Increasing adoption of new techniques combining physical, chemical and plant-based interventions to improve soil function on Eyre Peninsula

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Location
Brooker: Jason Challinger
Wharminda: Evan & Ed Hunt
Koongawa: Todd Matthews
Elbow Hill: Jon Hills
Greenpatch: Mark Modra
North Shields: Mark Modra
Mt Dutton: Bruce Morgan
Streaky Bay: Phil Wheaton
Buckleboo: Brett Zibell

BOM av. rainfall / 2020 rainfall
Brooker: 398 mm / 380 mm
Wharminda: 338 mm / 311 mm
Elbow Hill: 281 mm / 285 mm
Greenpatch: 522 mm / 525 mm
North Shields: 389 mm / 485 mm
Mt Dutton: 519 mm / 487 mm
Streaky Bay: 377 mm / 312 mm
Buckleboo: 291 mm / 325 mm

Soil type
Brooker: Deep sand over clay
Wharminda: Sand over clay
Koongawa: Sand over clay
Elbow Hill: Brown calcareous sandy loam
Greenpatch: Gravelly fine sandy loam
North Shields: Gravelly sandy loam
Mt Dutton: Sodic sandy clay loam
Streaky Bay: Grey calcareous loamy sand
Buckleboo: Red calcareous sandy loam

Plot size
2 m x 25-30 m x 3 reps

Trial design
Farmer managed demonstration (randomised)

Key messages

- **Deep ripping with inclusion plates generally resulted in lower plant numbers than unripped plots.**
- **Yield increases to ripping were observed mainly in sandy and calcareous soils.**
- **Treatments including the incorporation of mineral nutrients and organic amendments delivered mixed results but were generally the highest yielding treatments.**

Background

Trials and demonstrations involving soil mixing either with a spader or ripping with inclusion plates have been shown to increase yields on sandy soils on Eyre Peninsula (EP). Many of these trials have included the addition of organic material incorporated at rates of 5-10 t/ha. Whilst generally these treatments have provided yield increases for a number of years post application, the rates applied have proven to be uneconomic (EPFS 2019, p 71).

This project was originally developed by the Lower Eyre Ag Development Association (LEADA) with two major objectives being:

1. To test ripping with inclusion plates on a wider range of soils.
2. To trial rates and sources of organic matter that are practical for broadacre use.

How was it done?

The project steering committee selected 5 sites in both Lower and Upper EP.

Sites were chosen to represent a range of soils with constraints and included:

- 4 sands ranging from shallow to deep sand over clay - Treloar, Matthews, Hunt and Challinger.
- 3 calcareous soils - Wheaton, Zibell and Mills.
- 3 Ironstone / poorly structured soils - Modra (2 different locations) and Morgan.

The Modra Greenpatch site aimed to improve the outcome of ripping with foliar treatments whilst the other nine sites compared an unripped control to ripping and to ripping with amendments (Table 1). Treatments were replicated three times at all sites but not every site received the same suite of treatments. Amendments and soil mixing were applied during March to April 2020. Amendments included an animal manure and a nutrient package with similar elemental rates of N, P and trace elements to the manure application. The package was applied either directly to the soils or pre-sorbed to “Biogro” Biochar and wheat straw pellets (Table 1). Amendments were spread across the whole plot (Matthews, Hunt, Mills) or along furrows corresponding with ripper tyne spacings.

Following application of the product all sites were ripped to 25-40 cm deep using either a ripper with inclusion plates or a spader (Matthews site only). Inclusion plates were set at approximately 100 cm below the soil surface, except for the Treloar site where the shallow clay meant the top of the plates were level with the soil surface. The Modra GP site included a calcium foliar spray with/without ripping and foliar chelated trace elements compared to sulphates. Sowing and in-crop management was undertaken by the landholder with all plots receiving the same basal fertiliser application.

Biogro biochar is a low-grade, relatively cheap ($270/tonne at the source) biochar made from forestry waste. It was selected as it has low nutrient value allowing for assessment of a carbon only benefit

What happened?

