8. FARMING SYSTEMS TRIALS

8.1 SUSTAINABLE MIXED FARMING SYSTEMS FOR THE HIGH RAINFALL SOUTHERN AUSTRALIA (VICTORIA)

Location: Gnarwarre

Technical support:
Scientific Management Team, *SFS Ltd.* and
Gary Sheppard, N Islam, *DPI*

Collaborators:
The University of Melbourne, La-Trobe University

Growing season rainfall:
353 mm (April – Nov)
333 mm (May - Nov)
Seasonal rainfall distribution is illustrated in a figure elsewhere in this publication.

Aim:
Three different rotations (systems) involving crops and pastures are being evaluated on narrow (1.7m) raised beds on different soil types with the aim of identifying the most profitable and sustainable system for the region, that will also prevent the degradation or loss of soil chemical, physical and biological characteristics. The two major soils on which the systems are being evaluated (Gnarwarre A & B) are different in their surface structure, bulk density, porosity and the extent to which they are prone to waterlogging. There are also two variants of the above soils (Gnarwarre C & D) within the trial area. These soils are representative of the range of soil types that exist in the southern part of southwest Victoria and cover a large area of the volcanic plains. The hypothesis being tested is that "drainage of waterlogged soils in southwest Victoria through raised beds will increase crop and pasture production with beneficial modifications to soil properties".

Researchers:
Renick Peries, Chris Bluett and Bruce Wightman, *DPI*

Background:
The systems trial was in its fourth year of planned rotations in 2002. During the year, there was a change in emphasis in the trial; the comparison of 'systems' per-se was considered low priority and greater attention was concentrated on soil structure issues that impacted on the long-term sustainability of farming systems (rotations) on raised beds. The Scientific management Team (SMT) also decided to give up the comparison of wide raised beds as farmers were already convinced that the narrow raised beds were the way forward, given the greater risk of failure of the wide raised beds under waterlogging.

Treatments:
The three systems treatments are
(a) Continuous Cropping: CWPeB,
(b) Two year annual pasture rotation: CWPP and
(c) Four year perennial pasture rotation: CWPeBPPPP (C: Canola; W: Wheat; Pe: Field Pea, B: Barley).

Sowing:
Canola (var. Pinnacle) 7.5 kg/ha (27 May), Wheat (var. Declic) 90-100 Kg/ha (30 May), Field Pea (var. Jupiter) 125 Kg/ha (3 July), Barley (var.Gairdner) 90 Kg/ha (2 June), Vic. Perennial Rye (10 Kg/ha) + Gosse clover (5 Kg/ha) for perennial pasture and Concorde Rye (10 Kg/ha) + Balta Balansa (5 Kg/ha) for annual pastures (2 May) were sown using a cone seeder. Crops and pasture were managed to 'best-practice' guidelines established by the SMT.

Results and Discussion:

(a) Productivity of Systems

The growing season rainfall total was identical to the previous season but there were distinct differences in its distribution. The absence of heavy (20<mm) rainfall events during the growing season (only a single event) and the very low autumn rainfall compared to previous years resulted in almost no waterlogging during the growing season. The grain yield and harvest index from the different crops are shown in Table 70, along with the values obtained in 2001 for comparison.

Crop yields across the trial were generally better than in 2001 and there were early signs that yield differences due to the hostile nature of the different subsoils that existed during the early stages of the trial were gradually disappearing. A comparison of productivity between continuous cropping and the 2x2 system will be available in mid 2003

Table 70: Systems Trial Crop Yields 2002/03.

