Soil Health in the West 2012

Soil testing to benchmark DGT phosphorus testing and other soil health parameters on calcareous soils on Western Eyre Peninsula.

Project Report.

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Government of South Australia
Department of Environment, Water and Natural Resources

Agricultural Bureau of South Australia Inc.
PATHWAY TO IMPROVEMENT

CARING FOR OUR COUNTRY

Government of South Australia
Eyre Peninsula Natural Resources Management Board

RURAL SOLUTIONS SA

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1 INTRODUCTION

The West coast of Eyre Peninsula is characterised by sandy highly calcareous soils that have a high capacity to "tie-up" nutrients such as phosphorus. Traditional soil tests for phosphorous do not adequately identify the availability of soil phosphorus under these conditions making it difficult for landholders to adequately match fertilised to crop potential. The Agricultural Bureau of South Australia sponsored project "Soil Health in the West" was funded under the Department of Environment and Natural Resource's State NRM program's 2011-2012 community Landcare grants with the aims of;

- Improving landholder understanding of soils and best management practices
- Improving landholder understanding of key soil health parameters and the implications for production.
- Investigating new DGT technology as a tool for measuring soil phosphorus and helping farmers match fertiliser inputs to crop requirements.
- Benchmarking DGT phosphorus testing on calcareous soils.

Figure 1. Grey calcareous soil profile from Streaky Bay to depth 70 cm.

2 SAMPLING AND METHODOLOGY

2.1 SOIL SAMPLES

A total of 114 soil sampling kits were distributed to landholders in the Streaky Bay, Ceduna, Port Kenny and Minnipa districts during February and March. Landholders were encouraged to submit samples for analysis.

A sampling program was also conducted for interested landholders using a soil sampling trailer on the 4th and 5th of April. Samples were submitted from sites at Goode, Haslam, Streaky Bay, Piednippie, Calca, Port Kenny, Mt Cooper, Poochera and Minnipa (Figure 2).

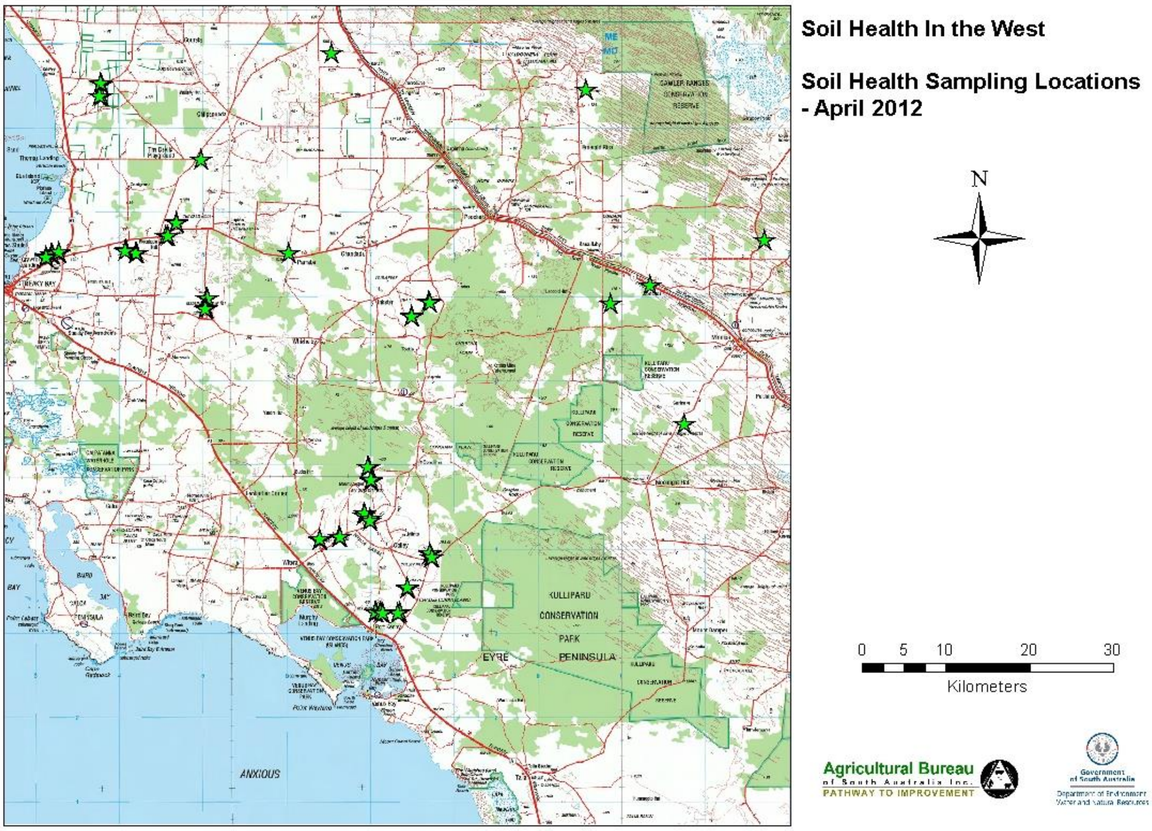

Figure 2. Locations of site sampled in the Haslam, Streaky Bay, Piednippie, Mt Cooper, Port Kenny and Minnipa districts.

