FINAL REPORT

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

CSP00195

Soil Constraints Initiative- Management of Non-Wetting Sands

PROJECT DETAILS

PROJECT CODE:	CSP00195
PROJECT TITLE:	SOIL CONSTRAINTS INITIATIVE- MANAGEMENT OF NON-WETTING SANDS
START DATE:	01.05.2015
END DATE:	30.09.2015
SUPERVISOR:	DR THERESE MCBEATH
ORGANISATION:	CSIRO
CONTACT NAME:	THERESE MCBEATH

Summary

This project reviewed the current state of knowledge of management strategies for addressing the non-wetting (water repellent) behaviour of sandy soils and associated constraints to water use and crop yield. It also developed recommendations for a targeted research, development and extension (RD&E) program to enable growers to better manage this problem.
This review involved four key activities;
1. Review of the literature and outcomes of recent research in Western Australia (WA).
2. Definition of the characteristics of non-wetting soil types and mapping of the affected cropping area.
3. Evaluation of the current adoption of practices to manage non-wetting soils.
4. Development of a proposal for research direction.

Report Disclaimer

any loss, damage, cost or expense incurred or arising by reason of any person using or relying on information in this publication. Products may be identified by proprietary or trade names to help readers identify particular types of products but this is not, and is not intended to be, an endorsement or recommendation of any product or manufacturer referred to. Other products may perform as well or better than those specifically referred to. Check www.apvma.gov.au and select product registrations listed in PUBCRIS for current information relating to product registration.

Old or Archival Reports (Projects that concluded in 2007 or earlier)

The information contained in these older reports is now several years old, and may have been wholly or partially superseded or built upon in subsequent work funded by GRDC or others. Readers should be aware that more recent research may be more useful for their needs. Findings related to agricultural chemical use are also potentially out of date and are not to be taken as a recommendation for their use.

Conclusions

It is estimated that 16% of crop land in the study area is susceptible to water repellency, with approx. 1.4 million hectares in South Australia (SA) and approx 0.6 million ha in Victoria (VIC) affected and no repellency identified in New South Wales (NSW). Current farming, with delayed and weaker seasonal breaks and more prevalent dry sowing, increases the crop area sown into dry, water repellent soil. While it has been stated that legumes may cause greater repellency, there is no robust data to support this and severe repellency also develops under continuous cereals.

Growers identified water repellency and fertility management as the two key management issues affecting sandy soils, with water repellency being highlighted more in the SA regions and crop nutrition more so in VIC. Poor crop establishment, erosion, lack of soil water, crop nutrition and weed control were seen as the biggest management challenges on water repellent sands. Despite the high cost, growers seem more likely to ameliorate soils using clay than mitigating against water repellency by using treatments such as soil wetters or furrow sowing.

Mitigation strategies include controlling the movement of water repellent soil during sowing to improve germination. There is a range of sowing strategies that might improve water harvesting in water repellent soils. As water infiltration on repellent soils is primarily by macropore flow, maintenance of crop root and faunal channels in the soil, as in no-till stubble retained systems, increases soil water infiltration. But knife points can funnel water repellent soil into the furrow and alternatives require consideration.

Wetting agents are a useful adjunct to furrow sowing, but the surfactant must be applied in a continuous (banded) stream. There has been no investigation of the efficacy of available wetting agents in GRDC's Southern Region. It is unlikely that in-field inoculation with specific hydrophobic degrading organisms will prove fruitful, but encouraging the growth of useful in-situ soil micro-organisms needs further exploration.

Soil inversion-based amelioration techniques bring a raft of changes to the soil, and in WA have generally resulted in substantial crop yield increases. However, potential risks of soil reforming must be carefully managed. A majority of growers believe that they do not have access to appropriate clay sources for clay spreading to be feasible on their farm and clay spreading or delving is unlikely to be feasible on more than 50% of sandy soils. Further research is required to understand the long-term consequences of different deep tillage and inversion techniques for soil and crop health. An assessment of current actual, achievable and potential yields on ameliorated soils could form the basis for well-informed decision making by growers considering mitigation and amelioration strategies.

Recent developments describing water repellency as a soil state, rather than as a single analytical value, could improve understanding and approaches to management of water repellent behaviour. Combined with modern statistical approaches, mid-infrared spectroscopy (MIS) would be invaluable in improving the understanding of the role of organic matter (OM) and

mineralogy in repellent behaviour of soils and in developing rapid cost effective tools to support response management decisions based on current soil status.

