Newsletter of

WANTFA

Western Australian No-Tillage Farmers Association (Inc)

SURFACE MAIL | POSTAGE PAID

GRDC

PP 634505/0010 ISSN 1329-7600

APRIL 1998 *"Sustainable high production agriculture - now!"* Vol 6 No.2 pp 152-175

Don't no-till grassy pastures

New no-tillers should be aware that grassy pastures are not a good no-till starting base. Yield losses can be as high as 30% compared to a cultivation and then seed strategy. I have seen this often on south coast sandy soils.

You do not have to no-till if the paddock is not ready for it. In contrast, with excellent crop agronomy and in crop rotations, yield losses to no-till are unlikely. Remember yellow loamy sands do respond to deep knife-point cultivating below the seed.

Clay needs dry incorporation

Claying for water repellent soil is in full swing on the south coast. This is an exciting development, at a cost that may take a few years to recover. However, claying can convert troublesome repellent soils into very productive soils again, as Dan Carter's work with AgWA Albany shows.

I recently visited the pioneer of this technique, Clem Obst (see his story in this newsletter) from Bordertown, SA. One point Clem thought needed stressing to new adopters of claying is "the clay needs to be incorporated while dry to the full depth of the topsoil. Otherwise the clay can inhibit crop emergence and will not mix well when wet". Obviously, cultivation for some years after claying will continue to improve even mixing. However, what ants, earthworms and other bugs might do for incorporation – who knows!

Clem considers that dry cultivating is essential to claying success!

Follow glyphosate with Spray.Seed

For 10-15 years now John Moore from Albany AgWA, has been promoting the excellent strategy of using glyphosate as the first knockdown, followed by Spray.Seed. Amazingly, this is rarely used over east, while it is a common strategy for many south coast no-tillers. It makes even more sense now that glyphosate resistance has occurred in ryegrass in NSW (see Derek Barnstable's article in this issue).

It also provides effective dollar weed control and makes good sense. We have often seen weeds recover from high rates of glyphosate (see Feb '98 newsletter story by David Minkey), especially when there is no full-cut cultivation, as with no-till. Making the plants' roots sick with glyphosate and then blowing the tops away with 0.5-1.0 L/ha of Spray.Seed makes it almost impossible for the plants to recover. The Spray.Seed mixes well with many other useful soil-active herbicides.

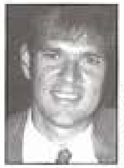
Ant heaps after 6 years of ZT

Gairdner farmer and WANTFA committee member Ric Swarbrick, has recently observed a new and interesting problem – ant nests at harvest time! Ric has been zero-tilling for 6 years and only in the last few years has he seen ant nests build up prior to harvest, which do not exist at seeding time. In low or weak areas of crops, Ric has to be careful not to clip the top off the 30 cm high ant nests with his header. Obviously, the extra ant numbers have implications on soil air and water pathways and weeds seeds left on the surface.

Make your break!

With the recent, and variable thunderstorm rains, the question is "do I kill the weeds

CONTENTS



Bill Crabtree, WANTFA's Scientific Officer is funded by:

GRDC
Grains Research & Development Corporation

with spray or cultivation?" Obviously, killing weeds early, ensures you store soil moisture, helping you to "make your break" (from Wayne Smith) on less rainfall, perhaps before the break would have otherwise occurred. Spraying the weeds before the soil gets dusty, and after the weeds germinate, is a tough call.

On heavy soils with poor structure, you may find it useful to scratch slots in the soil with knife-points, not too deep (5-7 cm), and on wider row spacings. The "fluffy" layer created is an evaporation barrier and also the knife slots can catch future run-off water. As soil structure improves, such a "tickle" may not be needed. Increased organic matter and soil structure will also improve infiltration.

The problem with the knife cultivation is that most weeds are not killed. Therefore, spraying with a soil active herbicides (as the weeds have not yet germinated) before the tickle would make good sense. Be sure not to let any of these weeds set seed. Remember also that it is hard to kill dusty weeds.

Free living N fixing bacteria

Did you know, that there are bacteria that can fix N in the soil - all on their own! – without legumes! Therefore soils without legumes in them can produce their own nitrogen to a small degree. However, the degree is increased with no-till and stubble retention, cultivating soils decreases bacteria's ability to fix nitrogen.

Dr. Margaret Roper

When I visited Dwayne Beck in 1996, he was keen to get out his pocket knife, dig out some soil from 5 cm deep, and put it in under my nose and insist I smell it. And to my surprise, there was a unique smell about the sod. Dwayne told me that the smell was the result of free living N fixing bacteria. CSIRO researcher, Dr Margaret Roper has done considerable work in this area. Her published work goes back to the early 1980's.

SBU helps define fertiliser toxicity risk

SBU (seedbed utilization) terminology is commonly used in the Great Plains of North America and has benefits for us. SBU is the width of the fertiliser and seed row as a percentage of the space between the rows. For example, if the seed and fertiliser spread is 2 cm wide on a 20 cm row spacing, then the SBU = 2/20 x 100 = 10%.

A high SBU means a low risk of N toxicity, while a low SBU - which is common with discs, means higher toxicity risk. The following table is modified from the Manitoba North Dakota Zero Tillage Farmers Association's publication *"Advancing the Art"* of zero-tillage, 1997. The table does not cover the gutless sands and is based on the maximum estimated-seed placed N for the Great Plains on 15 cm row spacing, in moist soil and for canola.

Soil Texture	Particle Size (%)			Max. estimated N (kg/ha) — Seedbed Used (%)		
	Sand	Silt	Clay	15 Discs (2cm)	30 2"pts (5cm)	60 Sweeps (10cm)
Loamy sand	80	10	10	5	10	25
Sandy loam	60	35	15	10	15	30
Sandy clay loam	55	15	30	15	20	35
Loam	40	40	20	20	25	40
Silt loam	20	65	15	25	30	45
Silty clay loam	10	55	35	30	35	50
Clay loam	30	30	40	35	40	55
Clay	20	20	60	40	45	60

Congratulations Pitmans

Lawry and Jenny Pitman from Corrigin, received the 1997 Farm Weekly no-till achiever of the year award at WANTFA's annual meeting in February. Well done Lawry and Jenny! Thanks to "Farm Weekly" for independantly conducting the award.

ZT canola problems after barley?

I know of at least 3 farmers who have experienced canola establishment problems with disced seeders on the south coast. A spraying contractor has also passed on the same observation. However, there are also many farmers that have not experienced the problem.

We are not sure of all the reasons for the problem It is possible that a combination of factors is involved. Obviously thick barley stubble will leak potentially nasty products out (especially in the wet). Hordenine and acetic acid are two such products. Moving barley stubble from the seed row would have to reduce the problem. Also insects, perhaps false wireworm could be more of a problem in this situation. I would like to talk to anyone who has any insights in this complex problem.

Canola loves lime!

Chris Gazey from AgWA, Perth, has shown some excellent canola grain yield responses to lime applied 1-6 years previously on acidic soils in the medium rainfall areas. Chris presented these results at the recent AgWA Crop Updates. These positive lime responses were despite one site (Narrogin) having a modest acidic level of pH 4.7. Lorelle Lightfoot of AgLime told me after seeing

Chris's work that, interestingly, many eastern states farmers have concluded the same thing - that the best crop to apply lime to is canola.

The challenge to no-tillers then is 'how to get the lime into the soil without tillage?' Those in the medium-high rainfall areas who have been no-tilling for a few years will get some earthworm incorporation. Dr Albert Rovira has presented data (Feb '92) showing significant lime incorporation with earthworms over a few years.

However, some of you in low erosion areas may need to use the plow to get the lime properly and quickly mixed in. In which case, you probably should also apply a good dose of trace elements before plowing. For those in areas at risk of wind erosion you may need to wait for the soil life to mix the lime in.

Location	Varley	Varley	Varley	Narrogin
pH at 0-10cm	4.40	4.33	4.3	4.72
pH at 0-20cm	3.9	3.93	3.9	4.66
Year applied	1991	1994	1996	1996
Variety	Karoo	Karoo	Karoo	Narendra
Sown	16/4	16/4	16/4	
Lime rate	Grain yield (t/ha)*			
0 t/ha	1.51 a	1.29 a	1.10 a	1.32 a
1 t/ha	1.57 ab	1.55 b	1.25 b	1.46 b
2 t/ha	1.62 b	1.69 c	1.36 c	1.60 c

*Numbers with the same letter in the same column are not significantly different.

TOPICAL SECTION

CHAIR'S CORNER

Geoffrey Marshall, President, (08) 9880 0018, fax 38

I would like to introduce myself to members with a brief profile of my past. My father was an original settler in Hyden who sold out in 1968. My two brothers and I developed new land properties east of Hyden until we disbandened our partnership in early 1977.

With my wife Vivienne we have continued to develop our property in this same area. Much of our driving force has been to educate our three children - two daughters, now at University and a son at Wesley College.

Other major driving forces are the aims to achieve profitable farming techniques and systems, and focusing on a sustainable system. From the late 70's we practiced reduced tillage, adopting direct drilling for many years with progression to no-till fór the last four years.

I view the future with excitement and optimism, knowing that there will be constant challenges, developments and improvements which we will all need to adapt to our specific needs. There will be opportunities throughout the year to meet and talk with a lot of WANTFA members and I look forward to these times.

I am fortunate to be working with a team of wonderfully enthusiastic and energetic people, who all display total commitment in their respective roles. I thank them for their support and look forward to a very productive year.

ANNUAL CONFERENCE REPORT

Kevin Bligh, Committee Member, (08) 9755 7589, fax 90

Some 250 people attended WANTFA's 1998 Annual Conference at Muresk Institute of Agriculture - 215 on the first day, and 150 on the second.

Keynote Speaker, Dr. Cynthia Grant, of Agriculture Canada, led with loads of information on No-till fertiliser placement in North America. Consultant, Geoff Fosbery and WANTFA's Scientific Officer (and Newsletter editor), Bill Crabtree followed with challenging local issues.

Monty House, Minister for Primary Industries, spoke on partnerships in agriculture. WANTFA's partnership with Muresk Institute at Curtin University was then launched by Professor Murray McGregor and current WANTFA president, Geoffrey Marshall. Both looked forward to increased cooperation (Bill Crabtree has been stationed at Muresk since commencing with WANTFA in April, 1997).

left: Minister for Primary Industry Monty House catches up with keynote speaker Dr Cynthia Grant of Agriculture Canada and Graeme Malcolm, retiring President of WANTFA.

Farm Weekly's No-Till Achiever of the Year was awarded to Lawry Pitman of Corrigin, for his family's progressive development of landcare with no-till – now partly funded by the Federal Government's National Heritage Trust.

Farmers, Stuart McAlpine of Buntine, Chris Syme at Cunderdin and Norm Flugge of Katanning then detailed no-till rotations that work well on their properties. They emphasised that each farmer must develop their own best rotations (See stories in the February newsletter and this issue).

After WANTFA's AGM, in the second morning, seven farmers and consultants then described results of extending rotations using lucerne and warm season crops, such as fodder sorghum (sown in September/October).

Former WANTFA President, Ken de Grussa of Esperance, described how canola yield increased from 0.8 to 1.8 t/ha following sorghum, while waterlogged lupins over the fence failed. Dr Phil Ward of C.S.I.R.O. described how lucerne lowered underground watertables at Katanning.

David Pfeiffer of SBS Rural IAMA, described the state of the art with pesticides and no-till. AgW.A. researchers Dr Paul Blackwell and Mike Collins showed data suggesting that disc no-till seeders may be more appropriate as soil structure improves, after several years of narrow-point sowing.

Dr Melina Miles of Agriculture Victoria described insect problems and solutions with stubble retention. Consultant Lyn Sykes from NSW discussed sustainability of the family on the farm. She observed that the Courts are saying divorcing wives can take 70% of farm assets. She challenged us to find a better investment than keeping the family together!

State Salinity Action Council chairman (and Mt Barker farmer), Alex Campbell described his excitement at hearing of farmers developing lucerne and warm-season crops. The threat of 30% of cropland becoming salty in 30 years time can, perhaps, be avoided by such no-till crop rotations.

Thanks to BankWest – whose Terry Budge gave an entertaining talk on farm businesses- for major sponsorship of the conference. Wesfarmers – CSBP also sponsored the marquee that housed nine exhibitors of no-till equipment.

RAFCOR's half-funding of farmers attending is also gratefully acknowledged. Thanks to consultant John Duff and Associates for organising the conference on behalf of the WANTFA committee - a worthwhile two day event!

K-KOMPLEX UPDATE

Bill Crabtree, Scientific Officer, 0417 223395

You may have read in the last February WANTFA newsletter a concluding comment to my K-Komplex article where Rural Liquid Fertilisers were invited to submit some more independent trial data on the performance of K-Komplex. I was supplied with 28 trial data sets from RLF, which were not from an independent source, as requested.

