LONG TERM TILLAGE AND ROTATION TRIAL

Merriwagga 1999-2016 FINAL REPORT

KEY OUTCOMES 1999 TO 2016

- After 18 years there was no standout rotation, in terms of profitability, in any given season. All rotations had their pros and cons in both wet and dry years. Therefore having a mix of rotations and doing things on time is a recipe for a resilient business.
- The most profitable rotation for the duration of the trial was the continuous cropping rotation, which included two wheat crops followed by a pulse crop in a no-till system. The addition of the pulse crop every third year was beneficial, especially for adding extra nitrogen, however added issues such as broadleaf weed blowouts with weeds like fumitory.
- 18 years no-till continuous wheat rotation was a very close second. The possibility of continuous cereals is understated in general farming. This trial proves that whilst higher in disease risks and hungrier for nitrogen, continuous cereals are profitable and can form a possible low risk rotation as part of any farming business whilst maintaining maximum groundcover.
- No-till took 3 years to get going in this trial, but once it was established it was equal to or higher in yield and more profitable than cultivated treatments. The biggest advantage of a no-till system is efficiency. It is important to always keep cultivation as a tool up your sleeve, because this trial proves it doesn't do any harm to long term yield.
- The success of no-till depends on weed control and nutrition. Effective preemergent herbicide strategies are an integral part of this system.
- After 18 years the trial showed that the cleanest weed free rotation was where fallows are included in conjunction with cultivation. When cultivation was excluded weeds in the fallow began to become problematic, and perennial grasses became an issue in fallows after about 6-8 years.
- Under continuous cropping rotations, there are less weeds in a no-till system than cultivated systems, as pre-emergent herbicides work better.
- Soil diseases are least prevalent in rotations with fallows, however in all rotations (especially continuous wheat which hosted the highest soil disease levels) the expression of any root disease has been limited since 2005.

Background to the trial

The on-farm long term trial at Merriwagga was initially set up by a group of local farmers, with the support of NSW Department of Primary Industries (DPI) and Central West Farming Systems (CWFS). From 2013 the site has been managed by Ag Grow Agronomy and Research, on behalf of the Merriwagga growers and research partner CWFS Inc.

The trial site is located at "Sylvanham", owned by Ian and Emily Barber, on the corner of Black Stump Road and Greenhills Road, approximately 10km South West of Merriwagga. The paddock chosen for the trial had a long history of traditional low input cropping. The soil type is a red sandy loam, pH 5.5-6.5 (CaCl2), with a calcareous subsoil.

At the time the trial was set up in 1999, stock were a significant enterprise in the area, with a pasture/ley/fallow rotation dominant and minimal break crops grown. Growers were also experimenting with no-till cropping systems.

Questions were beginning to be raised about no-till farming techniques and how they compare to conventional farming methods. Growers were particularly interested in moisture conservation and weed control of no-till farming systems.

The Merriwagga tillage and rotation trial was set up in 1999 to answer grower questions, with the aim of evaluating the productivity and profitability of no-till farming techniques against conventional farming methods under various cropping rotations.

After 18 years, and having answered all it was set out to do, 2016 was the last year of the Merriwagga long term trial.

Trial details

The trial was designed so as all operations were able to be carried out using growers equipment The site consisted of a total of 30ha. There were 10 treatments in total replicated 3 times, with each plot 1ha in size. The treatments consisted of·

Two tillage treatments

1. No-Till· where all weed control is by either herbicides or narrow windrow burning, the plots are sown with a NDF single disc seeder and stubble retained where possible.
2. Conventional: where weed control is both by herbicides and cultivation, the plots are sown with a NDF single disc seeder in a cultivated system where stubble is incorporated.

Five Rotations

1. Continuous Wheat

This treatment is not common in the area, however growers wanted to see what happens when wheat is grown over a long period of time.

2. Continuous Rotation 1

Two cereals followed by a break crop such as peas or canola.

3. Continuous Rotation 2

Two cereals followed by a break crop such as peas or canola, not in synchronisation with continuous rotation 1.

4. Wheat - Fallow - Wheat

This is a traditional cropping system. The paddock is cropped every second year and fallowed in between aiming to conserve soil moisture, mineralise nitrogen, and break disease cycles.

