Benchmark soil sampling of weather station sites across NSW

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Key points

- These results provide some benchmarking of soil chemistry for the Riverine Plains region.
- There was a high variance in soil chemistry parameters across the seven monitor sites.
- Results showed the timing of sampling had some influence on the results obtained.
- Consistency in sampling method and timing will improve the quality of results obtained.

Background

Through a partnership with the Murray and Riverina Local Land Services (LLS), Riverine Plains Inc installed seven on-farm weather stations across southern NSW during 2016. These weather stations were installed to address the shortage of local weather information and are accessible via the Riverine Plains Inc website: riverineplains.org.au.

To develop greater value from these sites, a series of benchmark soil samples were taken at each site during May and August 2017 and January 2018. These soil samples, in conjunction with soil pit workshops held at selected sites, were used to better understand the soil profiles and properties across the region and to understand how some soil properties, such as soil pH and carbon (C), change with time.

Methodology

Soil samples were collected at three depths (0–10, 0–30, and 30–60cm). These depth increments were chosen to reflect the different analyses at different depths (i.e. phosphorus [P] is generally measured in the 0–10cm increment, while other analyses are generally carried out at the 0–30cm increment). The 30–60cm depth was sampled to determine which nutrients had moved to depth (i.e. nitrogen [N], sulphur [S]).

A selection of soil analysis results is presented in Table 1. The intent of presenting this information is to demonstrate the range of results obtained throughout the region and to understand the key indicators associated with each parameter. These results are obtained from one location in the paddock and do not consider the broader context of the farming system they came from.

Note the 0–30cm depth measurement includes the 0–10cm increment. If the 0–10cm depth result is higher than the 0–30cm depth result, this indicates the result was lower in the 10–30cm depth compared with the 0–10cm surface depth measurement. Conversely, if the 0–10cm depth result is lower than the 0–30cm depth result then the soil from 10–30cm has a higher measurement than the surface 0–10cm.

The soil test results indicate that most sites showed variation in pH measurements taken at different times (Table 1) due to both spatial and temporal variation. A soil's composition can fluctuate widely on a small scale, due to differences in the amount of plant or root material collected in the soil corer (even with sieving, small pieces of organic material will pass through with the sample). Given a soil core sample contains a relatively small amount of soil the effect of these variances is increased. Sample timing is also important and while analysis techniques adjust for seasonal variation to some degree, there will be still be some variance through the year. This means it is always advisable to be consistent with the timing of sampling for soil chemistry parameters.

Results

i) Soil pH

While the 0–10cm depth results show that most soils are considered acidic, the only site considered strongly acidic is Barooga, where a pH of 4.8 may be limiting growth of acid sensitive crops (Table 1). This is also the only site where the aluminium percentage of the cation exchange capacity (CEC) is more than 5%, and likely to show phytotoxicity (there is a direct relationship between increasing soil acidity and increased exchangeable aluminium).

Most sites show an increase in pH from the 0–10cm layer to the 0–30cm layer. This means there is generally an increase to depth, with all sites except Henty showing an increase in pH at the 30–60cm depth.

ii) Salinity

The salinity, or salt content of the soil solution, is generally considered in the context of the environmental system it is within. For example, in agriculture the EC value would be considered in respect to the salt tolerance of the plants being grown. On average, the thresholds of low (<0.24 dS/m),



TABLE 1 Soil pH measurement at weather station and soil moisture probe sites across southern NSW*

Site	Depth (cm)	Soil pH		
		May 2017	August 2017	January 2018
		(pH)	(pH)	(pH)
Barooga	0–10	4.8	4.5	4.7
	0–30	5.5	5.5	6.3
	30-60	7.4	7.1	8.0
Berrigan	0–10	5.4	5.8	5.2
	0–30	6.3	5.6	7.3
	30–60	8.0	6.9	7.9
Culcairn	0–10	6.1	6.1	6.3
	0–30	6.0	5.2	5.6
	30–60	7.3	6.7	7.6
Henty	0–10	6.3	5.4	6.0
	0–30	6.2	5.4	5.6
	30–60	5.9	5.7	5.4
Lockhart	0–10	5.7	6.3	5.8
	0–30	6.9	5.5	6.9
	30–60	8.5	6.7	8.4
Pleasant Hills	0–10	5.7	6.7	5.8
	0–30	5.4	5.1	5.0
	30–60	6.3	6.3	6.3
Rand	0–10	5.0	4.6	4.4
	0–30	5.7	4.7	6.0
	30–60	7.1	5.9	7.3

* Measured in calcium chloride ($CaCl_2$).