Samples obtained can be classified into 4 main soil types. These are;

- Grey calcareous soils (28 sites, 58 % of all sites sampled) – highly calcareous (calcium carbonate > 30%), loamy sand/fine sandy loams from Piednippie and Port Kenny.
- Red brown earths (12 sites, 25% of all sites sampled) – Red brown loams/sandy clay loams with varying carbonate (to 20%) from Mt Cooper.
- Red sandy soils (6 sites, 12.5% of all sites sampled) – Light textured surface soils with less than 6% carbonate from Minnipa/Poochera
- Deep sand (2 sites, 0.05% of all sites sampled – Deep siliceous sand (carbonate less than 1%) at Minnipa).

In total samples from 48 sites (paddocks) belonging to 28 landholders were submitted. Results of soils analysis were sent to individual landholders and a summary of the results was presented at the Streaky Bay, Mt Cooper and Minnipa Agricultural Sticky Beak field walks.

In addition to the samples submitted from these districts, a demonstration site was also sampled at Wharminda investigating the potential use of EM38 mapping and DGT phosphorus testing in determining variable phosphorus rate applications under an EP Farming Systems Project. Samples from different production zones across this site were submitted for PBI, DGT P and Colwell P analysis with results being presented to landholders at the Wharminda Precision Ag workshop and Mt Cooper and Minnipa Agricultural Bureau Sticky Beak field walks.

2.2 SAMPLING METHODOLOGY

Surface soil samples were taken to a depth of 10 cm at each site along a linear sampling transect of at least 100 m. Samples collected during the April sampling (a total of 38 samples) were taken using manual and mechanical soil probes (Figure 3). Those submitted by landholders (10 samples) were collected by landholders using a spade.

Figure 3. Hydraulic soil sampling trailer.

A minimum of 15 samples were taken and bulked for analysis. GPS co-ordinates were taken at the start and end of the transect for paddocks sampled using the sampling trailer.

The bulked samples for each site were divided into two subsamples and sent for analysis. One sample from each site was sent to CSBP for analysis of some soil health parameters including; Organic Carbon (Walkley Black), Calcium carbonate content (%), Electrical Conductivity (EC1:5) and pH. The other subsample was analysed at the University of Adelaide for Phosphorus Buffering Index (PBI), Colwell Phosphorus and DGT Phosphorus. From the PBI and Colwell P results Dr. Sean Mason (University of Adelaide) was able to calculate an adjusted critical Colwell P value. The DGT P results enabled Sean to calculate a P fertilizer recommendation for a yield targeting 90% fertiliser efficiency. This fertiliser recommendation was based on the yield response curve Sean has calculated from trial sites showing different DGT phosphorus levels and the actual yield achieved.
Complete results from analysis are detailed in appendix 1.

3 RESULTS

3.1 Organic Carbon

Organic carbon content is an indicator of soil fertility. Desired values are greater than 1% for sandy soils and greater than 1.5% for heavier textured soils. These values can be expected to be slightly higher in calcareous soils and a proportion of the organic carbon present in calcareous soil may be fixed to soil particles and not directly contribute to fertility.

The range of values from across the sample area was 0.44 % to 1.80 (Figure 4).

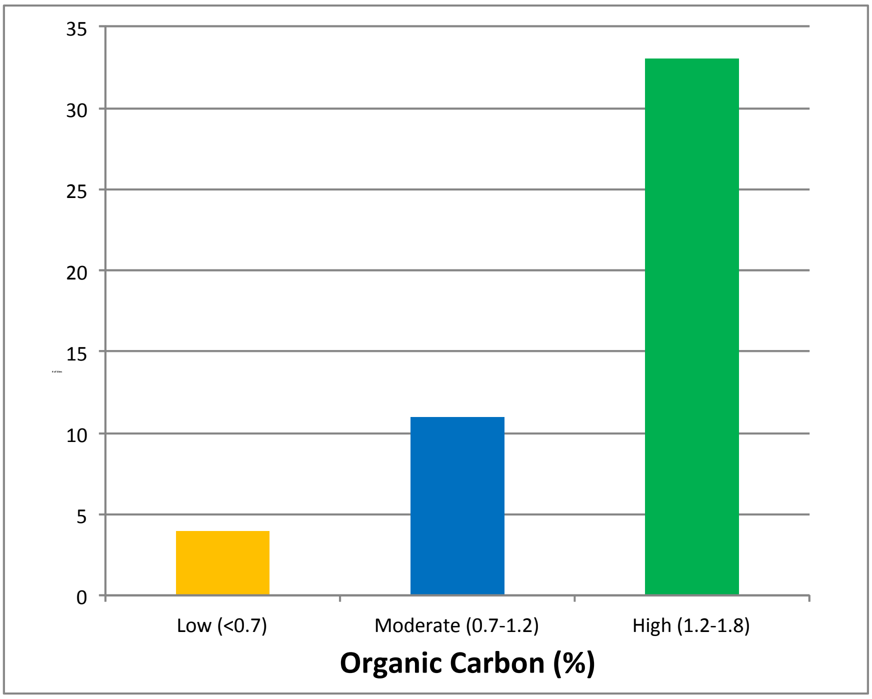

Figure 4. Range of Organic Carbon values (OC %) across sampled sites

Of the 48 sites sampled 67% were above 1.2 % and are in the moderate to high range for the soil textures. The lowest organic carbon was recorded on deep

siliceous sand at Minnipa and the highest organic carbon figures was recorded on a red brown earth at Mt Cooper.

