Using precision ag to understand constraints to crop production

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Key words

Precision ag, constraints, spatial, GIS, soil water, subsoil constraints, production

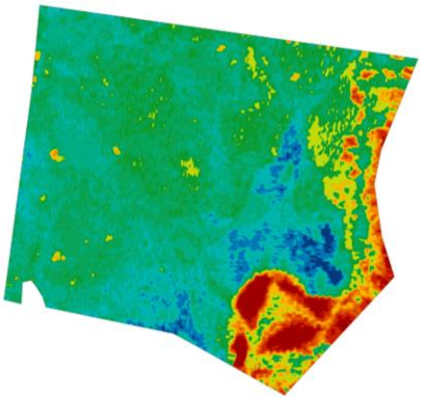
Take home message

Most of our work in the DATA Ag business involves the collection and management of spatial GIS data, and applications for the use of that data via management and analytics. Our challenge has been to develop methods of measuring soil physical characteristics that are repeatable, reliable, and accurate to a reasonable degree of confidence, largely revolving around spatial estimation of soil water, and subsoil constraints. Through these methods we are able to determine the main constraints to production spatially across a field. Typically, in farming systems in the northern grey vertosols the key drivers of yield are:

- Soil water holding capacity
- Drainage/ elevation
- Subsoil constraints
- Soil nutritional variability - will be present but is more often a function of other forms of variability and not often a cause of yield variability.

There are a range of different methods that may be utilised in estimating soil water, and we are investigating several different applications for the use of spatially generated EM datasets. At present, the most repeatable and reliable method that we utilise is derived from a pedotransfer function. These functions model a range of soil physical parameters, including soil water, based on soil textural analysis - from sand, silt, and clay.

We use regression analysis to create a three-dimensional layer of soil water holding capacity, from geo-referenced soil test points, generated to represent the dataset from the spatially collected EM survey. This gives us a modelled, unconstrained soil water holding capacity in three dimensions, and at field level. Figure 1 is an example of a spatially modelled, unconstrained soil water holding capacity map output of a soil profile to a depth of 90cm.

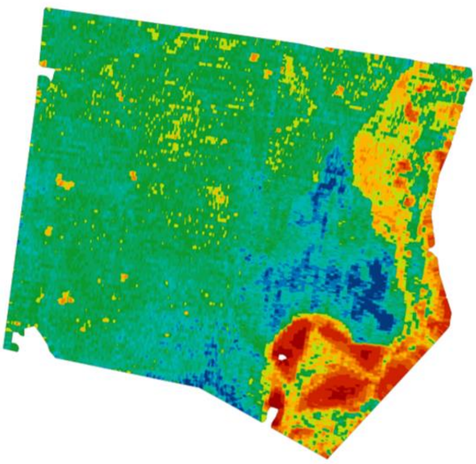


< 134.03 ml	33.68 ha	2.5 %
134.03 - 154.53 ml	22.61 ha	1.68 %
154.53 - 175.03 ml	25.89 ha	1.92 %
175.03 - 195.53 ml	30.49 ha	2.26 %
195.53 - 216.02 ml	38.38 ha	2.85 %
216.02 - 236.52 ml	73.92 ha	5.48 %
236.52 - 257.02 ml	173.47 ha	12.86 %
257.02 - 277.51 ml	409.98 ha	30.4 %
277.51 - 298.01 ml	349.13 ha	25.88 %
298.01 - 318.51 ml	134.34 ha	9.96 %
318.51 - 339.01 ml	46.25 ha	3.43 %
> 339.01 ml	10.67 ha	0.79 %

Min:	80.89 ml
Max:	380 ml
Mean:	263.16 ml
Standard Deviation:	43.04 ml
Mode:	380 ml
Coefficient Of Variance:	16.36 %
Area:	1347.05 ha
Total:	354948.79 ml

Figure 1. Spatial surface showing distribution of volumetric soil water 0-90cm.

From the same EM survey and the same geo-located soil testing points, we again apply regression analysis against other soil test data. This allows us to classify other spatial layers showing the extent of, and depth to, a range of subsoil constraints, largely related to sodicity or salinity, or both. Figure 2 is an example of how soil surface sodium percentages may be spatially illustrated.



< 0.87 %	8.14 ha	0.61 %
0.87 - 1.68 %	33.56 ha	2.5 %
1.68 - 2.5 %	29.79 ha	2.22 %
2.5 - 3.32 %	39.01 ha	2.91 %
3.32 - 4.14 %	67.95 ha	5.07 %
4.14 - 4.96 %	110.77 ha	8.27 %
4.96 - 5.78 %	298.68 ha	22.29 %
5.78 - 6.59 %	395.44 ha	29.51 %
6.59 - 7.41 %	197.3 ha	14.72 %
7.41 - 8.23 %	92.75 ha	6.92 %
8.23 - 9.05 %	44.81 ha	3.34 %
> 9.05 %	21.97 ha	1.64 %

Min:	0.39 %
Max:	13 %
Mean:	5.78 %
Standard Deviation:	1.64 %
Mode:	13 %
Coefficient Of Variance:	28.34 %
Area:	1347.05 ha
Total:	7741.5 %

Figure 2. Spatial surface showing distribution of soil sodium percentage, 0-10cm.

Where are we are at?

