Best bet management of nutrition on ameliorated non-wetting soils in the Geraldton Port Zone - Eneabba

Alana Hartley, Research Agronomist and Coordinator, Liebe Group

Key Messages

- This site was unresponsive to nutrient treatments in 2017
- Treatments were adjusted to reflect grower standard practice due to drier than normal conditions at the beginning of winter.

Aim

To determine the most effective way to apply nutrients (granular, banded, top dressed or liquid) on non-wetting soils after amelioration, in the Geraldton Port Zone.

Background

Water repellence is a significant constraint to production in Western Australian broadacre farming systems. It is estimated that 6.9 million hectares are considered at moderate risk of water repellence, whilst 3.3 million hectares are considered at high risk, based on the area of coarse sand with low clay content (van Gool 2008). In the Geraldton Port Zone, approximately 52% of the arable soils are at moderate to high risk of water repellence (van Gool 2008).

Water repellent soils are defined by having slow permeability to water, characterised by uneven wetting of soils, water run-off and pooling and/or, flow through the soil via preferential pathways, leaving the surrounding soil dry (Roper et al. 2005).

Over the years, farmers have adopted many practices to mitigate soil water repellence, with various levels of success. These include; furrow sowing, use of surfactants, addition of clay and, more recently, deep cultivation through complete or partial inversion of the soil by mouldboard plough, rotary spader or one-way disc plough, which has been successful in mitigating water repellence issues (Davies, Scanlan & Best 2011).

These tillage practices that mitigate soil water repellence can alter crop nutrition; including nutrient availability and distribution through the soil profile. Physio-chemical aspects of the soil profile are also disturbed and will influence root growth and biological activity (Robson & Taylor, cited in Vu et al. 2009). The implication of the redistribution of the organic matter and nutrient rich topsoil from the use of cultivation equipment varies for each nutrient. Both spading and mouldboard ploughing are likely to increase N mineralisation however, the distribution of other nutrients highlights the need to conduct soil testing post cultivation to understand the new soil profile (Davies, Scanlan & Best 2011).

To investigate the impact of cultivation has to the management of nutrients post amelioration, three sites were selected across the Geraldton Port Zone; Eneabba, Marchagee and Irwin. At these sites, the project team chose to select two nutrients, Potassium (K) and Nitrogen (N) which were applied in various forms; granular, banded, top-dressed and liquid. It was also agreed that, to avoid the initial flush of nutrients after the first year of cultivation, that selected sites would have been ameliorated a minimum of two years prior to implementing the trial.

The Eneabba site was established on white non-wetting sand over gravel, which had been rotary spaded in 2015 to ameliorate the non-wetting soil surface.

Trial Details

Property	Rohan Broun, Eneabba
Plot size & replication	1.54 m x 20 m x 4 replications
Soil type	White sand over gravel
Soil pH ($CaCl_2$)	0-10cm: 6.0 10-20cm: 6.0 20-30cm: 5.8
EC (dS/m)	0-10cm: 0.085
Sowing date	23/05/2017
Seeding rate	Mace 70 kg/ha
Paddock rotation	2014: Wheat 2015: Wheat 2016: Wheat 2017: Wheat
Amelioration	2015: Rotary Spaded
Fertiliser	See Table 1 and 2
Herbicides, Fungicides & Insecticides	23/05/2017: 1 L/ha Sprayseed, 1.5 L/ha Treflan, 118 g/ha Sakura, 13/07/2017: 800 ml/ha Velocity + 1 % Hasten 15/08/2017: 300 ml/ha Prosaro
Growing season rainfall (GSR)	265 mm

Trial Layout

The initial trial design included a combination of N and K rates ranging from nil to very high. Poor seasonal conditions early in the season resulted in the project team altering the original trial design to reflect grower standard practice during a dry season. This meant the Z23 application of Flexi N was adjusted to 50 L/ha and the Z30 application was omitted from the trial. Due to a mistake made during the application of Flexi N at Z23, all treatments received 50 L/ha of Flexi N therefore, there is no nil N treatment at this site. The final implemented treatments can be found in Table 2.