3.2 Conductivity (EC1:5)

Electrical conductivity is an indicator of soil salinity. This analysis measures the electrical conductivity of a 1:5 soil water solution. Soil texture influences the degree to which the amount of salt present in the soil will affect plant growth. EC1:5 figures are usually converted to EC_e using a conversion factor based on soil texture. There is not usually any impact on the growth of salt sensitive plants where the EC1:5 values are below 0.4 mS/cm.

Electrical conductivity results on soils sampled for this project ranged from 0.07 mS/cm to 0.52 mS/cm. Of the 48 sites sampled 41 (85%) of the sites had $EC_{(1:5)}$ results below 0.4 mS/cm (Figure 5).

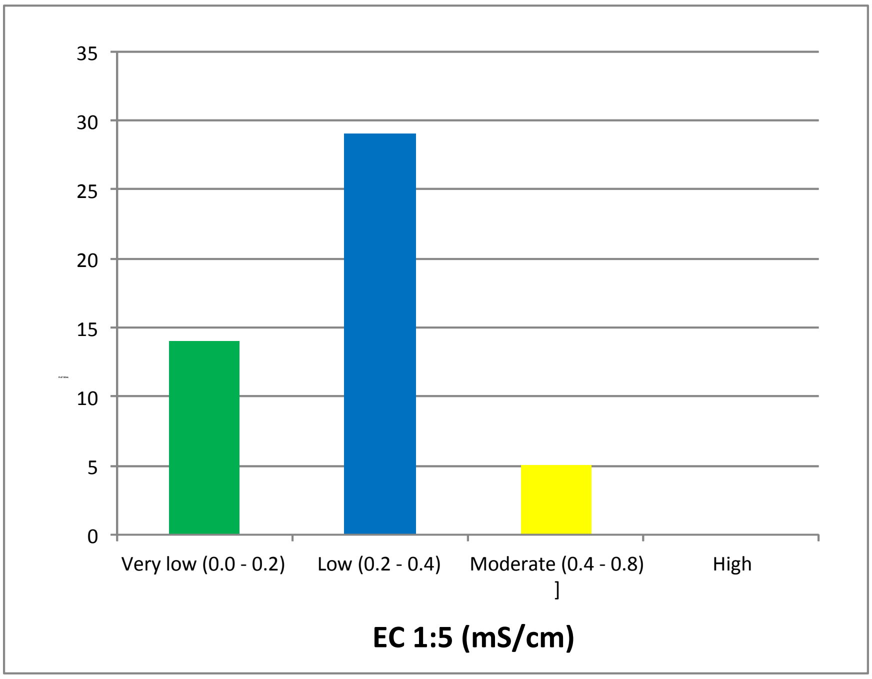

Figure 5. Range of EC(1:5) values across sampled sites

3.3 Soil pH(CaCl2)

Soil pH is a measure of the amount of acid (H^+ ions) in the soil. Soil pH has an influence on nutrient availability and soil microbial function. There are two different ways of measuring soil pH. $pH_{(water)}$ measures the pH of a 1:5 soil water suspension. Where a calcium chloride salt is added to this extraction $pH_{(CaCl_2)}$ can be measured. Due to seasonal fluctuations in soil moisture the soil $pH_{(water)}$ can vary during the course of a year. The $pH_{(CaCl_2)}$ figure is less variable and in neutral to acidic soils is a more reliable measure of the "true" pH of the soil. In calcareous soils pH water is generally considered to be more reliable. The $pH_{(CaCl_2)}$ figure is generally 0.5 to 1 unit lower than the result for $pH_{(water)}$ analysis. The desired $pH_{(CaCl_2)}$ is in the range 5.5 to 6.5.

The pH($_{CaCl2}$) of all sites except one was above the desired range (pH_{ca} figures ranged from 6.5 to 7.9) (Figure 6)

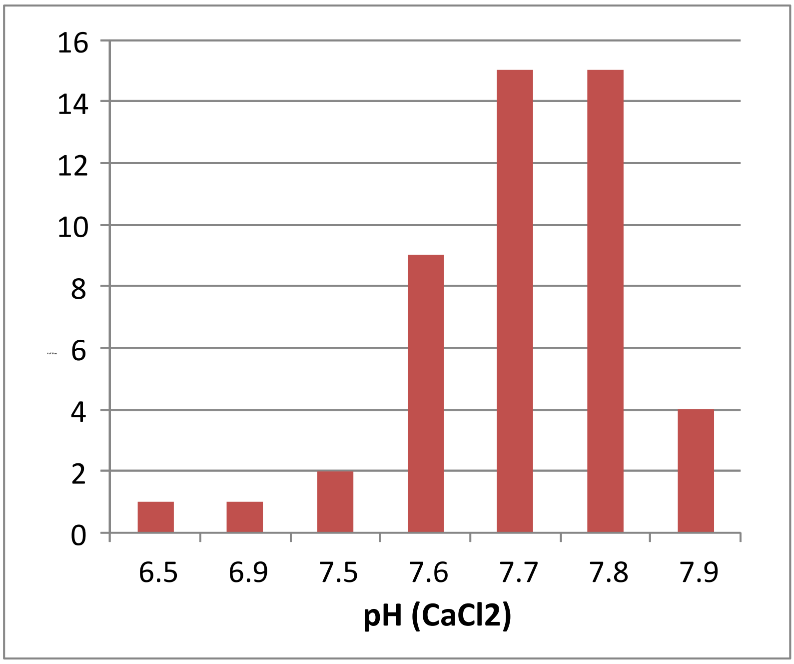

Figure 6. Range of pH(CaCl2) values across sampled sites

3.4 Calcium Carbonate %

Analysis of the amount of calcium carbonate (lime) in the soil can indicate the potential for reduced nutrient availability ("tie-up"). Some nutrients, particularly phosphorus, manganese and iron, have reduced plant availability where high amounts of calcium carbonate ($CaCO_3$) or other carbonate salts are present in the soil. It is desirable to have less than 5% calcium carbonate in the soil.