Rural Liquid Fertislisers submitted only one independent trial data set. The trial was conducted by researcher Bill Roy for the Beverly LCDC which showed no significant yield improvement to applied K-Komplex at the 5% level of significance.

THANKS TO: RAY HARRINGTON, KEN DE GRUSSA AND JOHN HICKS

Kevin Bligh, Committee, Busselton (08) 9755 7589, fax 90

WANTFA's foundation President, Ray Harrington of Darkan, received an Honorary Life Membership at WANTFA's 24-25 February Annual Conference, attended by some 250 people at Muresk Institute of Agriculture.

And pressure of other work has forced WANTFA's second President, and Committee-member (for nearly 6 years) Ken de Grussa of Esperance, and John Hicks of Pingrup (4 years) to stand down from the Committee. Having had the pleasure of working with them, I believe WANTFA has been extraordinarily well-served by all three.

Ray Harrington and his brother David, were deservedly acknowledged by "Farm Weekly's 1996 No-Till Farmer of the Year", Trevor Wilkins of Kondinin, as the "Fathers of No-Till". Both have been unstinting as invited speakers, even paying all their own costs as speakers at no-till field days as far afield as Morawa and Esperance. Few if any, paid full-timers have as much rubber on the road for no-till.

Together they oversaw the formation of WANTFA. Ray was President from 1992-94, with David - with four sons to settle - in the background. Ray continues to assist the WANTFA Committee, most recently serving on, no fewer than, four of its eight sub-committees.

Ken de Grussa of Esperance, took over as President in 1994, when Ray stood down for personal reasons. Ken's legacy is that no-till adoption by WA farmers increased from about 2 to 20% during his three years as President. Ken possess invaluable ability to accurately determine what the Committee wanted, and to then go out to achieve it. As a result, WANTFA assisted with the adoption of profitable soil conservation and other benefits only now becoming evident, through no-till sowing.

John Hicks of Pingrup, has likewise given much to WANTFA. Even when he had serious accidents to both of his eyes within six months, he was still contributing his valuable experience at Committee meetings. John brought to the WANTFA Committee many years of experience on the Kondinin Group Committee. His insightful interpretation of events, and courageous following through with well-measured action was invaluable, in my view.

I believe the relatively rapid adoption of no-till sowing - from about 0.1% of WA grain-growers in 1990, to an estimated 30% in 1997 - owes much to the quality of the people involved. None have contributed their talents more willingly than Ray Harrington, Ken deGrussa and John Hicks. I believe I speak for the WANTFA Committee in wishing them all the very best in their future endeavours.

NO-TILL WEED ISSUES

Bill Crabtree, Scientific Officer, 0417 223395

Did you know that weeds have developed resistance to cultivation and burning! We have been applying these selection pressures on weeds for about 6,000 years. A Wongan Hills farmer told me that his father had cultivated 14 times before late sowing a wheat crop in the 1960's, and amazingly the crop still failed due to large ryegrass competition.

It is clear that no-till systems offer some useful weed control windows that are not available with tillage based systems (see Stuart McAlpine's article in this issue). Some benefits from no-till weed management systems are: less stimulation of weeds; the time between crop and weed emergence is increased allowing Spray.Seed or gramoxone to be applied to emerging wheat or barley; soil active herbicides are usually more effective with no-till systems; increased crop safety with pre-sowing soil applied herbicides; and weeds are exposed to increased surface environmental factors (like sunshine, temperature extremes, surface-feeding insects and microrganisms).

Many people say no-till is doomed to fail due to herbicide resistance. However, there are many long-term no-tillers with excellent crop yields and minor herbicide resistance, and there are some conventional sheep:crop farmers who got resistance very quickly. I think the first recorded resistance was in SA was by a cultivating farmer with pasture in the rotation, who tried to kill very high ryegrass numbers with Hoegrass®.

There are three aspects to weed destruction; physical (includes cultural), chemical and biological. Resistance will develop to all three, and we need to use a mix of strategies to keep the weeds "off-balance" (Dr Doug Derksen, Ag Canada). Since our systems are always changing and we are gaining new insights, I suggest that we still do not know the full range of options available for us?

No-till weed control is more than just herbicides. Stubbles exude or leak chemical substances that upset germinating weeds. Notice how poor pastures often are after a 3-4 t/ha wheat crop, especially where the trash is thickest. Stubble can be used against weeds and in favour of the crop. By using wider rows and by moving some, preferably most of the stubble away from the seed row we can put the weeds in a hostile place - under the trash. This is a common practice among leading Canadian farmers. Destroying stubble with stock, cultivation or burning reduces this bio-chemical weed control mechanism.

Biological control has not been discussed much and I think is poorly understood. Trash and dying weeds left on the soil surface create a friendly environment for fungi, bacteria, insects and other bugs. These organisms will eat weed seeds left on the surface. Several studies around the Great Lakes of the US show that 95% of weed seeds left on the soil surface (no-tilled) are gone within 2 years. They are either eaten or, deep-buried by insects, become non-viable through pathogens, or try to germinate but die in the process.

What will our ants and termites and other critters do to our weeds after a few years of being left on the surface in our no-till farming systems? No-one knows! However, David Bowran's (Northam AgWA) herbicide trial at Avondale will be investigated for this possible change.

Changing tillage systems will change the weed sprectrum! Full-cut cultivation is just what ryegrass has adapted to. In Canada, fox-tail barley grass has adapted well to cultivation systems while other weeds, such as dandellion, like no-till. In WA, marshmallow likes no-till. Using least tillage means least ryegrass, the double disc show this most clearly.

No-till ensures consistent seed-placement and shallow or surface weed-placement, creating a window of opportunity for gramoxone or Spray.Seed. Seeding into marginal moisture is easily done with no-till. The crop therefore can be placed into moisture while weed seeds may be in dry surface soil before the next rain, as happened in 1997. These later emerging weeds are less competitive with the crop, but may still require attention.

"What do you do with sleeping dogs? Stir them up and shoot them, or let them lie?" May I suggest that we have resistance to cultivation, burning, sheep hooves, harrowing and raking just as we have to chemicals and the associated biological benefits (yet to be understood) of no-till with stubble retention. (For more of my thoughts on this issue see May 1996 WANTFA newsletter.)

HARROWS OR PRESS WHEELS?

Bill Crabtree, Scientific Officer, 0417 223395

Just how useful are harrows? And what are we using them for? Is it to mix the herbicide into the topsoil properly, or for levelling the soil surface, or for some other reason? The following useful data from Lamond and Burgess and Associates (printed in full in WANTFA's November '97 newsletter) shows that we are probably not using harrows to reduce weed numbers!

The challenging data set, and my discussions with many farmers, suggests that if you are hooked on harrows with your no-till system, then you should probably try some laps without them, provided you use some sensible soil active herbicide program.

	Ryegrass control (%)			
Treatment (L/ha or g/ha)	No-till IBS PW*	No-till IBS + PW Harrows	Direct drill IBS + Harrows	Direct drill PSPE + Harrows
Treflan 1.0	87	81	42	57
Treflan 2.0	97	86	78	74
Treflan 3.0	94	90	94	85
Treflan 1.0 + Logran 35	92	87	92	89
Treflan 2.0 + Logran 35	99	98	93	95
Treflan 1.0 + Diuron 1.5	90	80	67	87
Treflan 2.0 + Diuron 1.5	96	86	85	80
Tref 1.5 + Drn 1.0 + Log 35	98	93	89	83
Above + Lexone 150	98	95	92	88
Simazine 1.0	79	63	32	38
Logran 35 + Diuron 1.0	94	75	57	69
Logran 35 + Diuron 1.5	95	89	68	73
Logran 35	90	80	70	72
Diuron 1.5	72	63	31	60
Lexone 150	57	33	48	45
No Herbicide (pl/m2)	*960*	*630*	*480*	*520*
Average % control	**89**	**80**	**69**	**73**
Average **Treflan** % control	93	86	71	72

*PW = Press Wheels

SCIENCE SECTION

N PLACEMENT AND NO-TILL IN NORTH AMERICA

C.A. Grant, Ag Canada, Brandon, MB
email: cgrant@em.agr.ca

Effective fertilizer management is critical for crop production. Not only to improve farm financial returns, but also to maintain soil quality and reduce the likelihood of damage to the environment. Effective fertilizer management systems deal with four major factors:

1. Rate: Selected to optimize yield, without negative effects on crop or environment,
2. Source: Suited to the time and method of application,
3. Timing: Selected to ensure enough nutrients are available when needed, losses are minimized and operation is time-wise efficient and
4. Placement: Put where they are available to the crop when the nutrient is required, losses are minimized, crop damage is avoided and nutrient use efficiency is optimized.

Rate, source, timing and placement options can be combined into many effective management packages. The "best" fertilizer management package for a particular farm will vary, depending on crop grown, environmental conditions and other constraints within the overall production systems.

Tillage systems greatly effect fertilizer management decisions. Reduced tillage gives important advantages for crop production in the prairie provinces.

By reducing the number and intensity of tillage operations, a producer can improve water use efficiency, lower the cost of crop production, decrease the time required for field operations, and reduce the risk of soil erosion and degradation. However, reducing tillage has important implications for nutrient management. With no-till: moisture relations, distribution of nutrients in the profile, deposition of organic residues and the type and activity of soil microorganisms will change as compared to a conventional tillage system. This will impact directly on nutrient availability and on fertilizer management decisions. In addition, if the yield potential is increased under reduced tillage through improvements in moisture conservation, fertilization rates may need to be adjusted to take advantage of the increased productivity of the system.

Impact of reduced tillage on soil nutrient dynamics

With reduced tillage, residue from previous crops remain on the soil surface, rather than incorporated. This surface residue break down more slowly than incorporated residue, because contact between the residue and the soil microorganisms is restricted, the microclimate at the surface is less favourable for decomposition than in the soil, and the high C:N ratio of the straw may slow microbial action. The amount of legume in the rotation will greatly affect surface residue breakdown rates.

Residue accumulates at the soil surface as a mulch which improves soil physical properties and changes the microclimate. Surface crop residue reflects light and insulates the soil and buffers soil temperature and slows microbial breakdown of organic material. The soil will generally be slightly cooler during the spring and summer, but warmer during the fall and winter. The mulch and standing stubble will reduce evaporation and may increase water retention, so soil moisture content is generally higher under reduced tillage than under conventional tillage.

Slower microbial activity will also reduce organic matter loss. In addition, organic matter in the soil is frequently occluded within macroaggregates, where it is protected from decomposition. Tillage exposes this protected organic matter and increases its breakdown. Therefore, with no-tillage, organic matter accumulates, this thereby improves soil aggregation, water-holding capacity, tilth, and resistance to wind and water erosion. The amount of nutrients available for crop growth may be decreased, in the initial years of no-till. Therefore, it may be necessary to compensate for this by increasing fertilizer rate or improving the efficiency of fertilizer management.

While nutrient dynamics may be altered with reduced tillage, other mechanical considerations may also be important. Frequently under no-till, there is a desire to restrict soil disturbance as much as possible. This reduces moisture loss, maintains residue cover and can reduce weed competition. In some situations, however, some degree of soil disturbance may be beneficial, allowing for some drying and warming of wetter, colder soils, and improving access to the land earlier in the spring.

The most efficient placement method for macronutrients (N, P, K, S) is generally in-soil banding, which increases soil disturbance. But, including banding openers on a seeder can increase draft requirements and problems with trash clearance. Therefore, selecting a fertilizer handling system for no-till is often an exercise in compromise, where one must balance the pros and cons of each decision on the overall crop production system.

N fertilizer management considerations

Nitrogen is the nutrient most commonly limiting to crop production in most areas of the world and the nutrient generally applied in the largest quantity. On the Canadian prairies, soil testing for prediction of N requirements is relatively effective, as the nitrate N contained in the soil in the late fall or early spring is a reasonable predictor of available N for the crop. Combining information on soil nitrate content, predicted moisture conditions and estimated yield potential provides an estimate of the amount of fertilizer N that must be added to optimize crop yield and quality.

Nitrogen fertilizer supplies N in the form of ammonium, nitrate, urea (which rapidly converts to ammonium in the soil), or as a blend of these ions. Soil microorganisms convert the ammonium to nitrate through nitrification, with conversion increasing as soil temperature increases.

Nitrogen is subject to losses by volatilization, immobilization, denitrification and leaching. Volatilization refers to the loss of N in the form of ammonia gas. Ammonium and ammonium-producing sources, such as urea, are readily lost by volatilization when left on the soil surface in North America, while nitrate sources are not. Volatilization losses increase with factors that increase evaporation, such as high air and soil temperatures and wind. Applying the fertilizer when temperatures are cool, winds are light and there is a good likelihood of receiving rain in the near future would help to reduce volatilization losses.