5. Wheat - Ley - Fallow - Wheat

This system was practiced traditionally, however declined as stock numbers reduced. After harvest the paddock was left as a ley, where naturalised grasses and legumes emerge. The paddock was then grazed until it was brought into fallow the following year. Cropping occurs every third year in this system. This rotation was changed to Wheat - Fallow - Wheat in 2005, and alternates with the above wheat - fallow - wheat rotation.

A summary of the treatments and rotations for the past seventeen years is shown in Table 1.

TREATMENT	ROTATION																	
	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Wheat/Ley/Fallow/Wheat	L	F	W	L	F	W	W	F	W	F	W	F	W	F	W	F	W	F
Continuous Rotation 1	P	W	C	W	W	B	P	W	B	P	W	W	C	W	W	Lu	W	W
Continuous Rotation 2	W	P	W	C	P	W	B	P	W	W	P	W	W	C	W	W	P	W
Wheat/Fallow/Wheat	F	W	F	W	F	W	F	W	F	W	F	W	F	W	F	W	F	W
Continuous Wheat	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W	W

B = Barley F = Fallow Lu = Lupins W = Wheat
C = Canola L = ley P = Peas

TABLE 1 Treatments and Rotational history from 1999 to 2016.

Results and discussion

This report will focus on the measurements and assessments taken in 2016 as well as the key outcomes of nutrition, weeds and economics from 1999 to 2016.

2016 results:

2016 was a wet and mild season, with conditions from May to September one of the wettest on record in the area. Daytime temperatures in September were below average, whilst night time temperatures were above average. Total rainfall for 2016 was about 500mm, with 437mm falling in the growing season (April to October).

All treatments, with the exception of the wheat/ley/fallow/wheat which was in a fallow phase, was sown to Suntop wheat in 2016.

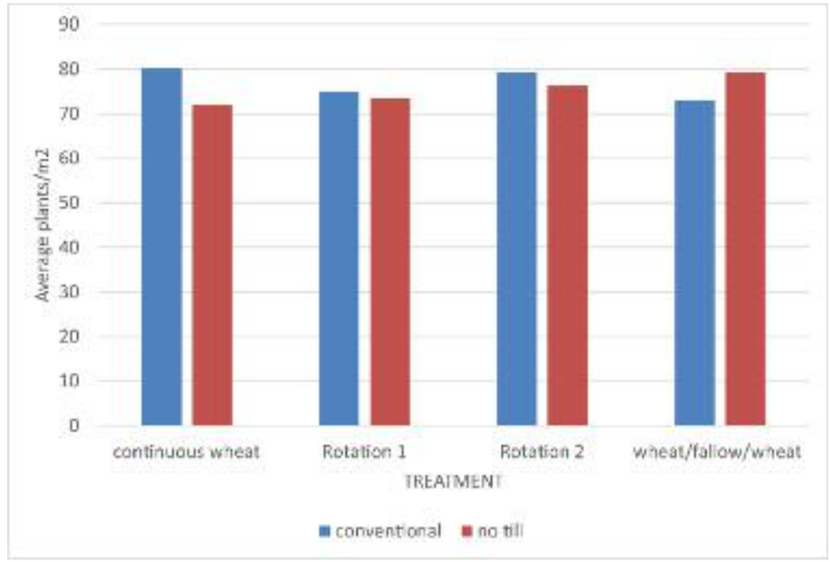

FIGURE 1 Establishment counts for each treatment for the long term trial 2016.

TREATMENT	TILLAGE	Average Weeds per treatment (weeds/m^2) August 16th					
		Ryegrass	Black Oats	Fumitory	Mustard	Turnip	Other
Wheat/Ley /Fallow /Wheat	conventional	Fallow Sprayed					
	no till	Fallow Sprayed					
Rotation 1	conventional	5	3	15	10	1	19
	no till	4	1	55	9	4	22
Rotation 2	conventional	20	8	17	7	1	10
	no till	7	2	72	19	2	17
Wheat/Fallow/Wheat	conventional	3	3	1	8	10	1
	no till	1	1	10	31	4	1
Continuous wheat	conventional	49	9	3	8	1	2
	no till	42	4	4	7	2	2

Other weeds include: fleabane, rough poppy, medic, milk thistle, heliotrope, skeleton weed, volunteer cereals, lupins, brome grass, spiny emex

TABLE 2 Weed counts for each treatment of the long term trial, measured before post emergent herbicides were applied in 2016.