TABLE 2 Salinity measurement at weather station soil moisture probe sites across southern NSW

Site	Depth (cm)	Electrical conductivity		
		May 2017	August 2017	January 2018
		(dS/m)	(dS/m)	(dS/m)
Barooga	0–10	0.14	0.07	0.20
	0–30	0.08	0.04	0.06
	30–60	0.21	0.08	0.29
Berrigan	0–10	0.64	0.26	0.31
	0–30	0.15	0.08	0.22
	30–60	0.26	0.10	0.22
Culcairn	0–10	0.31	0.13	0.14
	0–30	0.09	0.08	0.08
	30–60	0.10	0.16	0.18
Henty	0–10	0.14	0.20	0.06
	0–30	0.07	0.06	0.05
	30–60	0.05	0.09	0.10
Lockhart	0–10	0.09	0.08	0.12
	0–30	0.13	0.07	0.20
	30–60	0.54	0.13	0.55
Pleasant Hills	0–10	0.14	0.14	0.09
	0–30	0.04	0.04	0.04
	30–60	0.09	0.04	0.04
Rand	0–10	0.38	0.46	0.15
	0–30	0.12	0.43	0.10
	30–60	0.20	0.12	0.17

moderate (0.24–0.56 dS/m), and high (>0.56 dS/m) EC values can be used.

While the Berrigan, Culcairn and Rand sites measured higher EC values in the surface 0–10cm layer, the Lockhart site measured a high EC reading at the 30–60cm depth (Table 2). This indicates root growth to depth during wet seasons may be negatively affected, due to roots experiencing saline conditions, which impedes water uptake into the root and can induce a form of *physiological drought*.

iii) Sodicity

While **salinity** is a measure of the amount of sodium (salt) in the solution *between* soil particles, **sodicity** is a measure of the amount of sodium (salt) occupying the *surface* of the clay particles. So, salinity-salt floats around in the water, while sodicity-salt is stuck onto the clay, and has a chemical effect on how that clay particle behaves.

If lots of sodium sticks onto the clay, when that clay gets wet, all the particles blast apart and disperse. As the clay particles dry, they lose their order and settle into any tiny holes in the soil, blocking water movement through the profile. This is why a dispersive surface soil tends to get muddy on top quickly, while the subsurface might stay dry, as the sodium stuck on the clay has caused it to plug up biopores and limit water transfer down. As this soil dries it forms a crust on top, which may cause issues with plant emergence and water infiltration.

If the sodic, dispersive layer of soil is deeper down the profile, it will limit downwards root penetration. When that soil layer gets wet, it turns to mush, but when it dries, it sets hard.

A key measure of sodicity is the percentage of sodium on the CEC (the surface exchange sites of soil particles). When this value of the exchangeable sodium percentage (ESP), is greater than 6% the soil is likely to show characteristics of sodicity and dispersion.

Three of the monitoring sites measured an ESP above 6% in the 0–30cm layer, which indicates the problem zone is deeper than 10cm. All sites, except Barooga, had high ESP values at the 30–60cm depth, indicating root penetration to depth at most of these sites could be compromised by high sodicity.

TABLE 3 Sodicity measurement at the weather station and soil moisture probe sites across southern NSW*

Site	Depth (cm)	Exchangeable sodium May 2017 (%)	Exchangeable sodium August 2017 (%)	Exchangeable sodium January 2018 (%)
Barooga	0–10	1.5	0.7	1.8
	0–30	2.8	0.5	3.9
	30–60	5.3	0.7	7.1
Berrigan	0–10	2.6	1.6	3.1
	0–30	7.1	3.9	8.5
	30–60	12.0	8.0	13.0
Culcairn	0–10	3.5	2.0	2.2
	0–30	5.5	6.1	9.1
	30–60	9.7	12.0	14.0
Henty	0–10	1.2	5.3	<1
	0–30	1.2	5.9	1.6
	30–60	8.3	10.0	7.8
Lockhart	0–10	4.9	2.4	4.1
	0–30	14.0	7.5	12.0
	30–60	19.0	12.0	17.0
Pleasant Hills	0–10	2.2	0.9	0.4
	0–30	3.7	1.6	<1
	30–60	20.0	6.2	4.3
Rand	0–10	4.0	3.1	3.8
	0–30	7.7	1.7	8.5
	30–60	15.0	8.9	13.0

* Measured as exchangeable sodium percentage (ESP) on the cation exchange capacity (CEC).