Calcium carbonate percentages on the sites sampled ranged from 0.3 to 75.5% (Figure 7).

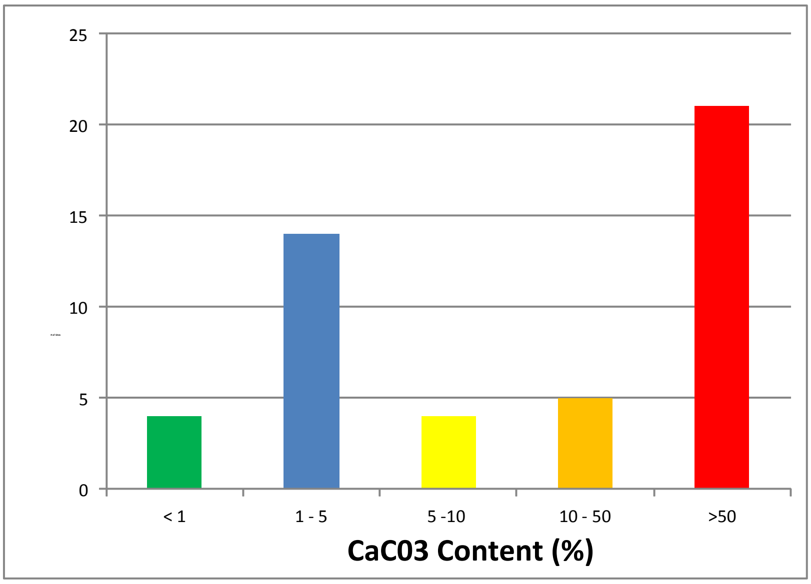

Figure 7. Range of Calcium carbonate (lime) % values across sampled sites.

Samples taken on the red brown earth at Mt Cooper and the red sandy soils around Minnipa had less than 10% calcium carbonate. Samples taken on the grey calcareous soils at Piednippie and Port Kenny had in excess of 40% carbonate.

3.5 Colwell P

Phosphorus analysis using the “Colwell” method has been the preferred indicator of plant available phosphorus in South Australian soils. Calibrations have been undertaken across a range of soils it has been found to be not highly accurate in calcareous or acidic soils. Phosphorus must be in solution for it to be available for uptake by plant roots. In soils with high calcium carbonate content (lime) much of the soil phosphorus is sorbed to the lime particles and is unavailable to plants. Historically the desired value for Colwell P has been greater 25 mg/kg. However, in soils with high levels of carbonate, desirable Colwell P value has been adjusted to greater than 35 mg/kg. Colwell P results for sampled sites range from 7 to 47 mg/kg (Figure 8).

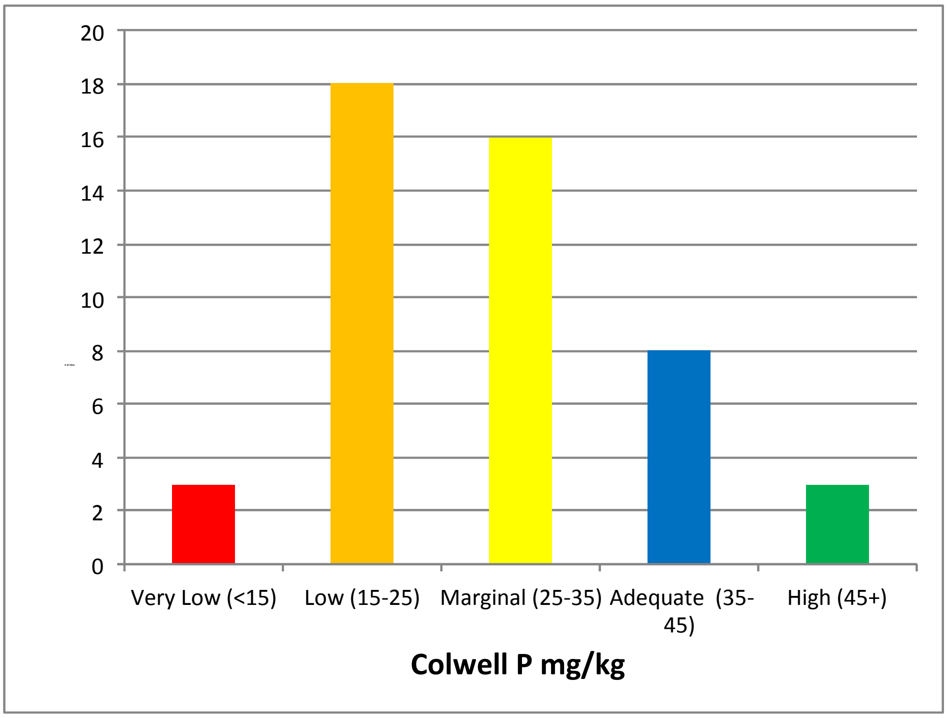

Figure 8. Range of Colwell P values across sampled sites.