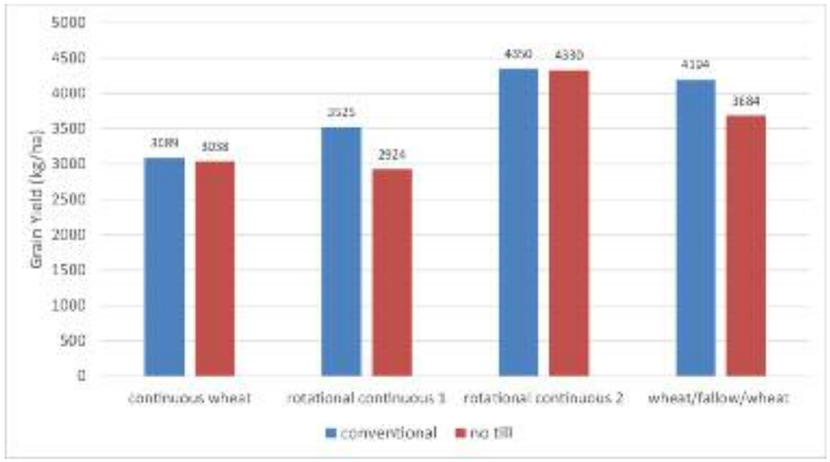

FIGURE 2 Grain Yield for each treatment of the long term trial in 2016, all sown to wheat.

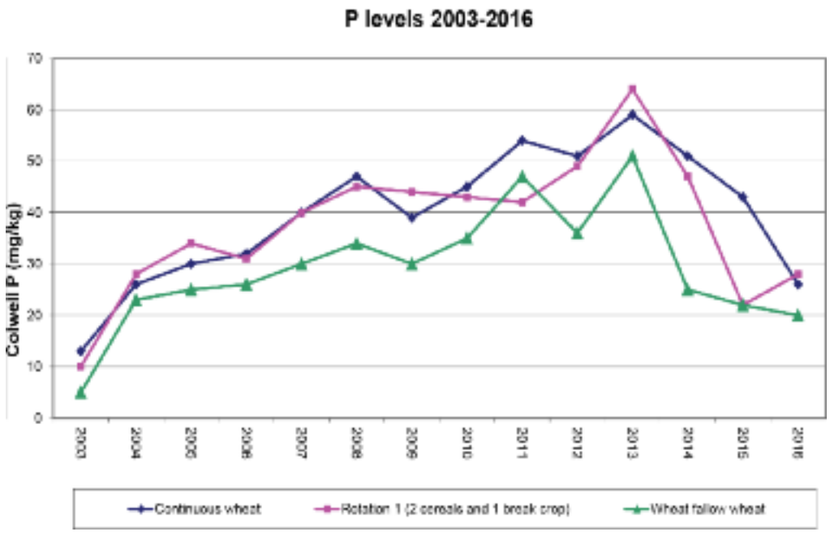

FIGURE 3 Soil P Curves for each treatment from 2003 to 2016.

		Variable costs ($/ha)	Grain Yield (kg/ha)	Gross margin ($/ha)
Continuous wheat	Conventional	$331.29	3089	$209.34
	No till	$281.75	3038	$249.96
Rotation 1	Conventional	$331.29	3524	$291.36
	No till	$281.75	2924	$276.44
Rotation 2	Conventional	$331.29	4349	$437.31
	No till	$281.75	4329	$475.94
WLFW	Conventional	$57.21		-$57.21
	No till	$57.21		-$57.21
WFW	Conventional	$331.29	4193	$341.76
	No till	$281.75	3684	$336.58

TABLE 3 Costs and profit for each treatment in 2016, WLFW was in fallow, hence no yield data.

