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# Western Australian No Tillage Farmers Association

## NEWS SHEET

**Volume 2, No. 2 April 1993**

About 115 farmers, scientists and engineers attended the seminar on the frist day of the Associations 1st Annual Conference held at Darkan, WA on 24-25 March, 1993. Half as many were present to hear talks by farmers and trade representatives, and view machinery displays on the second day. Scientific papers presented at the Conference are attached.

The Association's Annual General Meeting was held from 8.00 a.m.-10.00 a.m. on 25 March.. Ian Edwards (Beverley), Darren Baum (Wellstead) and Ray Harvey (McAlinden) retired as committee members, and Peter Wittwer (Carnamah), Jim Baily(Wellstead) and Tim Trethowan (Kojonup) were elected. The meeting decided to foster general meetings in the Northern Agricultural Region (at Morawa) in July/August, and at Esperance in October. Information will be included in further News Sheets.

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**1993-94 EXECUTIVE**

**President**
**RAY HARRINGTON**
Post Office Box 65,
Darkan, W.A. 6392
Phone-Fax: (097) 36 3030

**Vice-President**
**KEN DE GRUSSA**
Post Office Box 772,
Esperance, W.A. 6450
Phone: (090) 78 2026

**Secretay/Treasurer**
**KEVIN BLIGH**
Department of Agriculture
Baron-Hay Court,
South Perth, W.A. 6151
Phone: (W) (09) 368 3893
(H) (09) 332 7003
Fax: (09) 368 3355

**COMMITTEE**

**LINDSAY CHAPPEL**
Post Office Box 45,
Perenjori, W.A. 6620
Phone: (09) 71 5011
Fax: (099) 71 5023

**PETER WITTWER**
Post Office Box 76,
Carnamah, W.A. 6517
Phone: (099) 51 1225
Farm: (099) 51 1167

**TIM TRETHOWAN**
Post Office Box 476,
Kojonup, W.A. 6395
Phone: (098) 34 1056

**JIM BAILY**
Royal Mail Box 87,
Manypeaks W.A. 6328
Phone: (098) 47 1036
Fax: (098) 47 1012

# ZERO TILLAGE TRIALS 1992 - SOUTH COAST

**R.J. JARVIS**
**Western Australian Department of Agriculture**
**South Perth**

During 1992, field experiments were conducted at Esperance Downs Research Station, Kojaneerup annexe of Mt Barker Research Station and on the properties of Geoff Bee (Jacup) and Rick Swarbrick (Gairdner). Treatments in the trials included zero till and a range of tillage intensities using a combine as well as press wheels compared to finger harrows. Deep ripping after zero till seeding was also investigated. A zero phosphorus treatment was also included to (a) examine if toxic effects of P near the seed occurred; (b) measure the yield response to P.

The barley trial at EDRS was severely waterlogged, had very pinched grain, and was unfortunately not harvested. There were large responses to deep ripping evident during the season. Zero till had poor growth and more rhizoctonia patch. The lupin trial at EDRS suffered maggot damage, waterlogging and some rhizoctonia making yield results variable. Despite this yields ranged from 1.7 to 2.5 t/ha even where maggots reduced establishment to 15 plants/m$^2$.

**Lupin Trials 1992**

Yields are the average from 3 sandplain trials at Kojaneerup, Gairdner and Jacup where stubble from the previous cereal was retained.

The lupin variety was Gungurru sown at 105 kg/ha with 145 kg/ha plain super. All treatments were sown on the same day within any trial and varied from 20 May to 2 June depending on the trial location.

The double disc + press wheel (PW) units used were the standard end wheel Great Plains at 2 sites (150 mm row spacing) and John Deere units at one of the sites (190 mm row spacing). The combine had John Deere 700 series tines with a raised box to allow deep banding on wide spacings and to allow normal spaced seeding on all 6 rows. One side had finger harrows, the other side had harrows (to level soil) plus press wheels. Combine row spacings were 190 mm, and 380 mm for the wide spacing.

The Agrisystem cross slot machine was not built in time to be included in these trials. Separate trials were designed for later planting and results are presented in a separate section of this paper.

Table 1. Average 1992 lupin yields from 3 south coast trials on sandplain with stubble retained.

| Treatment | Yield (t/ha) | |
|---|---|---|
| No till double discs | 1.95 | |
| Combine | Press wheels | Harrows |
| DD 50 mm points | 2.09 | 2.16 |
| DD 180 mm points | 2.22 | 2.18 |
| Cultivate/seed 50 mm points | 2.16 | 2.25 |
| Deep band/wide spacings 50 mm points | 2.27 | 2.32 |

In the below comments G = Gairdner, J = Jacup, K = Kojaneerup trial sites.

( i) Press wheels

(a) establishment using PW was better at K, worse at G and no effect at J.

(b) yields were not affected in 2 trials and were reduced by 220 kg/ha at K (where establishment was improved).

( ii) Treatments

(a) establishment was lower for cultivate/seed at G & J, for the double discs at K, and better for banding wide at K.

(b) yields were variable but not significantly different except at G where Rick's Great Plains treatment grew well, but yielded less than the other treatments.

Table 2. Effect of superphosphate on lupin yields from 3 trials

| Treatment | | Yield (t/ha) | |
|---|---|---|---|
| | | P | No P |
| Double Discs | | 1.95 | 2.22 |
| Combine (50 mm points) | + PW | 2.09 | 2.19 |
| | + Harrows | 2.16 | 2.30 |
| | Average | 2.07 | 2.24 |

145 kg/ha of super reduced yield by an average of 8% compared with application of no super. Two sites had a soil test of 22 ppm P and Kojaneerup had only 7 ppm (however it is a deep leaching sand).

At Gairdner, P did not affect establishment, but reduced yield by 400 kg/ha (18%). At Jacup, establishment was down by 15% and yield by 8%. At Kojaneerup establishment was reduced more by applying P with the combine compared to the double discs, but P decreased yield for the double discs and increased yield for the combine.

Additional treatments at the trial sites

1. At Gairdner and Kojaneerup the cereal stubble was retained or raked and the wind-rows burnt, giving 2 blocks which the machinery treatments seeded across. Although not providing completely accurate comparisons, at Gairdner the stubble block looked better during the year but yielded 200 kg/ha less, while at Kojaneerup the stubble block looked better and yielded 560 kg/ha more.

2. At Jacup, Geoff Bee's double disc machine had the option of tines cultivating in front of the discs in the one pass. These had no effect on establishment nor yield compared with discs alone.

3. At Gairdner, Rick Swarbrick's Great Plains machine had one treatment with super topdressing while seeding, one drilled with the seed, one deep ripped after seeding and the no P treatment. The latter was the only one to increase yield, and plant establishments were not different.

**Cereal results 1992**

These trials were conducted into lupin stubble on the same properties as the previously detailed lupin trials. Kojaneerup had Onslow barley sown on 2 June; Jacup, Spear wheat on 26 May; Gairdner, Spear on 20 May. All had super at 145 kg/ha and 80 kg/ha urea was topdressed 4 weeks after seeding.

Table 3. Average cereal yields from 3 south coast sandplain trials

| Treatment | Yield (t/ha) | |
|---|---|---|
| No till double discs | 4.30 | |
| Combine | Press wheels | Harrows |
| DD 50 mm points | 4.64 | 4.49 |
| DD 180 mm points | 4.80 | 4.61 |
| Cultivate/seed 50 mm points | 4.66 | 4.65 |
| Deep band/wide spacings 50 mm points | 4.87 | 4.44 |

( i) Press wheels -

| | |
|---|---|
| Kojaneerup | PW did not affect establishment but increased yield by 250 kg/ha |
| Jacup | no effect |
| Gairdner | did not affect establishment but increased yield by 190 kg/ha |

(ii) Treatments - Significant differences at K & G with no till being lower yielding. Establishment and growth during the year was very good for no till at Gairdner.

Additional treatments

( i) Superphosphate did not affect cereal establishment at any of the sites. There were large positive responses to P at K (soil test 18) and J (35) and a small response at G (31) during the season. There were no yield differences at the first two sites, and at G super reduced Spear yield by 490 kg/ha (10%). Very strange! Topdressed P at this site yielded mid way between nil P and P drilled with the seed.

( ii) Tines in front of discs at J slightly increased yield (by 260 kg/ha). Deep ripping immediately after seeding at G did not affect yield.

**Additional Cereal Trials**

1. Wheat after pasture - G. Bee, Jacup.
The site was yellow gravelly mallee sandplain which was sown with similar treatments to the other trials on 26 May after Roundup plus 3 g/ha Ally about 3 weeks before seeding. 145 kg/ha super was used with 40 kg/ha urea topdressed 4 weeks after seeding. The variety was Spear.

| Treatment | Yield (t/ha) | |
|---|---|---|
| No till double discs | 2.52 | |
| Cult. tines in front of discs | 2.99 | |
| Combine | Press wheels | Harrows |
| DD 50 mm points | 2.77 | 2.47 |
| DD 180 mm points | 2.91 | 2.54 |
| Cultivate/seed 50 mm points | 2.83 | 2.48 |
| Narrow winged blades | 2.89 | 2.60 |
| Deep band/wide spacings 50 mm points | 2.80 | 2.77 |

Press wheels significantly increased yield by 256 kg/ha (10%) although they only marginally increased establishments. Discs on their own had the lowest yield. Tines in conjunction with discs increased the yield by 470 kg/ha (19%). The combine treatments were not significantly different from each other despite DD with wide points having the lowest establishment (but still 110 p/m$^2$).

The result at this site was confounded by early crop damage in the greater disturbance plots. This was suspected as being due to residual ally being mixed to seed depth. Plants lost two of their early leaves whereas zero till or narrow winged blades were not affected. These latter treatments looked best until 8 weeks after seeding. Without this problem, the response to cultivation could have been far greater, which would be expected for cereals after pasture.

2. Deep ripping after zero till seeding
On deeper sand sites, large yield responses have been achieved from deep ripping on the south coast (i.e. EDRS, Kojaneerup 1984-89). A sustainable system could be to deep rip immediately after seeding.

92E57 was conducted on white sand to 25 cm over gravelly clayey sand to 70 cm over dense clay sand at EDRS. The site was sown with Onslow barley with a triple disc drill into lupin stubble on 15 May and then treatment plots of deep ripping with an Agrowplow at 3 shank spacings and 3 depths were conducted.

Establishment was only reduced by 10% maximum and the yield increases over zero till were very large despite occasional waterlogging of the site (Fig. 1). Figure 2 shows the relationship between soil strength and yield. At high strength (zero till) on the right hand side of the graph, yield was well down. As soil strength declined (due to ripping intensity) yield increased. Protein is being tested.

Figure1. The effect on barley yield by depth of ripping with 3 shank spacings.

