High sodium levels in subsoil limits yield and water use in marginal cropping areas

**PROJECT DETAILS**

**PROJECT CODE:** DNR6  
**PROJECT TITLE:** HIGH SODIUM LEVELS IN SUBSOIL LIMITS YIELD AND WATER USE IN MARGINAL CROPPING AREAS  
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**ORGANISATION:** DEPARTMENT OF NATURAL RESOURCES AND MINES  
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**Summary**

Over the past 30 years, only small gains in crop yields have been made in the marginal cropping areas of north west New South Wales (NW NSW) and south west Queensland (SW QLD) in spite of the fact that new wheat varieties have the potential to increase yields by more than 25%-30% compared to old varieties. In these areas, low rainfall and high sodium levels have led to restricted water entry into the heavy clay soils, consequently leading to high salinity levels in the subsoil due to limited leaching opportunities. This is confirmed by limited land surveys, which show high sodium and salinity levels in the subsoils of this region. However, the effects on water use by crops and their effects on crop yields have not been documented in this region.

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Conclusions
The project consisted of the assessment of subsoil sodicity and salinity constraints to wheat grain yields, and evaluation of management options to reduce or remove the impact of subsoil sodicity and salinity on wheat productivity in the northern grains region. The main findings were:

1. Surface soil sodicity was associated with both rooting depth and wheat grain yields; as surface soil sodicity (expressed as exchangeable sodium percentage (ESP)) increased, rooting depth as well as wheat grain yield decreased.
2. Increase in subsoil salinity (measured at 40-50cm depth) was also associated with decreasing rooting depth and wheat yields.
3. In addition to surface soil sodicity and subsoil salinity, subsoil acidity in brigalow soils seemed to restrict rooting depth.
4. Consequently, there appears to be an interaction of surface soil sodicity, subsoil salinity and subsoil acidity on limiting rooting depth and hence resulting in reduced water use and wheat yields.
5. Gypsum application (surface, 20cm depth or both) to a sodic soil with high subsoil sodicity and salinity showed increasing trend in wheat yields. Water use efficiency (WUE) increased significantly from surface application of gypsum while deep ripping had no effect on yield.

Recommendations
1. As a general guideline, wheat yield decreases by 6% for each unit of increase in ESP (0-10cm depth) above ESP of 4% and for each 100μS/cm above 400μS/cm in subsoil salinity (40-50cm depth).
2. There is a research need to unravel the main causal factors of subsoil constraints to wheat yields in this region since a number of factors identified in this project (surface soil sodicity, subsoil salinity and sodicity, and subsoil acidity in brigalow soils) are interrelated and possibly have an interactive effect on water use and wheat yields.
3. There is a need for creating greater appreciation of surface sodicity effects on land use among growers in the northern region because it was found to be the least understood factor affecting the productivity of their land.

Outcomes
Expected Outcome (benefits)

Economic Outcomes
The northern grains cropping soils (mostly grey, brown and red cracking clay soils) from NW NSW, SW QLD and Central QLD show variable rooting depths to as shallow as 50cm or less. These shallow rooting depth soils have as little as 80mm of plant available water when the soil profile is full. Due to shallow rooting depth, the potential yield losses, estimated in the 1999 season in marginal cropping areas, are worth $90/ha or $36 million per year over 0.4 million ha in the northern grains region.

Environmental Outcomes
The potential environmental outcomes include reducing runoff and increasing water stored in the soil profile and increasing WUE. Benefits may also occur to the management of soil salinity in the region.

Social Outcomes

Mirella Blasi, University of Queensland (UQ), was trained as a post-graduate student in this project on management of salinity and sodicity for grains production in the northern grains region.

Achievements/Benefits

Overview of Project Achievements

Background

For further details see Attachment.

It is important to identify the subsoil constraints to crop yield and how these constraints affect crop water use, as well as identify other factors that limit crop yields, since managing these factors is essential for the development of sustainable farming systems in this region. This way sound guidelines to growers and property planners can be provided to identify and assess yield limitations due to subsoil constraints for the northern grains region.

Aim 1: Measuring the effect of subsoil limitations such as sodium and salinity on water use by crops and crop yields on major soil types.

Achievements:

Experiments were established on major soil types in the southern QLD region in 1999 to examine the effects of sodicity and salinity on wheat grain yields. The soils had ESP of 3-16 in the top 0-10cm depth and 15-40 in 50-60cm depth, and soil pH 6 to 8.5 in the top 0-10cm depth and 5-9 in the 50-60cm depth, but below 1m depth it was usually less than pH 5 in these soils. Electrical conductivity (EC) (in 1:5 soil:water) was high to very high at 40-50cm depth (less than 200 μS/cm to 1,200 μS/cm), and in some soils, more than 4,000 μS/cm at 60-70cm depth.