It was sown 21st May at 30kg/ha, with 60 kg/ha Granulock 10Z and with a NDF disc. The crop was topdressed with 80 kg/ha urea at the end of July.

Establishment

Plant counts were taken mid July, with the crop establishing well given the season. Plant counts ranged from 72 plants/m^2 for the no-till continuous wheat to 80 plants/m^2 for the conventional continuous wheat, figure 1.

Weeds

Differences in weed numbers and weed spectrum were measured in 2016 between rotations and between tillage treatments, table 2.

The main weeds observed in the trial were ryegrass, black oats, fumitory, mustard and turnip. Other weeds observed in the trial included fleabane, rough poppy, medic, volunteer cereals, milk thistle, heliotrope, skeleton weed, lupins, brome grass and spiny emex.

As observed in previous seasons, where rotations include a fallow, as in the WFW treatment, total weed numbers were generally lower.

The continuous wheat rotation, for both conventional and no-till, had a large number of ryegrass, as did the conventional treatment of rotation 2.

Rotation 1, lupins in 2014, and rotation 2, field peas in 2015, both had a large number of fumitory.

Broadleaf weeds, such as fumitory, were generally higher in no-till treatments, whereas ryegrass and black oats were generally higher in the conventional treatments.

Grain Yield

The average grain yield of the trial in 2016 was 3.64 t/ha.

The lowest yielding treatment was the no-till continuous rotation 1 treatment, yielding 2.92 t/\ha. The two highest yielding treatments were the conventional and no-till continuous rotation 2 treatments, which were field peas in 2015, yielding 4.35 t/ha and 4.33 t/ha respectively, figure 2.

For each of the rotations in 2016 the conventional tillage treatments were slightly higher yielding than the no-till treatments.

Grain quality was not analysed on the trial in 2016 as all samples went ASW grade at $175/t.

Economic Comparisons

The costs, grain yield and profit of each treatment in 2016 are shown in table 3.

1999 to 2016 RESULTS: Nutrition

The trend in soil P levels at the trial site for the past 14 years is shown in figure 3.

Unlike the drought years, where we saw an increase in soil P levels as a result of adding more phosphorous than what was being taken out, the last few years has seen a decrease in soil P levels at the site.

Whilst Nitrogen hasn't been reported here, soil nitrogen levels have declined sharply since 2010, to the stage where nitrogen is the second most limiting factor following moisture.

Economic Analysis

Table 4 and figure 4 show the individual gross margins for each year the trial has been running as well as the long term gross margins for the past 18 years.