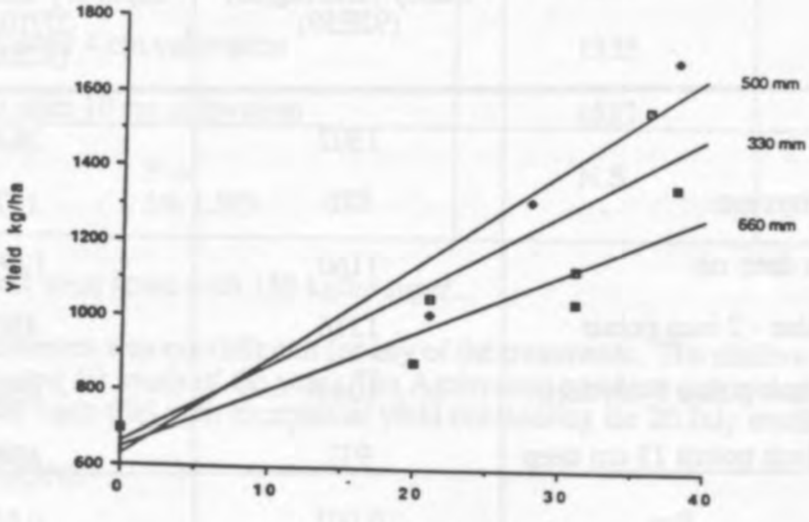
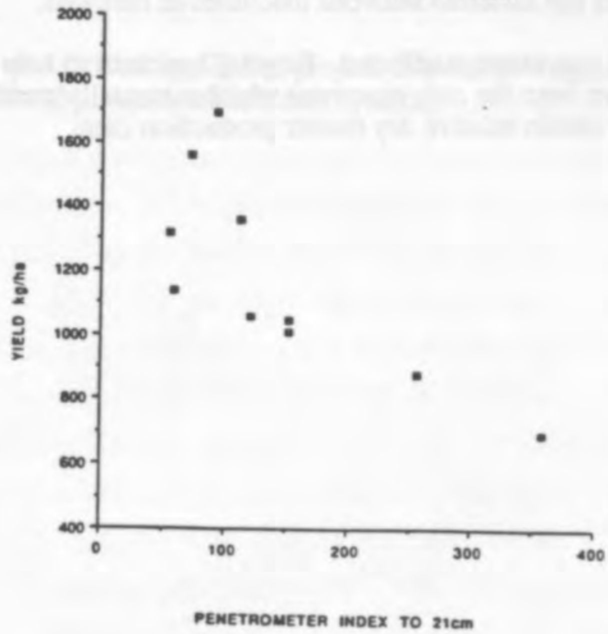



FIG 2. RELATIONSHIP BETWEEN SOIL STRENGTH AND BARLEY YIELD.



3. A trial at Kojaneerup to study fertiliser toxicity with a combine, Agrisystem and Great Plains was sown on 5 November just to measure plant emergence. Data is still to be collated, but it is of interest to note that Spear wheat, sown after pasture on 5 November, yielded 2.5 t/ha.

**Agrisystem Cross-Slot Experiments** - Esperance and Kojaneerup

The machine was not completed until mid July because of the late arrival of parts, and hydraulic problems.

Two trials at Esperance suffered waterlogging for a large part of the season. Lupins and barley were sown on 22 July in cereal/lupin rotation paddocks of shallow sand over gravelly sand and clay.

| Treatment | Barley yield (kg/ha) (92E59) | Lupin dry matter (kg/ha) 27/10/92 (92E60) |
|---|---|---|
| DD Agrisystem | 1302 | 284 |
| 9cm cult. + Agrisystem | 870 | 117 |
| Agrisystem then deep rip | 1160 | 1295 |
| DD Level combine - 2 inch points | 1216 | 480 |
| DD Mod C - 2 inch points 9 cm deep | 1044 | 633 |
| DD Mod C - 2 inch points 13 cm deep | 932 | 608 |
| P = | 0.001 | 0.01 |
| 5% LSD | 130 | 530 |

The barley yields indicate minimum surface disturbance is desirable when very wet conditions occur. Plant establishment was not different between machines or methods.

For lupins plant establishment was also not affected. Ripping appeared to help relieve waterlogging and this may have been the only treatment which eventually produced grain, however the plots were cut to obtain relative dry matter production data.

Kojaneerup - A trial with barley and a trial with lupins were sown on 20 July. The barley site had 30 cm sand over gravel and clay. The lupin site was deep white sand. Both sites were in paddocks of cereal/lupin rotation. Cultivation was two days before seeding with a scarifier plus harrows.

| Treatment | Header grain yield (kg/ha) Barley | Lupins |
|---|---|---|
| Agrisystem DD | 1543 | 3955 |
| Agri after 4 cm cultivation | 1299 | |
| Agri after 10 cm cultivation | 1543 | 3590 |
| Great Plains discs + PW, DD | 1299 | 3027 |
| Great Plains after 4 cm cultivation | 1335 | |
| Great Plains after 10 cm cultivation | 1513 | 3068 |
| P = | N.S. | 0.009 |
| 5% LSD | - | 477 |

All treatments were sown with 150 kg/ha super.

Plant establishment was not different for any of the treatments. The shallow duplex barley site was waterlogged for much of the year. The Agrisystem machine outyielded the double disc openers in the lupin trial with exceptional yield considering the 20 July seeding.

## CONCLUSIONS

1992 was a very wet year. Results may differ in a "normal" year. Zero tillage trials will be conducted mainly at EDRS and Kojaneerup in the next few years, and will include different times of seeding. The 1992 results indicate that more research should be conducted on P nutrition and prediction of economic rates as well as the potential for wider row spacing for cereals.

This research was funded by GRDC project DAW59W "Demonstration and evaluation of zero tillage and reduced tillage establishment systems.

## QUANTIFYING SYSTEM BENEFITS OF NO-TILL

Bill Crabtree, Adviser, Department of Agriculture, Esperance
At Darkan 24/3/93 for WANTFA

**Background**

There are obviously numerous costs and benefits associated with the No-till system. I have attached some notes on this issue for background reading (see EDRS talk - 14/10/92). Previous Departmental trial programs have not been targeted at establishing what the overall net effect of a major tillage system shift is on a farm enterprise. It is obvious that there are many farmer perceived net positive benefits for adopting a No-till system. This is despite numerous trial results which frequently demonstrate grain yield penalties for sowing with No-till compared with the more conventional (1992), Minimum tillage sowing technique (for 1992 being; cultivate, spray, then seed). This technique will be refereed to as minimum tillage hereafter.

In this brief paper I will attempt to put a **first draft** together on quantifying the costs and benefits associated with a No-till system. I will make many bold assumptions and use crude economics (not being an economist) to demonstrate what might be how a farmer would compare the two systems. I will adopt a hypothetical case study to investigate the complex interactions of grain yield, with the two tillage techniques, with probable seasonal conditions for an Esperance farm. I will then attempt to value other more hidden costs and benefits of No-till by putting, perhaps controversial, dollars and cents to them.

**Case Study Assumptions:**

1. the No-till machine is a cheap 24 run Combine with narrow sowing points (5 mm) only,
2. there is a 10% yield penalty for No-till compared with Minimum tillage,
3. we are using a wheat program of 1,000 hectares on the Esperance sandplain with 500 mm rainfall,
4. there is a 40 kg/ha/day wheat yield decline for delaying sowing after 1 May,
5. both systems seed 40 hectares per day (Minimum tillage is slow due to the pre-sowing cultivation and perhaps the raking and burning of some heavy stubbles),
6. the wheat is grown in a rotation with lupins, which are sown on wide rows with a standard cheap combine (i.e. no significant economic impact on this case study),
7. the wheat costs $140/ha to sow and harvest, and a wheat farm gate price is $140/t,
8. there is a typically staggered start to the season in early May which is followed by some transitional waterlogging in early June. There are 3 main fronts that pass through Esperance in May each with increasing rain falling. The first front brings 10 mm of rain, the second 15 mm and the third 40 mm. The last front is followed by another 60 mm two weeks later and results in parts of some paddocks being transitionally waterlogged.

**Case Study Results:**

The practical impact of these rainfall events or lack of them is that sowing with the Minimum tillage technique is penalised by three factors. Firstly on 1-3 May there are other pre-sowing cultivations and stubble raking that detract from the sowing operation while soil moisture levels are good, secondly soil drying halts Minimum tillage sowing's but not the No-till operation on the 6th and 17-22nd of May, and thirdly, waterlogging occurs on the 12 June which delays the last 120 ha of cropping by 9 days (see Figure 1 and the appendix). The resulting sowing days are: Minimum tillage seeding occurs on 4-5, 11-16, 28-31 of May and 1-11, 21-23 June, while the No-till paddocks are sown on 1-6, 11-22 and 28 May - 3 June. Conserved soil moisture and less wind erosion risk are the main reasons for the No-till sowing continuing into the 'dryish' soil conditions in May while the Minimum tillage sowing was halted.

The crude economic sums in this situation, using the above assumptions, show that both techniques gave a similar economic return of about $320/ha across the wheat program (see appendix). There is nothing in it! and this is despite a 10% yield penalty for adopting a No-till strategy. However, if we assume that there is now only a 5% yield penalty for No-tilling (perhaps we put winged, narrow points on the combine) then we might achieve $319/ha for Minimum tillage and $356/ha for No-till. This equates to a $37/ha or a 12% overall increase for adopting a No-till seeding strategy. This crude analysis does not include other more hidden, yet probable, costs and benefits of a No-till system.

**Other Costs/Benefits of No-till:**

The other costs and benefits of No-till are numerous (perhaps most are tabled below). I have taken an enormous liberty at guessing what these might equate to in $/ha on a south coast, sandy farm. However, these figures were derived from 'gut level' discussions with numerous farmers and do reflect some reality for farmers. The figures are not espoused as being 'water tight'.

Qualification of what these other costs and benefits are may not surprise anyone but the quantification may shock some. Again, this papers purpose is to be a springboard for discussion. Using the figures shown below there is an $90 - $20 = $70/ha more benefits in a No-till system compared to a Minimum tillage system in the absence of grain yield costs and benefits.

| COSTS | | BENEFITS | |
|---|---|---|---|
| $/ha | Reason for cost | $/ha | Reason for benefits |
| 5 | More exposure to herbicides (perhaps more headaches and some possible long term effects) | <br>4<br>3<br>16<br>6 | Less tractor hours result in:<br>a) less back problems,<br>b) better hearing,<br>c) better crop monitoring,<br>d) more time for recreation, the TV news, kids & wife |
| 10 | Rhizoctonia will eventually occur (SA experience) so put an annual cost in up front | <br>8<br>3<br>2<br>2<br>5 | No wind erosion which gives:<br>a) better community self esteem,<br>b) cleaner dams,<br>c) less fenceline maintenance,<br>d) maintained soil nutrients,<br>e) a better marriage – no dust in the house |
| 5 | More root rots like pythium and fusarium with stubble retention | 10 | Less weed emergence is stimulated (no light flash) giving less selective herbicide use and resistance (and see next point) |
| | | 2 | More uniform crop emergence giving a bigger selective herbicide window, including an in-crop gramoxone use at the 1/2 leaf stage |
| | | 5 | Soil benefits (earthworms, more biological activity, compaction, structure) |
| | | 5 | More seeding flexibility, farmers are not committed to sow an uncultivated paddock |
| | | 5 | Soil is more trafficable to apply; in crop herbicide, insecticide, and nutrients |
| | | 7 | Less capital overheads |
| | | 4 | Less fuel required |
| | | 3 | Less repairs required |
| **$20** | **Total** | **$90** | **Total** |