Seasonal conditions ranged from good in the south with the Treloar and Morgan sites delivering historically high yields. The Wheaton and Mills sites were impacted by low growing season rainfall and weed competition (particularly on the Wheaton site).

Production monitoring included plant numbers, biomass and yield. Plant numbers were generally more variable and lower on ripped treatments than the nil. This is not unusual following ripping due to the uneven soil surface created. Also, the use of farmer seeding equipment that crossed a number of plots resulted in some rows being buried. This variation may have contributed to the large error bars observed in biomass and yield data. Full data analyses are yet to be completed and cannot be covered in detail in this article.

While the data needs to be treated with caution initial observations include:

- No significant biomass or yield differences in treatments observed on the Treloar and Zibell sites.
- On the Morgan site there were no significant differences between treatments. However, all ripped treatments recorded higher yields than the nil with the rip treatment 127% of the control. The Modra sites showed strong visual responses to ripping with some visual differences between amendments. However, there were no significant yield differences between treatments.
- On sandy soils spading/rip treatments delivered yields ranging from 117-137% of the nil. The addition of amendments further increased yield with the best performing treatment (biochar + nutrient + rip) delivering yields ranging from 124-214% of the nil.
- Of the highly calcareous soils low yields and large error bars have added to the difficulty in interpreting the data. At the Mills site the yield of the rip treatment was 133% of the nil, the biochar + nutrient + rip treatment was 160% of the nil. Despite some early visual differences ripping alone resulted in no yield increase on the Wheaton site. The best performing treatment on this site was the low rate biochar + nutrient + rip that delivered 124% yield of the nil treatment.

Table 1. Treatments applied at EP sites in March and April 2020.

Treatment	Product	Amount of product (kg/ha)
Nil		N/A
Ripping		N/A
Biochar + Rip	Biochar	680*
Biochar LR + Nutrient + Rip	Biochar, + P, UAN, Cu Zn, Mn	200
Biochar HR + Nutrient + Rip	Biochar, + P, UAN, Cu Zn, Mn	680
Wheat stubble + Nutrient + Rip	Wheat straw pellets + P, UAN, Cu Zn, Mn	1000
Manure + Rip	Neutrog animal manure	1000
Nutrient + Rip	Phosphoric acid, UAN, Cu Zn, Mn	**P 20, N 30, Cu 2, Zn 5, Mn 7

**Mills site applied at 1200 kg/ha, ** Elemental rates.*

Table 2. Soil monitoring activities.

Analyses	When taken	Sites	Treatments
Mineral N and water	Germination	All except Modra GP	All
Soil enzymes	Germination	Challinger, Hunt, Modra NS, Mills, Wheaton	Various (Table 3)
Soil chemistry	Post-harvest	All	Nil, Nutrition + Rip, Biochar + nutrition + Rip
Bulk density	Post-harvest	All	Nil, ripped

Table 3. Soil enzyme activity (mmol/g/h) 10-30 cm layer. NAG - carbon and nitrogen; P - phosphorus; S - sulphur; GLC - carbon; LEU - nitrogen; ACE - non-specific.

