Case Study 1 – West Midlands Group, Evolving Soils Project.

Joy Sherlock – Valle Agribusiness and Environmental Services.

Interpretation of lab data and graphical results for BE and BH Paddocks including Biology infield and laboratory tests.

First paddock tested – BE Paddock!

Figure 1 BE Paddock

At the time of soil sampling BE paddock (a pasture/grazing paddock) we collected 0 - 10 cm, 10 - 20 cm and 20 - 30 cm samples (71 sub samples of each). They were collected in a grid pattern over the entire paddock for optimal scientific representation of the average of the paddock, avoiding some of the excessive variability we often see within paddocks.

Figure 1 BE Paddock Data Graph

Soil texture was loamy sand over sand. The paddock was quite hard and rocky in some areas.

pH levels are fine at all depths but are lower at depth. BE paddock has a higher CEC consistent with loam/sand so good nutrient holding ability.

Phosphorous (P) levels are fine, but we do see lower levels in the 20 -30 cm depth (seems to be no issues with leaching reflective of soil type). Most parameters decrease as the depth increases.

Phosphorous Buffering Index (PBI) is on the low end of the scale (58, 48 and 49) indicating plant available P (higher PBI soil binds P). Total P indicates P is available via microbial activity to plant also.

Table 1: PBI Categories and published indicator Colwell P values required to support strong plant production.

PBI Category	Classification	Colwell P indicating good soil P status
<15	Extremely low	20-24
15-35	Very very low	24-27
36-70	Very low	27-31
71-140	Low	31-36
141-280	Moderate	36-44
281-840	High	44-64
>840	Very high	64+

Potassium is sufficient in the top 0 - 10 cm reducing at depth. Excessive Magnesium is apparent in the top 0 -10 cm with good levels in the lower depths.

Calcium is also excessive in the top 0 -10 cm. Sufficient in the lower depth and low at depth. The Ca:Mg ratio is out of balance with more calcium then required (even though both are high). If lime has been applied this can take time to further incorporate into the soil, it was suggested to not apply lime for some time until comparative testing has been done. Impacts of liming may take a year or two to become apparent.

Sodium also very high in the top 0-20 cm.

Trace elements (Copper, Zinc and Manganese) are at sufficient levels in the top depths with Iron being very high, suspected due to the nature of the geology in the region. Boron is fine to low at 0.64, 0.5 and 0.36 mg/kg.

Nitrate Nitrogen (N) is sufficient and a low C:N ratio indicates sufficient N in the system if high organic matter is existing. All soils in the wheatbelt have a typically low OM content so keep an eye on N levels but the system is functioning quite well with good organic carbon and organic matter levels in BE paddock. The balance of Nitrate to Ammonium Nitrogen is also good 11:5.9 indicating good mineralisation is occurring. Ideal ratio is 2:1. Total Nitrogen levels are also looking quite high at 0.2, 0.18 and 0.093 which is multiplied by 10 000 to give total N levels of 2000, 1800 and 930. The low C:N ratio can also indicate a soil structure problem, with field work also indicating very hard (and rocky) soil, potentially being an issue but not necessarily due to induced compaction.

Due to high Sodium in the paddock consideration should be given to products to use to not exacerbate the situation i.e., use Sulphate of Potash in preference to Muriate of Potash in the future. At times high Sodium levels can be treated with Gypsum but considering Calcium is in excess it is not the best solution in this situation. Consideration is also given to exchangeable sodium percentage (ESP) values and as under 15% not a real situation calling for Gypsum until soil balance changes.

The high sodium and high magnesium are representative of these hard setting soils, but the high calcium levels are also needing to be a focus. Potentially introducing elemental Sulphur may be of value however it is hard to gauge Sulphur levels due to volatility due to variations of moisture and temperature etc. Also, pH considerations are utilised here as pH is ok but adding too much Sulphur can increase acidity. In situations where soil is very alkaline then there are less concerns with doing this, but it needs to be monitored.

The reason we can use elemental Sulphur on soils that have high Calcium is so that we can create Calcium Sulphate ($CaSO_4$) which is Gypsum. If the soils did require Nitrogen (in this situation waiting before applying more N is fine) then options such as Sulphate of Ammonia would also assist the soil balance.

The second paddock that was tested for comparisons was BH paddock!

The same depths as BE paddock where sampled and tested in BH paddock. This paddock is used for growing cereals and has had pig manure spread for many years. At the time of sampling, it was very sandy with little organic matter, but the pig manure was apparent in small clumps.