**Other Considerations:**

This study is obviously incomplete and perhaps requires a whole farm computer model to analyse this concept further. Some weak points, that I perceive in this case study, include:

a) farmers do not cultivate lupin paddocks prior to sowing a cereal on them as the risk of wind erosion is just too great,

b) in reality a cropping program usually consists of some pasture cropped in rotation with wheat or barley,

c) varietal use changes with time of sowing and so may yield potential with sowing date,

d) late May sown crops sometimes (perhaps 1/5 years) yield better than early May sown crops,

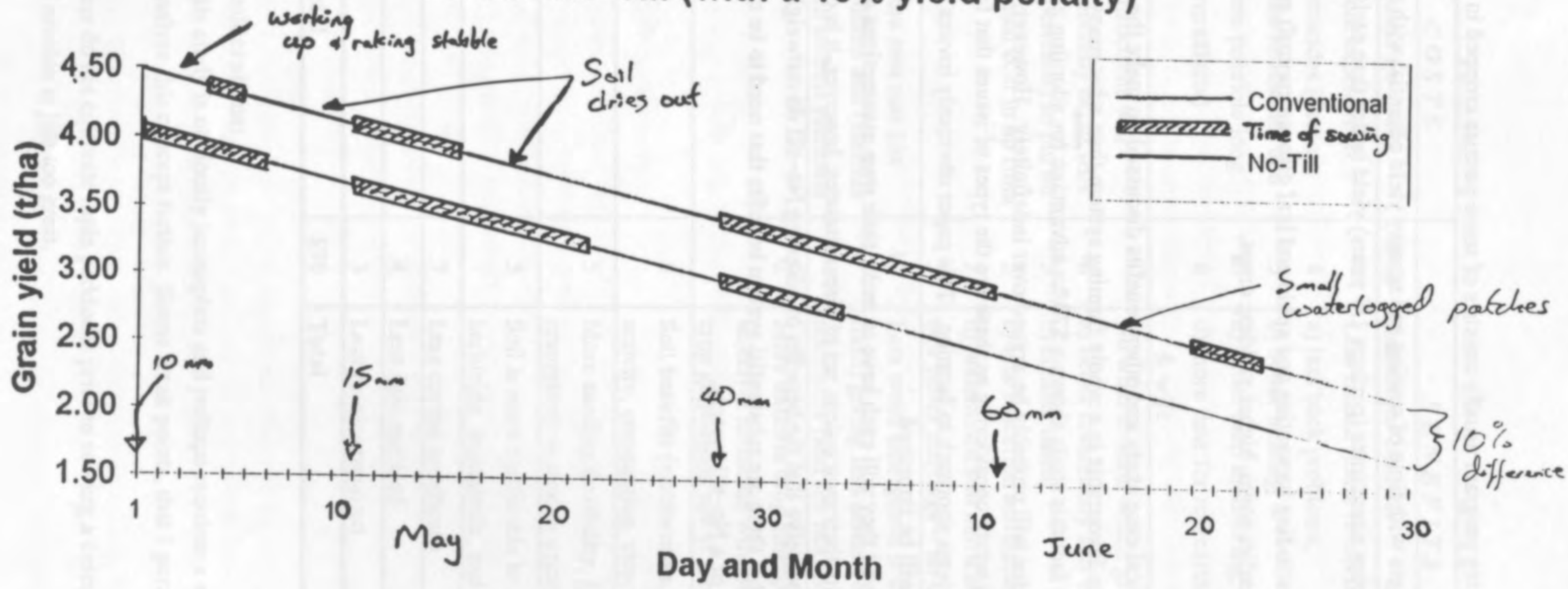
e) cropping costs (including harvesting and aphid and leaf disease control) are more expensive with earlier sown, higher yielding crops,

## Conclusion

This hypothetical case study and other benefits discussed do make the option of going No-till look quite favourable in a whole farming system than what many may haave previously thought. In fact this study shows a $70/ha advantage for adopting a No-till system. This dollar value will probably be argued over indefinitely. However, I think the essence of this study is worth considering as these are the types of issues that farmers have to consider in their systems approach to farming. This paper obviously invites critical comment for which it will be improved.

For farmers, well they will each have to make their own assumptions as to which tillage system most suits their own unique set of circumstances, however, it is quite clear that many farmers do perceive that the benefits of adopting No-till do outweigh the costs. This study highlights that there are substantial system benefits that need to be considered in a cost/benefit analysis of a No-till system.

## Time of sowing chart by yield comparisons using Conventional versus No-Till (with a 10% yield penalty)



Appendix to Quantifying No-Till Benefits

| Day | GY (MT) | GY (No Till) | ha | ha | GM (MT) | GM (No Till) |
|---|---|---|---|---|---|---|
| 1 | 4.50 | 4.05 | | 40 | 0 | 16680 |
| | 4.46 | 4.01 | | 40 | 0 | 16456 |
| | 4.42 | 3.97 | | 40 | 0 | 16232 |
| May | 4.38 | 3.93 | 40 | 40 | 18528 | 16008 |
| | 4.34 | 3.89 | 40 | 40 | 18304 | 15784 |
| | 4.30 | 3.85 | | 40 | 0 | 15560 |
| | 4.26 | 3.81 | | | 0 | 0 |
| | 4.22 | 3.77 | | | 0 | 0 |
| | 4.18 | 3.73 | | | 0 | 0 |
| 10 | 4.14 | 3.69 | | | 0 | 0 |
| | 4.10 | 3.65 | 40 | 40 | 16960 | 14440 |
| | 4.06 | 3.61 | 40 | 40 | 16736 | 14216 |
| | 4.02 | 3.57 | 40 | 40 | 16512 | 13992 |
| | 3.98 | 3.53 | 40 | 40 | 16288 | 13768 |
| | 3.94 | 3.49 | 40 | 40 | 16064 | 13544 |
| | 3.90 | 3.45 | 40 | 40 | 15840 | 13320 |
| | 3.86 | 3.41 | | 40 | 0 | 13096 |
| | 3.82 | 3.37 | | 40 | 0 | 12872 |
| | 3.78 | 3.33 | | 40 | 0 | 12648 |
| 20 | 3.74 | 3.29 | | 40 | 0 | 12424 |
| | 3.70 | 3.25 | | 40 | 0 | 12200 |
| | 3.66 | 3.21 | | 40 | 0 | 11976 |
| | 3.62 | 3.17 | | | 0 | 0 |
| | 3.58 | 3.13 | | | 0 | 0 |
| | 3.54 | 3.09 | | | 0 | 0 |
| | 3.50 | 3.05 | | | 0 | 0 |
| | 3.46 | 3.01 | | | 0 | 0 |
| | 3.42 | 2.97 | 40 | 40 | 13152 | 10632 |
| | 3.38 | 2.93 | 40 | 40 | 12928 | 10408 |
| 30 | 3.34 | 2.89 | 40 | 40 | 12704 | 10184 |
| | 3.30 | 2.85 | 40 | 40 | 12480 | 9960 |
| | 3.26 | 2.81 | 40 | 40 | 12256 | 9736 |
| June | 3.22 | 2.77 | 40 | 40 | 12032 | 9512 |
| | 3.18 | 2.73 | 40 | 40 | 11808 | 9288 |
| | 3.14 | 2.69 | 40 | | 11584 | 0 |
| | 3.10 | 2.65 | 40 | | 11360 | 0 |
| | 3.06 | 2.61 | 40 | | 11136 | 0 |
| | 3.02 | 2.57 | 40 | | 10912 | 0 |
| | 2.98 | 2.53 | 40 | | 10688 | 0 |
| 10 | 2.94 | 2.49 | 40 | | 10464 | 0 |
| | 2.90 | 2.45 | 40 | | 10240 | 0 |
| | 2.86 | 2.41 | | | 0 | 0 |
| | 2.82 | 2.37 | | | 0 | 0 |
| | 2.78 | 2.33 | | | 0 | 0 |
| | 2.74 | 2.29 | | | 0 | 0 |
| | 2.70 | 2.25 | | | 0 | 0 |
| | 2.66 | 2.21 | | | 0 | 0 |
| | 2.62 | 2.17 | | | 0 | 0 |
| | 2.58 | 2.13 | | | 0 | 0 |
| 20 | 2.54 | 2.09 | 40 | | 6880 | 0 |
| | 2.50 | 2.05 | 40 | | 6656 | 0 |
| | 2.46 | 2.01 | 40 | | 6432 | 0 |
| | | | | | $329/ha | $320/ha |
| Area x day sown | | | | | 329,000 | 320,000 |

10% penalty

| Day | GY (MT) | GY (No Till) | ha | ha | GM (MT) | GM (No Till) |
|---|---|---|---|---|---|---|
| 1 | 4.50 | 4.28 | | 40 | 0 | 17940 |
| 2 | 4.46 | 4.24 | | 40 | 0 | 17716 |
| 3 | 4.42 | 4.20 | | 40 | 0 | 17492 |
| 4 | 4.38 | 4.16 | 40 | 40 | 18528 | 17268 |
| 5 | 4.34 | 4.12 | 40 | 40 | 18304 | 17044 |
| 6 | 4.30 | 4.08 | | 40 | 0 | 16820 |
| 7 | 4.26 | 4.04 | | | 0 | 0 |
| 8 | 4.22 | 4.00 | | | 0 | 0 |
| 9 | 4.18 | 3.96 | | | 0 | 0 |
| 10 | 4.14 | 3.92 | | | 0 | 0 |
| 11 | 4.10 | 3.88 | 40 | 40 | 16960 | 15700 |
| 12 | 4.06 | 3.84 | 40 | 40 | 16736 | 15476 |
| 13 | 4.02 | 3.80 | 40 | 40 | 16512 | 15252 |
| 14 | 3.98 | 3.76 | 40 | 40 | 16288 | 15028 |
| 15 | 3.94 | 3.72 | 40 | 40 | 16064 | 14804 |
| 16 | 3.90 | 3.68 | 40 | 40 | 15840 | 14580 |
| 17 | 3.86 | 3.64 | | 40 | 0 | 14356 |
| 18 | 3.82 | 3.60 | | 40 | 0 | 14132 |
| 19 | 3.78 | 3.56 | | 40 | 0 | 13908 |
| 20 | 3.74 | 3.52 | | 40 | 0 | 13684 |
| 21 | 3.70 | 3.48 | | 40 | 0 | 13460 |
| 22 | 3.66 | 3.44 | | 40 | 0 | 13236 |
| 23 | 3.62 | 3.40 | | | 0 | 0 |
| 24 | 3.58 | 3.36 | | | 0 | 0 |
| 25 | 3.54 | 3.32 | | | 0 | 0 |
| 26 | 3.50 | 3.28 | | | 0 | 0 |
| 27 | 3.46 | 3.24 | | | 0 | 0 |
| 28 | 3.42 | 3.20 | 40 | 40 | 13152 | 11892 |
| 29 | 3.38 | 3.16 | 40 | 40 | 12928 | 11668 |
| 30 | 3.34 | 3.12 | 40 | 40 | 12704 | 11444 |
| 31 | 3.30 | 3.08 | 40 | 40 | 12480 | 11220 |
| 32 | 3.26 | 3.04 | 40 | 40 | 12256 | 10996 |
| 33 | 3.22 | 3.00 | 40 | 40 | 12032 | 10772 |
| 34 | 3.18 | 2.96 | 40 | 40 | 11808 | 10548 |
| 35 | 3.14 | 2.92 | 40 | | 11584 | 0 |
| 36 | 3.10 | 2.88 | 40 | | 11360 | 0 |
| 37 | 3.06 | 2.84 | 40 | | 11136 | 0 |
| 38 | 3.02 | 2.80 | 40 | | 10912 | 0 |
| 39 | 2.98 | 2.76 | 40 | | 10688 | 0 |
| 40 | 2.94 | 2.72 | 40 | | 10464 | 0 |
| 41 | 2.90 | 2.68 | 40 | | 10240 | 0 |
| 42 | 2.86 | 2.64 | | | 0 | 0 |
| 43 | 2.82 | 2.60 | | | 0 | 0 |
| 44 | 2.78 | 2.56 | | | 0 | 0 |
| 45 | 2.74 | 2.52 | | | 0 | 0 |
| 46 | 2.70 | 2.48 | | | 0 | 0 |
| 47 | 2.66 | 2.44 | | | 0 | 0 |
| 48 | 2.62 | 2.40 | | | 0 | 0 |
| 49 | 2.58 | 2.36 | | | 0 | 0 |
| 50 | 2.54 | 2.32 | 40 | | 6880 | 0 |
| 51 | 2.50 | 2.28 | 40 | | 6656 | 0 |
| 52 | 2.46 | 2.24 | 40 | | 6432 | 0 |
| | | | | | $319/ha | $357/ha |
| | | | | | 319,000 | 357,000 |