3.6 Phosphorus Buffering Index

Phosphorus buffering index (PBI) is an indicator of the soil’s ability to tie up phosphorus. It semi-simulates the efficiency of phosphorus fertiliser additions and can help to interpret Colwell P phosphorus analysis results. However PBI is not directly a measure of phosphorus availability. Where the PBI value is low (less than 70) it can indicate potential phosphorus leaching from the soil. Where the PBI value is high (greater than 100) it can indicate low phosphorus availability (phosphorus tie-up).

PBI values on the sampled sites ranged from 2 to 160 (Figure 9).

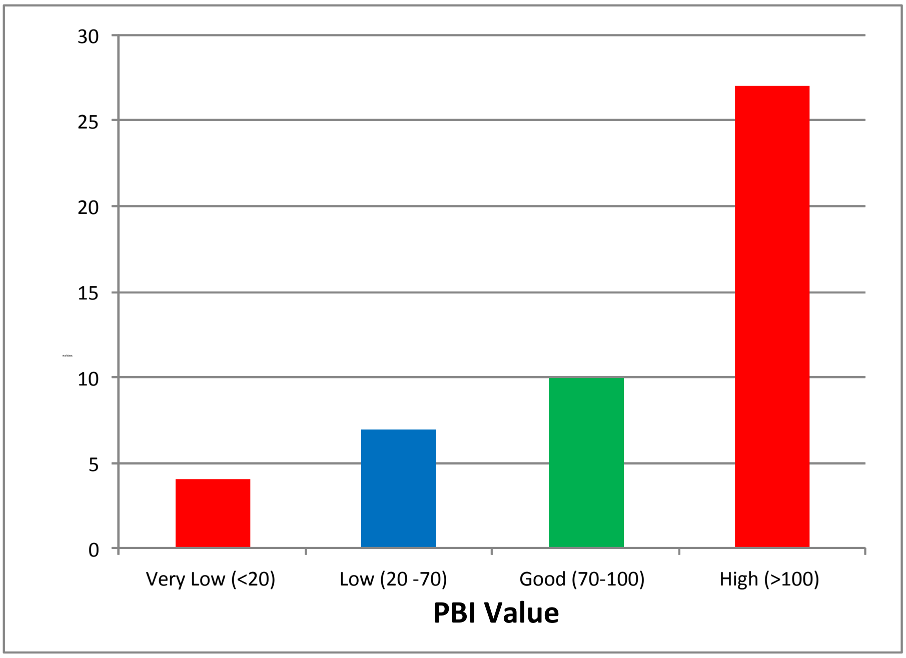

Figure 9. Range of Phosphorus Buffering Index (PBI) valued across sampled sites.

Low PBI values (<50) were recorded on the highly leaching sandy soils at Minnipa whilst the high PBI figures (>100) correlated to the grey, highly calcareous soils at Piednippie and Port Kenny. However, while high PBI figures were recorded on the grey highly calcareous soils at Piednippie and Port Kenny there is a poor correlation between PBI and % $CaCO_3$ (R2= 0.5582), (Figure 10). This is because PBI analysis was developed to identify P sorption to iron and aluminium oxides rather than to carbonate. The red brown earth soils around Mt Cooper recorded PBI values 64 to 95.

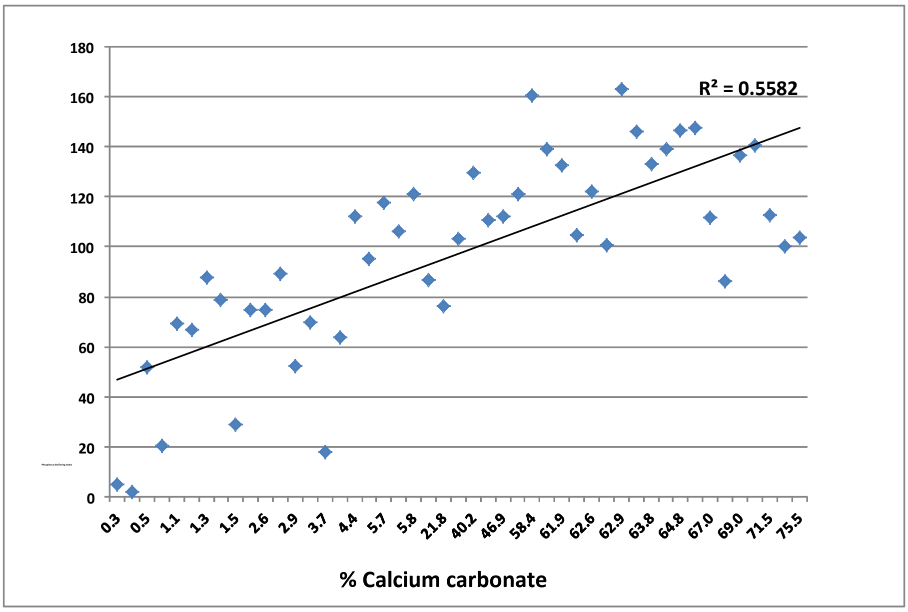

Figure 10. PBI vs. % calcium carbonate for sample sites.