TABLE 4 Soil organic carbon measurements at the weather station and soil moisture probe sites across southern NSW

Site	Depth (cm)	Soil organic carbon May 2017 (%)	Soil organic carbon August 2017 (%)	Soil organic carbon January 2018 (%)
Barooga	0–10	1.4	1.5	1.6
	0–30	1.0	0.6	0.3
	30–60	0.3	0.2	0.2
Berrigan	0–10	1.9	2.6	1.9
	0–30	0.6	0.6	0.3
	30–60	0.4	0.3	0.3
Culcairn	0–10	1.9	1.7	1.7
	0–30	0.9	0.8	0.7
	30–60	0.3	0.3	0.2
Henty	0–10	1.2	1.1	1.0
	0–30	0.7	0.5	0.5
	30–60	0.3	0.2	0.2
Lockhart	0–10	1.1	1.2	0.9
	0–30	0.7	0.6	0.6
	30–60	0.3	0.2	0.2
Pleasant Hills	0–10	1.3	2.0	1.3
	0–30	0.6	0.5	0.5
	30–60	0.2	<0.15	<0.15
Rand	0–10	1.9	2.0	1.4
	0–30	0.7	2.1	0.3
	30–60	0.4	0.4	0.3

iv) Soil organic carbon (SOC)

All sites had soil organic carbon values (SOC) of around 1% or more in the 0–10cm depth. Variation is high at some sites, potentially due to the inclusion of plant matter into the soil sample. As SOC is comprised of plant (root and shoot) residues, which have been decomposed by soil microbes, SOC values are expected to decrease with depth. As microbes require oxygen and moisture to function, most decomposition happens near the surface, where oxygen and moisture are most readily available.

v) Mineral nitrogen

The May 2017 values for mineral nitrogen indicate appreciable mineralisation of organic nitrogen during summer at some sites, as measured by the 0–10cm values, which ranged from 22–143kg N/ha (Table 5). There also appears to be some residual nitrogen stored from the 2016 season in the 0–30cm zone (this is seen at sites where the 0–10cm value is less than the 0–30cm value,), which means more nitrogen was present in the 10–30cm layer. Some nitrogen at the 30–60cm layer would also have been left over from last season; likely leached to depth.

The August 2017 samples showed depletion of nitrogen compared with the May 2017 samples for most sites, with the Henty and Rand sites likely sampled immediately after urea was spread. This depletion during late spring was generally seen with the 2017 soil samples, showing that even where adequate fertiliser was applied, crops could utilise the nitrogen quite efficiently.

The January 2018 surface samples show some nitrogen mineralisation across all sites, with some movement of nitrate to depth.

vi) Phosphorus

The two phosphorus tests commonly used are the Olsen phosphorus and Colwell phosphorus tests. The Olsen phosphorus is a measure of the readily available phosphorus in the soil, while the Colwell phosphorus test measures the total available pool, as well as some of the less available, chemically-bound phosphorus, which is likely to become available through the season. This is why the Colwell test always gives a higher value than the Olsen test.



TABLE 5 Soil mineral nitrogen measurement at the weather station and soil moisture probe sites across southern NSW

Site	Depth (cm)	Soil mineral nitrogen May 2017 (kg N/ha)	August 2017 (kg N/ha)	January 2018 (kg N/ha)
Barooga	0–10	88	31	111
	0–30	117	25	30
	30–60	13	12	20
Berrigan	0–10	47	25	23
	0–30	42	11	15
	30–60	22	7	16
Culcairn	0–10	143	48	41
	0–30	99	40	32
	30–60	24	11	15
Henty	0–10	30	67	11
	0–30	68	12	25
	30–60	15	7	24
Lockhart	0–10	22	13	47
	0–30	60	22	49
	30–60	13	12	32
Pleasant Hills	0–10	84	13	46
	0–30	61	9	39
	30–60	28	3	14
Rand	0–10	60	221	42
	0–30	32	181	31
	30–60	23	31	21

TABLE 6 Soil Colwell P measurement at the weather station and soil moisture probe sites across southern NSW

Site	Depth (cm)	Colwell P May 2017 (mg P/kg)	August 2017 (mg P/kg)	January 2018 (mg P/kg)
Barooga	0–10	100	120	170
	0–30	54	36	20
	30–60	6.5	<5.0	<5.0
Berrigan	0–10	190	240	130
	0–30	18	96	<5.0
	30–60	5	<5.0	<5.0
Culcairn	0–10	170	67	89
	0–30	56	34	21
	30–60	5	<5.0	<5.0
Henty	0–10	79	61	83
	0–30	29	11	28
	30–60	5	<5.0	<5.0
Lockhart	0–10	62	49	62
	0–30	17	25	16
	30–60	5	<5.0	<5.0
Pleasant Hills	0–10	120	83	100
	0–30	37	37	18
	30–60	5	<5.0	<5.0
Rand	0–10	51	55	51
	0–30	14	41	<5.0
	30–60	5	<5.0	<5.0

The Colwell results indicated good stores of phosphorus in the surface soil across all sites. The increase in Colwell phosphorus from August 2017 to January 2018 may be due to mineralisation of organic phosphorus to plant-available phosphorus, with spatial variability also likely to have contributed to the difference.