5% penalty

## ZERO-TILL HAS BENEFITS Bill Crabtree
## (Stubble and EDRS field day 14 October 1992)

The many merits of zero-till should not be overlooked. It is true that there are some limitations with using a zero-till system and it is often difficult for researchers and farmers to put all the puzzling factors together. At the end of the day though, farmers need to adopt one or more seeding techniques that will satisfy all the requirements of an environmentally safe and economical cropping program.

### Zero-Till definition

Tillage as defined in both the Collins and Britannica dictionary's is "the act of cultivating". To cultivate is to "prepare land for the growth of crops by breaking up the soil with a cultivator". A cultivator is "a farm implement with shovels, blades, etc., used to break up the soil **and kill weeds**".

Obviously planting a crop with "no breaking up" of the soil is difficult and perhaps even impossible. However, the second part of the zero-till definition "and kill weeds" is definitely not achieved with disk zero-tilling machines. Another dictionary definition of tillage, as adopted by WANTFA, is 'the complete disturbance of the topsoil'.

It is difficult to know if sowing with a standard combine with knife points (1.0 cm wide) should be called zero-till or direct drill, especially if lupins are being sown on 36 cm spacings. One centimetre being cultivated every 36 cm is arguably a zero-till technique.

### Problems with Zero-Till

There are problems and potential problems with zero-till for sandplain soils on the south coast of Western Australia (see attached April 1992 Agmemo articles). Perhaps the two most negative aspects of zero-till on the south coast are a lack of early vigour with cereals and an increase in Rhizoctonia incidence in crops.

Research by Ron Jarvis and myself have shown that in many trials cereals grown on south coastal sands respond about 10% in grain yield to cultivation in all but the wettest of years when sown into pasture. In a crop rotation this figure may be less. We also know, through trial work by Brennan, Jarvis, MacNish and myself, that both cereals and lupins grown in Rhizoctonia affected soil respond to deeper cultivations. But we do not know what percentage grain yield loss will be incurred on paddocks or on farms in any one year with zero-tillage.

There are many successful farmers who are prepared to suffer some yield loss, on some parts of their paddocks or farms, in order to secure an insurance policy against wind erosion and improve their whole farm time of sowing opportunities. This keenness of successful farmers, who have a whole farm system to consider, to adopt zero-till must cause us to reflect carefully on whole farm ramifications of zero-till.

### Benefits of Zero-Till

Zero-till has many attributes other than eliminating the risk of wind erosion and improved time of sowing. It also allows farmers to; have increased flexibility, leave stubble on the surface, have fewer tractor hours, have less wear and tear on their bodies, maintain better hearing, have less fuel costs, have more time for better whole farm planning, have more time with wife and kids, build populations of beneficial soil fauna, improve soil trafficability and on heavier soils it enables them to improve soil structure.

Perhaps the biggest benefit from zero-till is the very clear grain yield advantages possible from bringing the average farm sowing time 1-3 weeks earlier than with more conventional methods. Any delay in the whole seeding operation adversely affects tonnes of grain produced on the farm. This whole farm systems approach to thinking needs to always temper trial results which, unfortunately cannot compare the opportunities that a season may present a farmer. Perhaps we need to look further at the south coast farm computer model to find some answers.

To use real life examples is perhaps the most powerful way to illustrate, in part, a case for defending a zero-till system. Last year a farmer in the Esperance area had his whole farm sown by the 18 May when virtually no other farmer on the sandplain had began sowing in earnest. This whole farm cropping program was sown perhaps a month earlier the neighbours and his grain yields demonstrated this. His good yields were also associated with no wind erosion.

Wind erosion affects a caring farmer in many ways. Wind erosion will affect his pride, self esteem, fencelines, dams, topsoil life, soil fertility, neighbourly relations, community self esteem, marriage and so on. A farmer is powerless to arrest a wind eroding patch, and once it starts, in many cases all he can do is look the other way and hope for more favourable weather conditions.

## Other Options

There is of course more than zero-till available for those who wish to avoid wind erosion on perhaps more stable sands. A one pass with a modified combine that achieves a full cut is an option if stubble is not of concern and it will not cause the paddock to blow (the soil has evenly wet up, is not severely water repellent or too sandy {<0.75% clay}).

Another option that would avoid wind erosion and Rhizoctonia is to use a zero-till machine and deep rip the soil immediately afterwards. This approach may not be practical though in very dense stubbles and will impact on time of sowing operations for many farmers.

## Summary

We still have a lot to learn about zero-tillage and the size of the problems we will encounter with zero-tillage. However, it is clear that there are many system benefits to adopting some form of zero-tillage on south coastal soils of Western Australia. Zero-tillage should be considered as another tool that will increase a farmers opportunities in a range of situations.

Strategies To Reduce Rhizoctonia Damage in Direct Drilled Cereals - A South Australian Perspective

*David K. Roget, CSIRO Division of Soils, Adelaide*

Introduction

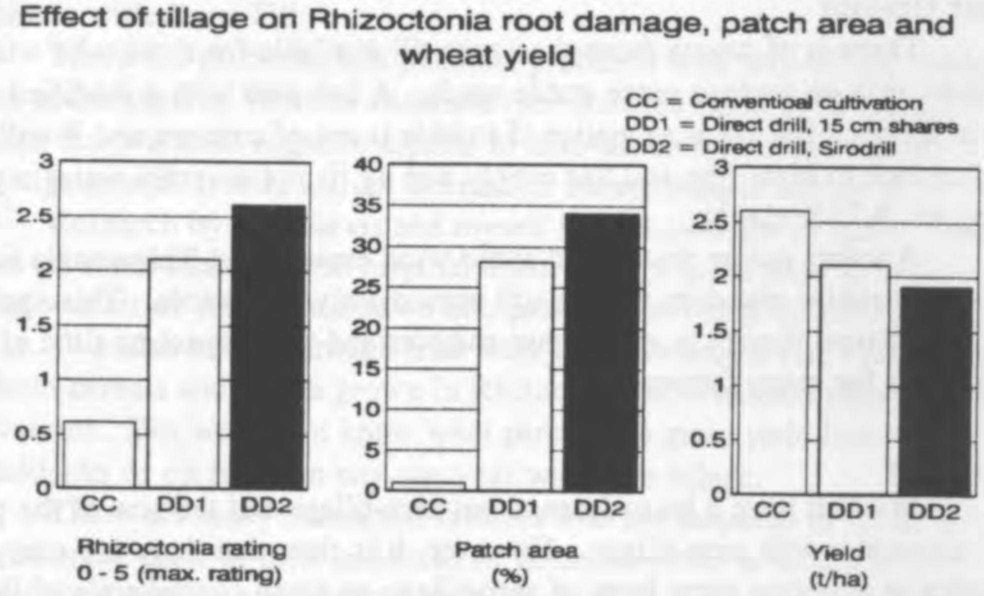
Rhizoctonia root disease has historically been a problem in S.A. on the poorer sandy soils of Eyre peninsular and the Murray Mallee. With the introduction of direct drilling the level of Rhizoctonia damage increased in these areas and Rhizoctonia began to appear in non traditional Rhizoctonia soils. Rhizoctonia disease was the major reason for the failure of the initial move to direct drilling in the late 1970's.

Experimental results

***Effect of tillage***

Research has consistently demonstrated that Rhizoctonia damage increases and hence yields decrease with direct drilling (Fig.1). Direct drilling with specialised equipment that gives minimal soil disturbance gives a small increase in Rhizoctonia damage when compared to direct drilling with conventional wide shares.

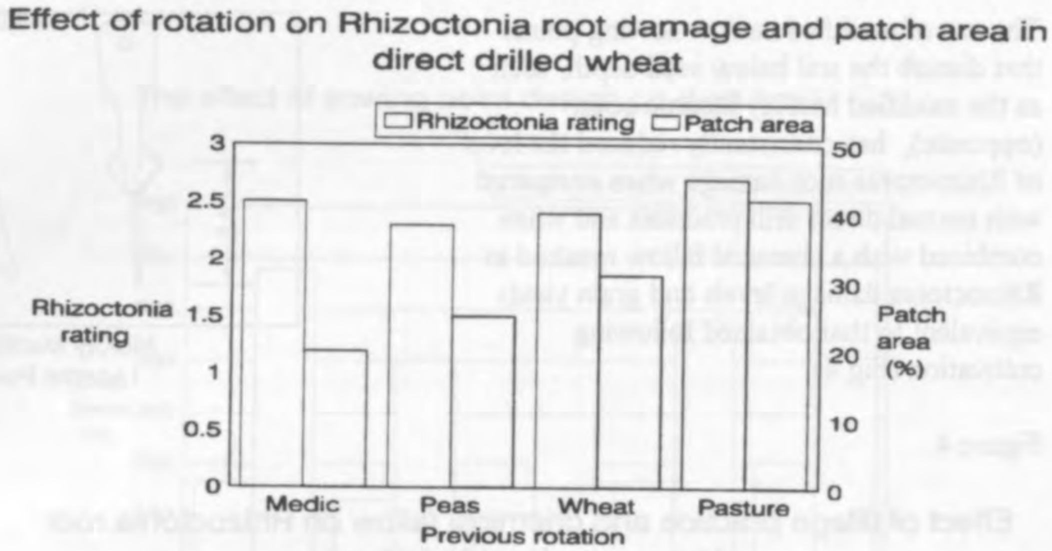
Figure 1




***Effect of rotation***

There was only a small effect of rotation on the extent of Rhizoctonia root damage with a tendency for slightly higher damage in wheat following pasture compared to wheat following medic, peas or wheat. However the area of patch showed consistent and significant differences with the rotations in order of increasing patch area being medic, peas, wheat, pasture (Fig.2)