These soil salinity and sodicity characteristics affected crop rooting depth, WUE and wheat grain yields. For example, wheat grain yields were reduced by one tonne for every 30cm decrease in rooting depth from 105cm or less. Similarly, increase in salinity from 200 μS/cm to 1,000 μS/cm at 40-50cm depth reduced wheat yields by 57%, from more than 3.5t/ha to 1.5t/ha.

WUE was closely linked with rooting depth of the wheat crops. It varied from 18kg grain/mm from 105cm root-depth soil to less than 8kg grain/mm in a 45cm root-depth soil. Similar to wheat crop yields, it was associated with sodicity, salinity and acidic subsoil.

Aim 2: Monitoring the relative performance of different management practices.

Achievements:

A field experiment was set up in March 2000 to evaluate tillage and gypsum practices to correct or reduce the adverse effects of sodicity and salinity on wheat. The treatments included deep ripping and gypsum applied at 0, 2.5t and 10t/ha, and gypsum placement at the surface, in ripped slots, and subsurface at 10cm depth.

Although after the gypsum application, there was only 50mm of rainfall before planting at the end of June, there was a significant difference (P<0.05) in initial moisture contents between topsoil gypsum treatments (average 19.2%) and no gypsum treatments (average 17.8%).

Although bulk density was reduced due to ripping and soil disturbance for subsoil gypsum application, there was no significant effect of ripping on yields, but the grain yield was lower from subsoil disturbance without gypsum application treatment.

In the second year of the experiment, surface application of gypsum had significantly higher wheat establishment than the subsoil gypsum application treatment. Gypsum application significantly increased wheat yields, although harvest index (0.39) was similar for all treatments. Subsoil application of gypsum gave wheat grain yields similar to that from surface gypsum
application, although WUE was much higher from the latter treatment.

Aim 3: Providing guidelines for growers and property planners to identify and assess yield limitations.

Achievements:

ESP (0-10cm) guidelines for wheat yields show that wheat yield decreases by 6% for each unit of increase in ESP above 4%.

Similarly, guidelines for EC (1:5) at 40-50cm depth gave only 2/3 yield at 800μS/cm (equivalent to EC of a saturated extract (ECse) of approx. 4,800μS/cm) compared with 200-400μS/cm, while wheat grain yield decreased to 50% when EC increased to 1,200μS/cm (ECse of 7,200μS/cm). Thus, for every 100μS/cm increase in EC above 400μS/cm, grain yield decreased by approx. 6%. Although the ECse threshold values found in this study are lower than those reported by Maas and Hoffman (1977), the rate of decrease in yield due to increase in salinity was found to be essentially similar.

In the brigalow soils studied, subsoil pH exerted a significant control on limiting the rooting depth of the wheat crop. At the rooting depth, soil profile pH turned from alkaline to acidic (pH <6.5) at depth where root growth stopped. As the soil pH decreased at the rooting depth, the wheat grain yield also decreased. Soil pH below six at the rooting depth decreased grain yield by 40% per unit decrease in pH.

Apparently, there is a strong interaction between soil sodicity, soil salinity and soil pH, and all these factors directly and indirectly affect wheat grain yields.

These guidelines and the project's outcomes were communicated to growers through GRDC research updates, grower meetings, news media and workshops.

Communications with growers, landholders, agribusiness and researchers: This project is mostly concerned with on-farm research, working with various growers in the northern region. Hence the project outputs and results were communicated to, and shared and discussed with them, as they were with growers in the Western Farming Systems (WFS) groups at Talwood, Nindigully, Roma and Dulacca. Project results were presented at the GRDC Research Updates at Goondiwindi and Narrabri in February 2000, Westmar in March 2000, Claremont and Emerald in August 2000, and Moura in March 2001. Project results were published and circulated in GRDC Grains Research Update proceedings, the Balonne Broadcaster, and local newspapers, as well as local radio and other media.

Other research

There are a number of unanswered issues such as elucidation of the causal factors for limiting yields on soils with subsoil salinity and sodicity, interaction with nutrient uptake and water use, the extent of distribution of such soils in the northern grains region, and the management solutions for these soils, which would assist landholders with increased productivity as well as economic and environmental sustainability.

GRDC has initiated a five year project 'SIP08- Combating Subsoil Constraints (SSC)' to address the unanswered issues identified in this project.

Additional information

Publications

Thesis 'Sodicity and Salinity Effects on wheat production in northeastern Australia' by Mirella Blasi, University of Queensland (UQ).

Attachment

Supplementary data - Tables and Figures.