006). Maximising canola performance. Proc. GRDC Adviser Update, Wagga Wagga.

Moisture management

- Late season moisture stress and high temperatures can cause flowering in canola to stop prematurely, limiting yield potential.
- TImely sowing reduces the chance of flowering in periods of moisture and heat stress, although extreme events may still occur.
- Careful management of fallow and in-crop rainfall may reduce the impacts of late season moisture stress on flowering and crop yields.

The recent run of poor seasons, particularly dry springs, has highlighted the relatively poor ability of canola to adapt to the conditions when compared with wheat. Although the physiology is not well understood, severe moisture stress and high temperatures cause canola to stop flowering prematurely, ultimately affecting yields.

Recent late breaks and/or dry winters have also exacerbated the situation, with delayed emergence and slow early growth resulting in late flowering during periods of higher moisture and heat stress.

The Canola Survey project identified emergence date and seasonal water supply (SWS) as the main drivers of canola yields. While emergence date can be relatively well managed through timely sowing (facilitated by no-till systems), seasonal water supply is more difficult to manage due to the unreliable nature of rainfall. However improved storage of fallow moisture and protection of in-crop rainfall, both components of SWS, can be achieved in no-till, stubble retained farming systems.

Having been identified as a strong driver of yield, seasonal water supply has been incorporated into a revised formula for determining water use efficiency (WUE) in canola by CSIRO[1] - see inset. Applied to the 42 paddocks in the Canola Survey project which all yielded to their water limited potential, WUE varied between upper and lower boundaries of 15 and 8kg/ha/mm respectively, with an average of 11kg/ha/mm. The variability in WUE was primarily due to differences in sowing time and rainfall distribution.

[1]M. Robertson et al (2005). Water use efficiency of dryland canola in an equi-seasonal rainfall environment. Australian Journal of Agricultural Research 56, 1373-1386.

Yield limiting factors in the Canola Survey project*

*(*Collaborative project between FarmLink, CSIRO & local consultants, funded by GRDC, 2003-2005.)*

From 2003 to 2005, a survey of 42 canola crops was conducted across southern NSW to identify possible causes of low yields. Under-performing paddocks were identified by comparing actual paddock yields with simulated potential yields (through calculation of water use efficiency and APSIM modelling).

Seasonal water supply[#] and sowing date were the dominant drivers of canola yields. Overall, yields increased by 7.5kg/ha/mm of additional water supply above a threshold of 103mm, but decreased by 14kg/ha for each day emergence was delayed past late April.

The most common factors associated with under-performing canola paddocks were subsoil constraints and late season moisture stress. The impacts of late season moisture stress and high temperatures (of which the physiology in canola is poorly understood) were more severe than predicted by modelling.

[#]Seasonal water supply (SWS) = in-crop rainfall + soil water at sowing - soil water at harvest.

S. Lisson et al (2007). What is limiting canola yield in southern NSW? A diagnosis of causal factors. Australian Journal of Experimental Agriculture 47, 1435-1445.

WUE?

WUE (water use efficiency) is a measure of crop yield in relation to available moisture (kg/ha/mm).

Although the French & Schultz method of calculating WUE has been widely used, a more accurate method specific to canola has been developed by CSIRO to account for stored water at sowing and water remaining at harvest, as follows:

WUE = yield ÷ seasonal water supply (SWS)

or

Potential yield = WUE x seasonal water supply (SWS)

where SWS =

in crop rainfall[a] -120mm (evaporation)

+ soil water at sowing[b] (fallow rain - 80) x 0.5[c]

- soil water at harvest (post flowering rain - 50) x 0.5[d]

[a] in-crop rain up to 450mm

[b] assuming a weed free fallow with stubble cover

[c] can vary according to timing of summer rain, eg. 0.6 if majority falls in March, or 0.4 if most falls in December

[d] varies from 0.2-0.5 in drier locations, 0.5-1.0 in wetter areas

FarmLink Research

For further information:
ph: (02) 6924 4633
farmlink@farmlink.com.au
www.farmlink.com.au