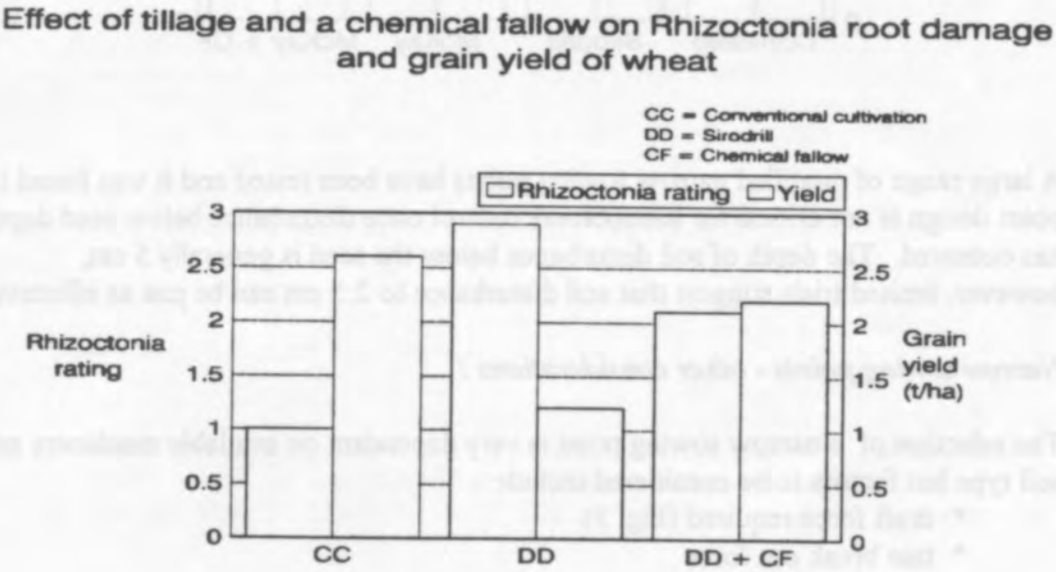
Figure 2.




### *Chemical fallow*

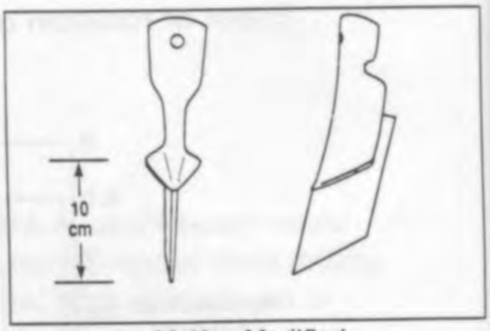
Volunteer pasture growth that occurs between the opening rains and sowing can cause a build up of Rhizoctonia. Chemical removal of this material 3 to 4 weeks before sowing can significantly reduce Rhizoctonia root damage in direct drilled wheat (Fig. 3), although damage is usually still higher than that following cultivation. The use of a short chemical fallow is of most benefit in seasons with an early break and is a technique that has been very consistent in its effect in S.A.

Figure.3



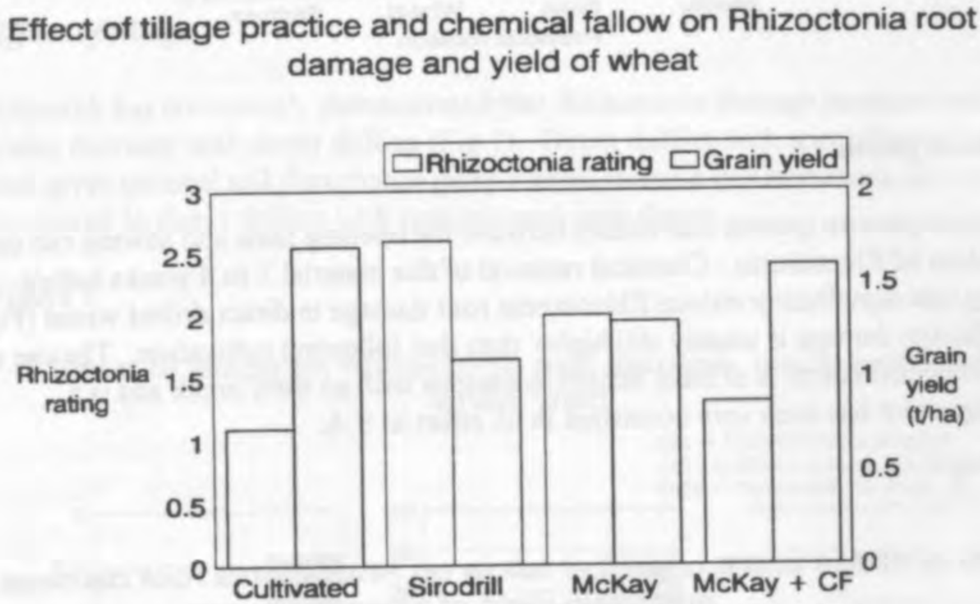
### *Narrow sowing points - effect on Rhizoctonia*

The use of modified narrow sowing points that disturb the soil below seed depth, such as the modified McKay lucerne point (opposite), has consistently reduced the level of Rhizoctonia root damage when compared with normal direct drill practices and when combined with a chemical fallow resulted in Rhizoctonia damage levels and grain yields equivalent to that obtained following cultivation (Fig.4).



McKay Modified Lucerne Point

Figure 4.




A large range of modified narrow sowing points have been tested and it was found that point design is not critical for Rhizoctonia control once disturbance below seed depth has occurred. The depth of soil disturbance below the seed is generally 5 cm, however, limited trials suggest that soil disturbance to 2.5 cm can be just as effective.

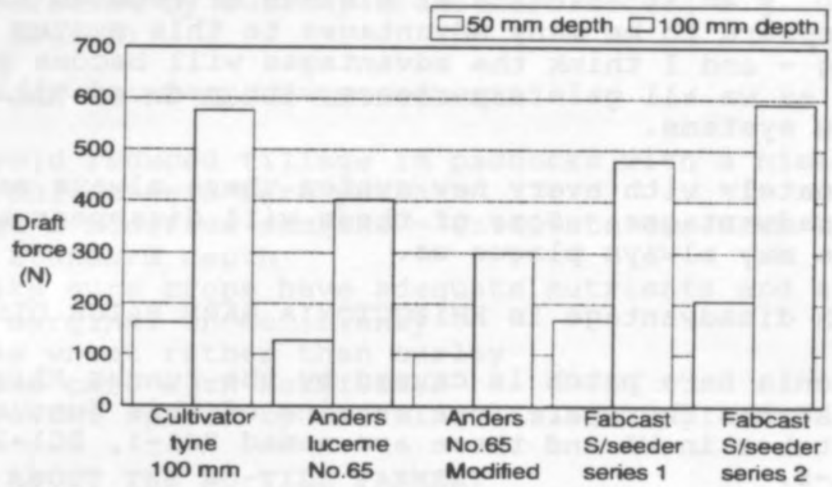
### *Narrow sowing points - other considerations :*

The selection of a narrow sowing point is very dependant on available machinery and soil type but factors to be considered include :

* draft force required (Fig. 5)
* tine break out force
* wear rates
* seed placement ie. use of seed deflectors
* resulting seedbed

Figure 5

**The effect of sowing point design on draft force**




From T. Riley and J. Fielke, University of S.A.

In S.A. there are currently a range of narrow sowing points in commercial use, many being fabricated by individual farmers to suit their particular conditions. The two most commonly used points are the Anders lucerne point (No. 65) which is often modified with the addition of tungsten carbide tips and Fabcast Superseeder point.

The agronomic considerations in selecting and using narrow sowing points are very important as the benefits of reduced Rhizoctonia damage can quickly be overtaken by problems of incorrect seed depth or poor emergence.

## RHIZOCTONIA BARE PATCH - THE DOWNSIDE OF NO-TILLAGE

by Dr. Gordon Mac Nish

### INTRODUCTION

Firstly, I am an advocate of minimum or reduced tillage. There appears to be many advantages to this system of cropping - and I think the advantages will become more obvious as we all gain experience with reduced tillage cropping systems.

Unfortunately with every new system there always seems to be some disadvantages. Some of these will disappear with time but some may always plague us.

One such disadvantage is RHIZOCTONIA BARE PATCH DISEASE.

Rhizoctonia bare patch is caused by the fungus *Rhizoctonia solani* AG-8. There are four strains of this fungus causing bare patches in WA and these are named ZG1-1, ZG1-2, ZG1-4 and ZG1-5.

### WHERE DID RHIZOCTONIA COME FROM?

This disease has been observed in South Australia since the mid 1920's and has been recorded in New South Wales and Victoria in the 1930's. It was first seen in WA in the late 60's and early 70's. It was probably accidentally introduced to WA from SA in the 1960's on farm machinery or in trash in medic seed.

### WHAT DO WE KNOW ABOUT RHIZOCTONIA?

# Patches are caused by *R. solani* AG-8
# The pathogen causes patches of stunted plants in otherwise healthy crop or pasture
# The fungus growth through the soil & does not need a host
# Most of the fungus is in the top 10 cm of soil
# Patches appear to expand between seasons
# Most growth occurs during the growing season but goes undetected because the pathogen is unable to stunt mature plants
# Patches can be present for 1, 2 or more seasons and then suddenly disappear
# Cultivation reduces the effects of the fungus but does not destroy it
# Patches tend to be in clusters
# Patches often elongated in the direction of sowing
# All crops and pasture are affected
# Barley most susceptible, then wheat, then oats

**WHAT FACTORS AFFECT RHIZOCTONIA?**

# Reduced by cultivation
# Reduced by deep ripping
# Reduced by Nitrogen
# Increased by Zn deficiency
# Increased by Sulfonylureas herbicides( e.g. Glean, Ally, Logran)

**WHAT CAN WE DO ABOUT RHIZOCTONIA?**

# Avoid reduced tillage in paddocks with a history of Rhizoctonia bare patch
# Use a modified combine - cultivate to 10 cm and sow at standard depth
# Make sure crops have adequate nutrients and avoid marginal Zn deficiency
# Use wheat rather than barley
# Take care with herbicides
# Prevent spread by cleaning tillage implements

**WHAT ABOUT THE NO-TILL FARMER?**

# The old triple disk drill is bad news
# Some of the modern no disturbance machines can also be expected to have problems

**GRASS CONTROL AND CHEMICAL FALLOWS**

Research in WA has failed to show any evidence that grass removal or short chemical fallows prior to sowing can reduce Rhizoctonia bare patch or root rot.

**FUTURE RESEARCH**

The aim of my GRDC funded project is to understand the fungus better and determine possible weak point in it's survival phase or during it's growth phase

# HOW TILLAGE AFFECTS SOIL STRUCTURE

Harry Cochrane
Soil Science, The University of W.A., Nedlands 6009.

## I. Introduction

The physical properties of wheatbelt soils have changed significantly since they were first cleared for farming. Generally they have become more compact, less permeable and more difficult to work: In most respects soil physical properties have deteriorated and one of the major reasons for this "structure decline" has been excessive tillage.