Immobilization refers to the "tie-up" of N in the soils microorganisms, as they use the N for their growth and reproduction. Both ammonium and nitrate sources of N are subject to immobilization losses.

Denitrification is the conversion of nitrate-N to gaseous forms of N, which can be lost to the atmosphere. Denitrification occurs when available oxygen in the soil is limited. This can occur under flooded conditions or when the soil is very compacted. Even when the soil is not completely flooded, there will be microsites in the soil where oxygen availability is limited and denitrification can occur. Rate of denitrification will be faster when soil temperatures are warm, because the activity of the microorganisms that cause denitrification increases with increasing soil temperature.

Leaching is the movement of N in the soil water down through the soil profile. When the N moves below the rooting depth, the plants can no longer reach the N, so it is lost for crop use. Ammonium-N is normally bound to soil particles and so protected from leaching losses. Therefore, nitrate sources of N are much more susceptible to leaching losses than are ammonium sources. Leaching will increase with increasing rainfall and on sandy soils.

The potential for N loss from these pathways will depend on soil type and environmental conditions. Nitrogen source, timing and placement can be manipulated to minimize N losses and maximize fertilizer use efficiency.

Broadcast and surface applications

Broadcast fertilizers may be less available under a reduced tillage as compared to a no-till systems, especially when urea is used. Surface applied N is subject to volatilization loss, if it remains at the soil surface. Use of a source containing a relatively high proportion of nitrate, such as ammonium nitrate, may reduce volatilization losses, since nitrate is not subject to volatilization. Urea is particularly subject to volatilization losses *(Editor: especially in Canada)* if topdressed, since the concentration of ammonium released from urea is high.

The presence of crop residues at the soil surface may increase volatilization, since the residues contain the urease enzyme which breaks down urea and makes it subject to loss as ammonia gas. The crop residue may also increase immobilization, since the raw organic matter, with a high C:N ratio will tie up N as the residue decomposes. Therefore, separation of the crop residue and the N, by placing the fertilizer below the residue may be even more important under no-till compared to conventional tillage.

Barley grown under no-till can yield less than when grown under conventional tillage when urea is broadcast, but can be equal if the fertilizer was side-banded or placed below the seed. The following table, from Malhi and Nyborg 1991, shows barley grain yield under no tillage (NT) and conventional tillage (CT) with three methods of N placement at 67 kgN/ha over 6 years.

Placement Method	Grain Yield (kg/ha)		
	CT	NT	Ave
Broadcast[1]	1.40	1.21	1.31
Side Band	1.45	1.53	1.49
Below Seed[2]	1.57	1.51	1.54

1. Broadcast without incorporation for NT and with incorporation for CT
2. Banded 5 cm directly below the seed

The barley yield increased when N was banded as compared to broadcast under both no and conventional tillage. However, the increase was greater under no tillage. In spite of the potential for loss of surface applied N (in Canada), broadcast application may be a practical choice particularly for beginning no-tillers, since it allows for application of large amounts of N without soil disturbance, investment in specialized equipment, or high cost of field operations. While a higher rate of fertilizer may be required to compensate for the reduced fertilizer use efficiency, this may be a practical compromise, particularly for those who are not willing or able to purchase specialized equipment for in-soil fertilizer placement under no-till.

Ammonium nitrate is generally considered more efficient than urea when broadcast, since ammonium nitrate is less subject to volatilization. However, under the right conditions, surface applications of urea can be as effective as surface applications of ammonium nitrate (Table 3). Volatilization losses will be minimized by application of the fertilizer when air and soil temperatures are cool. Rainfall soon after application will wash the fertilizer into the soil, reducing losses. Use of ammonium nitrate or urea ammonium nitrate (UAN) dribble bands as post-seeding treatments up to the 4th leaf stage of the crop may also produce good results.

Another possibility may be the use of urease inhibitors in the urea fertilizer to reduce volatilization losses. Urease inhibitors slow the conversion of urea to ammonium ions. This would allow more time for the urea to move into the soil before release of ammonium ions led to a high risk of ammonia volatilization. Also, with slower release of the ammonium ions, concentration of ammonia at the soil surface would be reduced, which reduces the rate of volatilization.

Seed placement

N placement in the seed-row is a popular option, as it eliminates an extra pass for fertilizer application. If the fertilizer is placed directly with the seed, it eliminates the extra expense, draft requirements and soil disturbance required to side-band. Seed-row placement is a form of banding, so it is efficient in terms of reducing N losses. However, applying excess N with the seed can lead to seedling damage, reduced crop yields, reduced response to nitrogen fertilizer and reduced nitrogen use efficiency.

Canola is more sensitive to seedling damage than wheat or barley. Urea tends to be more damaging than ammonium nitrate, while urea ammonium nitrate (UAN) tends to be intermediate, since it is a blend of urea and ammonium nitrate. The amount of damage from seed-placed fertilizer will vary year to year. A reasonable compromise may be to apply a portion of the fertilizer with the seed and broadcast the remainder.

Use of urease inhibitors will increase the level of urea that can safely be applied with the seed. Since urease inhibitors will slow the conversion of urea to ammonium/ammonia, the concentration of toxic salts and ammonia in contact with the seedling will be reduced and the urea will have a greater opportunity to diffuse away from the seed before causing injury. Field studies have shown that this can increase stand density and vigour at high rates of urea application, leading to a higher final yield.

Ultimately, any N fertilization package has advantages and disadvantage. In selecting the optimum fertilizer management system for a farming operation, the balance between rate of application, cost and availability of equipment, soil disturbance, seed-bed quality, moisture conservation, time and labour constraints and fertilizer use efficiency must be considered. Often losses in efficiency in one area can be compensated for by improvements in efficiency in another. The "best" management system is not fixed, but will depend on the major limiting factors on each individual farm. *(Editor: This paper has been greatly distilled in order to fit into this newsletter, a second part to this talk will be presented in the next WANTFA newsletter).*

AVOIDING DRILLED UREA TOXICITY

Bill Crabtree, WANTFA's Scientific Officer 0417 223395

Wider rows and narrower points make for more efficient dryland cropping, but with increased fertilser toxicity risk. There are two types of fertiliser toxicity - a salt effect: phosphate, sulphate and nitrate salts particularly in drying conditions - and a urea associated effect which rapidly converts to toxic ammonia and ammonium. The problem can be avoided by; using liquid fertilisers with uniform flow, or by providing some distance between seed and fertiliser by,

a) splitters on knife point openers,
b) banding below or to the side and
c) using a disc to place fertiliser off to one side

The most popular method of overcoming fertiliser toxicity with no-till in Canada has been to split the seed and fertiliser with two openers, like the ConservaPak and Seed Hawk. In this case the N and P is placed 2 cm below and 2 cm to the side of the seed. While effective in Australia, this method is perhaps not precise enough for water repellent soils and on our sandier soils where toxicity is a greater risk. However, apart from these limitations, I think these machines have exciting potential for WA.

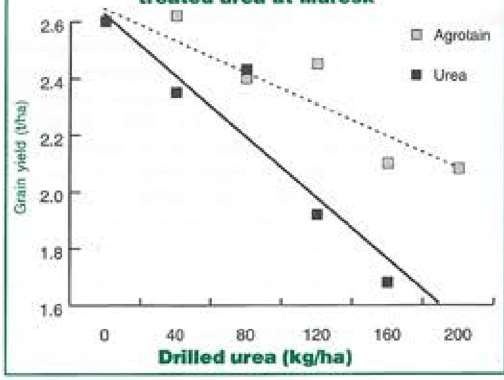
Another way to overcome urea toxicity, which is now commercially available, is by adding a urease inhibitor (enzyme) called Agrotain® to urea. Agrotain can be purchased from Elders, Summit or KFP at about $85 for 5 L which will treat one tonne of urea. This product will likely halve urea toxicity (see data below).

Agrotain 1997 trial results:

My work shows that Agrotain® has halved urea toxicity. Alternatively, you could use twice the urea rate for the same degree of toxicity. This result is similar to work by Canadian Dr Cindy Grant, Keynote Speaker at WANTFA's '98 Annual Conference.

Agrotain® delays the conversion of urea to ammonia or ammonium from 1 to over 14 days. By slowing ammonia production, the emerging seed can develop with less ammonia damage. Also the urea molecule has the potential to move below the soil surface before it converts to the binding ammonia form or the volatile ammonium form. Such benefits make Agrotain® potentially useful.

There was a negative grain yield response to applied N for the trial site, because barley was sown into a N-rich faba bean stubble on 20th June, limiting yield potential. The data is still useful as its main objective was to investigate N toxicity, which it did effectively. It also shows that even where responses to N are negative, which often occurs in parts of N responsive paddocks, yield loss can be greatly reduced with Agrotain® application.

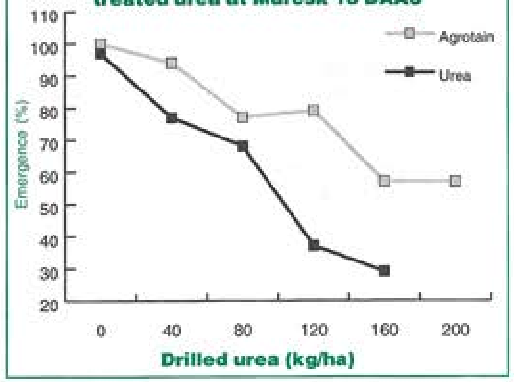


Barley grain yield with Agrotain® treated urea at Muresk

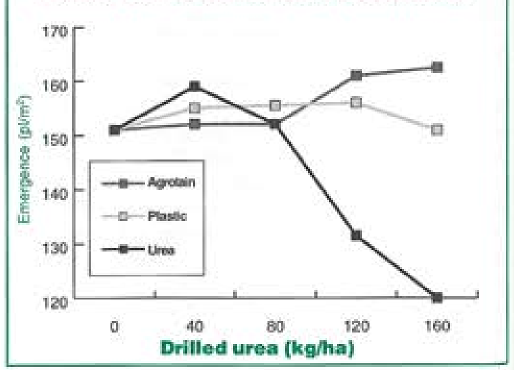
Plastic coated urea trials in 1997:

Plastic coated urea (found on the Internet) also has exciting potential to reduce toxicity and provide other benefits. While not commercially available in 1998, it may be in 1999, depending on this years trial results. The technology has wide potential if it can be done at an affordable price. WANTFA will test plastic treated urea in large and small trials in WA in 1998. The company involved have excellent trial results from China, as well as my own 2 trials (see below).

The plastic coat can be made of varying thickness which, along with soil moisture and fertility, determines its rate of release. The urea can release from 20-120 days after seeding. Quickest release product will be least expensive, provid-



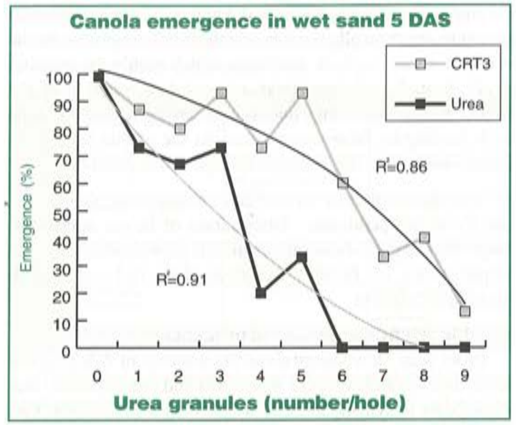
Barley emergence with Agrotain® treated urea at Muresk 18 DAAS



Wheat emergence with Agrotain® & Plastic treated urea at Dowerin at 18 DAAS, 1997 ing opportunities for a range of ideas, including other nutrients (K), inoculants, fungicides or crop seeds (as Paul Blackwell has suggested).

During 1997, I conducted two field trials (sown 2nd August) to test for toxicity effects. August was a wet month and wheat emergence was only slightly decreased with 160 kg/ha of urea which was drilled with 120 kg/ha of Wilgoyne wheat sown with the Great Plains with 80 kg/ha of Double Super. Because of the late sowing the two trials were not harvested. Photos of the site show that the plastic release profile was as it should have been.

A glasshouse experiment at Muresk showed that canola emergence in sandy acidic soil was much safer when urea was treated with a plastic coat CRT3. The experiment was done in a glasshouse at 25°C with soil kept at field capacity.