As PBI increases the critical Colwell P value increases proportionally. Using a calibrated trendline and the PBI values from the soil analysis a critical Colwell P figure was able to be calculated for each site (Figure 11).

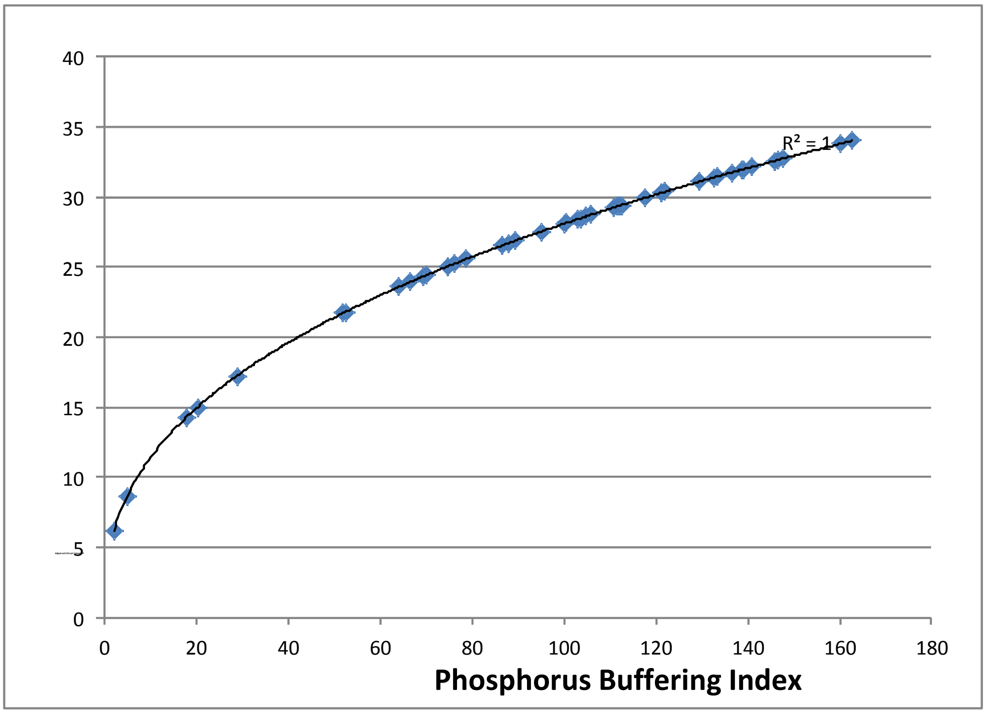

Figure 11. Phosphorus buffering index vs. adjusted critical Colwell P

A P fertiliser recommendation can then be determined by subtracting the current soil phosphorus (Colwell P) from the adjusted critical Colwell P (P required) values. .

3.7 DGT Phosphorus.

Diffusive gradients in thin film (DGT) phosphorus testing uses a ferric gel membrane placed in situ on the soil surface to extract phosphorus from the soil solution as it passes through the gel. This process mimics the way in which phosphorus is taken up from the soil solution by plant roots and is considered to more accurately indicate plant available phosphorus levels than Colwell P.

The desired DGT P values for a target of 90% relative yield (a measure of fertiliser efficiency) based on yield response curves for wheat from trials conducted throughout southern Australia is 50 ug/L. DGT Phosphorus values across the sampling sites ranged from 4 to 84 ug/L (Figure 12) with a high percentage below the desired value.

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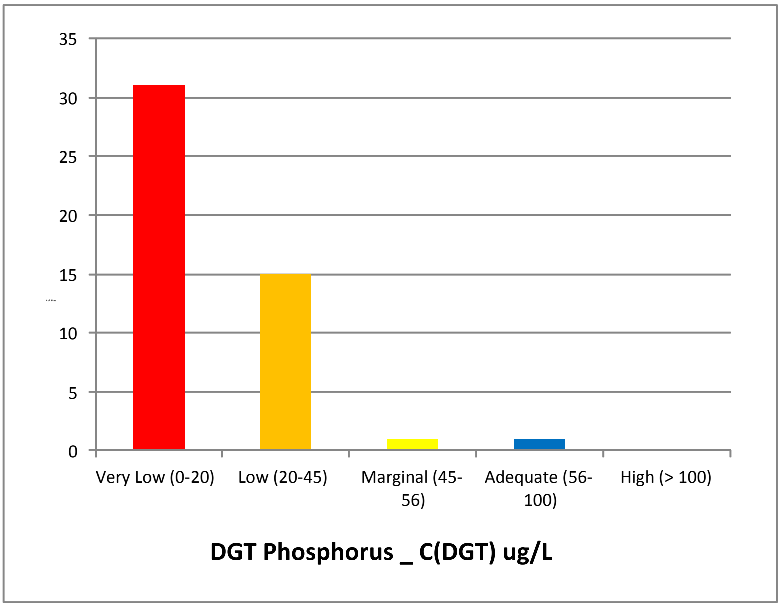

Figure 12. Range of DGT values from sampling sites.

3.8 What are the advantages of using DGT testing for Phosphorus?

Using the traditional Colwell P analysis method values, 54% of the sites sampled had phosphorus levels above the historical desirable value of 25 mg/kg (Figure 13). When the critical Colwell P value was adjusted for potential tie up based on the site PBI the percentage of sites with sufficient soil P was reduced to 50%. However, DGT P analysis identified that sites with sufficient P to target 90% of potential yield was less than 0.05% of the sample set. This finding suggests that there may be many soils on Western and Central Eyre Peninsula with below optimum P levels.