No-tillage sowing systems offer a way of reducing or even reversing the deterioration in soil structure that occurs with cropping, at least on some soil types. The vast majority of studies which have examined the effects of reduced and no-tillage sowing systems on soil structure, both in Australia and overseas, have found that no-tillage sowing systems improve soil structure relative to more tillage intensive conventional systems.

Tillage prior to or at seeding changes soil structure to a greater extent than any other normal farming operation so choosing the right tillage system for each soil is an important factor in maintaining soil structure on your land.
No single tillage method will be optimum for all soils. Soils differ in the type of structural deficiencies to which they are susceptible and in their ability to recover good structural characteristics. This article outlines some of the principles which should be taken into account when comparing tillage options for your soils.

## II. Why is soil structure important?

Soil structure can have a great influence on how productive your land is. Through the growing season it affects seedling emergence, root growth and rainfall acceptance - all of which affect crop yield potential. In the long term allowing soil structure to deteriorate could limit the sustainability of arable agriculture over a large area of the wheatbelt.

## III. What is soil structure?

Soil "structure" describes the way soil particles are arranged and bound together. In practice it is useful to think of soil structure in terms of three physical properties:

1. Porosity - pores provide pathways for roots; allow water and air to move through the soil and provide storage space for water. A well structured soil has a range of pore sizes to fulfil these functions and has good continuity between pores.
2. Strength - which affects trafficability and the ability of shoots to emerge and plant roots to grow through the soil.
3. Stability - a measure of the soil's resistance to break down under the influence of both natural forces and those associated with the way the soil is managed.

Structure is determined both by the soil's primary particle composition (the proportion of sand, silt, clay and organic matter) and by the way these components combine to form aggregates.
All soils (with the exception of pure sands) have at least some of their primary particles clumped together to form aggregates. Soils in which a high proportion of primary particles are aggregated together have better physical properties than the same collection of primary particles would have if there was no aggregation (larger, more continuous pores and lower strength). This is the reason why measures of aggregate stability such as "water stable aggregates" and "modulus of rupture" are so commonly used to assess soil structural condition.

## IV. The effects of tillage on soil structure

Tillage does not have much impact on the size of the primary soil particles but is capable of both breaking down aggregates and creating them. The balance of aggregate creation/destruction depends very much on soil moisture content. Tillage induced aggregate destruction usually far exceeds aggregate creation, particularly if the soil is worked too wet or too dry; if the soil is inherently unstable; and if the tillage implement has a particularly violent action on the soil. For wheatbelt soils it is much easier to destroy structure than it is to build it up.

The changes in soil structure caused by tillage can be beneficial in some respects but deleterious in others: For example intense cultivation to produce a fine seedbed may result in improved crop establishment but will also break up aggregates and accelerate the oxidation of organic materials which stabilise soil structure. For this reason it is often quite time consuming to get a balanced assessment of the changes occurring in soil structure and relying on simple observations or measurements of structure can occasionally be misleading.

The effects of tillage on soil structure depend on:-

1. The characteristics of the implement used, for example tyne or disk shape and size, speed of travel these will determine the proportion of the soil surface which is disturbed and the extent of soil fragmentation.
2. The characteristics of the soil for example it's composition particularly clay and organic matter contents, recent management history and moisture content at tillage.

This article deals mainly with how soil characteristics determine the effect of tillage on structure.

## V. Soil characteristics which determine the way tillage will affect structure.

### A. Soil texture.

More than any other soil component, clay content determines how a soil will behave when cultivated. As clay content increases soil behaviour becomes more dependant on the extent to which fine particles are aggregated into larger particles.
As a general rule, soils with loamy sand or coarser texture do not develop clearly defined aggregate structures, finer textured soils do and their reaction to tillage depends strongly on how aggregate structure is affected by disturbance.
Figure one, derived from measurements made by Ron Jarvis, shows changes in aggregate stability on a Merredin sandy clay loam resulting from a number of years

Table 1 Relative differences in seedbed characteristics for three tillage treatments on Wongan loamy sand.

| | Conventional tillage | Triple disk drill |
|---|---|---|
| Drainage porosity | 100 | 80 |
| Permeability | 100 | 52 |
| Evaporation | 100 | 105 |
| Penetration resistance | 100 | 219 |
| Crop yield | 100 | 87 |

Clay content is a general indicator as to whether or not soil structure will respond to no-tillage sowing; finer textured soils show more potential for structure development under no-tillage cropping. There are however more subtle differences between soils, in terms of their particle size composition, that influence their likely response to tillage: Clay type and sand size distribution are two factors that we know have a distinct influence.

1. Clay type and behaviour.

Some clays swell and shrink appreciably as they wet and dry, others, for example the moort clays, do not. Soils with at least some swelling clays have a greater potential for structure development with no-tillage - although there are no long term field study results from W.A. to corroborate this claim.
Clay behaviour is even more important than clay type. If clay is easily detached or "dispersed" from aggregates and moves as a suspension in the soil water it can dramatically reduce soil permeability and increase dry soil strength. Results from tillage trials on the Merredin sandy clay loam have confirmed that no-till sowing dramatically reduces the deleterious effects of dispersed clay on soil structure, compared with conventional tillage practices. Differences in soil behaviour between tillage treatments at this site both in continuous cropping and 1/1 rotation with medic pasture were predominantly attributable to changes in clay dispersion between the treatments.
Gypsum application can improve structure on soils which have become dispersive as a result of excessive tillage. However no-tillage or reduced tillage sowing systems offer a better option for potentially dispersive soils as soils are less likely to become dispersive if soil disturbance is reduced to a minimum.

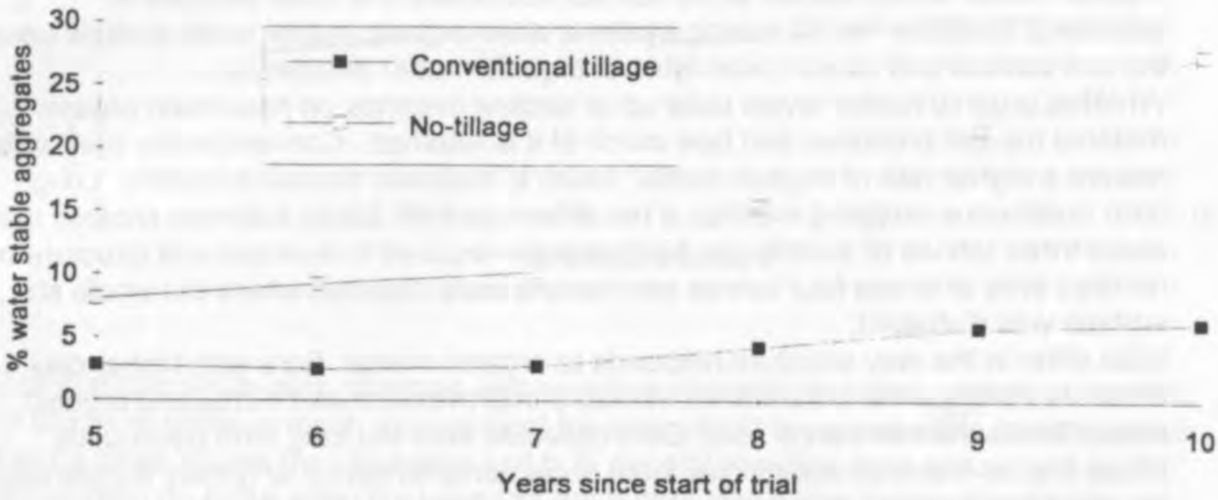
2. Sand particle size

Soils which have little aggregation differ in their susceptibility to compaction both from natural forces (wetting/drying, pressure of overlaying soil) and as a result of tillage and traffic. The most easily compacted soils have an even grading of sand particle sizes, that means there are a range of small particles which can find their way into the spaces between larger particles. To produce a good seedbed most highly compactable soils require greater loosening than a no-till seeder provides. However such soils are also vulnerable to compaction problems, in topsoil or subsoil, due to the extra traffic required for the additional tillage operations. The answer for these soils is a controlled traffic system which allows complete soil disturbance but restricts traffic to limited areas of the paddock.

of continuous cropping by both conventional tillage and no-tillage. This soil has sufficient clay to form aggregates, created mainly by the action of plant roots and their associated microorganisms.

Soil disturbance by frequent cultivation destroys aggregates at roughly the same rate as they are formed, whereas there is a useful build-up of aggregates under zero till conditions.

Figure One Change in water stable aggregation with tillage on continuously cropped Merredin sandy clay loam




These changes in aggregate stability were also indicative of changes in soil permeability. In the second year of the trial, soils from both treatments were equally permeable but by the fifth year the zero till site had become approximately 15 times more permeable than the equivalent conventionally tilled treatment.

In contrast to the changes in soil structure on the Merredin sandy clay loam, structural change associated with different tillage technique did not persist from year to year on a loamy sand at Wongan Hills. The physical properties of this soil are determined more by the arrangement and packing of the sand particles than by any build-up of aggregates. Complete soil disturbance creates porosity and reduces soil strength in the seedbed and although the effect of this loosening is temporary it is sufficient to give the crop a much better start to the growing season. The responsiveness of this soil type to tillage is indicated in table one by comparison of some seedbed physical properties and crop yields in zero tilled relative to conventionally cultivated soil - measured in the third year of the trial.
Permeability in the zero tilled soil was only half that of the conventionally tilled soil, penetration resistance was doubled and more water evaporated from the soil surface leaving less available for crop growth. Differences in crop yields between tillage treatments on wheatbelt soils can be attributed predominantly to differences in water use which is in turn controlled mainly by soil structural properties.

No-till seeding systems should be most successful on soils which show little or no clay dispersion and are not particularly susceptible to compaction. It is possible to measure soil susceptibility to both dispersion and compaction using simple laboratory tests.

### B. Soil organic matter

Organic matter is the universal soil structure improver. Although it is chemically very complex and the reasons for its role in stabilising soil are not clearly understood, all soils show an improvement in soil structure as organic matter levels increase. Tillage increases the rate of organic matter oxidation in the soil and effectively dilutes the organic matter concentration at the soil surface where it is most effective in stabilising structure. No-till sowing systems allow organic matter levels to build up at the soil surface and cause lower rates of organic matter destruction.

Whether organic matter levels build up or decline depends on how much organic material the soil produces and how much of it is retained. Conventionally tilled soils require a higher rate of organic matter return to maintain structural stability. Long term continuous cropping trials on a red-brown earth in South Australia showed that about three tonnes of stubble per hectare were required to maintain soil structure on no-tilled soils whereas four tonnes per hectare were required where the whole soil surface was disturbed.

Soils differ in the way structure responds to organic matter. Soils with higher clay contents have greater potential for structure improvement with increasing organic matter levels than do sandy soils. Soils collected from the long term continuous tillage trial on Merredin sandy clay loam show some evidence of greatly accelerated structure breakdown when organic matter drops below a critical level due to excess tillage. At present we do not know how typical this behaviour is and what the critical levels of organic matter might be for the range of wheatbelt soils.

