Core Site - 2004

Catherine Evans, CWFS

Key Points

- There is little difference between the three cropping systems in terms of grain yield and quality.
- The drought over recent years has particularly affected the livestock data. Differences between the systems prior to the drought no longer exist as the sheep have spent about half their time off the trial due to lack of feed.
- Other research across Australia is supporting the management issues of some farming systems that have been highlighted by this trial.

Background

The fanning systems comparison trial commenced in 1998, to investigate the management, profitability and sustainability of four farming systems. The trial occupies 160 ha and is located at the Condobolin Agricultural Research and Advisory Station. The trial balances the needs of research and farmers to ensure results are significant. The trial is not managed exactly as a farmer would manage his own farm but imitates a farming system as much as possible.

Four systems are compared, using four replicates of each system with every rotational phase within each system present in every year (Table 1). The four systems vary in cropping intensity and use of perennial species. Each of the 5 plots, in all cropping systems, in each replicate, is approx. 2 ha. They are –

- *Traditional (mixed farming) system* - The five-year rotation consists of long fallow wheat (LFW), followed by short fallow wheat undersown (SFWu/s) with a lucerne/clover/medic-based pasture, then three years of grazed pasture.
- *Reduced tillage including livestock (mixed farming) system* - This system grows all wheat crops on long fallow. The rotation is long fallow wheat (LFW), skip a year (stubble is maintained, weeds controlled by grazing and a chemical application in August), long fallow wheat undersown (LFWu/s) with a lucerne/clover/medic-based pasture, then two years grazed pasture.
- *No tillage, no livestock (continuous cropping) system* - This system reliant on chemicals only for weed control. The five-year cropping rotation is canola, wheat (SFWaC), pulse, wheat (SFWaP) and a green manure crop. This system represents a significant intensification of cropping in this district and no perennial species are included in the system.
- *Perennial Pasture System* - Each replicate in the perennial pasture system is approximately 10 ha and is divided into 12 equal-sized segments radiating from a central watering point. At present, sheep are rotationally grazed with half-weekly intervals on each segment.

Table 1: Rotational nhases for each of the four farmins systems.

FARMING SYSTEM	**phase 1**	phase 2	**phase 3**	**phase 4**	**phase 5**
Traditional	long fallow wheat (LFW)	short fallow wheat undersown (SFWu/s)	pasture	pasture	pasture
Reduced tillage including livestock	LFW	no crop	LFW undersown (LFWu/s)	pasture	pasture
Continuous cropping	canola	SFW	pulse	SFW	green manure
Perennial pasture	pasture	pasture	pasture	pasture	pasture

2004 Methods

There was no significant rainfall until June (Table 2), which resulted in late sowing of most crops and the decision not to sow canola, as it was considerably later than the optimum sowing time.

Sowing dates and varieties for 2004 and the past 5 years are shown in Table 3. In the *continuous cropping system* (no tillage, no livestock) canola was not sown. Instead wheat was sown into that rotational phase. It is planned that in 2005 instead of sowing wheat-011-wheat, as would be the case if we maintained the rotation, we will instead sow barley.

Drysdale wheat and the field peas were sown a little late. H45 was at the edge of the sowing window. We had intended to not sow H45 because of its susceptibility to stripe mst but with the late sowing, H45 was the most suitable variety and with a dry season we considered that stripe rust should be a minor problem.

The *traditional system* had pasture establishment failures in the last few years due to the dry conditions. The chaimian decided to resow pastures under a cover crop of field peas. If there was sufficient field pea growth, we planned to cut hay from these resown pasture plots.

The dry seasonal conditions meant that feed for sheep became quite scarce at times. Locust plagues also depleted what little feed was available a couple of times through the year. For six of the 12 months, sheep were removed from the trial and fed elsewhere. This has affected fleece quality information. Sheep were weighed onto and off the plots and so liveweights should not be affected by this forced agistment. Fleece weights and quality are affected by the movements on and off the trial.