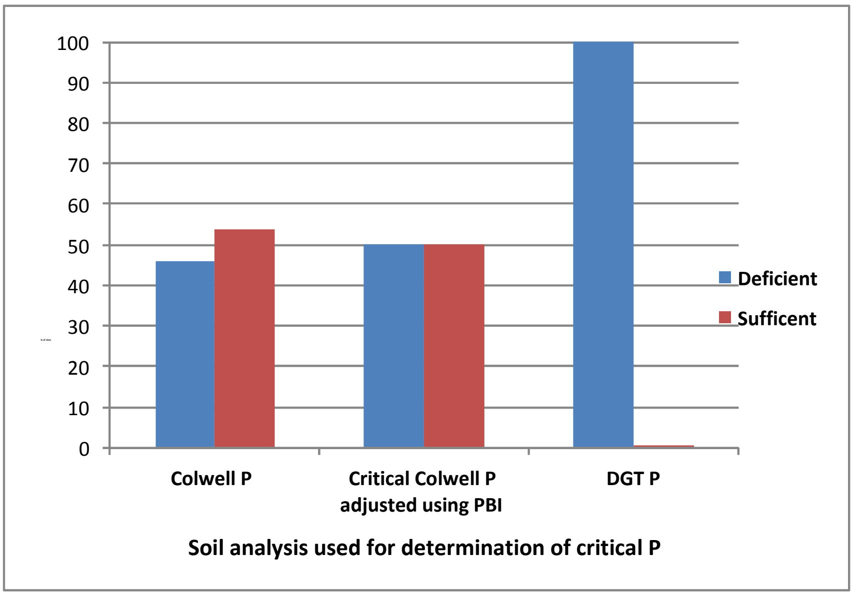

Figure 13. Comparison of percentage of sites showing sufficient (deficient) soil P using a different soil analysis tools.

4 SUMMARY AND CONCLUSIONS

Analysis of soil tests for soil health parameters identified that the sites sampled had generally high organic carbon levels when compared to levels often found in other soils types. However, a lack of research on soil organic carbon in calcareous soils makes it difficult to determine benchmark values. Electrical conductivity (an indicator of soil salinity) was generally low with 85% of sites having EC1:5 values below that which are likely to significantly impact upon crop and pasture growth.

The calcium carbonate percentage varied significantly across the sampling area. The sandy soils around Minnipa had very low carbonate levels and the grey calcareous soils around Piednippie and Port Kenny had very high levels (>40%) of carbonate. All sites sampled were alkaline (>6.5 pH_{Ca}), with most sites falling in the pH range 7.6 to 7.8 (pH_{Ca}).

Colwell P values also varied widely, however the majority of site showed low to marginal phosphorus levels. Samples were also analysed for phosphorus buffering index to provide an indication of the soil's potential to limit phosphorus availability. PBI varied across the sampling sites with very low values (<20) on the sandy soils at Minnipa and high values (>100) on the grey calcareous soils. Moderate values were recorded on the red brown earths at Mt Cooper. Despite recording higher PBI values on the calcareous soils, PBI did not correlate directly to calcium carbonate percentage and is an indicator more of the capacity for phosphorus to be fixed where there are iron and aluminium oxides present in the soil.

Using the PBI value an adjusted critical Colwell P value was able to be determined to account for some of the potential phosphorus tie up on these sites. The results indicated that when adjusted for PBI around 50% of sites had lower Colwell P values that the desired level.

DGT phosphorus analysis (a method that measure phosphorus available in the soil solution) identified that more that 99% of sites had lower than the critical DGT phosphorus levels.

These results highlight the poor correlation between Colwell P and soil available P even when adjusting the critical P value using PBI. DGT P analysis may be a more reliable indicator of plant available P and be a more effective tool for determining phosphorus fertiliser requirements. However, it is recommended that trial strips using higher levels of applied P be evaluated to confirm the analytical results.

Further trials are also required to determine the required phosphorus fertiliser application rate when DGT P is lower than 10 ug/L.

