# AMELIORATION OF WATER REPELLANT SOILS AND IMPROVING THE PRODUCTION OF CALCAREOUS SOILS IN SOUTH AUSTRALIA – A FARMER EXPERIENCE

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We farm 18,000 acres of grain at Lock which is on central Eyre Peninsula in South Australia. The crops grown are wheat, lentils, barley and canola.

The climate is semi-arid and Mediterranean with hot dry summers and cool damp winters. The crops are grown through the winter and spring period with planting in May and harvest beginning in November at the beginning of summer. Frost is uncommon but does occur and although the rainfall is low it is relatively reliable. There is some risk of frost damage at flowering, and that risk decreases further into spring, however the risk of heat damage during flowering and grain fill increases further into spring.

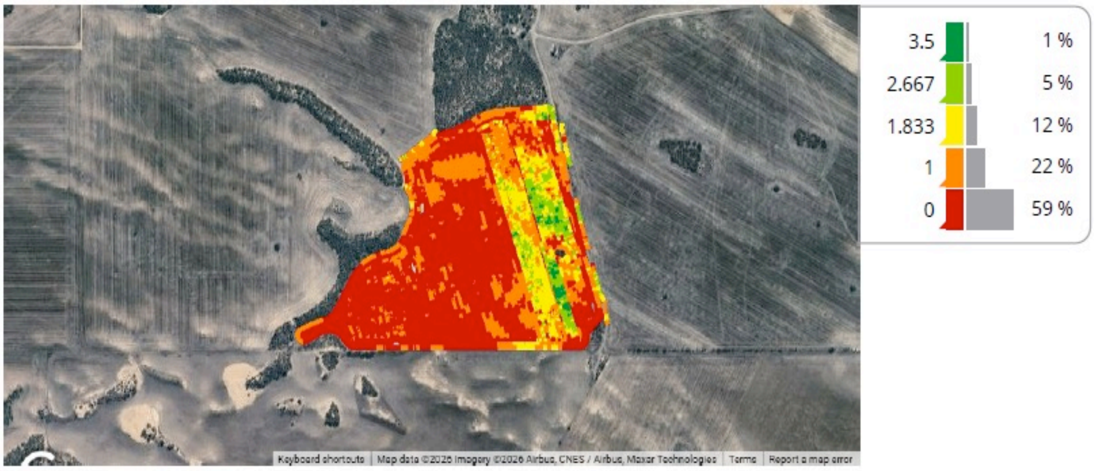
Crops are established with full residue retention and zero tillage. Crops are grown in a dryland farming system where annual rainfall is 350 mm (13.75 inches) and ranges from 200mm (8 inches) through to 420mm (16.8 inches). July is the wettest month and the rainfall decreases either side of July and January is the driest month. May is when the seasonal break from the summer dry period usually occurs.

The soils are duplex sands over clay and other areas of calcareous sands with high pH and with some surface limestone. The duplex sands tend to be water repellent which often means poor crop establishment and reduced yields. The pH of the duplex soil is around 6.5 - 7.0 at the surface and the clay is higher pH, often up to 8.0. In the calcareous soil the pH is 8.4 – 8.7 at the surface and increases with depth, often up to 9.5. There can be up to 50% free lime in the calcareous soils soils.

We have developed various techniques and machinery to overcome the limitations of these soils and in most instances are able to immediately almost double yields. The techniques include using a machine to delve clay up from below the sand, mix the clay and sand and plant the crop. This is achieved all in one pass of the machinery. Once these soils are ameliorated in this manner they can be farmed in our normal way for at least ten years before a repeat treatment may be necessary. We also use soil wetters applied in the furrow at planting on fields that have not yet been ameliorated to address immediate crop establishment issues. There are other techniques used such as clay spreading and incorporation, some deep ripping, but most involve the mixing of clay with the sand in some form.

When planting crops into water repellent sand, germination is staggered and uneven, plant populations are often low.  The delayed germination reduces the length of the growing season and so reduces yield.

This yield map below shows the motivation for carrying out the amelioration. It also shows the changes in soil type from the parallel dune swale system where there are duplex soils on the dunes and then the random calcareous dunes towards the bottom of the picture.




