Case study 1

Interpreting test results of two broadacre soils in the Riverina

The Riverina region supports more than 15 diverse soil types of which the chemical and physical and biological properties vary considerably, as well as their fertility and crop productivity. Here, we compare two different soils from two farm sites located in two different agroecological climates in Riverina that have been supporting the similar broadacre crop rotations in recent history.

Figure 1: Condobolin field site (L), Wagga Wagga field site (R)

Condobolin (33°03'44.1" S, 147°14'41.8" E) receives a lower average annual rainfall (457 mm), with minimum mean temperature of 10.2°C and maximum mean temperature of 24.6 °C. Although dryland cropping is the usual practice, this site is prone to flooding occasionally. Wagga Wagga (-35°02'00.5" S 147°21'40.6" E) is in a medium rainfall zone which receives an average of 571.5 mm of rainfall annually, with a mean minimum temperature of 9°C and a mean maximum temperature of 22.2°C.

Soils in both locations are gradational red and red-brown earths, which have been identified as a sodosol in Condobolin and a kandosol in Wagga Wagga according to current Australian soil classification.

Both sites are in southern mixed farming region focused on broadacre crops and livestock production. Condobolin has had wheat, hard-seeded legumes, and cover crops in rotation whereas, Wagga Wagga site has had rotations of wheat, barley, oats, canola, hard-seeded legumes, and cover crops.

In general, standard cultural practices were applied in both locations including the application of a pre-emergence herbicide prior to the planting of cereal crops, pre-seeding application of inoculants for the legumes and pre-sowing insecticides applied to canola plots. For all cereal crops, diammonium phosphate (DAP) fertiliser was applied at a rate of 100 kg/ha. Additional nitrogen top-dressing was applied Following higher rainfall, as required.

Soil samples for testing were collected by hydraulic coring in March 2023 in fallow, on a transect across the field in depths, 0-10cm, 10-20cm, 20-30cm.

Soil analysis was performed at a NATA accredited Environmental Analytical Laboratory. The results are shown in the following table.

Parameter	Wagga Wagga	Condobolin	Expected values for loam soils	Critical values for common broadacre crops in southern region for kandosols & sodosols	
				Wheat	Canola
Nitrate Nitrogen (mg/kg N)	2.5	7.2	10	10–50	
Ammonium Nitrogen (mg/kg N)	5.7	5.6	15	0–5	16–19
Phosphorus (mg/kg P)	26.5	40.2	45	17–28	43–47
Potassium (%)	15.4	2.6	5.2	45–52	4.8–15
Sulphur (mg/kg S)	26.5	34.5	8.0	3.2–6.4	
pH (water)	6.0	7.7	6.3	5.0 – 6.5	
pH (CaCl2)	5.6	6.9	N/A	6.0 - 7.0	
Electrical Conductivity (dS/m)	0.1	0.2	0.0	<0.15	
Estimated Organic Matter (% OM)	2.0	1.7	> 3.5		
Exchangeable Calcium (cmol+/kg)	5.0	12.9	5.0		
Exchangeable Magnesium (cmol+/kg)	1.3	9.0	1.2	10-20	
Exchangeable Potassium (cmol+/kg)	1.2	0.6	0.4		
Exchangeable Sodium (cmol+/kg)	0.1	2.1	0.22		
Exchangeable Aluminium (cmol+/kg)	0.0	0.0	0.4		
Exchangeable Hydrogen (cmol+/kg)	0.2	<0.01	0.4		
Effective Cation Exchange Capacity (ECEC) (cmol+/kg)	7.8	24.8	7.8	5-25	
Calcium (%)	64.3	52.5	65.6		
Magnesium (%)	16.8	36.6	15.7		
Calcium/Magnesium Ratio	4.0	1.4	4.2		
Sodium - ESP (%)	0.8	8.3	2.9		
Aluminium (%)	0.5	0.1	10.5		
Hydrogen (%)	2.2	0.0	0.0		
Chloride Estimate (equiv. mg/kg)	46.5	96.4	N/A		
Zinc (mg/kg)	53.7	66.8	4.0		
Manganese (mg/kg)	41.8	43.9	18		
Iron (mg/kg)	63.3	46.3	18		
Copper (mg/kg)	1.3	2.2	1.6		
Boron (mg/kg)	0.8	1.4	1.4		
Silicon (mg/kg Si)	62.5	46.6	40		
Total Carbon (%)	1.1	1.0	> 2.0	1 - 2	
Total Nitrogen (%)	0.1	0.1	> 0.20	0.15 – 0.25	
Carbon/Nitrogen Ratio	9.4	8.7	10–12		
Basic Texture	Loam	Loam			

What are reasonable expectations for these soils? - Interpreting soil test results.

Both soil samples had a loam texture which is a generally desirable for crop production. However, in comparison to expected values for a loam-textured soil, both sites had lower available nitrogen, total soil nitrogen and soil carbon, leading to lower than expected C/N ratio and soil organic matter content.

Available phosphorus in Condobolin was closer to the expected values for a loam soil, but it was 30% lower than the expected in Wagga. Condobolin soil had 50% of the potassium of expected level, but Wagga soil contained a higher level (3 times) potassium of the typical loam soil. However, CEC was greater than the expected. Both soils showed very high levels of sulphur.