		1999-2016	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007	2006	2005	2004	2003	2002	2001	2000	1999	Average	
Continuous wheat	Conventional	$731.16	$209.34	$92.96	$90.31	$144.87	$40.97	$99.64	$300.64	-$116.18	-$50.52	-$182.70	-$121.40	$31.48	-$74.41	$250.16	-$129.78	$51.93	$330.78	$33.40	$24.19	$169.92
	No till	$1,066.60	$249.96	$129.56	$110.10	$183.91	$54.28	$50.40	$359.89	-$66.53	$18.05	-$134.79	-$85.95	$45.14	$64.71	$255.66	-$129.78	$55.64	$188.23	$55.68	$6.08	$100.48
Rotation 1	Conventional	$887.04	$291.36	$98.16	$39.50	$151.72	$25.39	$345.15	$335.64	-$91.38	-$99.95	-$224.60	-$50.65	-$2.07	-$9.88	$274.13	-$129.78	-$159.89	$343.61	$91.74	$57.08	$103.82
	No till	$1,342.29	$276.44	$214.56	$214.56	$214.17	$41.01	$308.86	$436.69	-$64.68	-$103.50	-$146.99	$48.77	$20.30	-$10.10	$305.93	-$129.78	-$156.86	$225.23	$88.69	$8.34	$34.19
Rotation 2	Conventional	-$20.99	$437.31	-$208.70	$98.03	$185.28	-$57.69	$85.10	$342.64	-$217.53	-$25.17	-$189.50	-$153.47	$72.00	-$37.13	$53.33	-$129.78	$112.81	$49.54	$9.23	$1.65	$50.71
	No till	$435.39	$475.94	-$174.70	-$155.36	$275.95	-$59.25	$82.47	$443.69	-$167.85	-$90.02	-$132.89	-$80.96	$71.61	-$60.56	$61.61	-$129.78	$57.97	$50.71	$81.65	$18.00	-$21.00
WLFW	Conventional	$61.62	-$57.21	$199.00	-$78.00	$191.48	-$159.42	$110.72	-$126.77	-$33.24	-$110.88	-$61.70	-$21.06	$217.91	$73.04	-$57.00	$0.00	$77.93	-$21.00	-$18.00	-$18.00	-$21.00
	No till	$6.08	-$57.21	$240.40	-$78.00	$293.18	-$126.50	$108.88	-$148.04	-$30.11	-$86.10	-$74.10	-$47.56	$178.20	-$81.96	-$46.50	$0.00	-$17.72	-$21.00	-$18.00	-$18.00	-$21.00
WFW	Conventional	$529.90	$341.76	$118.41	$348.33	-$79.72	$43.10	-$113.55	$265.86	-$77.78	$58.83	-$112.72	$78.91	$0.00	$66.50	-$57.00	-$129.78	-$54.91	$351.00	$55.76	-$23.76	$201.91
	No till	$893.24	$336.58	-$93.41	-$410.82	-$47.73	$123.80	-$109.25	$297.86	-$58.01	$26.08	-$66.22	$213.23	$0.00	-$60.72	-$46.50	-$129.78	-$54.28	$201.91	-$23.76	$24.19	$169.92
		$5563.23	$250.43	$35.30	$114.65	$144.41	-$7.43	$94.74	$250.79	-$92.39	-$39.22	-$132.60	-$26.02	$63.56	-$24.99	$100.48	-$103.82	-$8.34	$169.92	$24.19		

	Moderate soil moisture in summer. Extremely wet winter and spring, with long cool finish and very few frosts.
	Low soil moisture at sowing. Sowing 2nd May, moisture marginal. Wet winter and very dry spring.
	Moderate soil moisture. Sowing 3rd May. Low spring rainfall and very dry and hot from July onwards.
	Moderate soil moisture. Sowing 29th May. Low spring rainfall but timely.
	Very wet summer. Soil profiile full. Sown 3rd May. Very dry spring.
	Moderate soil moisture. Early break, sown 3rd May. Mice an issue. Average spring.
	Moderate soil moisture, ealy break. Sown 30th April. Locusts an issue. Very wet spring and harvest.
	Moderate soil moisture. Late break, sowing 11th June. Dry spring.
	Moderate soil moisture. 7th May sowing. Dry spring.
	Very dry summer, 23rd May sowing, but no spring rain. Crop virtually died.
	Late break, no stored moisture. Sown 18th June. Dry spring.
	Late break, no stored moisture. Sowing 18th June. Wet spring but too late for this trial.
	Late break, no stored moisture. Sowing June 6th. Dry spring.
	Wet summer, early April sowing. Good rain in spring.
	Didn't sow. No fallow rain or rain incrop. Driest year on record.
	1st June sowing. Dry spring and low yields
	Mid May sowing. Wet spring and wet harvest.
	6th June sowing. Average year, but underperformed due to dry spring.

TABLE 4 Economic analysis of trial from 1999 to 2016.

It is important to note that all costs are calculated at locally validated contract rates. This is very different to the costs a typical farmer would apply, but it allows a very good comparison of the real costs associated with each farming system.

It is clear that the no-till system is more profitable than the cultivated system in almost every rotation.

This is mostly due to lower associated costs with seedbed preparation with no-till systems compared to cultivated systems when operations are performed at contract rates.

It is also clear that the two most profitable rotations are Rotation 1 (Wheat/Wheat/Break crop) and Continuous wheat.

These two rotations have been able to capitalise on good years, whilst still maintaining profits in drier years.

When a fallow is included, not only do the costs rise, but so does the risk of missing a good year. In saying that rotations including fallow are less volatile and less risky as they do better than other rotations in drier years.

Soil diseases

Whilst not shown in this report, we have measured soil diseases over multiple years through both DNA testing and white tray extraction.