Table 2: Monthly rainfall at Condobolin ARAS (1997 - 2004) - average annual rainfall (1881 - 2004) = 442 mm

Yr	J	F	M	A	M	J	J	A	S	O	N	D	AAR
1997	21.6	6.0	4.1	0.9	44.6	16.3	15.7	27.4	122	24.0	27.8	6.6	**317**
1998	35.8	4.5	4.4	53.7	56.3	48.0	75.3	82.0	79.0	47.9	50.9	14.2	**552**
1999	37.2	16.3	73.3	34.5	7.0	26.9	53.2	41.9	16.8	122	16.9	128	**574**
2000	8.8	30.6	**76.1**	45.0	95.0	17.8	14.9	58.7	12.5	64.0	63.2	16.7	**503**
2001	2.2	39.9	38.2	16.3	27.4	51.0	28.6	19.6	42.0	25.4	46.6	2.8	**340**
2002	0.8	172	19.4	11.0	22.1	4.4	8.0	6.6	45.1	0.0	2.8	14.2	**307**
2003	26.2	**63**	25.7	11.2	7.4	19.7	60.7	70.7	9.8	19.3	16.8	18.3	**348**
2004	90	32.1	8.3	2.3	17.8	46.9	13.9	32.2	26.9	52.7	30.8	45.8	**400**

2004 Results

Results of the trial are summarised in the tables below. The first 3 years of the trial, when systems were being set up, have been the wettest years. Pastures were sown in 1998 and sheep were not introduced to the trial until early 2000, to allow for pasture establishment. Since then, a successive run of 4 dry years (Table 2) has not shown the full potential of any of the four systems.

Cropping information

Grain yields in 2004 (Table 4) were again just above district average. In the continuous cropping systems the H45 wheat replacing the canola yielded significantly higher (1.16 t/ha) than the Drysdale (WaC 0.85 t/ha) which was higher than the H45 after pulse (WaP 0.76 t/ha; 5% lsd = 0.091).

Table 3: Varieties sown and sowing dates for crop plots in each year.

<table>
<tr><th>System</th><th>Phase</th><th>1998</th><th>1999</th><th>2000</th><th>2001</th><th>2002</th><th>2003</th><th>2004</th></tr>
<tr><td rowspan="2">Tradition</td><td>LFW</td><td>Janz (31/5)</td><td>Janz (9/6)</td><td>Janz (22/5)</td><td>Sunbri (9/5)</td><td>Sunbri (26/4)</td><td>H45 (7/7)</td><td>Drysdale (17/6)</td></tr>
<tr><td>SFWu/s</td><td>Janz (31/5)</td><td>Janz (10/6)</td><td>Janz (29/5)</td><td>Janz (30/5)</td><td>H45 (5/6)</td><td>H45 (7/7)</td><td>H45 (22/6)</td></tr>
<tr><td rowspan="2">Reduced tillage with livestock</td><td>LFW</td><td>Janz (31/5)</td><td rowspan="2">Janz (1/6) Janz (2/6)</td><td>Janz (25/5)</td><td>Janz (30/5)</td><td>H45 (30/5)</td><td rowspan="2">H45 (4/7) H45 (7/7)</td><td rowspan="2">Drysdale (17/6) H45 (22/6)</td></tr>
<tr><td>LFW u/s</td><td>Janz (29/5)</td><td>Janz (30/5)</td><td>Sunbri (9/5)</td><td>Sunbri (27/4)</td></tr>
<tr><td rowspan="5">Continuous</td><td>SFWaC</td><td>Janz (31/5)</td><td>Janz (12/6)</td><td>Janz (20/4)</td><td>Sunbri (7/5)</td><td>Sunbri (24/4)</td><td rowspan="5">Sunbri (1/5) H45 (20/5) ATR Beacon (30/4) Wonga lupins (30/4) HDLs (29/4)</td><td rowspan="4">Drysdale (17/6) H45 (22/6) H45 wheat (22/6) Parafield peas (24/6)</td></tr>
<tr><td>SFWaP</td><td>Janz (31/5)</td><td rowspan="4">Janz (12/6) Mystic (8/6) Bohatyr peas (14/6) Bohatyr peas (15/6)</td><td rowspan="3">Janz (19/5) Oscar (18/4) Bohatyr peas (31/5)</td><td>Sunbri (7/5)</td><td>H45 (1/6)</td></tr>
<tr><td>canola</td><td>Monty (22/5)</td><td>46C03 (5/5)</td><td>ATR Beacon (7/4)</td></tr>
<tr><td>pulse</td><td>Bohatyr peas (5/6)</td><td>Snowpeak peas (31/5)</td><td>Wonga lupins (18/4)</td></tr>
<tr><td>green manure</td><td>Bohatyr peas (5/6)</td><td>Bohatyr peas (31/5)</td><td>Popany vetch (23/3)</td><td>Popany vetch (8/4)</td><td>Morgan peas (25/6)</td></tr>
</table>