Duplex sand over clay

Water Repellent Sand


Two examples of ameliorated soil production alongside non ameliorated soil


The spader used for ameliorating the soil.  The front view shows the clay delving tynes that lift the clay to the surface, followed by the mixing action of the spader and then the seeder to place the seed and fertiliser, with the press wheels to firm the seedbed and assist with germination.

The wheat on the left has been established with the spader. (Mohawk on the left, Scepter on the right)

**Calcareous Soils**

Australian soils have a low phosphorus (P) status compared with soils in the United States or Europe (Donald 1964). According to the recent National Land and Water Audit, there are over 76 million ha of alkaline soils (soils with pHCaCl2 > 7.0), with the major portion of the area situated in SA, Victoria, WA and parts of NSW and Queensland (Figure 2).

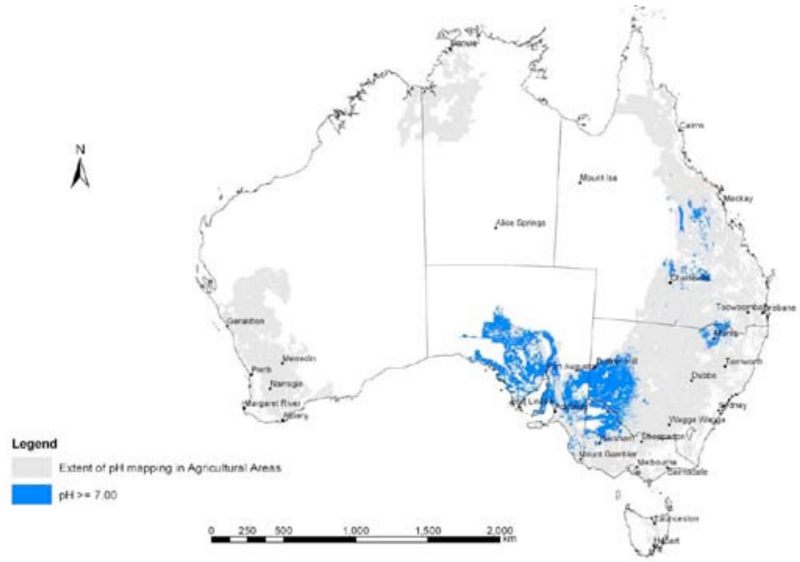



Figure 2. Alkaline soils predominate in the arable regions of SA, south-western NSW and north-western Victoria.

These soils are usually in low to medium rainfall environments with moderate potential grain yields, and fertiliser input costs are a critical component of farm productivity. In the northern and western part of Eyre Peninsula in SA, arable calcareous soils (5-90%) calcium carbonate ($CaCO_3$)) cover an area greater than 1 million ha and produce 10% of the South Australian wheat crop.
Wheat growth on these soils is often poor, particularly in the early stages following emergence when P requirement is critical.
The major chemical constraints for agricultural productivity associated with alkaline soils under the dryland climate of southern Australia include low P and nitrogen (N) availability, micronutrient (zinc - (Zn) manganese, - (Mn),
copper - (Cu), and iron - (Fe) deficiencies, and/or toxicities (e.g. excessive boron (B), sodicity, salinity).

