Waterlogging: what have we learnt to date

Background

Waterlogging remains one of the biggest limitations for farming on Kangaroo Island having a significant impact on crop and pasture growth in winter. Considerable trial work has been undertaken by AGKI in conjunction with PIRSA since 2007 from engineering to agronomic solutions.

Below is a summary of what's been done and results to date. Remember results often reflect one or two years of trial data at one location, they are only a guide to what may happen.

Results

1. **Engineering solutions:**

   A variety of techniques to drain water away were tested on a typical waterlogged ironstone plateau soil. Treatments included raised beds, gravel slots (a trench dug to 50 cm and back-filled with gravel), conventional mole, gravel mole (like a conventional mole but gravel is used in the cavity) and delving.

   All treatments yielded more than the control, with the raised bed treatment almost double the yield of the control. The conventional mole was the lowest yielding but still yielded almost 40% more than the control. The sodic clays possibly resulted in the conventional moles collapsing to some degree during the season.

   The measurement of runoff drained per plot indicated the gravel moles and slots drained the most water. Whilst the raised bed recorded the highest crop yield it did not drain the most water, indicating that the formation of these beds improved the yield in addition to drainage.

   At a second trial site agricultural pipes were installed in a waterlogged gully. The pipes did not effectively drain the site, except for the land within about 5 m of the pipe. Whilst no yield data was collected, visually, the growth of the canola crop was very poor across the whole site.

2. **Monitoring soil and plant samples**

   Soil and plant samples were collected from a number of wheat paddocks across KI from both waterlogged and drained sites and analysed for nutrient differences (deficiencies or toxicities). The soil measurements showed that most top soils were acidic with subsoils acidic to neutral. Some of the clay subsoils also dispersed indicating that sodicity might be a problem.

   The analysis of plant material showed no clear indication of any single consistent element deficiency or toxicity associated with waterlogging on KI:

   - Potential for aluminium (Al) toxicity in both waterlogged and drained soils. The highest Al levels were recorded in low soil pH($CaCl_2$) 4.7 – 4.8
   - Marginal problems with iron toxicity in both waterlogged and in drained KI soils, but not at levels that would significantly reduce yield
   - No indication of manganese or boron toxicity in waterlogged soils and only minor zinc deficiency and no sign of potassium deficiency in waterlogged plants
   - Some evidence for the beginning of salt toxicity of waterlogged plants. Whilst levels measured might reduce growth they are unlikely to impact on plant survival

   Soil redox potential, which measures the oxygen availability in the soil, was tested on several sites. Low redox potentials can result in deficiencies of nutrients eg. nitrogen, and toxicities of metals such as aluminium. Soil redox decreased on waterlogged soils and remained low for 2–3 months or more. This lack of oxygen in the soil (anoxic conditions) would be expected to have a severe effect on crop growth.

3. **Agronomic Options**

   a. Soil amelioration

   After anecdotal reports were received from farmers that the addition of chicken manure or lime may reduce waterlogging impacts a trial was established on waterlogged ironstone plateau soil. No significant difference in yield or quality between treatments was observed over time. Soil redox potentials showed that the soil lacked oxygen due to waterlogging, and this effect lasted for several months. There was little impact of the poultry manure on redox potential but there was an increase in redox potential with lime application (with an increase in pH). The higher redox potential for the lime treatment would suggest better conditions for plant growth with potentially more nitrogen available and less severe aluminium toxicity. But this did not translate into a yield difference.

b. Timing of nitrogen applications

A trial was established on a waterlogged sand over clay site, to explore the impact different rates and timings of nitrogen (N) had on crop yield on a waterlogged site. Due to the considerable variability in results, it was not possible to determine if the yield response was due to either the timing of N application, crop growth or waterlogging impacts. Whilst double the N application did increase crop yield, it may not be worthwhile economically.

Applying N once waterlogging has abated, may have some benefit, but late application may increase quality but not yield.

c. Variety differences

There is potentially a large genetic variation in the tolerance of wheat to waterlogging. A demonstration of commercial varieties best suited to waterlogged acid soils was set up on a site that ranged from well- drained to waterlogged. The waterlogged portion became too wet and it wasn't possible to establish the varieties due to burst seed (indicating a lack of genetic variation in tolerance to burst seed). Whilst the varieties only grew on the drained site they were exposed to waterlogging for a couple of weeks. Krichauff, Mace, Espada, Tinamou, Savannah, Indus 66 and Bayles yielded better than Wyalkatchem.

d. Broad Beans

In general wheat crops in waterlogged KI soils often do poorly and broad beans perform much better. Why beans have better tolerance to waterlogging is unclear, but it may be associated with good root aeration and survival under waterlogged conditions. Wayne Hawthorne (Pulse Australia) inspected a number of broadbean crops and noted the following:

- Poor performing beans had poor or no nodulation.
- Extremely acidic soils (pH($CaCl_2$) < 5) and waterlogging due to shallow soils over hard setting clay prevents root development, nodulation and induced trace element deficiencies.
- Poor root development; resulting in moisture stress in spring
- Shallow seeding depth reducing tolerance to herbicides.
- Molybdenum may be required pre-seeding to assist nodulation.
- Correct fertiliser type drilled at seeding may have had an impact on nodulation on acidic soils.

Take home messages

Engineering solutions:

- On flat waterlogged land, raised beds provided the best yield result but they do have some management issues.
- Gravel slots and moles also worked well but the slots are expensive for broad acre use.
- Conventional moles are prone to collapse with Kangaroo Island's sodic clays.
- The nature of many of our clays (sodic and poor draining) results in poor water movement from the soil into a slotted agricultural pipe.

Agronomic solutions:

- The adverse effects of waterlogging are primarily due to anoxic conditions in the soil, rather than element toxicities or deficiencies, except perhaps for aluminium. Liming acidic soils will reduce al toxicity.
- In waterlogged soils the application of poultry manure doesn't appear to improve yields. But the application of lime may increase yield.
- Waterlogging may cause nitrogen (N) deficiency but high rates of N will not turn a waterlogged crop into a good crop.
- There may be some potential for varietal difference to waterlogging in wheat.
- Broad beans: improve nodulation through a combination of liming and application of molybdenum. Liming will also reduce inherent nutritional problems of low soil pH. Early tissue testing and nutrient correction with foliar applications help overcome some soil ph deficiencies .

Funding/Sponsors

- GRDC
- Federal Landcare Programs
- Woolworths
- KI NRM Board
- KI Pure Grain
- plus numerous KI farmers who provided all the trial sites.

For further information contact

Lyn Dohle PIRSA Kingscote on 85534999 or
email lyn.dohle@sa.gov.au