In creating these spatial surfaces, we can gain a far better visualisation of the ability of the soil to hold water and the things that may inhibit the ability of the plant roots to extract it. Once we have classified our layers of soil water holding capacity and of subsoil constraints we can then relate those layers/datasets back against yield and/or crop biomass to gain an understanding of the extent to which those layers are influencing yield, either positively or negatively. The two graphs below illustrate how we use this information to understand the impact of the soil constraints. Figures 3 and 4 illustrate the relationship, in terms of soil sodium percentages (at their respective depths of 0-10cm and 60-90cm), and where the constraint will begin to impact crop biomass or yield (with the use of plant cell density (PCD) in absence of yield data).

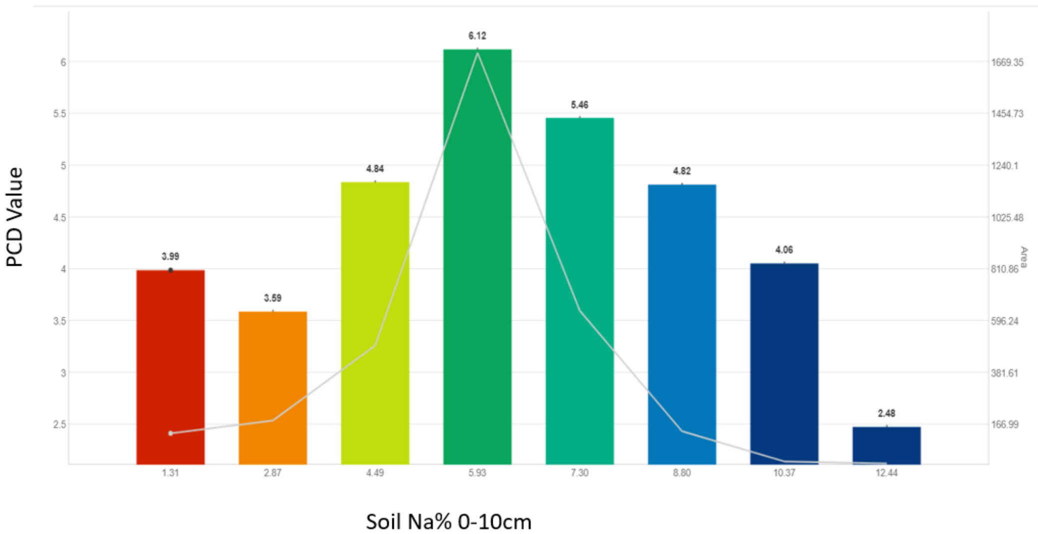


Figure 3. Comparison between soil sodium % (0-10cm) and wheat crop biomass (plant cell density).

Figure 3 illustrates the point at which sodium percentage in the soil surface begins to have a negative impact on crop biomass (yield). Crop biomass increases until sodium percentage in the 0-10cm layer reaches approximately 6%, where the PCD value is 6.12 . After this point biomass begins trending downwards to a point where the PCD value is 2.48 at a surface sodium percentage of 12.44%.

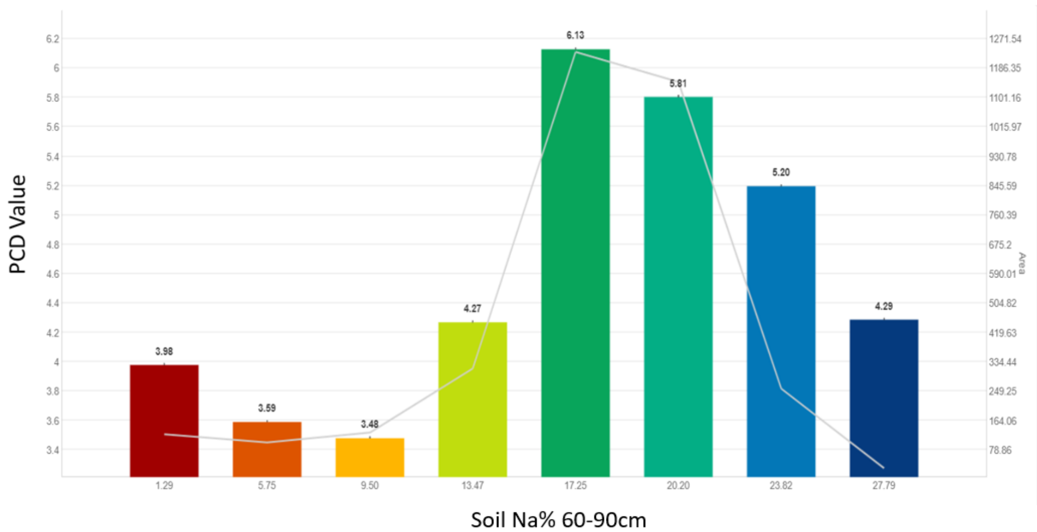


Figure 4. Comparison between soil sodium % (60-90cm) and wheat crop biomass (plant cell density).

Similarly, Figure 4. illustrates the point at which sodium percentage at depth (60-90cm) begins to have a negative impact on crop biomass (yield). Yield increases until sodium percentage in the 60-90cm layer reaches approximately 17%, where the PCD value is 6.12. After this point biomass begins trending downwards to a point where the PCD value is 4.29 at a surface sodium percentage of approximately 28%.

Conclusion

The examples provided in this paper illustrate some insights into the applications used in determining the drivers of crop productivity, spatially, across a field or farm. By understanding the ability of the soil to hold water and the plants' ability to extract moisture from it, we can begin to gain a much more objective understanding of the agronomic drivers of yield.

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