Figure 2 BH Paddock

pH levels are fine to a little low at depth (6.63, 6.46 and 6.54 in pH. 1:5 water and a little lower when looking at pH $CaCl_2$). BH paddock has a lower CEC consistent with sand so lower nutrient holding ability.

Figure 3 BH Paddock Data Graph

P levels are very high to excessive at all depths indication leaching of P (consistent with CEC above). Most parameters are reduced as the depth increases except for P which increases again from 10 - 20 to 20 - 30 cm depths, Iron which seems to increase in 10 – 20 cm depths but still low.

PBI is on the very low end of the scale (20, 12 and 16) indicating plant available P (higher PBI soil binds P). Total P indicates P is available via microbial activity to plant also. The excessive P can also illustrate problems with P mobility and availability to plants (less microbial action then we would like).

Potassium is sufficient in the top 0 - 10 cm reducing at depth.

Excessive magnesium is apparent in the top 0 -10 cm with low levels in the lower depths.

Calcium is sufficient at all depths. The Ca:Mg ratio is in balance with calcium a little on the high side.

Sodium is low and very low at depth.

Trace elements (Copper and Manganese) are at sufficient levels in the top depths with Zinc being excessive and Iron low. Zinc is usually higher in clay soils and lower in sandy soils. Zinc along with copper can be higher in paddocks that have had pig manure spread and in this case over years. Increased P levels and availability does occur due to spreading pig manure and Nitrogen is also increased but can leach quite quickly so applications at the correct time are important. Boron is a little low.

Nitrate Nitrogen is sufficient and a low C:N ratio indicates sufficient N in the system if high organic matter is existing. Organic matter was surprisingly sufficient in the top depth as visually in the field it appeared very sandy, and the pig manure applied over time had broken down to a certain degree but also possibly blown a little due to wind erosion.

The balance of Nitrate N to Ammonium N indicates slight trouble with the mineralisation of nitrogen with ratio of 9.3: 6.3 (ideal 9.3: 4.65 or 2:1). Some mineralisation is occurring, but it can be improved.

Total Nitrogen levels are also looking quite high. The low C:N ratio can also indicate a soil structure problem. It does seem the manure has helped to improve organic matter, P and N in the paddock, which is very sandy, but we are still needing improvement at depth whilst not increasing already excessive P and Zn and sufficiently high total N reserves.

Sulphur is also low. Expecting to see some/relatively good microbial activity in biology testing conducted via topsoil however it is apparent little activity at depth!

Considerations where to hold off on pig manure applications short term (utilise elsewhere) and re-test in a year. Consider Muriate of Potash to improve K and Na and Magnesium Sulphate to improve MG and S may be useful.

When comparing paddocks there are varying considerations:

It appears BE has had a more intensive fertiliser program. High sodium (has urea been extensively used?) and iron and imbalance in Ca: Mg are the main issues at BE paddock and BH paddock has high P and Zn may be larger issues in this location.

Big difference between biological interaction where BE has a higher functioning system, improvements are apparent at BH but need further work at depth. Perhaps leaving in a standing cover crop or implementing a good pasture system for some time will allow organic matter to build up in the sandy soils at BH. Applications of microbes are always beneficial which can be done via applying to seed or with/fertiliser.

It is apparent the benefits of spreading pig manure in BH paddock after a field visit with very sandy soil characteristics and potential for wind erosion. There is a definite improvement on the topsoil by comparing to lower depths at BH. However, the potential soil structure issue may be related to lack of oxygen/anaerobic soils which have restricted flow of air within its soil pores. Potentially the high level of true anaerobes detected in Biology testing (refer to biology test results below) confirms this. Due to sandy nature of soil, I would be a little adverse to tillage and would like to consider previous history a little further.

In field Biology testing!

Microbial biomass is the best single indicator of soil health (Doran, 2000) - poor fertility soils have very low microbial populations while highly fertile, productive soils have high microbial populations. As out rule of thumb, soil under 200 µg/g is low in microbial biomass, 200-400 µg/g is fair, 400-600 µg/g is good, and 600 µg/g plus is excellent. Microbial biomass rises and falls naturally throughout the year.

As expected, the microbial mass and bacterial to fungi ratios are very good in BE paddock and very low in BH paddock. The Pig Manure (PM), also tested, conversely showed relatively high proportions of these so is a good indicator that benefits are occurring through the past applications. See screen shots of in field test results below. Lab tests however did identify low levels of Fungi in the pig manure.