Canola emergence in wet sand 5 DAS

DEEP Mn FOR LUPINS

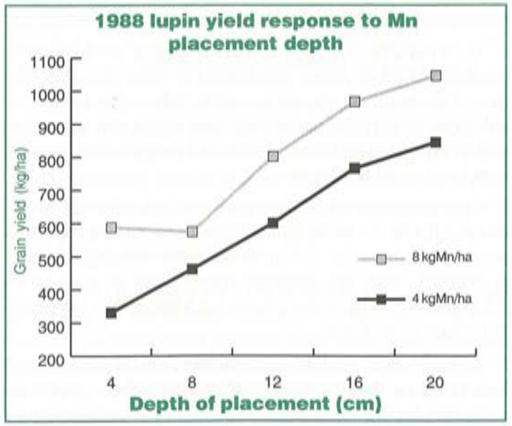
Bill Crabtree, Scientific Officer 0417 2233 95

In 1987, I initiated trialling deep placed Mn for lupins at Esperance, on soils without applied Mn history. These two trials were ably assisted by Ross Brennan and Mark Seymour of AgWA and the trials gave the first significant grain yield responses to deep placed fertilisers in WA. Subsequent trials by Ross, generally gave smaller and sometimes no yield responses to deep placed Mn.

The Mn placed 30 cm deep increased grain yield by 10% (from 2.68 to 2.93 t/ha) over plots that were also ripped to 30 cm and had shallow Mn placement depth. In the following year, spectacular yield responses occurred (see graph).

The 1988 trial was unusually responsive to deep Mn. Subsequent work by Ross has been unable to repeat these large responses. However, they are worth showing as liming has made this information potentially more valuable. Placing Mn into more acidic soils at depth, will increase Mn availability. Foliar applied Mn at flowering in this 1988 trial gave 800 kg/ha (lsd at 5% = 144 kg/ha).

1988 lupin yield response to Mn placement depth



The big 1988 yield responses could be due to the suppression of aphid damage, as aphicides were applied on a neighboring lupin trial by Mark Seymour, and gave large yield responses. Applying micronutrients to many crops often increases a plant's ability to resist numerous diseases, and disease suppression following applied Mn is often documented. Aphicide was applied to this trial, but it was after huge aphid numbers had built up.

FALSE WIREWORMS IN CANOLA

Dr Melina Miles, VIDA, Horsham,
Vic (03) 5362 2191, fax 87

We do not know very much about false wireworm. They have not traditionally been considered pests although they are common in pastures. They are generally considered to feed on organic matter or the microorganisms (fungi) associated with decomposing organic matter.

There are four main species. In Victoria the dominant species associated with seedling loss in canola is *Isopteron punctatissimus* (grey false wireworm). In SA the species are *Adelium brevicorne* (bronze field beetle) and *Gonocephalum sp.* (southern false wireworm). *Gonocephalum* is associated with damage by adult beetles to spring-sown canola in the upper south east of SA. In WA, *Adelium* and *Gonocephalum* are the species implicated in damage to canola crops. The fourth species, *Pterohelaeus* is common in Victoria, but is not associated with crop damage.

Life cycles

Isopteron, *Gonocephalum* and *Adelium* have 1 year life cycle. *Pterohelaeus* has 2 year lifecycle. *Isopteron* adult beetles survive over summer, whether eggs are laid before or after the break is unknown. Larvae develop rapidly through the first 3-4 instars and then spend the rest of the winter and spring in the late instar. Pupation starts in early spring (Sept-Oct) and adult beetles start to emerge and disperse (large numbers caught in light traps) from December. *Gonocephalum* adults emerge before *Isopteron*. Although we know little about *Adelium*, it is likely to have a life cycle similar to that of *Gonocephalum*.

Isopteron larvae move up and down in the soil profile with noisture, but typically are found in the top 2 cm, just under the crust. Larvae ringbark seedlings which results in seedling leath through moisture stress, or complete severing of the lypocotyl. As seedlings mature they are better able to cope vith feeding by false wireworms. At the rosette stage, few plants continue to die, but root damage is still visible.

The distribution of larvae, and consequently damage, is patchy across paddocks. Distribution of larvae appears to vary with soil type. For example, friable grey clays have higher populations of false wireworm than red soils with higher clay content.

ítubble retention and no-till influence

From what I have heard about the situation in WA, it would eem that numbers of false wireworm and other species, like arwigs are increasing in no-till systems. The situation in Victoria, where I have looked at this issue, is not so clear. In WA, t is likely that the increase in the volume of stubble retained in o-till systems has provided an abundance of food and shelter hat is being exploited by the false wireworms.

Stubble provides shelter for the over-summering adults, educing mortality from exposure/dehydration. Eggs and early nstar larvae are similarly less vulnerable when protected from he elements by stubble, and not damaged or exposed by the oil disturbance that occurs when the ground is worked. These actors combine to result in a population increase.

In 1997 I surveyed 60 paddocks in north-west Victoria to etermine the numbers of *Isopteron* in them, and collected 6 ear paddock histories. All paddocks were in areas which ad a history of false wireworm damage to canola, although ot all paddocks had had canola. There was often considerable variation in false wireworm density between paddocks n the same farm.

There has been a lot of talk amongst canola-growers in he Wimmera about how false wireworm damage was much reater in paddocks that were direct drilled. There were no orrelations between false wireworm numbers and the number f cultivations, number of burns, or crop rotations - factors ırmers have thought to influence false wireworm numbers. The only thing the paddocks had in common was soil type, all vere grey cracking clays.

What this illustrates quite clearly is how little we under-tand about what factors are important in the survival and eproduction of false wireworms. It is not until we have a ound understanding of the biology and ecology of the species, that we will be able to identify which factors we can nanipulate to effectively manage damaging populations.

It is possible that the damage that we are associating with ılse wireworm alone is actually symptomatic of a combination of factors. It is possible that false wireworms are partly esponsible for damaging canola seedlings and it has been iggested by (Mike Grimm, AgWA Albany) that there is a elationship between fungal pathogens, false wireworms and he seedling damage we are seeing.

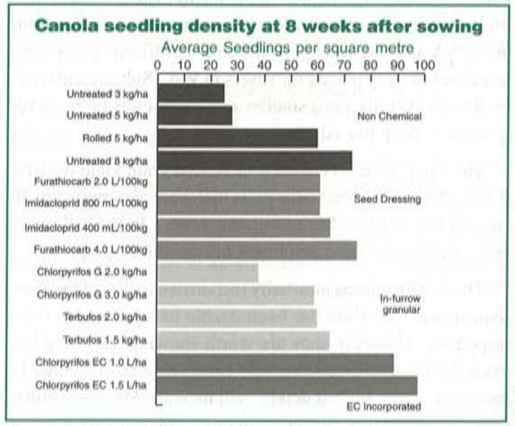
Two scenarios are possible. That the feeding injuries of ılse wireworm larvae allow entry of fungal pathogens, such as rhizoctonia. Rhizoctonia that has been linked to the so called "canola seedling blight, or hypocotyl rot" in Victoria. Alternately, false wireworm larvae may be feeding on fungal pathogens that have infected seedlings, and consequently damage the seedlings.

Options for managing false wireworm

In 1995, we conducted a field trial where we looked at a number of control options, including 5 chemical and 4 non-chemical treatments. The chemicals investigated were Lorsban U (chlorpyrifos), Counter (turbufos), Promet (furathiocarb), Gaucho (imidacloprid) and Lorsban EC (chlopryifos). Only 3 treatments did not work (<50 plants/m^2) - sowing at 3 kg/ha, sowing at 5 kg/ha (control) and the granular, in-furrow chlopyrifos treatment (Lorsban). (See below graph).

The exciting result from this trial was the good seedling survival in the plots that were rolled, and the plots sown at 5 kg/ha. Rolling may have two effects (i) compact the soil around the seed limiting movement of false wireworm larvae in the seed zone and (ii) increase seed-soil contact, resulting in increased seedling vigour. The success of this treatment suggests that the use of press wheels may minimise seedling loss caused by false wireworm. However, the use of press-wheels has not been investigated directly.

Canola seedling density at 8 weeks after sowing



Sowing at higher rates, has not been considered a viable option given the problems with lodging and harvesting of areas of the paddock not thinned out by false wireworm.

In Wimmera, a large number of canola growers have adopted the prophylactic application of chlorpyrifos as the means of minimising losses caused by false wireworm. The chlorpyrifos is applied pre-sowing, tank mixed with trifluralin, and incorporated into the soil surface. However, chlorpyrifos is not registered for this use.

This treatment certainly works, and probably has some advantages as far as RLEM control goes, but I have some hesitations about its sustainability. For many growers it is overkill. They are applying chlorpyrifos at rates up to 1.5 L/ha ($20-30/ha) without knowing whether they have false wireworm infestations.

Other growers are prepared to tolerate seedling losses and bare patches in the crop, as remaining plants often compensate well. The increasing use of chlorpyrifos is also of concern in terms of increasing the rate of resistance in RLEM populations; both chlorpyrifos and omethoate are organophosphates.

Research directions for false wireworm

Chlorpyrifos is a useful stop-gap tool, but we must pursue more sustainable solutions to managing false wireworm. In WA some preliminary work needs to be done to assess the distribution and impact of false wireworm in canola growing regions. We also need to gain an understanding of their biology and ecology in order to devise effective management strategies that will be sustainable and compatible with our farming systems. *(Editor: Melina also spoke on RLEM and other issues with stubble retention and no-till. Hopefully this will be included in the next newsletter.)*

ROTATIONS AND ISSUES

Geoff Fosbery, Farm Focus Consultants, Northam
(08) 9622 5095, fax 7153

Introduction

To me no-till means establishing a crop in a single pass operation, using cultivating points with a width less than 5 cm, on a machine with 15-30 cm seed row spacing. The technique has been adopted by many farmers for numerous reasons, including the ability to furrow sow, modified incorporation of soil applied herbicides, and a perceived/real improvement in 'soil health'. No-Till is developing at an exceptional pace and we tend to be solving problems on the run with some expensive and dire consequences along the way, especially for a few individual farming businesses. This paper discusses rotational techniques and the current and future challenges.

Soil applied herbicides

With no-till crop establishment regimes many soil applied herbicides have been 'reborn'. Of course, the rapid emergence of herbicide resistant weeds in paddocks has also contributed to making some rapid changes in weed management.

Trifluralin is the finest example, with dramatic increases in the area treated and the rates used. Its use post plant incorporated (POPI) and incorporated by sowing in no-till (IBS-NT) has made it into a relatively high percentage weed control herbicide (see previous WANTFA newsletters). Unfortunately, many of the herbicide product labels need updating to account for the rapid changes in crop establishment technology. Perhaps this may be achieved when the Criddle Review on pesticides has been analysed by the public and the government.

No-till crop establishment techniques with trifluralin have increased percentage ryegrass control from the 80's into the 90's. Annual ryegrass has lots of genetic variability in its population. Therefore beware of over-using trifluralin, as experience shows that highly efficacious pesticides tend to rapidly select for resistance. Follow the old adage, "when you are on a good thing, do not stick to it."

To avoid resistance for as long as possible, I would suggest a general use of trifluralin in the cereal part of the rotation, and preferably with a partner herbicide to assist trifluralin when ryegrass numbers are high. Below is an example of how I see a general ryegrass control program using a range of control measures, through a particular multi-crop rotation. However, remember that most things in agriculture are not black or white but mostly shades of grey. Hence there are always exceptions to the rule!

Crop	Herbicides	Seed set control	Mechanical
Lupin	Triazine, Fop, Dim	Crop top	Harvest seed collection?
Wheat	Trifluralin, SU	Bale & glyphosate blow out patches, graze residue.	Harvest seed collection?
T T Canola	Triazine, Fop, Dim		Swath, concentrate windrow, burn windrow
Wheat	Trifluralin, SU	Bale & glyphosate blow out patches, graze residue.	Harvest seed collection? Burn?
Barley	Trifluralin, Triazinone		Swath, concentrate windrow, burn/graze windrow?
Use a number of different techniques that suit your farm system!			

The limited soil movement of no-till equipment provides some great opportunities in revising the use of a range of soil applied herbicides previously found to be damaging to crops - Simazine in wheat for example. However, the biggest challenge will be to make sure that these new uses are fully investigated and registered prior to wide scale use, in order to ensure our clean product reputation is not tarnished. We do not want an accident like Helix on cotton stubble in NSW and Qld!

No-till rotations

I don't believe there are, as yet, common farm rotations specific to no-till. With the introduction of new crop species and varieties, along with new pasture species and varieties we can be a lot more flexible in our rotations. However, there are some general principles to follow:

- Grow a legume every 2-5 years (crop or pasture).
- Rarely have more than two cereals in succession.
- Have at least two seasons between canola crops, more in southern areas.
- Maintain or improve soil organic matter content (the soil's "Grunt!").
- Maintain good profitability, not necessarily maximum profitability each season.
- Have a pleasant life style and family life (you only live once!).