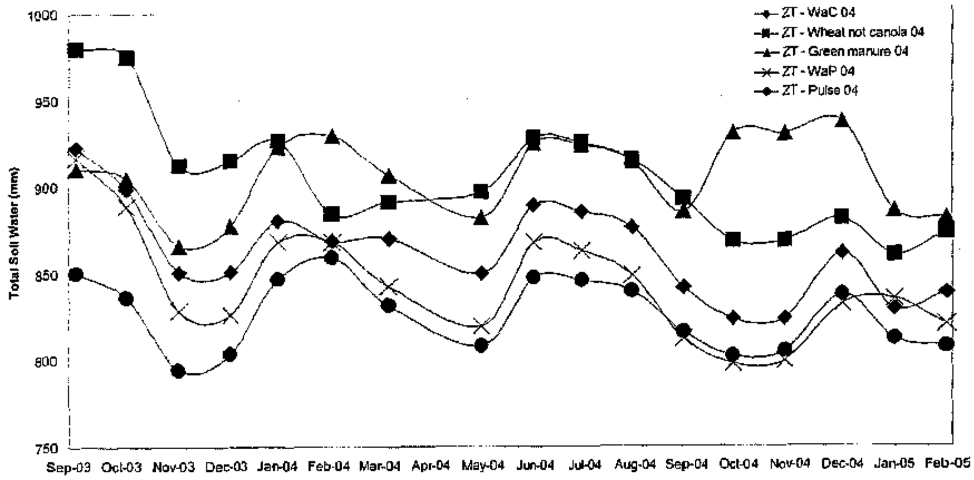
It is presumed that the wheat instead of canola plot yielded higher than other wheat plots because of the additional soil moisture (Figure 1). The wheat instead of canola plot is shown as the squares in Fig. 1. The squares and the triangles (green manure plot) both had higher soil moisture than the other three plots. The 2004 wheat instead of canola plot was a green manure (high density legumes) in 2003 that did not grow, so effectively a fallow. You can see the additional soil moisture in this plot from the high values for the squares on the left-hand side of the graph (Spring 2003). The same plot in 2002 was wheat but the low yields would not have used much soil water or nutrients from the soil. These additional "fallow" years probably account for the higher yields of this wheat crop in the continuous cropping system in 2004.

It is interesting that the WaC (Figure 1; diamonds) had higher soil moisture at sowing (June) than the WaP (crosses) and this too was reflected in the lower yields of the WaP. Both crops seemed to use the same amount of water through the growing season (distance between the lines remains constant from June to October; Fig. 1).

The soil water data is showing some interesting trends and Brett Honeysett (who is doing this work) has an interesting paper in this chapter further highlighting some of the soil water trends on this trial.

Wheat yields across the three cropping systems showed H45 (0.67 t/ha) yielded higher than Drysdale (0.59 t/ha; 5% lsd = 0.063). Across the three systems, the reduced tillage with livestock system had the lowest average wheat yield (0.5 t/ha), the traditional system (0.6 t/ha) was higher and the continuous cropping system had the highest wheat yield (0.8 t/ha; 5% lsd = 0.077). This higher average is largely attributed to the higher yield of the wheat replacing canola plot as discussed above.