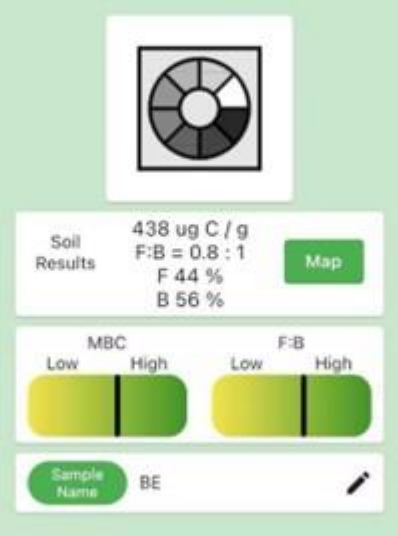

Figure 4 Infield Biology Test for BE paddock

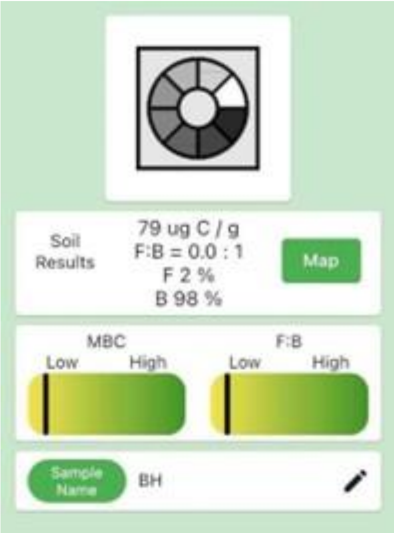

Figure 5 Infield Biology Test for BH paddock

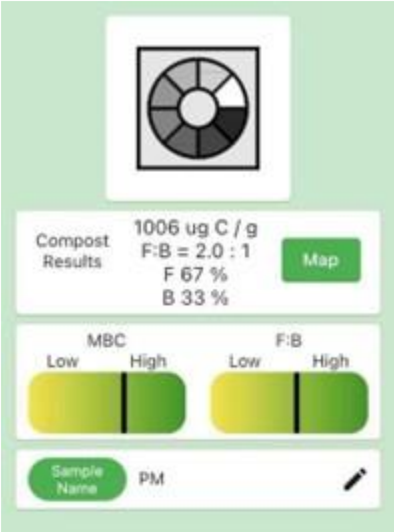

Figure 6 Infield Biology Test for Pig Manure

Further lab testing of microbiology provided further information:

BE paddock:

Potential for nutrient solubilisation, nutrient cycling, disease resistance, nutrient accessibility, drought resistance and residue breakdown rate in BE are high. Total microorganisms, bacteria and fungi are good with actual microbial diversity showing as low. Low methane oxidisers (methanotrophs) oxidize methane to derive energy and carbon for biomass. In so doing, they play a key role in mitigating the flux of methane into the atmosphere. These are higher in aerobic soils again highlighting issue with anaerobic soils (less circulation of oxygen in soil) highlighting hard ground/compaction issues (not waterlogging in this case).

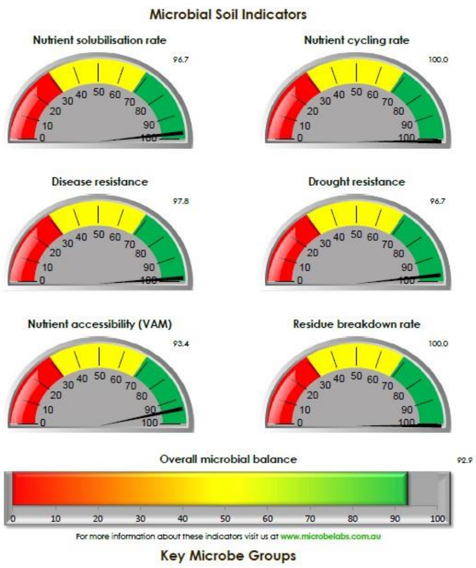

Figure 7 BE Paddock Soil Indicators

BH Paddock:

In BH paddock, nutrient solubilisation rates are lower, nutrient cycling capability, disease resistance, drought resilience and residue breakdown rate still high however low fungi levels decrease potential for nutrient accessibility.

Pig Manure:

The pig manure tests where not tested as compost or manure but soil to get a comparison between soil test results hence solubilisation rates etc. not detected as no soil. High levels of Sulphur reducers and true anaerobes and no fungi detected, characteristics of these samples. Conversely there are good levels of funghi detected in the BE paddock, lower in BH which does indicate positive systems in place. Perhaps the storing of manure in the sun does impact the fungi in this situation.

Figure 8 Pig Manure in BH paddock.

The amount of soil we had to send to lab was limited for these microbial lab tests, but it does seem that the in-field tests are a useful tool to measure changes over time. The costs of lab testing and really needing 500grams per sample that is representative of the overall paddock (obtained via multiple sub samples) is quite prohibitive at times.