Plot No.	Soil Gp.	Drainage	Rotation	Crop 2001	Gr.Yield t/ha	HI 2001	Crop 2002	Gr.Yield t/ha	HI 2002
A3	B	NR	4 x 4	Canola	1.8	0.35	Wheat	3.9	0.392
A5	B	NR	Cont.Crops	F.Pea	1.9	0.49	Barley	4.3	0.510
A6	B	NR	2 x 2	A.Pasture			Canola	1.8	0.301
B2	C	NR	4 x 4	P.Pasture			P.pasture		
B4	B	NR	Cont.Crops	Wheat	2.6	0.41	F.Pea	1.7	0.406
B5	B	NR	4 x 4	P.Pasture			Canola	1.7	0.288
C1	C	NR	4 x 4	Wheat	2.0	0.4	F.Pea	2.2	0.412
C3	B/C	NR	Cont.Crops	Barley	2.7	0.5	Canola	1.2	0.312
C4	B	NR	4 x 4	P.Pasture			P.Pasture		
D2	C	NR	Cont.Crops	F.Pea	2.1	0.49	Barley	4.1	0.550
D3	B/C	NR	2 x 2	Canola	1.4	0.34	Wheat	3.9	0.407
D6	B	NR	4 x 4	P.Pasture			P.pasture		
E1	A/D	NR	Cont.Crops	Canola	2.0	0.36	Wheat	4.0	0.402
E2	A/D	NR	4 x 4	Barley	4.8	0.46	P.pasture		
E5	B/D	NR	2 x 2	Wheat	4.7	0.38	A.Pasture		
F1	A	NR	4 x 4	F.Pea	2.9	0.48	Barley	3.9	0.537
F4	A	NR	2 x 2	A.Pasture			A.Pasture		
F6	A	NR	Cont.Crops	Barley	5.0	0.44	Canola	1.8	0.305

(b) Sustainability of systems

Waterlogging, hard-setting subsoil and poor soil structure were the main issues that this trial was designed to address through minimum tillage and controlled traffic that accompany the change in land use with raised beds. The trial layout was spread across two contrasting soil types and its variants and four years into the trial it has been observed that many beneficial changes in soil structure have occurred across the trial site that are impacting on crop performance on beds. Some of these changes are discussed in this report.

In order to assess the current status of the beds it is necessary to consider the 'starting point', i.e. the state of the soil profile in its equilibrium state under perennial pasture. For the purpose of this report, only Gnarwarre A and B are discussed. The baseline soil characteristics of Gnarwarre A and B are shown in Table 71 below.

Table 71: Physical Characteristics of Gnarwarre A and B Soils in their Equilibrium State Under Perennial Pasture

	Gnarwarre A Soil *A heavy black basaltic clay* *Higher baseline yield potential*					**Gnarwarre B Soil** *A hard-setting medium clay* *Lower baseline yield potential*				
Depth (cm)	**Soil BD g cm^{-3}**	**Total Porosity (%)**	**Macro Porosity %**	**PAW %**	**PL (%)**	**Soil BD g cm^{-3}**	**Total Porosity (%)**	**Macro Porosity %**	**PAW%**	**PL (%)**
0-10	1.4	50.8	15.6	21.1	22.4	1.5	46.6	14.4	17.1	14.0
10-20	1.4	50.0	15.2	15.9		1.5	43.6	15.4	18.6	
20-30	1.5	43.7	9.6	13.6		1.7	38.4	5.6	16.8	
30-40	1.7	37.9	4.5	12.4		1.6	40.4	7.5	13.3	
40-50	1.6	42.7	5.7	17.0		1.8	34.5	3.1	5.2	
50-60	1.7	38.9	4.8	8.2		1.8	33.5	4.3	8.9	
Total PAW to 60 cm				88.2 mm					79.9 mm	

Note: BD-soil bulk density; PAW-plant available soil water; PL-plastic limit of soil (*maximum soil water content at which the soil is friable*)

The higher density of the Gnarwarre B soil and its lower porosity throughout the profile are significant contrasting characters compared to Gnarwarre A. Despite the total PAW to 60cm being very similar (80 versus 88mm) in the two soil types, higher density and lower porosity would generally interfere with the processes of water infiltration and deep root penetration in Gnarwarre B. The very high BD at 20-30cm depth also reduces the hydraulic conductivity drastically and causes a perched water table to result after heavy rainfall events in Gnarwarre B compared to Gnarwarre A. Because of a lower plastic limit, the soil begins to puddle much quicker in Gnarwarre B, making it difficult to work under "wet" conditions compared to Gnarwarre A. These and other factors contribute to the generally lower productivity of Gnarwarre B compared to Gnarwarre A.