Figure 1: Continuous cropping system - soil moisture to 3 m in 2003-04 (data and figure from Brett Honeysett, NSW DPI).



Grain quality data (Table 5) showed that in 2004, Drysdale wheat (17.3%) had higher grain protein than H45 (16.5%; 5% lsd = 0.167). The Drysdale in the continuous cropping system had the highest grain protein (17.9%; 5% lsd = 0.289). There were no significant differences between wheat varieties or systems with screenings. Drysdale (79.4) had a higher test weight than H45 (78.5; 5% lsd = 0.658).

Over the last 7 years there has been no system that has produced higher yields or higher grain proteins than any other system. This indicates that there is no system difference in crop growth or quality (i.e. overall the presence or absence of sheep or tillage or perennial species has had no difference on grain quantity or quality).

Table 4: Grain yield (t/ha) and growing season rainfall (GSR$_{AD}$rii-scnt) for 1998 to 2004.

	1998 Yield	1999 Yield	2000 Yield	2001 Yield	2002 Yield	2003 Yield	2004 Yield
Traditional							
LFW	3.37	2.3	2.4	2.06	0.44	0.70	0.55
SFWu/s	2.67	1.12	**2.5**	1.67	0.73	0.86	0.65
Reduced							
LFW	3.35	1.98	2.2	1.69	0.1**4**^	0.84	0.47
LFWu/s	2.71	1.9	2.4	3.03	0.43	1.02	0.53
Continuous crop							
SFWaC	**3.17***	1.18	2.9	1.89	0.60	0.26	0.85
SFWaP	**3.17***	1.38	2.6	1.92	0.73	0.93	0.76
Canola	1.04	0.36	**1.5**	1.21	0.08	0.36	1.16 (wheat#)
Peas	1.71	0.77	**0**	0.71	0.13	0.18	0.91
GSR ***mm***	*394*	*180*	*244*	*185*	*97*	*180*	*140*

The wheat in 1998 was not separated between the two plots in the no tillage, no livestock system.

^ *Yield was low on this H45 wheat crop because of damage caused by herbicide application.*

#The sowing rains did not occur until June when it was too late to sow canola. Wheat was sown instead.

Table 5: Grain Drotein *(%)* for wheat crops, 1998 to 2004.

	1998	1999	2000	2001	2002	2003	2004
	Protein	**Protein**	**Protein**	**Protein**	**Protein**	**Protein**	**Protein**
Traditional							
LFW	11.7	13.8	10.9	16.2	15.2	15.1	**16.9**
SFWu/s	11.8	15.2	10.6	13.7	13.2	14.2	16.3
Reduced							
LFW	11.8	14.6	10.6	14.8	14.5	14.8	**17.2**
LFWu/s	11.8	15.2	10.6	14.3	**14.9**	13.4	16.5
Continuous crop							
SFWaC	**11.8***	15.1	10.5	13.8	15.2	16.0	16.7
SFWaP	11.8	14.2	11.2	12.4	13.5	**16.4**	**17.9**

The wheat in 1998 was not separated between the two plots in this system.

Livestock information

Sheep came onto the trial in March 2000 after pastures had been established. So the livestock information is about 2 years behind the cropping information. This has made it difficult to do analyses overyears. The early gross margin analyses did not take into account the livestock portions of the systems. The drought in the last few years has further hampered the livestock efforts as sheep have spent increasing amounts of time off the trial.

In 2004/05 sheep were present on the trial when feed was available - about 50% of the time. Sheep were taken off the trial, weighed, shorn and sold in March-April 2005. This decision was made because there was little feed available, the sheep were 5-year old wethers and with the sheep being off the trial more than they were on the trial, the wool quality no longer reflected the systems.

The fleece weights (Table 6) in 2003 showed that the perennial pasture sheep had significantly lighter fleeces than those of the mixed fanning systems. In 2004 and 2005 this trend did not continue, largely because sheep spent much of the year off the trial due to the dry conditions. The liveweights (Table 7) followed the same trend as fleeces. The perennial pasture sheep were significantly lighter than the mixed farming sheep in 2003 but in 2004 and 2005 this was again not evident.