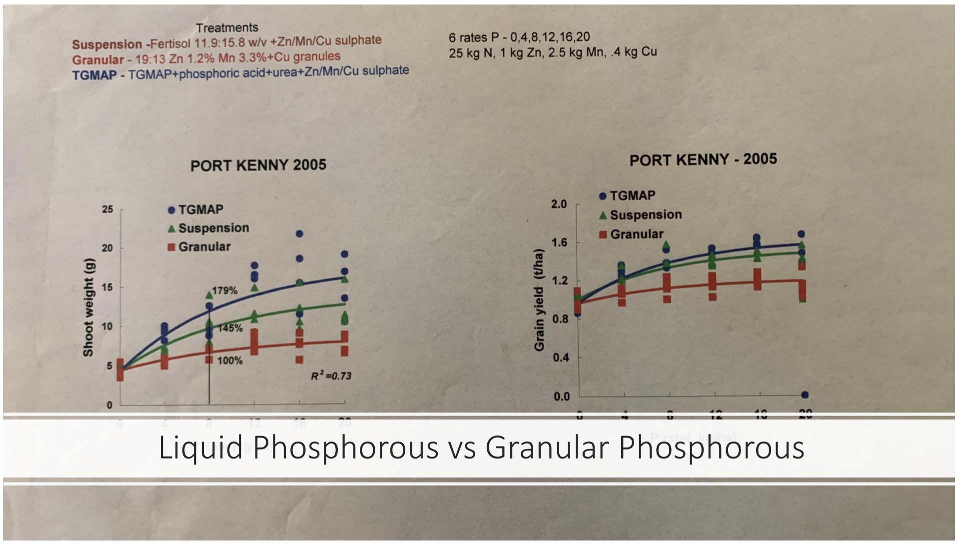
Granular P fertilisers have been used for more than 100 years in southern Australia. However, responses of wheat to increasing rates of granular P-fertiliser are very low on highly calcareous soils. Wheat plants are also commonly deficient in Zn, Mn, and sometimes Cu on alkaline soils. Fertilisers constitute the largest on-farm variable cost, yet efficiency of nutrient uptake is still inadequate. The technology has not advanced meaningfully in 50 years. In a survey of key research issues for growers on Eyre Peninsula in 2000, crop nutrition and soils were identified as the top two research issues needed to improve productivity.

Over the past decade new research using advanced spectroscopic techniques has shown that concentrated P salts in granular fertiliser attract soil water, which in calcareous soils, contains high concentrations of calcium, (Ca) (Figure 6).

The Ca combines rapidly with P, precipitating it as insoluble phosphates which are no longer readily available to plant roots (Figure 6 b & c). This is why the traditional way of providing P to crops on calcareous soils, using granular fertiliser, has not been as effective as it should be.

(Source: Fluid Fertilisers: A South Australian Manual
Project Leader: Prof. Michael McLaughlin, Soil and Land Systems, School of Earth and Environmental Sciences,
CSIRO Land and Water and University of Adelaide)

Calcareous soil profile




(R. E. Holloway et al)

Note both the dry matter response and the yield response to the P applied in the liquid form compared to the granular application.

Granular Phosphorous                                   Fluid Phosphorous

Bertrand et al. 2006: Nutr. Cycl. Agroecosys. 74: 27-40 • Plants took up 22% more P from liquid fertilisers in grey calcareous soils.

We have been using liquid phosphorous at seeding applied in the seed row and below the seed since 2003. Many of the initial trials were done on our place and while the yield gains ranged from a 7% to a 38% percent improvement over using granular fertiliser the change has given about a19% yield improvement on average. This has been one of the most worthwhile changes in technology for our farm. Phosphoric acid has been our main source of phosphorous, but in more recent years we have changed to mostly using ammonium poly phosphate which is a much safer product for staff to handle and is easier on equipment. The phosphoric acid has the advantage of being able to mix in good rates of sulphate trace elements of zinc, copper and manganese.

The blue and red liquid lines carry fertilizer and the yellow line soil wetter.

Phosphorous is applied at 12 (elemental P) kilograms per hectare (24.5 lbs/acre $P_2O_5$). There is usually some urea ammonium nitrate and trace elements added at the same time in a separate stream. The total liquid applied is 70 litres/hectare (7.5 US gallons per acre). Seeding is carried out with an 18 metre (60ft) seeder covering about 16 hectares/hour (40 acres/hr). Section control is used.

In the future we will apply a range of phosphorous rates across the field and the crop will be yield mapped to determine the response in varying soil types. Average field size is around 240 hectares (600 acres), so there can be significant variation across a field. Then variable rate application maps will be constructed to apply the optimum economic rate of fertilizer according to soil type and yield response.

## Summary

In the Australian environment it is possible to lift yields and therefore profit very significantly by targeted soil amelioration and soil fertility amendment in non-wetting soils.

On calcareous soils in the low rainfall environments there are good responses to using fluid phosphorous instead of granular phosphorous and the increased dry matter production assists in extra microbial activity and carbon cycling which improves nutrient availability.