The types of rotations that obtain most of these goals can include:

- Lupins: Wheat: Canola: Wheat
- Lupins: Wheat: Canola: Wheat: Barley
- Legume Pasture (2-3 years): Canola: Wheat: Barley: Lupin: Canola: Wheat: Cereal? Then re-establish pasture (a phased rotation of pasture and crop).
- Medic:Wheat:Medic:Wheat:Cereal

The above are just a few examples which can be used but there is no one correct rotation which will suit everyone. In a farm system you may have several rotations operating depending on soil type or other constraints. Every farm business and management team is different. You must sit down and determine your priorities and goals before deciding on your direction. What the farmer over the fence is doing may not be the direction in which your business should be heading.

I am yet to be convinced that a viable multi-cropping no-till system will consistently increase organic matter contents of many of our WA soils (perhaps zero-till can). No-till in a multi-cropping system will certainly reduce the rate of decline in organic matter. Therefore I have a biase towards having some pasture in the rotation to put 'grunt' back into the soil. However, at present there is extreme pressure to reduce the percentage of pasture in rotations.

It is definitely time to re-evaluate our attitude towards pastures. They should not be just those plants that happen to grow in the year after crop. The pasture has to work for you and the soil, hence should be at least 70-80% legume. To obtain this type of pasture most of us have relied on self regenerating subclover and Burr medic pastures after a crop. This has restricted the cropping phase of the rotation to 1-2 years, and blinkered our grazing techniques.

The use of soft seeded and well-above-ground-seeding pastures should be reviewed in farm strategies. Once you open the door you will see numerous opportunities, including the use of Phased Rotations. The wider use of Cadiz Serradella and Persian Clover has signified the beginning of new attitudes to pasture management. (A phased rotation is one that has numerous years of cropping followed by at least two years of pasture.)

Trace element application and re-application

Do you think that the trace element status on your farm has been okay? Think again! Ask yourself some of these questions in reviewing your farm:

- Was the wheat crop really frosted on those sand seams? Perhaps it was a copper deficiency. This has been especially the case on paddocks with dominant duplex soil types that could have been treated in the past as 'heavier' soil types and did not require trace element application. Hence the sand seams were the first to have copper levels depleted in the soil.
- Was the paddock classified as heavier soil and did not require trace elements? It is now more than 50 years since clearing, cropping intensity has increased and potential yields have increased dramatically. Hence the rate of nutrient removal has increased.
- Have SU herbicides damaged my alkaline soil wheat crops? Has the wheat crop looked affected by waterlogging but the crop is yellower on the white stony ridges than in the wet hollows? Many of us have forgotten about the reduced availability of Zinc in alkaline soils.

After asking appropriate questions and making some incorrect assumptions about some clients trace element histories, I am convinced that many farms have paddocks and significant areas within paddocks with marginal (<10% yield loss that you can't see) to deficient (>10% yield loss) trace element status. In the no-till crop establishment system it will not be easy to overcome trace element deficiencies, particularly copper and zinc, which are relatively immobile in the soil and require physical mixing.

Trace elements on acid to neutral sands and loams

In a copper deficient situation on newly cleared light land there is a requirement for at least two incorporations with full-cut points in order to overcome >90% of the copper deficiency. A foliar spray of copper prior to the wheat flowering along with the soil applied copper and two workings will give you maximum grain yield. This is shown in a trial by Bill Porter et al, on new land at King Rocks in 1982.

Fertiliser treatment (kg/ha)	Cultivation No.	Yield (t/ha)
Control-250 Super Zn, Mo	one	0.46
250 Super Cu, Zn, Mo	one	1.74
250 Super Zn, Mo + Cu soil spray	one	1.49
250 Super Zn, Mo + Cu soil spray	two	1.88
250 Super Cu, Zn, Mo + Cu foliar spray end of tillering	one	2.08
LSD at 5% level = 0.08 t/ha		

If you have copper deficiency, then perhaps you may need to "bite the bullet" and pull out those full-cut points and incorporate copper into the soil adequately, and maybe apply a copper spray at the end of tillering. You should then return to your no-till methods and apply a maintenance amount of trace elements. However, if you are determined to keep no-tilling, then here is another way of doing it:

- Apply trace element rich granular fertiliser (eg Super Cu Zn Mo) for at least three years to reach an equiva lent new land rate of copper. eg 3 years of 80 kg/ha Super Cu Zn Mo.
- For each of these years of fertiliser-applied copper, also apply copper as a foliar spray at the end of tillering.
- In the fourth year tissue test mid-tillering to determine plant Cu levels.

Determining the best method in overcoming the problem is a challenge to us all.

Trace elements on alkaline loams and clays

The availability of zinc in particular is low on loamy and clayey soils. I have had the unfortunate experience of applying half the acid sandy-soil, new land rate of zinc, and finding the crop still zinc deficient. A foliar application of zinc at the 3 to 5 leaf stage of the wheat crop was the only way to stop the problem and obtain close to maximum potential grain yield.

In no-till, the means of overcoming this problem of zinc being tied up on alkaline soils may involve seed coating with zinc, and/or foliar application to each wheat crop sown. Applying the normal trace element fertilisers is not the way to go, as on these alkaline soils the levels of available copper are often very high, and additional copper may cause a copper toxicity.

To determine whether you have a problem with zinc on heavy country, you need to take an early growth stage (3-5 leaf) tissue sample of the wheat crop. A grain sample is the next best, but you have already lost yield. Finally, a soil test can give you an indication but there are very large grey areas in interpreting the results.

Root lesion nematode

A survey of the WA wheatbelt is now being done to help determine the significance of root lesion nematode. It has been a major problem in South Eastern Australia for more than 10 years. In 1994 it was identified in the Esperance area by Bill Crabtree. However, during 1997 it was identified in numerous wheat crops around the State. The crop 'above ground symptoms' are a general ill thrift and the leaves can wilt even when there is deemed to be adequate soil moisture.

It is a complex root disease with at least two nematode species (*Pratylenchus thornei* and *Pratylenchus neglectus*) causing the same problem. Wheat and Chickpeas are the most susceptible crops to both nematode species. A range of plant species can be tolerant to one but susceptible to the other nematode. Also you can find varieties that are more tolerant and/or resistant to *Pratlylenchus*. Current work is determining the tolerance and resistance levels of crop species and varieties. Hence keep an eye out for the up-to-date details (*Editor: see next article*).

I am afraid at this stage the control measures for *Pratlylenchus* or root lesion nematode are a challenging problem for the no-till. In some 1997 trial work in Victoria by the Birchip Group (Research Report 1998, Harm van Rees) it was found that wheat and barley yield was doubled on cultivated fallow (October 1996) compared to chemical fallow medic pasture. These results could be directly attributed to the effects of root lesion nematode. The direct drilled treatment yielded significantly better compared to the summer dry cultivation and moist May cultivation practices. However, they were still only around half the yield of the long cultivated fallow plots. *(Editor: Postlethwaite experience, just immediately south of Birchip, was to remove the most susceptible crop from the rotation (chickpeas) and this pulled back their Pratylenchus problem).*

Much more research needs to be done on this disease in WA before large changes to present no-till systems would be deemed necessary. However, we should be aware of the potential problem and be prepared to meet the challenge!

MARGINAL MOISTURE SEEDING

Mike Collins, AgWA Northam, (08) 9690 2114

At the completion of a three year GRDC project, I can make some conclusions about the effects of opener type and stubble level on crop emergence in marginal soil moisture conditions. Triple disc seeders do conserve more moisture than tined seeders, due to less soil disturbance, more even seed placement and increased water harvesting in press wheel grooves, with increased crop establishment and increased yields.

Knife points (12 mm) will effectively cut and fracture the soil but with less soil throw than occurs with inverted "T" points. Knife no-till cropping systems, when used in moist soil conditions, and with good crop agronomy, will usually give crop establishment and yields similar to other tillage systems. However, in 'extreme' or 'marginal' moisture soil conditions, seeders with least soil disturbance will give the best crop establishment.

In 1997, we sowed 80 kg/ha of Halberd wheat (long coleoptile) into marginal moisture conditions at Merredin on a loamy sand. The seeding systems used were; full-cut direct drill, knife point, inverted "T", Triple disc with wavy front coulter. Fertilisers were topdressed on 2nd April at 150 kg/ha of Agras and 80 kg/ha of urea. Knife point sown seeds were deeper than those sown with inverted "T" points, which lead to the greater emergence at 14 days after sowing. At seeding, the soil moisture was 5.5 %, and drying. The maximum air temperature was 25°C and soil temperatures at 2 cm soil depth were warm (38°C max). There were big soil moisture and crop emergence differences between the openers, which persisted for some time.

	Soil moisture (%) at 2 days after sowing (das)		Emergence (%)	
Opener	0-40mm	40-80mm	14 das	24 das
Triple Disc	3.2	8.1	86	100
Knife Point	2.1	4.7	49	73
Inverted T	2.4	6.4	38	74
Full-Cut	2.1	8.1	2	29
lsd at 5%	0.7	1.0	44	34

With full-cut direct drilling, the cultivated topsoil was "fluffed up" and dried out, being separated from the lower soil, which stayed moist for a long time. This gave slow wheat emergence despite the lower soil maintaining even moisture content for a long period. A later trial, in October, to check the results, showed that deeper working (120 mm) and a 60 mm seeding depth (hand sown seeds) similarly gave significantly poorer early coleoptile growth.

The knife and inverted "T" no-till points disturbed and dried more soil, because the 'V' shape of the disturbance flattened out, disturbing the inter-row area completely at the surface (18 cm spacing). The surface soil was fractured from the lower soil, allowing more moisture movement to the seeds than in the direct drill treatment.

The triple-disc opener with a press wheel disturbed less soil and had more soil moisture in the top 40 mm of soil. In the main trial at the 40-80 mm depth, the triple disc and the direct drill had similar moisture levels, due to shallow working of the direct drill. In the October trial however, the triple disc with press wheels had higher moisture levels than all tined treatments at 40-80 mm.

The crop performance from triple disc was good, with evidence of water harvesting when 28% of the seedlings emerged on day 11, 6 days after 2.4 mm of rain. Where seeds had been sown onto moisture at 60 mm depth or more, there was a prompt emergence.

Effect of residue

Observations were also made of the variation in emergence within plots. Residue had been raked off, but there were patches of fine material remaining. On one triple disc plot, moisture levels were similar in the top 40 mm (5%), but twice as high at 40-80 mm (11%) under the residue. Penetration was easier under the residue so seeding depth was greater, into the moister soil. One week after seeding, there was a good even emergence where there had been residue, but no emergence where there was none. Time and subsequent rain caused the seed to germinate, resulting in an even plot.

On the unsown subplots, it took about four weeks drying from 11th - 12th April after 9.1 and 3.2 mm of rain, ('bare soil' and 'part cover' behaved very similarly) to drop to similar moisture levels for under 'heavy residue' and 'bare soil'.

Seeding with a greater range of options on 5th May (including either press wheels or harrows, or both, behind knife points, and angled and undercut discs) in residue and bare soil, showed disc openers to be superior to tined options in conserving moisture. Both press wheels and harrows were better than knife points alone, with press wheels generally better than harrows. Yields showed a significant benefit from the 10 t/ha of residue. The triple disc gave higher yields than the tined treatments in bare soil, with a similar tendency under residue.

The main trial yield results showed the superior ability of the triple disc seeder in moisture conservation. Also at the second sowing the triple disc yielded better (2.56 t/ha) than the direct drill treatment (2.40 t/ha, with lsd 5% = 0.13 t/ha). The trial also illustrated the usual lack of difference we have found between the performance of two popular WA made knife and inverted "T" points.

	Grain yield (t/ha)	
Opener	Bare soil	Residue
Triple-disc	2.24	2.71
Knife + PW	1.92	2.63
Knife + PW + Harrows	1.89	2.40
Knife + Harrows	1.86	2.48
Knife point	1.82	2.37
LSD at 5%	0.27	0.27

Conclusions

In marginal moisture conditions, in sandy soils, the 'best management options' could be to: retain and spread crop residues, carefully manage grazing to reduce bare areas, sow onto moisture, use tined no-till points to conserve more moisture than with cultivation systems and better still, use disc seeders which conserve more moisture than tined seeders.

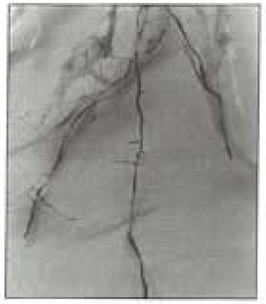
Press wheels have some real benefits over other covering systems. Press wheels and light rotary harrows can improve moisture conservation with tined seeders. Press wheel use improves emergence more than harrows. Press wheels enable seeds to be placed in the seed bed without deep sowing. And even small press wheel grooves help harvest water. Some of these effects can be additive to increase moisture around the seed quickly in order to evenly 'kick start' the crop.