Table 6: Average weight of fleeces (2003 - 2005)

	Average fleece weight -2003	*Average fleece weight - 2004*	*Average fleece weight-2005**
Traditional	5.67	6.53	4.63
Reduced	5.35	6.13	4.73
Perennial Pasture	4.80	6.37	4.26

** 9 months wool growth*

Table 7: Average weight of sheep from December 2003 to March 2005.

	Weight onto trial Dec 2003	*Weight off-shears Sept'2003*	*Weight onto plots - Aug 04*	*Weight off trial - Mar 05*
Traditional	44.7	57.2	60.58	63.9
Reduced	45.3	55.8	62.04	66.6
Perennial Pasture	44.5	49.8	60.72	63.8

Gross margin information

Gross margins were calculated by an economist for the information gained off the trial in the years 1998 to 2001. In the 3 dry years, we have no yet taken the data to an economist. We will be doing so soon. Table 8 gives the gross margins calculated by an economist. Table 9 shows rough calculations to give some indication of where the costs are occurring. **Please do not hold the figures in Table 9 as gospel** they are merely presented to give a guide to costs.

In 2001 when gross margins were calculated, there was little sheep data (sheep were introduced to the trial in 2000 after pasture establishment) for the gross margins (Table 8). Future gross margins will use livestock data to give a true indication of comparisons between systems. Table 8 therefore gives a gross margin analysis of only the cropping portion of the trial. This means that the mixed fanning systems and the perennial pasture system are disadvantaged because a portion of their system has been excluded. The figures for the continuous cropping system are the only ones that account for the entire system.

Gross margin calculations will be done again by an economist at the completion of the rotational phase. Estimated gross margins have been calculated to give an idea of the costs associated with each system but these are not calculated by an economist and therefore may not be accurate (Table 9). This data shows that high input costs associated with cropping, along with poor yields because of dry seasons, are making the gross margins of the continuous cropping system negative. In 2004, 3 wheat crops were sown instead of the usual 2 and the gross margin was positive. Alternative crops to wheat, particularly canola, have proved unreliable in the Condobolin district when the subsoil moisture is not available. Replacing canola in 2004 with another wheat crop seemed to be a profitable decision.

In 2004 on the Traditional mixed farming system, pasture failure in earlier years led to a decision to undersow peas in order to re-establish pastures and get some returns. You can see the higher variable cost of this system in 2004 ($97.80). Flexibility within this system meant that the peas could be grazed if the season was poor, cut for hay or harvested for grain in a good season depending upon market fluctuations. In a continuous cropping system, unless there is flexibility for hay cutting or grazing, you are locked into grain production, which in a poor season may not be profitable.

Table 8: Average and Cumulative Gross Margins ($/ha) for each cropping system (calculated by D. Patton, NSW Agriculture Economist)

	average annual gross margin				**4-year**	**cumulative**
SYSTEM	**1998**	**1999**	**2000**	**2001**	**average**	**98-01**
Traditional	+104.52	+ 51.85	+ 64.26	+ 78.63	+ 74.82	+299.25
Reduced tillage	+113.13	+ 31.67	+ 36.75	+107.81	+ 72.34	+289.35
Continuous cropping	+247.53	-40.35	+108.92	+ 57.99	+ 93.52	+374.08

Table 9: Very rough calculations of variable costs and gross margins from the 4 systems (2002-2004) to indicate the high costs of production in some systems.

	Total Variable Cost (S/ha)			Gross Margin ($/ ha)		
SYSTEM	**2002**	**2003**	**2004**	**2002**	**2003**	**2004***
Traditional	27.01	47.60	97.80	17.45	48.27	139.55
Reduced tillage	47.83	47.33	49.54	-26.17	50.51	-23.26
Continuous cropping	75.92	170.29	140.97	-12.53	-97.00	29.81

* *The high result from the traditional system is caused by an opportunistic hay-making operation carried out. The positive result in the continuous cropping system is largely due to the high price for field peas in 2004.*

Discussion

Rainfall data needs to be taken into account when looking at crop yields. If you look at the years 1999, 2001 and 2003, they each had about 180 mm growing season rainfall (GSR; Table 4) yet the average wheat yield (calculated from Table 4; 1.64 t/ha in 1999, 2.04 t/ha in 2001, 0.74 t/ha in 2003) for each year was veiy different.