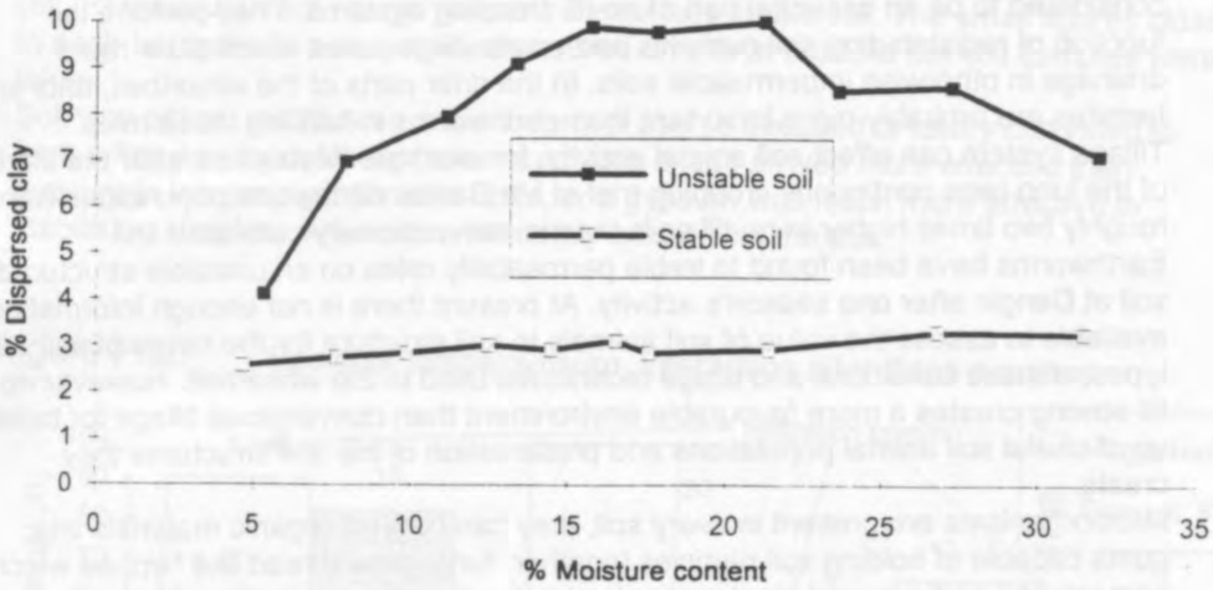
Organic materials grown on site are the cheapest materials available for maintaining and improving soil structure. There is no doubt that intensive traditional tillage systems underutilised these materials as structure improvers. No-till sowing systems preserve more of the root material produced by plants and this root material appears to be more effective in stabilising structure than equivalent weights above ground plant residues.

Plant species differ considerably in the effect of their roots on soil structure, particularly through the early growing season when soil structural stability is most critical. There is considerable opportunity to make better use of the structure improving qualities of plant materials in wheatbelt rotations particularly where cropping phases utilise no-till sowing systems.

### C.Soil moisture content

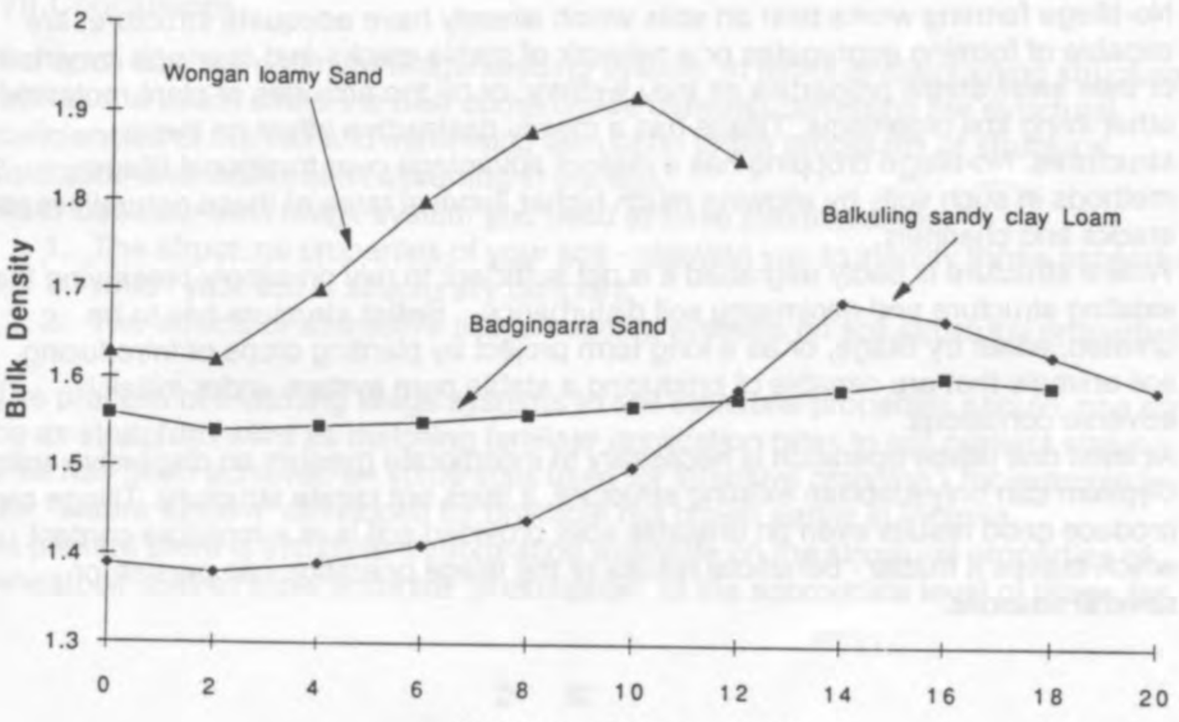
Soil moisture content at the time of tillage affects the result of the operation. Soils with stable structure can be worked over a relatively wide range of moisture contents to produce an adequate seedbed without smearing or pulverising the soil. Poorly structured soils such as the hardsetting "Sunday soils" can only be worked only over a narrow range of moisture contents without damaging structure. This is illustrated in Figure 2 which shows the difference in clay dispersion between a stable and an unstable structured soil of similar texture subjected to tillage at a range of moisture contents.

Figure Two Effect of tillage on clay dispersion at different moisture contents.




Soil compactability also changes with moisture content. Moisture content at the time of tillage or traffic is much more critical for soils which are susceptible to compaction. Figure three shows the change in soil bulk density resulting from a standard load application on three soils: Badgingarra sand does not suffer compaction problems, regardless of moisture content whereas the Balkuling and Wongan soils show much greater increases in density with increasing water content - both are equally susceptible to compaction but because of differences in texture the range of moisture contents at which compaction is most severe is different for the two soils.

Figure Three Change in compressibility with moisture content



### D. Soil organisms.

In wetter climates than the W.A. wheatbelt, active populations of soil animals are considered to be an essential part of no-till cropping systems. They perform the function of redistributing soil nutrients and create large pores which allow rapid drainage in otherwise impermeable soils. In the drier parts of the wheatbelt, ants and termites are probably more important than earthworms in fulfilling these roles.
Tillage system can affect soil animal activity, for example three years after the start of the long term continuous cropping trial at Mt. Barker earthworm populations were roughly two times higher in no-till soils than in conventionally cultivated soil.
Earthworms have been found to treble permeability rates on an unstable structured soil at Dangin after one season's activity. At present there is not enough information available to assess the value of soil animals to soil structure for the range of soil types, climatic conditions and tillage techniques used in the wheatbelt. However no till sowing creates a more favourable environment than conventional tillage for build up of useful soil animal populations and preservation of the soil structures they create.
Microorganisms are present in every soil, they can convert organic materials into gums capable of holding soil particles together, fungi grow thread like hyphae which enmesh soil particles and plant roots also bind soil particles together. All these materials are more effective soil stabilisers if left undisturbed and should therefore be more valuable in no-till sown soils; at present however it is not possible to quantify the extent to which different tillage practices affect their contributions to soil structure.

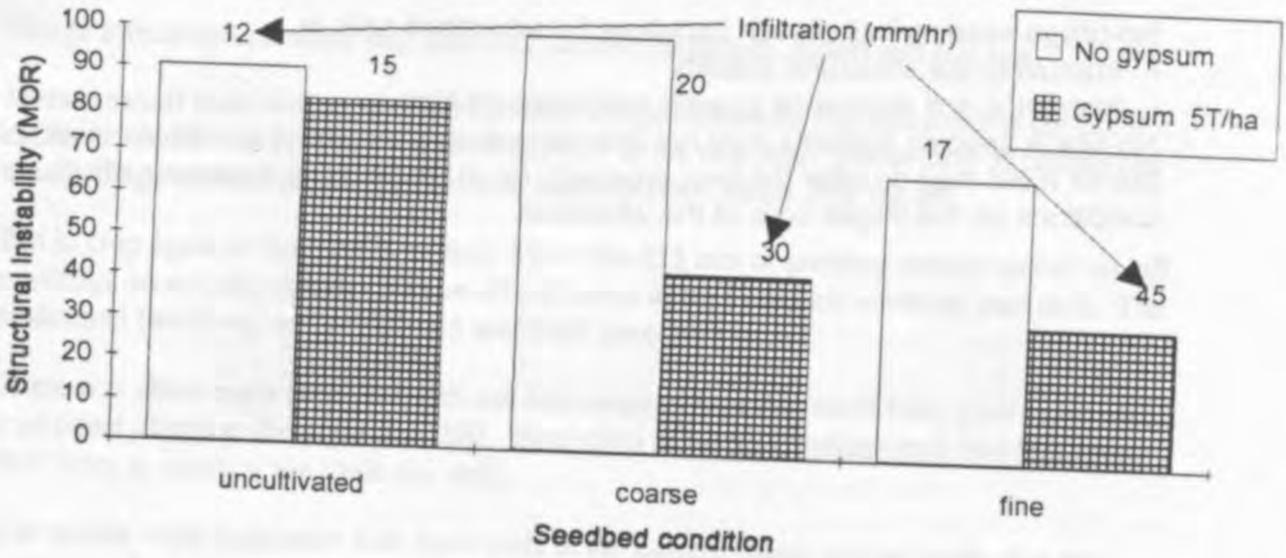
## VI. Tillage can benefit soil structure

For the fragile soils of the wheatbelt, improvements in soil structure brought about by tillage tend to be temporary and are generally outweighed by a reduction in structural stability - which affects the soils' long term productivity.
The effects of tillage are not always deleterious : Arable soils in Europe and Asia have withstood centuries of intense tillage and remain highly productive, tillage may be necessary to correct structure problems, incorporate soil amendments and control weeds and diseases.
No-tillage farming works best on soils which already have adequate structure, are capable of forming aggregates or a network of stable cracks and channels by virtue of their swell/shrink properties as they wet/dry; or by the activities of plant roots and other living soil organisms. Tillage has a mainly destructive effect on these structures. No-tillage cropping has a distinct advantage over traditional tillage methods in such soils by allowing much higher survival rates of these naturally made cracks and channels.
Where structure is badly degraded it is not sufficient to rely on simply preserving the existing structure and minimising soil disturbance. Better structure has to be created, either by tillage, or as a long term project by planting crops or introducing soil animals that are capable of producing a stable pore system under initially adverse conditions.
At least one tillage operation is necessary to incorporate gypsum on dispersive soils. Gypsum can only stabilise existing structure, it does not create structure. Tillage can produce good results even on unstable soils provided soil is at a moisture content which makes it friable - beneficial results of the tillage operation can persist for several seasons.