In heavier soils, similar results might be expected. A greater tendency for clod formation, may however give more seed depth variability and poor seed-soil contact, resulting in uneven and patchy germination. At weedy sites, significant yield penalties may not show in crop performance until head-fill, if moisture became marginal. Press wheels will then be important to promote a more even-establishing crop, by crushing clods (thus reducing seed depth variability), improving seed-soil contact, and forming water harvesting grooves.

ROOT LESION NEMATODE: SA & VICTORIA EXPERIENCE

Sharyn Taylor[1], Vivien Vanstone[2] and Grant Hollaway[3]
SARDI Field Crops Pathology Unit[1], University of Adelaide[2], Victorian Institute for Dryland Agriculture[3]

Collaborative research in SA and Victoria (GRDC funded) is assessing field crop varieties for resistance and tolerance to root lesion nematodes (*Pratylenchus* species). This information can help you plan rotations and choose crop varieties to manage nematode populations, and reduce yield losses caused by these nematodes. Root lesion nematodes are present in a wide range of soil types in southern Australia. There are two species of *Pratylenchus* (*P. thornei* and *P. neglectus*) that occur on cereals and on crops grown in rotation with cereals.



Symptoms

Root lesion nematodes cause indistinct crop symptoms. Plants may appear unthrifty, stunted or prone to wilting, even when there is adequate subsoil moisture. Lower leaves on some of the intolerant cereal varieties may turn yellow and die back from the tips as a result of nutrient deficiency.

Roots of infested plants have fewer and shorter lateral root branches, fewer root hairs and may have indistinct brown lesions. Similar lesions can be caused by fungi, so cannot be relied upon solely for identification. The only reliable means of diagnosis is to observe the nematodes through a microscope after extracting them from the roots or soil.

The first identified severe root lesion nematode damage at Salmon Gums in 1995

Yield loss

Yield losses due to root lesion nematodes are difficult to measure due to the presence of other pests and diseases, and the influence of environmental factors such as soil type, nutrition and rainfall. Severity of yield loss also varies between sites and seasons.

Nevertheless, SA research shows that *P. neglectus* and *P. thornei* can reduce yields of intolerant wheat, and the nematodes can be responsible for as much as 74% of the observed varietal differences in grain yield. From trials assessed on the Upper Eyre Peninsula of South Australia in 1996, the moderately tolerant variety Excalibur yielded 19 - 33% more than the moderately intolerant variety Spear.

The magnitude of the yield loss caused by *Pratylenchus* is related to the density of the nematode population present in the soil (as the population increases, so does the yield loss) and the tolerance of the field crop that is grown. *Field crop varieties which are **intolerant** to root lesion nematodes are more likely to suffer a yield penalty in the presence of the nematode, whereas a **tolerant** variety is less likely to suffer a yield loss.*

P. neglectus

Yield responses in SA of 13% and 17%, respectively, were observed in Machete and Beulah wheats in 1996 in a field trial with low nematode density. The most tolerant varieties in this trial were Spear, Frame and Krichauff wheat and Galleon barley. Based on these and previous results from South Australia, it now appears that yield loss will occur in highly intolerant varieties such as Machete even when low nematode levels are present. Varieties that are moderately intolerant (such as Janz and Spear) will suffer yield loss when initial nematode numbers are higher. When nematode numbers are very high, most varieties will suffer yield loss, including those with a greater level of tolerance (eg. Excalibur, Krichauff and Worrakatta).

P. thornei

In 1996, trials were sown in the Victorian Wimmera on sites with moderate *P. thornei* levels. Yield responses of 20%, 16% and 13% were measured in Kellalac, Meering and Frame wheat, respectively. The most tolerant varieties were Excalibur and Silverstar wheat, Yallaroi durum, Arapiles, Schooner and Sloop barley.

Resistance

P. neglectus

The following cereal varieties have been identified with useful resistance: Excalibur, Krichauff and Worrakatta wheat; Arapiles, Barque and Chebec barley; all oat varieties tested were moderately resistant; Tahara and Abacus triticale and rye. Vetch varieties were moderately resistant to *P. neglectus* and all pea and faba bean varieties tested have been resistant.

Cereal trials on the Upper Eyre Peninsula in 1996 showed that growth of the moderately resistant variety Excalibur could result in almost 70% fewer nematodes in the soil than the susceptible variety Spear. Similarly, in 1997, varieties with greater resistance (Krichauff, Excalibur and Worrakatta) on average led to 44% fewer *P. neglectus* in the soil compared to more susceptible varieties (Barunga, Frame, Spear, Machete and Janz).

In field trials in 1996 all canola varieties tested were susceptible. To assess potential biofumigation effects of canola stubble, plots were re-sampled at the beginning of the 1997 season, and nematode numbers compared with soil from plots of the susceptible wheat Machete. There was no drop in nematode numbers under the canola stubble over the summer period, indicating no biofumigation effect in this instance. Further investigation is required.

Grassy weeds (barley grass, brome grass, silver grass and wild oats) have been assessed in the glasshouse for ability to host *P. neglectus*. Nematode levels that developed on these plants were the same as or lower than those on the more resistant cereals (Excalibur wheat and Abacus triticale), so it seems that the grasses may be maintaining *P. neglectus* populations while not allowing much multiplication. These grasses will be tested for ability to host *P. thornei*.

P. thornei

As with *P. neglectus*, a range in resistance to *P. thornei* has been detected. Schooner, Arapiles and Sloop barley, Yallaroi and RH912025 durum were found to be resistant to *P. thornei*. The wheats Excalibur and Krichauff were also resistant. Silverstar, Goldmark and Yanac were moderately susceptible. Janz and Frame were the most susceptible cereals tested. Languedoc and Blanchefleur vetch were rated as susceptible, while pea, faba bean and lentil varieties were resistant. The subclovers: Seaton Park, Trikkala and Gosse were susceptible, but the medic varieties Paraggio, Sava and Mogul were resistant. In contrast to *P. neglectus*, all canola varieties were moderately resistant to *P. thornei*.

Control

Control of root lesion nematodes can be achieved by avoiding rotations which include consecutive good hosts (susceptible crops), and by choosing crop varieties that are less susceptible. When a **susceptible** crop is grown, nematodes are able to multiply and increase the population in the soil. A **resistant** crop, however, will greatly reduce nematode multiplication, and therefore reduce nematode density in the soil and limit yield loss in future crops.

So, options are available for controlling root lesion nematodes using resistant crops, and by choosing the appropriate varieties of each crop (particularly within wheat). Wheat is generally more susceptible to *Pratylenchus* than other crops although there are some varieties that are more resistant than others (like: Excalibur, Worrakatta and Krichauff). These three varieties are also moderately tolerant. Most barley varieties are less susceptible to *P. thornei* and to *P. neglectus* than wheat. Durum wheat also has good resistance and tolerance to *P. thornei*. Improvements in the resistance and tolerance of cereal varieties (especially for wheat) are expected to be made through breeding.

Crops such as rye, triticale, field pea, faba bean and safflower are poor hosts for both *P. neglectus* and *P. thornei*, so will reduce the population of nematodes available in the soil to infect subsequent crops. However, it is important to recognise that different varieties and crop species can react differently to the two types of root lesion nematode. For example Languedoc and Blanchefleur vetch seem moderately resistant to *P. neglectus*, but susceptible to *P. thornei*. Growers can use this information when planning rotations, to minimise the impact of root lesion nematodes on production, but it is important to identify the *Pratylenchus* species present *(Editor: talk to Ian Riley, AgWA South Perth).*

Nutrition is a further factor of importance for disease management: a crop with adequate nutrition is generally more able to tolerate disease. Trials have demonstrated that, with minimal phosphorus levels, yield loss for intolerant wheat was 12-33%. This was reduced to only 5% with application of high rates of phosphorus (50 kg P/ha). Furthermore, application of nitrogen (75 - 100kg N/ha) in trials has been shown to actually reduce the nematode population in the roots of susceptible wheat.

The best way for farmers to determine whether they have a root lesion nematode problem is to conduct tests on soil or roots. Assays are available to estimate root lesion nematode populations, and to identify the species.

Summary

Crops that are resistant to both *P. neglectus* and *P. thornei* are: faba beans, field peas and triticale. Lupins and sub-clover have good level of resistance to P. neglectus.

Chickpeas and some wheat varieties are more susceptible than other crops to both nematodes, with the exception of Excalibur, Worrakatta and Krichauff (which have consistently proven to be moderately resistant and moderately tolerant to both *P. neglectus* and *P. thornei*).

More detailed assessment on resistance and tolerance of Western Australian cereal varieties is required. The severity and distribution of root lesion nematode in Western Australian cereal growing regions has only recently been considered, and is under investigation by Agriculture WA researchers.

Usually, varieties that are more resistant are also more tolerant, although care must be taken as there can be exceptions. Barley is generally more resistant than wheat.

The best option for control is to reduce nematode levels in the soil through rotations using crops and varieties with greater resistance to *Pratylenchus*. Tillage has only a minor impact on *Praylenchus.*

Crop		*P. thornei*		*P. neglectus*	
		Resistance	Tolerance	Resistance	Tolerance
Wheat					
	Barunga	MS	MT	MS	MI
	Excalibur	MR	MT	MR	MT
	Frame	S	MI	MS	MT
	Goldmark	MS	MI	-	-
	Janz	MS	T	MS	MI
	Krichauff	MR	T	MR	MT
	Machete	S	I	S	I
	Ouyen	S	T	S	-
	Silverstar	MS	T	S	-
	Spear	S	MI	S	MI
	Yanac	MS	-	MS	-
	Worrakatta	MR	MT	MR	MT
Durum wheat		MR	MT	S-MR	I-T
Barley					
	Arapiles	R	T	MR	-
	Barque	MR	-	MR	MT
	Chebec	-	-	MR	MT
	Sloop	MR	T	MS	-
	Schooner	R	T	MS	MT
Oat		-	-	MS-MR	I-T
Rye		R	-	R	-
Triticale		MR-R*	MT	R	MT
Chickpea		S	MI	S	-
Field pea		R	T	R	-
Faba bean		MR-R	MI-MT*	R	-
Lentil		R	T	MS-MR*	-
Lupin		R	-	MR-R	-
Vetch		MS-S	I*	MS-MR*	I
Medic		R	-	MS-MR*	I
Sub-clover		S	-	MR*	-
Canola		MR	-	S	MI*
Mustard-		-	S	-	
Safflower		R*	-	R*	-

R-Resistant, MR-Mod Resistant, MS-Mod Susceptible, S-Susceptible.
I-Intolerant, MI-Mod Intolerant, MT-Mod Tolerant, T-Tolerant, -Not Available.
Resistant lines minimise nematode multiplication, while **Tolerant** lines suffer minimal yield loss in the presence of nematodes.
*Based on limited data.
Individual varieties of each crop can differ in their resistance or tolerance.

Acknowledgements

Thanks to the following: Danuta Szot (SARDI); Michelle Russ (Uni of Adelaide); Graham Exell, Angela Smith and Russell Burns (VIDA), Minnipa Research Centre staff, SARDI Field Crop Evaluation Program, Allan Mayfield Consulting, the Uni of Adelaide Wheat Breeding Unit, the many farmers who made land available for field trials, and GRDC for financial support.

THE LUCERNE OPTION FOR SUSTAINABLE ROTATIONS

Phil Ward, CSIRO Plant Industry, (08) 9333 6000

Current agricultural rotations are slowly proving themselves unsustainable for much of the southern Australian cereal belt. Severe waterlogging and salinity can both be traced to the replacement of native, perennial vegetation by annual agricultural crops and pastures. Native vegetation maintains a green cover all year, and can use water for the whole year from deep in the soil profile.

Annual crops and pastures only maintain a green cover for about 6 months, and have no mechanism for using water during the summer and autumn. Consequently, soil under native vegetation is usually drier to a much greater depth than a similar soil under agricultural plant communities. At the break of the season, a dry soil is better able to absorb and store all the rainfall, and so prevents or delays the onset of waterlogging and associated groundwater recharge.