1999 was a great rainfall year with about 30 mm rainfall each month, except May and September, of the growing season. However, in 1999 sowing did not occur on the April rains and so the trial was sown late, in early June (Table 3), missing weeks of the growing season, explaining the lower yield than in 2001.

The 2001 crops were sown in early May and received good rains in June and again in September, hence the decent yields. Contrast these two years with 2003 where there was very little rainfall in April, May and June. Crops were not sown until rain in July. July and August rainfall was high and September rainfall very low, hence the poor yields. In addition to the growing season rainfall, there was subsoil moisture in 1999 and 2001, yet no subsoil moisture in 2003. Rainfall is the most limiting factor to crop growth in this district.

Dry years, however, are not uncommon in Condobolin and the results to date indicate why there is a predominance of mixed farmers in the Condobolin district. There is much interest in the continuous cropping system but data in the dry years has shown that reliance on herbicides alone for weed management is difficult. In dry conditions some herbicides are inactive, there are fewer opportunities for weed control and herbicides are costly. Using sheep to help with weed management has an added advantage in dry conditions because weeds become extra feed and farmers can take advantage of another commodity.

The Condobolin district is a prime hard wheat growing area. With the exception of 1998 and 2000 (quite wet years), grain protein has made prime hard (Table 5). This trial does not have the capacity for opportunity buying and selling of stock. If this was incorporated into **a** mixed farming system, it would add even greater flexibility to the system and could potentially increase profitability. This can be modelled though and after the completion of the second rotational phase (2007), there will be sufficient data available for this sort of predictive modelling.

Sheep have not yet been present on systems for a full rotational cycle and so few calculations have been made, as yet, with the livestock data. Tables 6 and 7 give some of the livestock data - fleece weights and liveweight gain. Since 2002, the dry conditions have seen sheep moving onto and off the trial site according to feed availability. The number of sheep and grazing days is counted for each system and this will assist with data interpretation in the future. Sheep will be factored into the gross margin analyses in future.

Other Research

In 2003 there was some question as to the legitimacy of the results we were finding on this trial. These questions were largely posed in the GRDC review of the project but were made by others. Current research across Australia seems to be finding the same results as we have. Chris Preston (WAITE, SA) spoke at the 2005 GRDC Update in Dubbo about herbicide resistance. His work has shown that the systems most likely to develop herbicide resistance are those that rely solely on herbicides for weed control, are cropped heavily and have little flexibility. In recent years we have made similar comments about the continuous cropping system in this trial and have developed an integrated weed management system to slow the development of herbicide resistance. Work such as Chris' is showing that we were justified in the work that we have done on that system.

At a recent (March 2005) gathering of people working in low rainfall research, there was unanimous agreement that livestock are necessary for the farming system to be sustainable in low rainfall environments. In WA and SA, many fanners excluded livestock from their systems in the 1980s. Twenty years later, they are re-introducing livestock as their farms are not economic, particularly in dry years, without the diversified income. This is no different to the results found on this trial. Farmers around Condobolin have maintained the livestock portion of their farming systems and many claim that livestock have kept them going over the recent years.

Conclusion

This trial was an ambitious challenge started in 1998. None of the last 7 years have been easy but this trial is showing some good results that can be backed up by other work across Australia. It is a credit to CWFS that they started such an ambitious project and have kept their faith in the trial after much criticism. This trial is unique and vital to understanding why some fanning systems are successful and others are not, especially in these diy, variable climates. Further inteiTogation of the data, through statistics, modelling and economics, will give more valuable information over time.

In the Condobolin district, flexibility and mixed farming systems are the key to profitability - along with good luck!