For the purpose of illustration, six raised bed plots are selected where the three different systems have been running on the two contrasting soils since the growing season of 1999/2000. Figure 22, A and B show changes in soil bulk density under the different profiles in response to the different systems. During this time it should be expected that the soil profile has stabilized to a reasonable extent following the change in land use. The only area that gets destabilized annually is the 0-10 cm area that is disturbed at sowing.

The figures clearly show that soil bulk density has improved in both soils over the years but it is too early to speculate if one treatment (system) is better than other in the bulk density response.

With change in bulk density there was also a corresponding improvement in soil macro porosity across all treatments (data not shown here). It is also worthy to note that the plastic limit (PL: Ref. Table 71 for baseline values), improved 40-42% in both Gnarwarre A and B soil with the annual pasture (2 x 2) system, suggesting that the soils will now tolerate a higher level of water before they puddle in response to machinery use on the soil. The other treatments also showed smaller increases in plastic limit in both soil types. Overall, the improvement in PL in Gnarwarre B was far greater compared to Gnarwarre A, suggesting that the initial parameters of hostility in Gnarwarre B soils were improving more rapidly than in Gnarwarre A. The two treatments 2x2 and 4x4 in Gnarwarre B had 'tactical grazing' by sheep for 2 and 3 years respectively before they were both sown to canola in 2002. The BD values measured in early May 2002 (Figure 22B suggests that grazing by sheep has had no major effect on the surface or immediate sub-surface BD of the soil.

Photo 10: Sheep grazing systems trial at Gnarwarre

Figure 22: Temporal Changes in Soil Bulk Density in Gnarwarre A and B Soils in Response to Different Rotations (Systems)

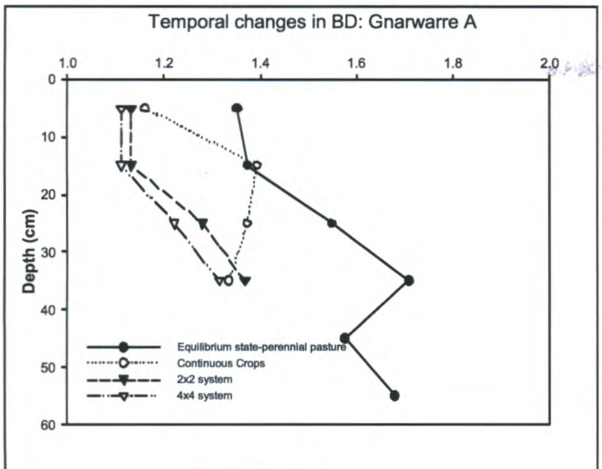

Fig. A

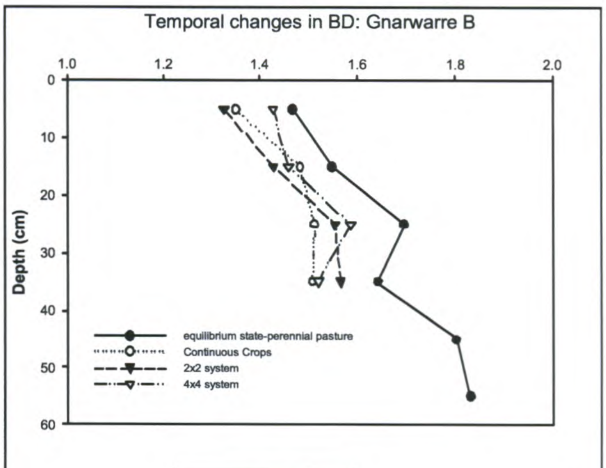

Fig. B

Figure 23: Temporal Changes in Plant Available Water under Different Treatments in Gnarwarre A and B Soils.