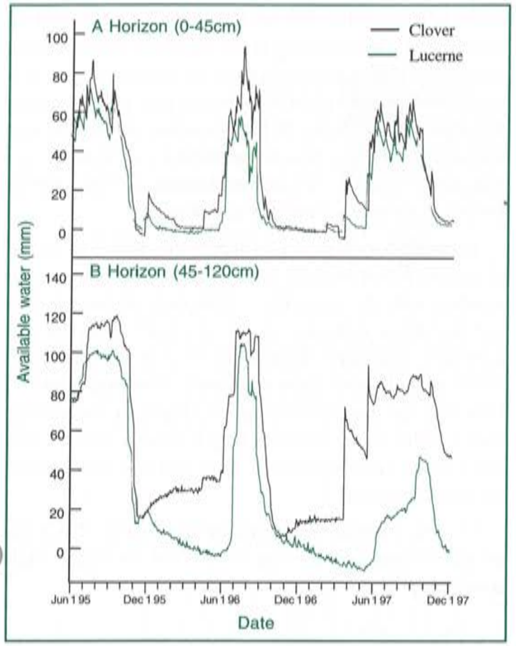
The popularity of lucerne is on the increase throughout southern Australia, largely due to the perception that it uses more water than comparable annual pastures. The suggestion is that since lucerne uses more water, it should result in drier soils, and hence reduce the risk of severe waterlogging and groundwater recharge. Several informal farmer observations have added weight to these suggestions. However, there is as yet very little scientific evidence to support lucerne as a user of excess water.

In 1995, CSIRO, AgWA, CLIMA, and UWA began a field trial to determine just how much water is used by a lucerne pasture (compared with subclover), and whether it has any effect on waterlogging severity and groundwater levels. The trial is located 10 km west of Katanning, on a duplex soil (sand over clay at 30-50 cm). Lucerne and subclover were sown in adjacent 5 ha blocks, and soil water and groundwater levels have been monitored intensively since then.

Lucerne water use

At the end of the third growing season, the benefits of lucerne are becoming clear. For water storage in the A horizon (sand), there is essentially no difference between sub clover and lucerne. This is because roots of both the subclover and lucerne pastures explore the entire A horizon, and use all the available water. However, differences between lucerne and sub clover became obvious in the layer of light to medium clay in December 1995, and continued through until the present. Lucerne roots have penetrated into the clay to a total depth of at least 120 cm, whereas roots under the annual pasture could not penetrate more than about 5 cm into the clay (total root depth of about 50 cm).

During the first summer (1995-96), lucerne continued to use water from the clay layer, and also used all the summer rainfall (about 40 mm). Although there was little growth, lucerne remained green throughout the summer and autumn. On the sub clover side, there was no green plant matter at all, and water storage in the clay actually increased in response to two summer storms. As a result, the soil under the lucerne was about 30-40 mm drier at the break of the 1996 season. This translated into a delay of about 3 weeks in the onset of waterlogging in 1996, and also reduced deep drainage (and potential groundwater recharge) from 50 mm under the sub clover to 20 mm under the lucerne.



The soil under both clover and lucerne recovered to similar available water contents during the quite wet 1996 growing season (May-October rainfall 380 mm). During the summer of 1996-97, water use patterns followed those observed in the previous summer. Water use by the sub clover pasture ceased in about December 1996, whereas lucerne continued to use water from the clay layer right through the summer and autumn period, and re-established the 30-40 mm buffer in water storage at the break of the 1997 season. In contrast to the previous summer, the lucerne went into dormancy, and there were very few green leaves, presumably because the soil was dried to wilting point earlier in the summer. At the break of the 1997 growing season, the lucerne recovered quickly, and appeared to sustain no damage from its 4 month dormant period.

During the 1997 growing season, rainfall was below average, and the clay under the lucerne remained drier than under sub clover throughout the season. This should make the 1997/98 summer very interesting, and we are closely monitoring lucerne growth and water use. Lucerne has already become dormant, but still appears to be using water slowly.

The analysis of groundwater levels (currently about 5m below the surface) is still at a preliminary stage, and it is too early to tell if lucerne is having a consistent effect. The perched water data from more than two years continuous recording are being analysed to draw a comparison between the quantity of water involved, and the duration of waterlogging for the lucerne and sub clover pastures. We intend to conduct a field day on the Rundle's farm in September or October 1998, and the latest results will be available then.

Possible rotations

In 1998, we plan to sow both areas (lucerne and sub clover) to wheat, and we aim to determine whether wheat roots can make use of the root channels opened up by the lucerne. If they can, and if the year is wet enough to replenish water supplies in the clay layer, wheat after lucerne may have a substantial advantage in terms of water availability during the grain filling period. This could also increase the total water use of the wheat crop, further assisting the prevention of water table rises.

A rotation involving three years of lucerne followed by five years of conventional cropping could reduce deep drainage (in 'average' years) from 240 mm (30 mm per year for 8 years) to 150 mm (30 mm for 5 years), which is an average reduction of more than 10 mm per year. In many areas this could be sufficient to prevent further groundwater table rises.

The next step in our research program is to determine the specific areas of southern Australia most likely to benefit from the inclusion of lucerne in such a rotation.

Acknowledgments

Thanks to the Rundle family, for the use of their land, and to the GRDC and CCMAR for partial funding. Thanks also to Kristi Lane, Greg Bartle, Jeff Galbraith, Paul Barton and Peter Taekema for technical assistance and F Dunin, S Micin and D Williamson (CSIRO), Brett Ward (AgWA) and Lisa Blacklow (CLIMA).

FARMER (ART) SECTION

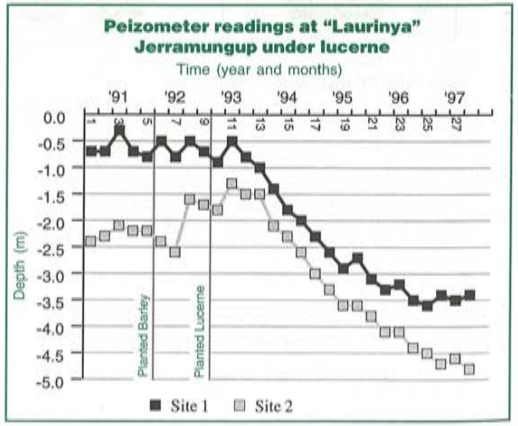
LUCERNE LOWERS WATER TABLE

Geoff Bee, Jerramungup (08) 9835 5030, fax 16

We have been growing areas of lucerne *(Medicago sativa)* on our 400 mm rainfall Jerramungup property since 1971. Our initial plantings were small and grown because of an interest in using some of our summer rainfall. A more concerted lucerne establishment effort was initiated in 1985 with plantings bordering the major creeks which were showing signs of encroaching salinity.

In 1990, a mining company drilling for kaolin clay alerted us to the real extent of our rising water table. Surprisingly, this drilling showed dangerously high watertables on the slopes, well above the major creeks.

The area had been cleared in 1964, and previously drilled for clay in 1973 showed no evidence of a watertable, let alone one so dangerously close to the surface. The 1990 drilling exercise greatly changed our understanding and perception of the watertable. We realised that we needed to apply water-use-efficient management to a much broader area of the landscape.



Two of the 1990 drill holes were cased and the water levels have been monitored since. Graphs of the water levels in both bores and the annual rainfall, for the last six years, after the lucerne was sown in mid-'92, are below. Note the constant trend of lowering watertables at the two bore sites where the lucerne is grown.

We plan to sow this paddock to wheat in 1998 to start the crop phase. We also plan to monitor the watertable during the crop phase, as a parameter to make the decision of when to plant the paddock back to lucerne. We expect a 4-5 year phase of lucerne will be enough to dry the soil profile to a safe depth to enable a cropping phase.

The length of each phase of the rotation will be determined by the economics of each enterprise and the watertable depth. Our area of lucerne has increased to about 600 ha over our whole farm. We have been thinking about all the benefits of lucerne growing in our environment that we perceive. We know lucerne will; lower the watertable, feed livestock, produce quality and out of season feed, produce quality hay, improve soil fertility, fix large quantities of nitrogen, recycle leached nutrients, improve the physical fertility of the soil, increase crop yields, reduce waterlogging, and be a morale booster in summer - especially after a rain.

However, we still have a lot of questions regarding the role of lucerne in our farming system. Like: how does lucerne interface with the watertable? How deep do lucerne roots go? Do lucerne roots stay alive in dry soil? What does the watertable look like? What is the level of the watertable? Where should we site more piezometers (monitoring bores)? How does the watertable recharge? Where are the recharge areas? What is the optimum length of each phase? How much N does lucerne produce? How well does lucerne recycle leached nutrients?

Lucerne is a plant that can enable us to apply reliable water use efficiency on a broad scale to the landscape, while increasing productivity and sustainability.

CLAYING WATER REPELLENT SOIL

Clem Obst, Bordertown, SA (08) 8752 2880, fax 8753 4166

With my son, we farm at Mundulla in 500 mm annual rainfall. Our soil is 15-20 cm of sand over clay, on the flat ground, with some limestone and many deeper sandy ridges. Water repellent or non-wetting soils are common in our area, particularly on the deeper sands. These soils produce patchy wetting, with poor crop and weed germination and restricted herbicide activity and fertiliser efficacy.

In 1968, we stumbled on the claying solution. The year before, I decided to excavate some holes at the end of two irrigation drains for stock water. After excavating the clay I decided to evenly spread it on some water repellent ridges. To my surprise, as I was ploughing the paddock the next year I struck the clayed area which was perfectly wet, alongside the dry repellent sand. The crop grew better and yielded way above the adjoining area. In following years sub-clover germinated and also grew well on the clayed patch.

After our discovery in 1968, we decided to spread clay with a road scraper over larger affected areas with lots of rate experiments. We have discovered many benefits of claying. However, as we extended the treated areas, friends questioned our mental stability! But within a few years, people were asking why our sand-hills were always so green.

The claying technique

We have found that 120-240 t/ha (100-200m^3) of dry clay is needed, depending on the depth of the sand. Deeper sands need most clay. The clay must be worked in well, while still dry to 10-12 cm, to ensure the plants get their roots into enough moisture and nutrients held in the clayed surface. The clay has a "magnetic" effect on fertilisers and reduces leaching while improving soil fertility and raising the pH.

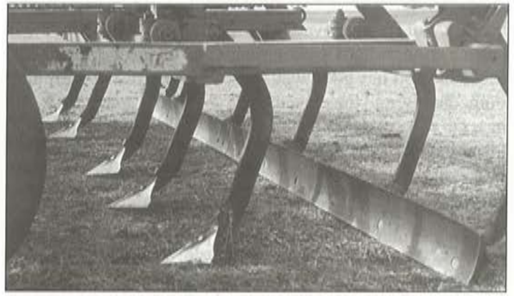
Our claying technique involves retrieving the clay from new dam sites or from low-wet areas, then spreading of clay by a scraper as thinly as possible onto sand rises or weak patches. The clay is spread, running in long lines up and down the affected areas leaving a gap between the rows of at least one and a half times the width of the scraper deposit.

Our first incorporation of the clay is with a scarifier set at 10-12 cm depth, which has a full scarifier-width blade, 12-15 cm high on the rear row of tines. The scarifier is pulled diagonally across the clay lines, overlapping half the scarifier width. This is repeated in the opposite diagonal direction, across the lines of clay, to make sure the clay is spread evenly. This working-in process is extremely important and it must be done dry. The scarifier also breaks up the compaction caused by the scraper.

Modified scrapers are commonly used for claying.

Recently, a number of different methods for getting clay onto the targeted areas have been used. Firstly, carry graders towed by 430 hp four-wheel drive tractors which spread the clay evenly over the whole surface. Secondly, the Claymate® which picks up and spins out the chopped up clay. Gypsum spreaders are also used but are loaded with an excavator or loader.

It is important to get the right formula, because the clay must not be applied too thickly or thinly. Ideally for us the cover should be about 2 cm of clay over the surface before incorporation. If the clay cover is too thick it tends to block off moisture and water will either run off or lie on the top of the soil.



Scarifier has blade fitted for good mixing of clay.

If applied too lightly the non-wetting will reduce in the short-term but it will not keep nutrients in the root zone or stop drift after grazing in the long-term. The clay used needs to be dispersive, like sodium kaolinite. A reasonably high pH of 9 is desirable for treating acidic water repellent sands. The clay needs to have the ability to accept water, mix well and spreading easily. The soil pH after we apply the clay is about 0.5 higher after a year or so.

Pleasingly to us - clayed soil lasts a long time. Sections treated in the late 1960's are as good today as ever. They may actually be even better, because soil fertility has built up with clovers and legumes growing well, instead of silvergrass. Dr Max Tate, from the WAITE Institute, through frequent visits and research, considers claying good for at least 100 years, and perhaps permanently. Also, effective field trials by Melissa Cann from PIRSA Struan, have confirmed our original observation and procedures.

Costs and limitations and benefits

Claying is not a short-term project. It is long-term and costly. The cost to us had originally been about $150/ha for 200 m^3/ha. At today's costs it might be $250/ha, depending on the distance hauled, and depth to quality clay. Claying has improved and maximised paddock production over many years, particularly on the weakest paddock areas. We believe the cost is reasonable, and it is tax deductible.