Site	Treatment	NAG	P	S	GLC	LEU	ACE
Challinger	Nil	0.07	0.56	0.01	0.11	0.07	0.49
Challinger	Neutrog	0.62	1.42	0.02	0.57	0.15	2.21
Hunt	Nil	0.07	0.46	0.01	0.09	0.04	0.30
Hunt	Nutrition	0.66	2.19	0.02	1.03	0.18	5.85
Hunt	Neutrog	0.61	1.78	0.02	0.63	0.20	4.20
Hunt	Biochar	0.40	1.24	0.02	0.54	0.13	3.24
Hunt	Biochar + Nutrition	0.53	1.47	0.02	1.12	0.20	4.75
Mills	Nil	0.16	0.06	0.01	0.75	0.72	7.50
Mills	Nutrition	0.15	0.41	0.02	0.95	1.43	20.64
Mills	Wheat straw + Nutrition	0.13	0.46	0.03	1.33	1.79	19.63
Mills	Biochar + Nutrition	0.09	0.39	0.02	0.74	1.39	20.21
Modra NS	Nil	0.24	0.93	0.02	0.32	0.06	7.79
Modra NS	Nutrition	0.51	1.31	0.03	0.81	0.12	7.65
Modra NS	Neutrog	0.25	1.12	0.03	0.55	0.15	7.89
Modra NS	Biochar + Nutrition	0.52	2.19	0.04	1.36	0.26	10.80
Wheaton	Nil	0.36	0.27	0.01	0.35	0.97	16.12
Wheaton	Nutrition	0.37	1.40	0.03	2.63	2.25	27.66
Wheaton	Wheat straw + Nutrition	0.59	1.20	0.03	3.04	1.95	22.53
Wheaton	Biochar + Nutrition	0.46	0.17	0.01	0.31	1.10	14.03

Table 4. Post-harvest soil Colwell P (mg/kg) at 5 sites.

Treatment	Sample Depth (cm)	Hunt	Matthews	Mills	Zibell	Morgan
Nil	0-10	32	13	26	27	63
Nil	10-30	8	<5*	<5*	<5*	15
Nutrition + Rip	0-10	27	12	31	23	68
Nutrition + Rip	10-30	20	9	<5*	<5*	23
Biochar + Nutrition + Rip	0-10	34	16	50	33	27
Biochar + Nutrition + Rip	10-30	20	12	12	6	12

** levels of <5 are considered below detectable limits*

Soil Impacts

Due to budget limitations soil monitoring was targeted to reflect the different treatments, soil types and site responses (Table 2).

There were minor differences in soil water levels between treatments. Soil mineralised nitrogen at germination was highly variable at each site with no clear trends obvious. With support from the Soil CRC and NSW DPI bioassays of soil enzymes were conducted on targeted treatments on some sites. This form of analysis is providing further understanding of changes to soil biology under different management systems. The enzymes measured are representative of nutrients cycled including: NAG - carbon and nitrogen; P - phosphorus; S - sulphur; GLC - carbon; LEU - nitrogen; ACE - non-specific. Results showed little difference in enzyme numbers in the 0-10cm layer but major differences in enzyme numbers on the rip lines in the 10-30 cm layer (Table 3).

Whilst statistical analysis has not been conducted there appears to be some interesting results in Colwell phosphorus (Colwell P). This analytical method has been used to provide an indication of “plant available” phosphorus in the soil. While there are questions on validity of this test in some soils the analyses received to date (Table 4) suggests:

- On sands (Hunt, Matthews) the nutrition treatment has had limited impact on Colwell P in the 0-10 cm layer but has increased P in the 10-30 cm layer. However, the biochar + nutrient treatment has delivered even larger increases in both layers.
- In calcareous soils (Mills, Zibell) the treatment differences are even greater with only the biochar + nutrition treatment providing any Colwell P in the 10-30 cm layer.
- On an acidic soil (Morgan) the biochar + nutrition treatment has resulted in a decline in Colwell P levels.

What does this mean?

- Practices and/or crop selection options to deliver more even plant germination on recently ripped areas need to be developed.
- Ripping on shallow sand over clay soils (i.e. Treloar) where inclusion plates were ineffective may not deliver production responses.
- The responses to biochar + nutrients on some sites require further research and raises the question: can a fertiliser product including carbon be produced to deliver similar results?
- In calcareous soils the difference in Colwell P levels in the biochar + nutrient treatment compared to the nil are greater than the amount of P applied. Phosphorus levels need to be validated and further research on biochar and the influence on plant available P needs to be conducted.
- To properly evaluate the cost effectiveness of treatments a number of sites will need further monitoring to determine if responses are maintained.

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SARDI South Australian Research and Development Institute