Soil pH in Condobolin was a slightly alkaline pH, higher than the typical loam soils, along with greater than the expected exchangeable calcium, magnesium, and sodium, indicating potential to develop alkalinity. With the ESP of 8.3%, it could also be dispersive; a dispersion test is the best way to check. In contrast, Wagga soil showed a moderately acidic pH value, however with lower exchangeable hydrogen and aluminium, it is within the expected cropping soil pH values for now. It should be noted that Wagga soil has recently been limed. As this site is continuously cropped it will continue to acidify unless lime is applied to counter ongoing acidification.

Levels of major nutrients calcium and magnesium were moderate in Wagga, but lower calcium and higher magnesium was present in Condobolin soils, leading to lower-than-expected Ca/Mg ratio.

Both soils were rich in in micronutrients zinc, manganese, copper, iron, and silicon. Boron and chloride were greater in Condobolin than in Wagga, which had lower than expected for a loam soil.

Both sodium and chloride values were greater in Condobolin suggesting the likelihood of salinity, which is typical of sodosols.

How do these results compare to the critical values for broadacre cropping and how to improve soil fertility in these soils?

In south-eastern Australia, profitable grain production depends on application of fertilisers containing nitrogen and phosphorus and to a lesser extent, potassium, sulfur, zinc, manganese, and copper. The test values used to determine if a nutrient is deficient or adequate to successfully produce a particular crop on a particular soil is called the "critical range". If a paddock soil test value is above the critical range, it is unlikely for a crop to increase yield in response to added fertiliser. If a soil test value is below the critical range the crop is likely to give a positive yield response to added nutrient.

To compare the soil test results from Condobolin and Wagga, critical values for all the nutrients are not currently available for common broadacre crops on kandosols and sodosols. However, in comparison to existing critical value ranges for available phosphorus, potassium, and sulphur, both sites appear to have enough phosphorus for canola, but Wagga soils will benefit from DAP application when wheat is grown. Available potassium in both sites is well below the critical range for wheat and canola, therefore application of potassium fertiliser is essential. Both soils have sulphur well above the critical range.

Desired range of nitrate N is 10-50 mg/kg while ammonium N is 0-5 mg/kg, for broadacre cropping. Total N percentage range of 0.15 – 0.25 is considered sufficient. Both soils appear to have enough available N for broadacre cropping but, considering the volatile nature of nitrates and ammonium reserves in soil and the specific requirements of various broadacre crops at different plant growth stages, application of nitrogen containing fertiliser such as DAP or urea would be required. Building up organic nitrogen reserves in soil by rotating with inoculated legumes to maintain healthy soil biological nitrogen fixation and incorporating cover crops to increase soil organic matter will be beneficial in long-term for both locations.

Electrical conductivity indicates salinity level in soil. An EC (1:5) water extract > 0.15 will affect the growth and the yield potential of salt-sensitive plants. Current EC levels at both sites are not limiting for broadacre crops. However, if perennial orchard trees are to be grown in these soils in future, following the recent cropping trends, salinity might be a problem, particularly, at Condobolin, where EC corrected for soil texture, denoted as ECe, is 0.2 × 9.5 = 1.9. Plants that are sensitive to salinity ECe > 2, such as peach, plum, apricot, almonds are likely to be affected by salinity if grown at Condobolin site.

CEC indicates the level of soil fertility. The desired range of Effective CEC for most crops is 5-25 cmol/kg. Where ECEC is less than 5, is indicative of low soil fertility. Both soils have eCECs falling within the desired range, therefore will response well to fertilisers. When eCEC is low, organic carbon is often lower as well. The desired range of organic carbon is 1 - 2 % for broadacre cropping, although in loam soils, it is >0.9. Increasing soil organic matter by retaining stubble, cover crops and manuring leads to high eCEC and TOC.

The general desired level of soil pH is a neutral pH (water) 6.0 - 8.5 or pH (CaCl2) 5.0 – 7.5. For most broadacre crops, soil pH (water) 5.0 - 6.5 or pH (CaCl2) 6.0 - 7.0 is ideal for balanced nutrient availability and good soil biological activity. Wagga soil is moderately acidic in comparison, therefore routine liming will be beneficial. In contrast, Condobolin soil can be considered as slightly alkaline, and adding compost and organic manures will be more appropriate than adding an acidifying sulphur-containing fertiliser, given the high sulphur content of that soil. Planting acidifying legumes such as lucerne in rotation will also help to reduce pH.

For sodic in Condobolin, gypsum can be applied at a rate of 2.5 - 5 t/ha, as gypsum is less effective at high pH and will not change pH, although it will increase Ca/Mg ratio by supplying soluble calcium and help to improve soil structure reducing the risk of soil dispersion. The desirable exchangeable magnesium level for broadacre crops is 10-20%. Levels above >20% may cause K deficiency or Ca deficiency. Cover crops, minimal tillage, stubble retention and increasing soil organic matter content will also prevent salinity build up and soil dispersion.

DID YOU KNOW?

he Making Better Fertiliser Decisions for Cropping Systems in Australia (BFDC) provides the knowledge and resources to improve nutrient recommendations for optimum crop production.

The BDFC Interrogator https://bfdc.com.au/interrogator/ provides information about critical soil test levels for the four nutrients that frequently account for 20–30% of variable crop production costs i.e., N, P, K and S.

Supported by the Grains Research and Development Corporation, and led by the NSW Department of Primary Industries, BFDC is recognised by the Fertiliser Industry Federation of Australia as the best available data for supporting the decision tools to formulate fertiliser recommendations.

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