Overall, we received a significant amount of information from this initial testing program, it would be very useful to follow up with tissue tests within the season to confirm efficiencies and further soil testing in the next year. This allows to assess changes and soil nutrient balance as we do have capacity to improve the system, impact soil structure and improve production at the same time as applying what fertiliser is needed (not applying what is not needed) and potentially in this economic climate saving quite a few $$$.

Refer to Table 2 below to see full lab data results for case study 1 of the WMG Evolving Soils Project.

Table 2: Lab Results Case Study 1 WMG Evolving Soils Project.

SampleName		BE-0-10	BE-10-20	BE-20-30	BH-0-10	BH-10-20	BH-20-30
SampleDepth		0-10	10-20	20-30	0-10	10-20	20-30
pH 1:5 water	pH units	6.74	6.57	6.16	6.63	6.46	6.54
pH CaCl2 (following 4A1)	pH units	6.4	6.13	5.28	6.18	5.86	5.94
Organic Carbon (W&B)	% (40°C)	2.43	1.98	0.94	1.88	1.01	1.01
MIR - Aus Soil Texture		Sandy loam	Loam	Loam	Loamy sand	Sand	Sand
Nitrate - N (2M KCl)	mg/kg	11	10	3.6	9.3	9.6	5.7
Ammonium - N (2M KCl)	mg/kg	5.9	4.4	1.8	6.3	4	2.8
Colwell Phosphorus	mg/kg	30	28	14	68	51	54
PBI + Col P		58	48	49	20	12	16
Total Phosphorus	mg/kg	239	225	130	338	165	169
Colwell Potassium	mg/kg	180	130	77	130	84	73
KCl Sulfur (S)	mg/kg	11	14	9.2	16	7.7	5.7
Calcium (Ca) - NH4Cl/BaCl2	mg/kg	1490	1130	505	792	454	457
Magnesium (Mg) - NH4Cl/BaCl2	mg/kg	154	128	90	96	56	56
Potassium (K) - NH4Cl/BaCl2	mg/kg	163	110	66	94	56	54
Sodium (NH4Cl/BaCl2)	mg/kg	144	120	62.5	20.9	16.8	12.4
Calcium (Ca) - NH4Cl/BaCl2	cmol/kg	7.43	5.65	2.52	3.95	2.27	2.28
Magnesium (Mg) - NH4Cl/BaCl2	cmol/kg	1.27	1.05	0.744	0.789	0.463	0.462
Potassium (K) - NH4Cl/BaCl2	cmol/kg	0.418	0.28	0.17	0.24	0.143	0.139
Sodium (NH4Cl/BaCl2)	cmol/kg	0.626	0.52	0.272	0.091	0.073	0.054
Ca:Mg ratio		5.9	5.4	3.4	5	4.9	4.9
K:Mg ratio		0.33	0.27	0.23	0.3	0.31	0.3
GTRI		0.05	0.04	0.05			
ECR	%	11	11	12	6.5	7.3	6.6
Exchangeable acidity	cmol/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Exchangeable aluminium	cmol/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
Exchangeable hydrogen	cmol/kg	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
ECEC	cmol/kg	9.74	7.5	3.7	5.07	2.94	2.93
Calcium	%	76.3	75.3	68	77.9	76.9	77.7
Magnesium	%	13	14	20.1	15.6	15.7	15.8
Potassium	%	4.3	3.7	4.6	4.7	4.9	4.7
Sodium	%	6.4	6.9	7.3	1.8	2.5	1.8
Aluminium	%	0	0	0	0	0	0
Hydrogen	%	0	0	0	0	0	0
Salinity EC 1:5	dS/m	0.3	0.22	0.079	0.14	0.098	0.079
Ece	dS/m	4.1	2	0.75	3.1	2.2	1.8
Boron	mg/kg	0.64	0.5	0.36	0.38	0.23	0.24
Iron (Fe)	mg/kg	75	75	58	20	23	29
Manganese (Mn)	mg/kg	11	8.7	6	11	4.4	3.5
Copper (Cu)	mg/kg	0.61	0.48	0.42	1.9	1.1	1
Zinc (Zn)	mg/kg	1.4	1.1	0.42	33	14	12
Dumas Total Nitrogen	% dry wt	0.2	0.18	0.093	0.19	0.11	0.11
TDS	mg/L	190	140	50	88	62	51
MIR CaCO3 equiv	%	<1	<1	<1	<1	<1	<1
MIR Tot IC	%	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Total Carbon	% dry wt	2.51	2.06	0.98	1.93	1.06	1.05