Figure 4 shows the results of tests performed on a gypsum responsive soil from Dangin three years after the tillage and gypsum treatments were applied. Bars in the figure represent the level of structural instability, assessed by modulus of rupture (MOR) measurement - larger values indicate less stable soil. The small figures close to each bar indicate permeability measured on site at the time the soil samples were taken.

Soil was either uncultivated, tilled to form a coarse seedbed or rotary cultivated to form a fine seedbed. Under these conditions tillage proved more effective than gypsum in increasing infiltration rates, and gypsum was much more effective in stabilising structure when more intimately mixed with the soil.

Figure Four **Residual tillage/gypsum interaction after three seasons**




## VII. Conclusions

For each soil, the optimum tillage/seeding system, in terms of maintaining structure, will be one which offers the best compromise between correcting the structural deficiencies of the soil and minimising disruption to the processes of structural formation and stabilisation occurring in the soil.

To choose the best tillage system you need to have information on:

1. The structural properties of your soil - allowing you to identify those aspects in which your soil is structurally deficient.
2. The effects of alternative tillage/seeding systems on soil structural properties

The process of matching tillage systems to soil structural properties should, one day, be as straightforward as matching fertiliser application rates to soil nutrient status. This has been achieved on some soils used for intensive cropping - for example in the "Tatura system" developed for unstable red brown earths in Victoria.

At present there is insufficient information available on the structural properties of wheatbelt soils to allow accurate "prescription" of the appropriate level of tillage for particular soil types; there is also a need to develop simple tests which can be used to identify structural deficiencies in wheatbelt soils and the effects of tillage and sowing machinery on soil structure can not be predicted accurately.

There will probably always be a role for complete soil disturbance on wheatbelt soils, to disrupt soil layers that have become too dense, restrict the movement of water into or through the soil as well as for weed and disease control and mixing of soil amendments.

Ideally tillage should be limited to soils and situations where the benefits are known to outweigh possible deleterious effects particularly those that affect structural stability.

For some soils tillage will be necessary each year of cropping, for others, every few years and for well structured, biologically active soils possibly not at all.

No-tillage seeding has proven beneficial for wheatbelt soils in

- improving soil structural stability
- improving soil resistance to wind and water erosion.

No-tillage seeding systems may not provide optimum structural conditions in all soils but for most they do offer the best prospect for maintaining or improving structural conditions on the fragile soils of the wheatbelt.

# WESTERN AUSTRALIAN NO TILLAGE FARMERS ASSOCIATION

## ANNUAL CONFERENCE DARKAN 24 MARCH 1993

## "No-Tillage Sowing and Water Erosion"

**By Kevin Bligh**

**Adviser, Department of Agriculture, South Perth**

## RAINFALL INFILTRATION FOLLOWING TILLAGE

Tillage affects soil structure and, therefore rainfall infiltration, runoff and soil loss.

Surface runoff from $4m^2$ areas under different tillage treatments was measured in the early eighties near Beverley. There was no difference in the first year. About 20% of rainfall ran off all tillage treatments. In the next year under pasture, about 10% ran off.

But in crop again in the third year, only 4% of the 253 mm of growing season rainfall ran off no-tillage-sown soil. About 13% ran off soil sown using a standard combine seed drill. The traditional (work-up, work-back and seed) still gave 20% runoff.

There was about eight times as much soil loss suspended in the runoff from plots sown using traditional tillage as the triple disc drill. Plots sown using the combine-seed drill lost about five times as much as the triple disc drill.

The results were consistent with most trials in the Eastern States and overseas. But we wanted to find out what the effects of tillage on a whole paddock scale were. So we started two trials using contour bays, one at Beverley, and the other at Chapman Research Station (about 30 km north-east of Geraldton).

## SURFACE RUNOFF FOLLOWING TILLAGE

On sandy loam over sandy clay soils at Beverley, no-tillage appears to have had little effect on surface runoff or seepage in reverse-bank seepage interceptors below 1 ha contour bays. It is possible that any greater infiltration of rainfall, results in a greater area of ponding at seepage spots. Then up to 100% of further rainfall can run off. There has been little difference in soil loss over the four years since the different tillage treatments were applied.

But at Chapman, surface runoff more than doubled from traditional tillage compared with no-tillage using narrow 55 mm wide, "inverted T"-shaped points, in the first big rain in the first year (1992.) (See Table 1). All four approximately 2 ha contour bays had given comparable runoff from the pastured loamy sand over sandy clay soil in 1991.

Table 1. Surface runoff after traditional and no-tillage sowing at Chapman (Geraldton).

| | Rain (mm) | Bay 1 (mm) | Bay 2 (mm) | Bay 3 (mm) | Bay 4 (mm) |
|---|---|---|---|---|---|
| 1991 | | Second year of pasture on all four bays | | | |
| 3-5 June | 26 | 0.5 | 0.1 | 0.1 | 0.6 |
| 13-18 June | 100 | 4.1 | 3.2 | 2.4 | 7.7 |
| 20 Jul-15 Aug | 72 | 1.8 | 1.4 | 4.4 | 3.0 |
| Total | | 6.4 | 4.7 | 6.9 | 11.3 |
| 1992 | | No tillage | Traditional tillage | No tillage | Traditional tillage |
| 8-9 August | 61 | 4.7 | 12.3 | 5.1 | 14.5 |
| 24-26 August | 38 | 0.4 | 2.7 | 1.2 | 2.1 |
| 27-28 August | 15 | 0.6 | 2.8 | 2.4 | 2.1 |
| 3-5 September | 22 | 0.01 | 0.7 | 1.2 | 0.8 |
| Total | | 5.7 | 18.5 | 9.9 | 19.5 |

The 61 mm of rain on 8-9 August 1992 included about 51 mm falling fairly uniformly over 6 hours. Its average recurrence interval is about nine years at Chapman.

Traditional tillage resulted in 11 mm more runoff than no-tillage in 1992. Local Departmental advisers attribute about 20 kg/ha grain yield to each millimetre of rainfall. Therefore the potential yield under no-tillage would be about 220 kg/ha higher than traditional tillage.

Actually the narrow-points-sown Bay 1 yielded 2.5 t/ha, but the traditionally-tilled Bay 2 was sown too deep, and only yielded 1.0 t/ha. Wheat yields were comparable from no-tillage and traditional tillage at about 1.7 t/ha from Bays 3 and 4 in 1992.

Note that runoff was greatest from the no-tillage Bay 3 in the last runoff events in both 1991 and 1992. It is probable that the soil became saturated on the relatively steep sides of a slight valley near the outlet of Bay 3 particularly with higher infiltration in previous rains under no-tillage in 1992. A high peak flow was measured from Bay 3 only, in the 3-5 September 1992 event, - further evidence for this saturation-excess runoff theory.

## SOIL AND PLANT NUTRIENT LOSSES

About 2.0 t/ha of silt was deposited in the contour bank channels of the traditional tillage Bays 2 and 4 in 1992. No silt was deposited below the no-tillage Bays 1 and 3.

Suspended soil losses in the runoff averaged more than 1.6 t/ha from the traditional tillage Bays 2 and 4 in the 8-9 August event - ten times higher than from Bay 3, and several hundred times more than Bay 1 (see Table 2). Again, suspended soil losses had been comparable from all four bays in the previous season under the same pastured land treatment.

Table 2. Suspended sediment loss before and after traditional and no-tillage sowing - Chapman

| | Rain (mm) | Bay 1 (kg/ha) | Bay 2 (kg/ha) | Bay 3 (kg/ha) | Bay 4 (kg/ha) |
|---|---|---|---|---|---|
| 1991 | | Second year pasture | | | |
| 3-5 June | 26 | 7 | 1 | 1 | 7 |
| 13-18 June | 100 | 27 | 29 | 16 | 98 |
| 20 Jul-15 Aug | 72 | 20 | 4 | 29 | 57 |
| Total | | 54 | 34 | 46 | 162 |
| 1992 | | No tillage | Work-up work-back and seed | No tillage | Work up work-back and seed |
| 8-9 August | 61 | 2 | 1,468 | 94 | 1,619 |
| 24-26 August | 53 | 0 | 72 | 2 | 77 |
| 3-5 September | 22 | 0 | 5 | 2 | 13 |
| Total | | 2 | 1,545 | 98 | 1,709 |

The combined 3.6 t/ha of silt and suspended soil lost from the traditional tillage Bays 2 and 4 is equivalent to about one quarter of a millimetre of topsoil. Available scientific evidence suggests that this takes about two hundred and fifty years at natural soil formation rates to replace. But the rain that caused the loss only occurs about every nine years, on average!

The various forms of the major plant nutrients nitrogen and phosphorus in the runoff water were also measured. "Cadoux" wheat had been sown about six weeks before the 8-9 August runoff event at 63 kg/ha, with 50 kg/ha of DAP fertiliser. All bays were then top-dressed with 50 kg/ha of Urea.

Total nitrogen losses averaged about 5 kg/ha from the traditionally-tilled bays, and 0.5 kg/ha from the narrow points sown bays. Relatively low levels of the ammonia and nitrate forms suggest that most nitrogen losses were as organic matter in the eroded soil.

The 5 kg/ha of nitrogen lost from the traditionally-tilled bays would have been available to crop plants in the long term. About 10 kg/ha of Urea (46% N) would be required to replace this loss, applied at the right time to suit the crops.

Looked at another way, not only were soil losses from the traditionally-tilled bays well above known soil formation rates, but the equivalent of about 10 kg/ha of urea was lost as well. The bays sown without tillage lost soil at about the soil formation rate, and only lost the equivalent of about 1 kg/ha of urea in 1992.

## ORGANIC CARBON AND SOIL ANIMALS

Organic carbon in the surface soil after three years was 1.8% on traditionally-tilled bays at Beverley, but about 3.0% on combine direct-drilled, narrow-points sown and pastured bays. Both soil organic carbon and earthworm numbers can influence infiltration rates, and therefore surface runoff and water erosion.

Earthworm numbers per hectare in mid-August 1992 (the fourth year after applying the different tillage treatments) increased from an average of half a million under traditional tillage, to three quarters of a million under both combine direct drilling and pasture, and to about two million under no-tillage sowing using narrow-points.

Average weights of the earthworms were halved under traditional tillage, compared with minimum and no-tillage sowing and permanent pasture.

Traditional tillage significantly reduced soil porosity and pore sizes below 40 mm depth in a South Australian study. Higher population densities of soil animals in combine direct-drilled than traditionally tilled plots were attributed to a superior habitat and the more ready availability of a food supply in organic matter on the soil surface.

## CONCLUSIONS

1. No-tillage sowing using narrow points resulted in less than half as much runoff as traditional tillage at Chapman, north-east of Geraldton.

2. After soils become saturated, up to 100% of further rainfall is available for runoff, regardless of tillage treatment. Saturated areas may, however, be larger under no-tillage on soils with less permeable subsoil layers, because of greater infiltration earlier in the growing season.

3. Soil and plant nutrient losses were reduced by a factor of ten after sowing without tillage using narrow points.

4. Earthworm numbers, size and food supply increase under minimum and no-tillage sowing.