Table 2 Implemented nutrient treatments for 2017

Treatment	Planned Description	Applied Description	IBS (Kg/ha)	Banded (L/ha)	Banded (kg/ha)	Z23	N	P	K
1	Std N No K	Std N No K		54 Flexi N	85 Agstar Extra	50 Flexi N	56	12	0
2	Std N Std K	Std N Std K		50 Flexi N	100 K-Till Extra	50 Flexi N	56	12	11
3	Liquid K	Liquid K		117 Flexi NK	85 Agstar Extra	50 Flexi N	56	12	11
4	Std N High K	Std N High K		50 Flexi N	100 K-Till Extra/28 MoP	50 Flexi N	56	12	25
5	No N	Low N High K			62 Big Phos/51 MoP	50 Flexi N	21	12	25
6	Low N	Std N High K		50 Flexi N	100 K-Till Extra/28 MoP	50 Flexi N	56	12	25
7	High N	Std N High K		50 Flexi N	100 K-Till Extra/28 MoP	50 Flexi N	56	12	25
8	High N No K	Std N No K		54 Flexi N	85 Agstar Extra	50 Flexi N	56	12	0
9	High K	Std N Very High K	200 MoP	54 Flexi N	85 Agstar Extra	50 Flexi N	56	12	99

Results and Discussion

In 2017, the Eneabba site received 265mm of GSR. Much of the rainfall received did not fall until late in the season, from July to September.

Early soil tests taken prior to sowing (Table 3), also indicated that low K (below 50 mg/kg) meant the possibility of the site being K responsive. Background soil N status was also high and was unlikely to respond to N treatments. Water penetration testing was also conducted to determine the effectiveness of the cultivation treatment removing the non-wetting layer, so ensure that non-wetting did not impact on the treatments being applied.

Table 3: Soil test results Eneabba, 29th March 2017

Depth	pH ($CaCl_2$)	OC%	EC	NO_3 N	NH_4 N	Col P	Col K	PBI	MED	WDPT (secs)
0-10 cm	6.0	0.57	0.085	35	2	9	20	7.2	0	6.8
10-20 cm	6.0	0.66	0.043	19	1	11	21	7.1		
20-30 cm	5.8	0.48	0.027	9	1	12	14	7.2		
30-40 cm	5		0.015	4	1	17	16			
40-50 cm	4.8		0.015	4	2	9	33			

Organic Carbon percent (OC% - determined by Walkley-Black method), Electrical Conductivity ds/m^2 (EC), Nitrate nitrogen (NO_3 N), Ammonium nitrogen (NH_4 N), Colwell Phosphorus (Col P), Colwell potassium (Col K), Phosphorus Buffering Index (PBI), molarity of ethanol droplet test (MED), water droplet penetration time (WDPT)

Table 4: Impact of fertiliser management strategy on 2017 wheat yield and quality.

Treatment	2017 Wheat Yield	Protein (%)	Hectolitre (g/hL)	Screenings (%)	Grade
Std N No K	2.16^a	12.0^{ab}	76.19^a	8.04^a	AGP1
Std N Std K	2.22^a	12.3^a	75.78^a	8.07^a	AGP1
Liquid K	2.04^a	12.2^{ab}	76.07^a	8.52^a	AGP1
Std N High K	2.20^a	12.3^a	75.97^a	8.43^a	AGP1
Low N High K	1.83^a	11.5^b	78.27^a	7.44^a	AGP1
Std N High K	2.23^a	11.8^{ab}	77.52^a	7.88^a	AGP1
Std N High K	2.28^a	12.0^{ab}	77.30^a	7.01^a	AGP1
Std N No K	2.19^a	11.9^{ab}	76.68^a	7.81^a	AGP1
Std N Very High K	2.40^a	12.0^{ab}	76.10^a	6.65^a	AGP1
LSD (P=0.05)	*0.644*	*0.771*	*4.014*	*2.996*	
CV (%)	*20.3*	*4.4*	*3.6*	*26.5*	
P value	*0.813*	*0.504*	*0.916*	0.926	

Means followed by a different letter are significantly different.

There was no significant difference in treatment effects for yield, protein, hectolitre weight or screenings in 2017 (Table 4). All grain samples with screenings above 5% resulted in a quality downgrade to AGP1. A combination of environmental factors such as a mild winter and warm spring and adequate N supply, caused the early haying off of the crop before completing grain fill.

The variable and low infrequent rainfall from the beginning of seeding to the end of June, impacted on early establishment, as plant counts ranged from 38-56 plants/m^2 (average 49 plants/m^2); there was no significant treatment effect evident. Plant counts were well below the target density of 150 plants/m^2 for a potential yield of 2 t/ha (Anderson and Garlinge 2000). Final head and tiller counts, before harvest, were not impacted by treatment however it did contribute to the additional yield recorded at harvest. Head density ranged from 147-214 heads/m^2 (average 177 heads/m^2) across the site which showed strong crop recovery when rainfall was received.