5 APPENDIX 1. SOIL ANALYSIS RESULTS

Sample ID	SOIL TYPE	Depth	Organic Carbon	Cond. EC (1:5)	pH (CaCl2)	pH (H2O)	Calcium Carbonate	Colwell P	PBI	Critical Colwell P	Colwell P -	C_{DGT}	Predicted DGT response	DGT adjusted P required
			%	dS/m			%	mg/kg		mg/kg	Critical Colwell P	µg/L	% relative yield	kg/ha
8	GREY CALCAREOUS	0-10	1.23	0.169	7.6	8.4	61.92	26	133	31	-6	9	43	> 25
9	GREY CALCAREOUS	0-10	1.47	0.225	7.5	8.2	62.88	30	101	28	2	11	48	> 25
10	GREY CALCAREOUS	0-10	1.15	0.202	7.8	8.6	68.80	26	86	27	-1	13	53	24
18A	RED BROWN EARTH	0-10	1.16	0.164	7.8	8.6	4.84	22	95	28	-5	18	61	19
18B	GREY CALCAREOUS	0-10	1.47	0.402	7.9	8.6	72.00	28	100	28	0	9	43	> 25
20	GREY CALCAREOUS	0-10	1.07	0.162	7.7	8.5	71.52	28	113	29	-1	11	48	> 25
22	GREY CALCAREOUS	0-10	0.96	0.272	7.9	8.8	62.40	32	105	29	3	13	53	24
32	GREY CALCAREOUS	0-10	1.67	0.262	7.6	8.3	58.40	39	160	34	5	12	50	> 25
38	GREY CALCAREOUS	0-10	1.66	0.242	7.7	8.6	62.88	36	163	34	2	11	48	> 25
41	RED SANDY	0-10	1.16	0.447	7.9	8.5	2.88	22	89	27	-5	22	67	15
49	RED SANDY	0-10	1.22	0.199	7.8	8.7	5.79	15	106	29	-14	22	67	15
67	GREY CALCAREOUS	0-10	1.18	0.459	7.7	8.3	40.96	19	111	29	-10	7	38	> 25
68	RED BROWN EARTH	0-10	1.42	0.523	7.7	8.3	7.52	18	87	27	-9	7	38	> 25
74	GREY CALCAREOUS	0-10	1.24	0.327	7.6	8.2	68.96	43	137	32	12	25	70	13
75	GREY CALCAREOUS	0-10	1.23	0.284	7.6	8.3	66.24	46	148	33	13	13	52	24
76	GREY CALCAREOUS	0-10	1.22	0.198	7.6	8.3	71.20	27	141	32	-5	4	32	> 25
78	GREY CALCAREOUS	0-10	1.21	0.287	7.6	8.4	64.16	42	139	32	10	13	53	24
79	GREY CALCAREOUS	0-10	1.20	0.247	7.7	8.4	63.84	28	133	31	-3	47	88	4
80	GREY CALCAREOUS	0-10	1.22	0.243	7.6	8.5	64.80	29	147	33	-3	11	48	> 25
81	GREY CALCAREOUS	0-10	1.47	0.247	7.8	8.4	5.65	32	118	30	2	13	53	24
82	RED BROWN EARTH	0-10	0.90	0.179	7.8	8.6	2.97	20	70	24	-5	13	53	24
83	GREY CALCAREOUS	0-10	1.41	0.200	7.7	8.4	46.88	30	112	29	1	7	38	> 25
84	RED BROWN EARTH	0-10	1.22	0.229	7.6	8.3	1.11	16	69	24	-8	22	67	15
85	RED BROWN EARTH	0-10	1.34	0.218	7.8	8.5	4.40	27	112	29	-3	13	53	24
86	GREY CALCAREOUS	0-10	1.31	0.238	7.7	8.4	55.20	27	121	30	-3	9	43	> 25
87	RED BROWN EARTH	0-10	1.22	0.274	7.8	8.3	4.23	22	64	24	-1	20	64	17
88	GREY CALCAREOUS	0-10	1.80	0.418	7.7	8.3	5.81	37	121	30	7	7	38	> 25
89	GREY CALCAREOUS	0-10	1.35	0.265	7.7	8.3	67.04	34	112	29	5	28	74	11
90	RED SANDY	0-10	1.02	0.224	7.8	8.7	2.90	16	52	22	-5	9	43	> 25
91	RED SANDY	0-10	0.50	0.126	7.8	8.5	0.74	21	20	15	6	84	97	1
92	GREY CALCAREOUS	0-10	1.20	0.377	7.6	8.3	62.56	42	122	30	12	11	48	> 25
93	RED BROWN EARTH	0-10	1.35	0.213	7.5	8.2	1.41	22	79	26	-3	34	79	8
94	GREY CALCAREOUS	0-10	1.23	0.374	7.7	8.6	33.28	47	103	28	19	13	53	24
95	RED SANDY	0-10	1.52	0.344	7.7	8.3	1.29	14	88	27	-13	7	38	> 25
96	SAND	0-10	0.69	0.097	6.9	7.5	0.30	7	2	6	1	25	70	13
97	RED BROWN EARTH	0-10	0.88	0.249	7.8	8.4	21.76	35	76	25	10	9	43	> 25
98	RED BROWN EARTH	0-10	1.21	0.212	7.7	8.4	2.58	19	75	25	-6	25	70	13
99	GREY CALCAREOUS	0-10	1.21	0.236	7.8	8.4	40.16	33	130	31	2	9	43	> 25
100	RED BROWN EARTH	0-10	0.95	0.163	7.8	8.5	1.67	20	75	25	-5	20	64	17
101	RED BROWN EARTH	0-10	1.38	0.179	7.7	8.4	1.26	19	67	24	-5	25	70	13
102	GREY CALCAREOUS	0-10	1.30	0.171	7.8	8.5	75.52	46	104	28	17	11	48	> 25
103	GREY CALCAREOUS	0-10	1.23	0.220	7.7	8.5	61.44	43	139	32	11	11	48	> 25
104	GREY CALCAREOUS	0-10	1.41	0.200	7.8	8.6	63.20	38	146	33	5	13	53	24
111	RED SANDY	0-10	1.29	0.228	7.8	8.6	3.73	18	18	14	4	42	85	5
112	RED BROWN EARTH	0-10	0.62	0.116	7.9	8.5	1.46	21	29	17	4	36	81	7
113	GREY CALCAREOUS	0-10	1.06	0.142	7.7	8.5	0.45	22	52	22	0	16	57	22
114	SAND	0-10	0.44	0.065	6.5	7.0	0.29	7	5	9	-2	38	82	6