In all cases the difference in pastures and crop where the clay has been spread is obvious right up to the borders. We can now grow good clovers, lucerne and crops on what was previously poor yielding and erodible sands. Wheat yields now average 2.7 t/ha on the light soil. Lupin crops may not be better in the first year, maybe due to higher pH, but after a couple of years of treatment average 2.1 t/ha.

After claying the soil wets up rapidly after rains, allowing good germinations of weeds such as silvergrass, capeweed etc. The clayed areas are always green first, which can then be killed by cultivation or herbicides. We have not yet adopted no-till sowing systems as we think we are probably still getting benefits from annual mixing the clay with the sand topsoil.

Trifluralin and Simazine work very well on this evenly wetted soil. If clayed areas are to be used properly we prefer to crop for a year or two after claying, to reduce undesirable weed species.

Disadvantages of claying

In the first year, depending on rain, the clay can be quite sticky. In pastures, a false break will germinate sub-clover quickly, but its improved seed set from previous years will ensure enough hard seed remains for the true break. Because the soil has good wettability, the seeds will germinate immediately, and the clayed areas are always green first. But in a very dry finish, clovers could finish a few days earlier than other pastures, especially if the clay has not been worked in properly, as this gives a shallow root zone.

The positives of claying

Non-wetting soils are eliminated, production is up to the rest of the paddock and we can now grow wheat on the treated areas. Soil pH rises slightly. Claying just about eliminates silvergrass and sorrel alone. Claying enables easier control of problem weeds due to even germination and increased herbicide effectiveness. We can now grow clover and wheat where previously it was impossible. We can drive anywhere with any vehicle in summer. There is no wind drift after cropping or when first applied at incorporation. We are able to crop more, can carry more stock a lot easier, and on quality pasture.

Above all, it is a long-term solution and it is tax deductible. We can now make the most of the land we have. We have brought the weak areas of the property into full production rather than considering buying more of the same. Claying provides effective use of fertilisers and has stabilised the soil.

There are millions of dollars of lost production from non-wetting sands, and the problem is getting worse. Landholders talk of the despair they face trying to establish pastures and sow crops and not being able to wet up the soil for a moist seedbed to plant their crops. Non-wetting sands cause reduced profitability and viability of farms.

Clem's clay goes out in strips.

We have always had the motto: "look after your soil and it will look after you," which, of course, is what sustainable farming practices are all about.

FINDING GLYPHOSATE-RESISTANT RYEGRASS

Derek Barnstable, Euchuca, Vic (03) 5482 4450, fax 5487 7311

Derek Barnstable tells us 'they said it would never happen!'

In the late 1970's I became interested in direct drilling, as we were changing from grazing, to winter and summer cropping on one block we owned. This farm had heavy grey soils in a flood prone area, and the soil became "puddly" when over-worked. Direct drilling needed less equipment and less time while we were running intensive livestock some distance away. At first we used paraquat and diquat with minimum till but with poor results.

Then glyphosate came at ~$24/L, but it did give us close to excellent weed kill. About this time I made my own designed tines and points, as it was obvious that standard combine tines and points were too feeble for no-tilling into heavy soils.

My first no-tilled wheat with Roundup as the knockdown, yielded 6 t/ha (30 bags/ac) which was way ahead of anything minimum tilled or conventionally cultivated in our district up to that time. Other high crop yields we achieved with this "new" cropping system, in t/ha were: canola 5.0, faba beans 6.2, safflower 3.1, chickpea 3.7 and barley 6.9.

We generally grew consecutive crops in rotation, always using a glyphosate knockdown (usually with 2,4-D ester) and an in-crop "fop" treatment. These cropping techniques were justified by high yields, little stubble left after heavy grazing, and good soil aggregation and stability - as monitored for about eight years by Judy Tisdall at Tatura Research Station.

In recent years, phosphorous levels had reached 80-90 ppm and potassium 600-650 ppm. However, organic matter was in decline, maybe because the soil processes were using it as fuel to give double the district average of potassium and high phosphorous levels. Organic matter decline may have been arrested by growing more cereals and the breakdown of stubble would contribute to the increase in organic matter. Earthworms increased from nearly nil to great abundance.

High stocking rates of 50 sheep/acre or the equivalent cattle, grazed the stubbles in the dry summer-autumn. They do not damage the soil structure in dry conditions. (Note that road-makers add water to achieve compaction). In my experience, the comment of livestock causing compaction on dry soils is a smoke screen for poor design or ability of the tine or point to penetrate the soil and to control soil flow.

In spring 1995, I decided to spray out a self-sown dill crop (essential oil) with a glyphosate and 2,4-D mixture, and plant a maize crop. Yet to my surprise, 2-3 weeks after spraying there were individual annual ryegrass plants which were obviously thriving, whilst the rest of the paddock was suitably dead. I concluded that the survivors were unlikely to be due to spraying error, as I have been using controlled traffic for many years where wheel traffic is confined to the same areas. Consequently, no weeds were missed and we knew we did not have blocked jets as we use clean water (drinking standard). I am sure that this was the first time that glyphosate was not effective on ryegrass. I had been using low rates of glyphosate (~250 gai/ha) each year.

I immediately realised that I could be looking at a resistance problem; after all, there is widespread resistance to "fops" and "dims" and sulphonylureas in weeds, and worms and blow flies in sheep, and antibiotics in humans. Also I'm lucky that I'm a bit of a sceptic and am not susceptible to saturation advertising such as ***"Guaranteed to work"!***

My query about glyphosate resistance passed through various Ag Dept Officers in Victoria without much reaction. It was not until I dropped about five complete, large and mature ryegrass plants at the Tatura Dept of Ag that some action was taken. The seed were stripped off and sent to Prof Jim Pratley of Charles Sturt University, Wagga Wagga NSW. Professor Pratley's trials proved beyond doubt that the ryegrass seed from my farm was glyphosate resistant, although the multi-national involved continued to throw doubt on the matter. Multi-national companies have spent hundreds of millions on breeding chemical resistance, eg Roundup Ready plants but seem to think nature cannot do exactly the same thing! What bloody arrogance!

What I find totally disappointing about this saga, is the lack of thought or discussion about suitable strategies that can be employed in the annual ryegrass belt in southern Australia, where no-till is virtually dependent on one chemical – glyphosate! *(Editor – amazingly, throughout eastern Australia, farmers have not yet adopted the glyphosate, then 1-10 days later apply Spray.Seed, as a "tillage replacement strategy", which is common in large areas of WA. Those who have not yet adopted this approach may be wise to do so soon!).*

Will no-tillers using techniques like mine be less than 20 years behind me in acquiring glyphosate resistance? In my experience no-tillers who have successfully combined chemicals, timing, equipment, and fertility, will be loath to change because they have seen improved yields, soil aggregation and stability and timeliness, although their dependence on chemicals may hasten their acquisition of chemical resistance.

Farmers who have not been able to get their no-till techniques organised enough to get good yields will likely go back to conventional cultivation. This will considerably slow glyphosate resistance but at the expense of timeliness, whole farm yields, soil erosion, soil aggregation and stability, and general soil fertility.

If my ryegrass seed had not gone through official scientific testing procedures, but went to a multinational laboratory, would we still have the world's first validated glyphosate resistant annual ryegrass?

What if 'fop' and 'din' resistance is a precurser to much hastened glyphosate resistance in weeds? This could have huge management implications! *(Editor: In talking to Derek in February I mentioned that there is 'fop' induced resistance to both low rates and high rates Hoegrass® applications. Derek wanted to then include the following comment).* It appears that now we have a parallel with both low and apparently high rate resistance with both 'fops' and glyphosphate.

I have since been contacted by numerous farmers and consultants who suspect that they may have a similar problem. *(Editor – since Derek wrote this article, Professor Steve Powles told the AgWA Crop Update attendees that glyphosate resistance has been found in an apple orchard at Orange, NSW, where high rates were applied every year.)*

ROTATIONAL STRATEGIES

Norm Flugge, Katanning, (08) 9822 1505 p/f

We are running a mixed grain, wool and sheep enterprise over approximately 5,400 ha east of Katanning in the great southern, cropping approximately 3,000 ha each year. In addition to our own experience we also use the services of a number of consultants in business management and agronomy.

Rotational strategies provide the framework for much of the decision making in our grain and sheep enterprise. In this decision making process we are trying to find the balance between the goals of short-term viability and long-term sustainability. In short, how to ensure we stay in the game long enough to achieve our longer-term goals. Our long-term goals may well be defined as using our "resources" to meet our current needs without compromising the needs of future generations.

This has meant that, at times, we have had to compromise on, what experts see as our optimum agronomic goals. Our rotations in themselves are not particularly innovative by today's no-till standards, but they do illustrate the various influences that farmers have to accommodate in the course of running their businesses. It is these influences that are significant rather than the detail of our rotations.

Like many businesses we carry a significant debt load that must be serviced as well as the normal operating requirements that come with largely seasonal enterprises. It is essential that the financial requirements of our business are planned for and met, by ensuring that the crop mix will provide adequate gross margins and cash flow while minimising the risk of the inevitable seasonal fluctuations in pricing and the impact of weather.

In addition to the financial constraints we impose on the optimal rotations, we are now, with the benefit of improved monitoring and testing, seeing significant herbicide resistance and nutrient imbalances appearing. Put these in the context of the mosaic of soil types that occur in almost every paddock and a desire to maintain a successful sheep enterprise, and the development of viable rotational strategies is a logistical and operational nightmare.

With herbicide resistance in particular, we are now considering strategic tillage and burning, in addition to more disciplined chemical usage, particularly in the pasture phase, as important tools in maintaining our crop rotations. Tillage and burning may seem inconsistent with our long-term goal of sustainability, but in the short-term it may be necessary to meet yield and financial objectives and in doing so, give us the breathing space to develop some better alternatives.

On the up side, the adoption of no-till using an Ausplow DBS has ensured that our agronomic objectives of, accuracy of seed and fertiliser placement, timeliness of sowing, improvement in soil structure, crop residue handling and an ability to handle varying soil types and conditions have been met. We remain firmly committed to no-till as part of a farming system that will see us moving closer to our long-term goal of sustainability. Our challenge is to ensure that all the other parts of our farming system are developed to complement the advances made in this area.

SUMMER CROPS - ROTATIONAL BENEFITS

Ken deGrussa, Neridup (08) 9078 2026, fax 07

We farm north of Esperance with 500 mm of annual rainfall on duplex sandplain soils. Our first attempt at broadening our crop rotations using warm-season crops was in 1996 following Professor Dwayne Beck's visit from South Dakota. We decided on grain sorghum, mainly because we had tried it in the late 1960's, with modest success by the standards of the time.

The 1996 crop was sown on September 12, by which time the soil temperature had risen to 16°C. Emergence was seven days later, but a cool period stopped growth for three weeks. The crop was not a great success. We harvested 300 kg/ha in March 1997.

While the grain sorghum crop may have failed, we also wanted to see if it could improve crop rotations. Since we used atrazine and felt there was a risk of carryover in the dry summer soil we chose TT canola as the next winter crop. The soil had about 50 cm of sand over hard clay and fairly flat. It is productive soil in most seasons, but can waterlog in wet years, and 1997 was a wet year.

The following canola crop had ideal soil moisture conditions from May until the end of July. However, August and September were very wet with 200 mm of rain falling. Most of our 1,600 ha cropland was severely waterlogged. However, the canola in sorghum stubble showed no waterlogging damage, while lupins on the south west-side and wheat on the north east-side were badly affected, with just a fence between

Ryegrass in canola crop after swathing

No ryegrass after sorghum crop in canola after swathing

each crop. There were four other canola crops in our total program, and all were badly affected by the waterlogging. All yielded 800 kg/ha or less, but the canola after the sorghum yielded 1,800 kg/ha.

The wet spring allowed a late and large germination of grasses, chiefly annual ryegrass, in most crops. However, the canola following the sorghum was almost totally weed free (see pictures below). This is not surprising, since we usually get late germinating weeds in our winter crops, which set seed. However, good weed control prior to planting a summer crop means destroying annual winter weeds just before they flower - and hopefully after they have all germinated.

For the current summer we have chosen forage sorghum which we seeded in mid-October, a little later than desirable, but we still got good establishment. The forage is more vigorous than the grain varieties, but not always palatable to sheep. We still have something to learn about the most effective use of forage sorghum.

The level of plant growth through December and January has been amazing! The sorghum was sown into saturated soil, but the October-February rainfall has been the driest in our 33 years of record keeping. Surprisingly, in some places the roots of the sorghum appear to have not penetrated deeply, which needs to be investigated more closely.

Whatever the problems, the role of warm-season crops in the rotation is still to be decided. We will follow the sorghum-canola with wheat in 1998, and repeat the process, perhaps with variations, where we now have forage crops. The many questions about weed and disease management and water-use, are all vitally important issues that have still to be properly investigated. However, our initial experience is, at least, promising!