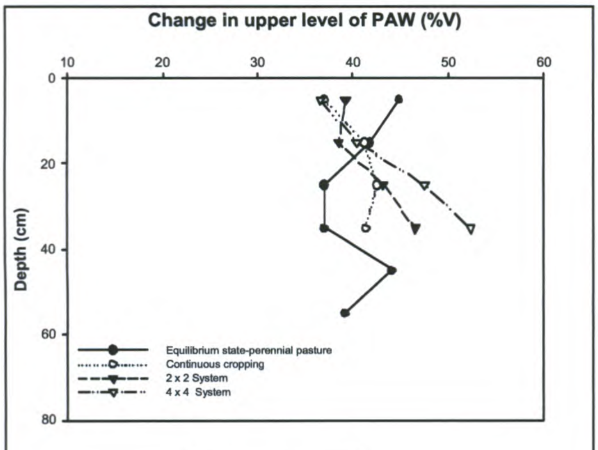

Fig. B

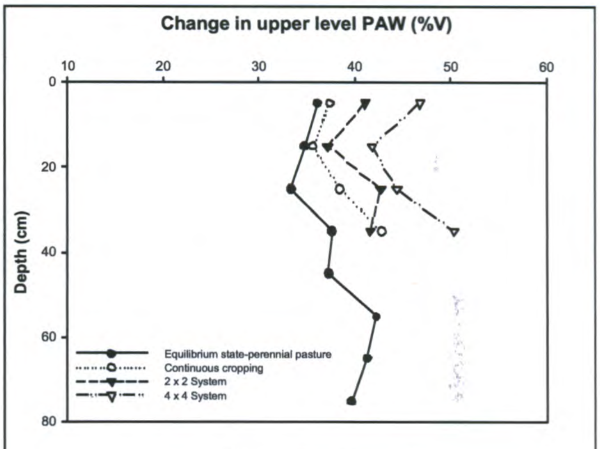

Fig. C

It must be noted that these beds despite being grazed, did not require any renovation prior to sowing with canola. However, the sowing operation would have an effect similar to a shallow cultivation and will result in the reversal of any increased BD at the surface as a result of pugging (the above data was generated prior to sowing).

The initial tillage in the systems trial prior to bed formation was to a depth of around 25cm. The BD profiles at mid-May 2002 suggest that despite not being disturbed initially, soil BD is continuing to improve below the depth of tillage with time.

These improvements will be further monitored in 2003 and 2004.

The improvement in BD and the corresponding increase in soil porosity have also led to an improvement in the upper level of PAW in all treatments (Figure 23). While these improvements should encourage deeper rooting and make more water available to plants during critical periods of development, if these improvements continue to further depths as a result of the continuing cropping sequences and methods, it should also provide a greater reservoir for soil water storage ensuring yield stability in poor rainfall years.

Conclusions:

The results to date from the systems trial can be broadly summarized as follows.

While raised beds in both Gnarwarre A and B soils have aided the alleviation of waterlogging, potential yield differences between once hostile soils appear to be gradually disappearing with temporal changes in subsoil structure.

It has been possible to direct-seed crops following grazed pasture. It would appear, if tactically grazed, minimum soil structure damage would result from wet-weather grazing in soils similar to those in this study.

Soil friability continues to improve on all narrow raised bed treatments in both soil types providing a greater window opportunity with machinery usage during the 'wet' autumn and winter.

Improvements in soil bulk density, porosity and water holding capacity in both Gnarwarre A and B soils should aid better crop production on raised beds with improved agronomy.

Such improvements at depth suggest plants now have a greater depth of soil to explore for water and nutrients compared to four years earlier. As this depth increases, it should provide an additional reservoir of water for plants during sub-optimal rainfall years, leading to yield stability over time.

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