A post emergent foliar nitrogen application was conducted on the 13th of July, where treatment 5 (nil N) received 50 L/ha of nitrogen, resulting in no nil treatment to compare other treatments against. Plant sampling was conducted three weeks post nitrogen application, plant samples were taken to assess the difference in nutrient uptake across the various treatments (Table 5).

Table 5: Average of plant sample analysis from plants sampled 7th August 2017, at Z28 (mid-late tillering)

Treatment	Tot N	NO_3 N	P	K	Cu	Zn	Mn
1	4.82	1526.7	0.42	3.20	8.29	33.14	25.7
2	4.84	1355.1	0.44	2.70	7.94	31.90	29.0
3	4.63	1061.0	0.43	2.64	8.21	32.22	29.4
4	4.76	1256.7	0.45	2.63	7.93	32.09	24.7
5	4.86	1401.1	0.45	3.01	7.41	31.78	23.8
6	4.85	1531.8	0.44	3.31	7.47	31.98	25.6
7	5.01	1385.7	0.46	2.98	7.83	32.59	25.8
8	4.65	1281.6	0.40	3.26	7.85	31.43	17.9
9	4.79	1334.2	0.45	2.96	7.96	34.20	24.8

There were minimal to no differences between treatments in any of the plant sample results. What was evident however; was all treatments had low nitrate levels, indicating that there was no translocation of N through the plant at the time of sampling. This aligned with a period of no rainfall post nitrogen application. Treatments 1 and 3 (nil K and liquid K) indicated a low level of K at the time of plant sampling however, this was only observed in samples from rep 4 and is not represented in the averaged data (of all four replicates) in Table 5. This suggests that there may have been soil type variability at this site. Manganese was marginal in all samples but showed no indication of treatment type interaction. All other nutrients analysed at the time of plant sampling, were considered to be adequate for optimal plant growth.

Plant sampling was only conducted once in 2017 due to poor seasonal conditions at early emergence, resulting in inadequate plant numbers and maturity for sampling. Warm weather and late spring rains (late August) resulted in the crop maturing very quickly, hence no second plant test was able to be conducted to capture changes in plant nutrient requirements.

Comments

The unresponsive nature of the results in 2017 was reflective of adequate soil nitrogen levels, the poor early season rains and subsequent lack of nutrition demand. Good spring rains received in September allowed the crop to recover resulting higher head counts and a crop which yielded above 2 t/ha.

Should the trial be continued in subsequent seasons the additional top up N treatments will be included providing an opportunity for a better understanding of N responses and interaction with K nutrition.

Acknowledgements

Thank you to the Broun family for hosting this site at their Eneabba property. The Liebe Group would also like to acknowledge the project team, including Stephen Davies (DPIRD) and James Easton (CSBP) who helped design this trial. Thanks are also extended to the field team at DPIRD Geraldton, for implementation, management and harvesting of this trial.

This project has been funded by the GRDC LIE00010-A Best bet management for ameliorated non-wetting soils of the Geraldton Port Zone.

Paper reviewed by: Dr Frances Hoyle, University of Western Australia

Contact
Alana Hartley
Research Agronomist and Coordinator
Liebe Group
research@liebegroup.org.au
(08) 9661 0570

Stephen Davies
Soil Scientist and Project Manager
Department of Primary Industries and Regional Development
Stephen.davies@dpird.wa.gov.au
(08) 9956 8515

References

Anderson, W K, Garlinge, J R, 2000, The Wheat book: principles and practice. Department of Agriculture and Food, Western Australia, Perth. Bulletin 4443. https://researchlibrary.agric.wa.gov.au/bulletins/6/

Davies, S, Scanlan, C, Best, B, 2011, 'Rotary spading and mouldboard ploughing of water repellent sandplain soil fulfils promise', 2011 GRDC Crop Updates: proceedings of a conference, Grains Industry of Western Australia, Perth.

Roper, M, Davies, S, Blackwell, P, Hall, D, Bakker, D, Jongepier, R, Ward, P, 2015, 'Management options for water-repellent soils in Australian dryland agriculture', Soil Research, Vol 53, pp 786-806, Available from: CSIRO Publishing, [29 March 2017].

Van Gool, D, Vernon, L, Runge, W, 2008, Land resources in the South-West Agricultural Region: A shire-based summary of land degradation and land capability, Resource Management Technical Report 330, Department of Agriculture & Food, WA.

Vu, D, Tang, C, Armstrong, R, 2009, 'Tillage system affects phosphorus form and depth distribution in three contrasting Victorian soils', Australian Journal of Soil Research, Vol 47, pp 37-45, Available from: CSIRO Publishing, [27 March 2017].