In short, soil diseases such as Rhizoctonia, Common root rot, Pythium, Crown rot and nematodes such as Pratylenchus neglectus are commonly found in these soils.

There seems minimal difference between tillage methods, however quite large differences between rotations. Continuous wheat had the highest soil inoculum levels of all diseases, whilst rotations with a fallow measured the lowest.

Expression of soil diseases has been minimal since 2005, but it is important to acknowledge the underlying risks of each rotation that could eventuate given the appropriate environmental conditions.

Acknowledgements

Ag Grow Agronomy and Research and Central West Farming Systems would like to acknowledge Ian Barber "Sylvanham" for undertaking various activities such as sowing and harvesting the trial, as well as other local farmers in their efforts to help make this trial what it is.

This trial in effect has been unfunded for the majority of its duration, with exception of part of the funding for the 2014- 2016 activities coming from the GRDC project CWF00018 'Maintaining profitable farming systems with retained stubble in Central West NSW'

Thanks to all the fun times looking after this trial with innovative growers over the years.

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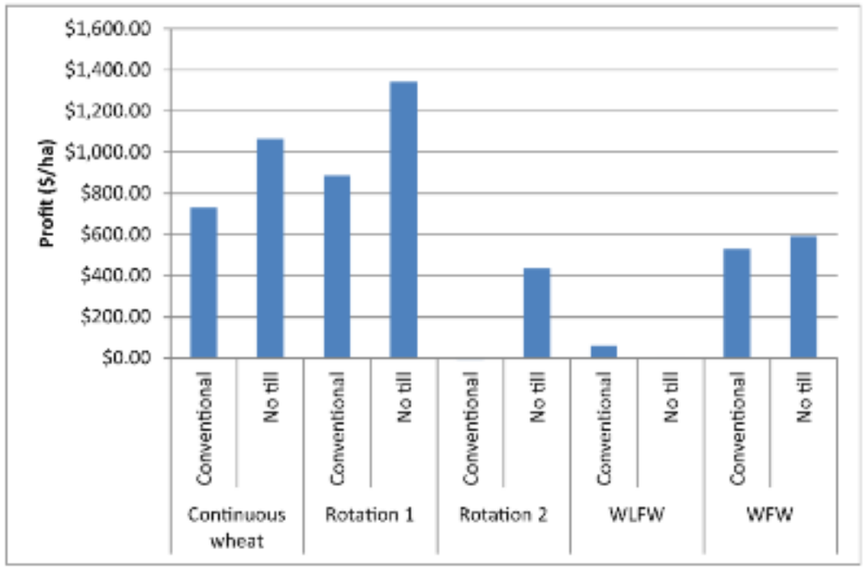


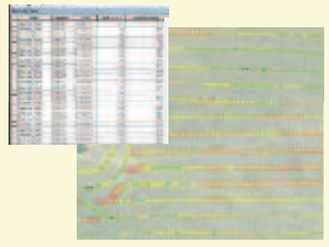
FIGURE 4 Long Term Gross margins for each treatment 1999 to 2016.

GETTING STARTED WITH MAPS: STEPS TO PHOSPHOROUS REPLACEMENT

The following steps show how to create a prescription map from yield data in order to target phosphorous applications. There may be a slight variation in the steps depending on the type of software being used. Check manuals or YouTube for instructional videos for your particular system.

STEP 1

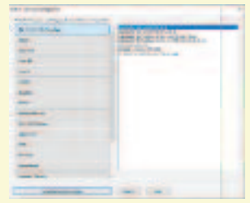
Download yield data from harvester and load into software



Raw imported yield data from the harvester will look like this – a series of GPS points recorded with correlating yield figures (and other data).

STEP 4

Export to seeding application format and load into tractor



Most agricultural software packages handle export in the correct format automatically, you just need to choose the right console and seeding machine in the software. Once exporting is complete, you're ready to go.

Keep an eye on the monitor as you are seeding. Does the fertiliser look to be going out at the correct rate for that part of the paddock? All monitors have a reading showing what application rate is being applied right at that point. Consider also printing a map of the paddock for reference in the tractor.