The Colwell phosphorus value should be taken in context of the ability of the soil to release phosphorus for plant use or bind it chemically (adsorbed phosphorus), rendering it non-available to plants. For this reason, a phosphorus buffering index (PBI) test is helpful.

vii) Phosphorus buffering index (PBI)

The PBI measurement is independent of the actual phosphorus levels measured in the soil at any time. Rather, it measures a soil's ability to chemically bind phosphorus.

While the values show some differences over time, this is largely due to the inherently high variation in clay content across small scales. Rather, it is more important that the range of results stays the same. A high PBI value means higher phosphorus application rates are needed to raise plant-available levels. A PBI value of <30 mg P/kg means the soil has a low phosphorus holding/buffering capacity, while a value of 30–60 mg P/kg is considered moderate and a value of >60 mg P/kg is considered high.

As an example, the Berrigan site had a Colwell value of 190mg P/kg for the 0–10cm depth (Table 6), which is considered quite high, however the Berrigan site's very high PBI value (150 mg P/kg for the 0–10cm depth) means that this soil holds onto phosphorus very strongly. Hence, a higher Colwell phosphorus is needed to ensure adequate phosphorus nutrition for the growing crop. This is also shown at the Rand site, with the high PBI values indicating this soil has a high proportion of clay, which will bind with the applied phosphorus fertiliser.

viii) Sulphur

The level of plant-available sulphur in the soil varies widely between sites. Historically, growers have been encouraged to apply sulphur with every canola crop, due to the higher sulphur demand of canola compared with cereals (up to 20–30 kg S/ha), however this could be revised in paddocks with a history of regular sulphur application

TABLE 7 Soil phosphorus buffering index measurement at the weather station and soil moisture probe sites across southern NSW

Site	Depth (cm)	Phosphorus buffering index		
		May 2017	August 2017	January 2018
		(mg P/kg)	(mg P/kg)	(mg P/kg)
Barooga	0–10	63	84	79
	0–30	66	84	110
	30–60	96	85	120
Berrigan	0–10	150	180	140
	0–30	140	110	140
	30–60	140	87	130
Culcairn	0–10	96	77	65
	0–30	87	81	90
	30–60	69	72	79
Henty	0–10	41	41	46
	0–30	39	65	55
	30–60	84	110	140
Lockhart	0–10	41	47	36
	0–30	64	72	91
	30–60	90	59	91
Pleasant Hills	0–10	65	95	79
	0–30	52	75	57
	30–60	76	98	72
Rand	0–10	89	81	110
	0–30	140	110	230
	30–60	180	210	230

TABLE 8 Soil sulphur measurement at the weather station and soil moisture probe sites across southern NSW*

Site	Depth (cm)	Soil sulphur		
		May 2017	August 2017	January 2018
		(kg S/ha)	(kg S/ha)	(kg S/ha)
Barooga	0–10	11	7	17
	0–30	12	6	6
	30–60	17	n.d.	32
Berrigan	0–10	392	154	140
	0–30	113	76	172
	30–60	88	71	97
Culcairn	0–10	32	22	21
	0–30	32	46	35
	30–60	27	59	42
Henty	0–10	55	18	7
	0–30	50	55	42
	30–60	42	76	97
Lockhart	0–10	10	4	8
	0–30	29	27	29
	30–60	185	50	134
Pleasant Hills	0–10	24	14	7
	0–30	21	55	21
	30–60	46	23	16
Rand	0–10	182	83	49
	0–30	130	840	80
	30–60	139	122	76

* Measured as sulphate sulphur.

(either through gypsum, ammonium sulphate or even single superphosphate).

Of interest are the high sulphur values present at the 30–60cm depth at the Berrigan, Lockhart and Rand sites, which could be utilised by crops. As sulphur is somewhat mobile, some of the sulphur present at depth may have leached through the soil profile as a result of the wet 2016 season.

Conclusions

The results shown here provide a benchmark of the soil chemistry status of the region for reference in future. However, they also demonstrate the variability across the region and highlight the risks of managing paddocks across a single farm with a blanket approach when the soil characteristics can vary significantly.

Some variability in results was seen across the three sampling times, even for parameters that would not change rapidly (e.g. pH).

To ensure the most accurate and meaningful results from soil sampling across years, always use the same sampling method, sample from the same GPS location in the paddock (while ensuring the same holes aren't sampled) and at the same time of year. Avoid sampling when conditions are wet, as this will affect the results. Send samples to the same NATA-accredited laboratory to minimise analytical variance.

Ideally, some understanding of the subsurface physical characteristics of the soil would aid in interpreting soil chemistry results. So, if possible, look at the soil moisture probe measurements from nearby weather stations, and/or dig a soil pit occasionally to see how the chemical measures interact with the physical structure of the soil.

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