Recommendations

Research Priorities
The research priorities identified in this scoping process can be grouped into three broad categories of mitigation, amelioration and diagnostics.

1. Mitigation Options

This refers to exploration of the fit of techniques adapted for WA systems, including sowing systems and options for inclusion of banded wetters in SA soils and farming systems. The importance of on-row seeding relative to other mitigation options needs to be investigated. Expertise from seeding and tillage system specialists would likely be invaluable here. Survey results indicate that growers may not be familiar with mitigation opportunities as a management tool for non-wetting soils.
The effect of crop or pasture residue type, amount and management on expression of water repellence does not appear to be well understood. Understanding the role of the residue and the conditions that favour biological activity that reduces water repellency expression may prove important to improving crop production on affected soils.

2. Amelioration Options
While clay spreading and deep tillage techniques such as ripping, delving and spading appear to have been researched and extended in the Southern Region, exploration of more affordable techniques, such as deep disc cultivation and mouldboard ploughing, require assessment. Based on the grower survey, the cost of deep tillage options is considered prohibitive to 75% of growers, while more than 48% of growers indicated that they do not have access to suitable clays for amelioration using delving or clay spreading. The merits of different amelioration options relative to crop yield potential and longevity of effects could be usefully explored to provide informed guidance for growers for choosing between mitigation and amelioration options.

3. Diagnostics and Measurement
In order to effectively manage the issues associated with water repellence, it is necessary to be able to diagnose both the potential for and expression of water repellence. In addition, the fate of water and nutrients in repellent systems is pivotal to the resultant production effects and an ability to measure this fate in a representative way needs addressing. Repellency should not be considered in isolation from other sandy soil problems, particularly fertility and nutrition issues - which may be inextricably linked.

Outcomes

The expected outcome of this project was to deliver a proposal for an intensive RD&E program to further the understanding and adoption of approaches to better manage non-wetting soils for increased crop production and profitability.

Economic Outcomes
The risk of investment in a research area without careful consideration of existing evidence and strategies available has been managed. In addition, the area affected by water repellence and current practice to manage the problem have been analysed for grower's 'willingness to pay' for mitigation and amelioration strategies. This provides important context for any future research activity.

Environmental Outcomes
The issue has been scoped with the potential environmental effects of interventions and required management considered. For example, vulnerability to erosion is a primary consideration when implementing amelioration strategies and crop management in an ameliorated paddock requires careful attention.

Social Outcomes
Utilising a literature review (consisting of both international literature and 'grey' (unpublished) literature), spatial and economic analysis has ensured broad engagement on the scoping of the issue.

Achievements/Benefits

Approximately 16% of the cropping land in the Southern Region of Australia has been classified as susceptible to water repellency (approx. 2 million hectares), with a further 2 million ha of cropping land in the Western Region also affected by water repellency. Loss of grain yield due to non-wetting soils is predicted to be in the order of 10%, largely due to the impacts of non-wetting on crop establishment in soils with a variable ability to retain moisture in the seedbed. Despite a number of improvements in the establishment of crops on non-wetting sands, largely through the use of improved seeding systems and crop sequences, a large gap between actual yield and water limited yield potential on sandy soils in the low rainfall cropping zone of south-eastern Australia has been identified (Hochman et al. 2009; McBeath et al. 2013).

Disappointing performance of crops on sandy soils is a common experience expressed by agronomists and growers, despite recent investments in research into nitrogen (N) and crop sequence management tailored to these soil types. A common diagnostic for this poor performance is low water use efficiency (WUE), seen in the presence of water in the sandy layers of the soil profile at harvest at depths that should be accessible to crop roots (approx 0.4m and below).

There are a number of strategies to ameliorate (e.g. delving, spading, mouldboard ploughing) and mitigate (e.g. surfactants, nutrition, seeding systems) the non-wetting behaviour of soils, which can be implemented at a range of costs. Indications are that the adoption of these strategies is low and it is perceived that there are knowledge gaps in the diagnosis, prediction of yield effect and strategic management of non-wetting soils.

This project delivered a comprehensive report scoping the potential for management of and research about non-wetting sands in the GRDC Southern Region. The report provided a spatial analysis of the area affected by non-wetting soils and the likely severity of the water repellence. It included a review of the diagnosis and management of non-wetting soils, using both the international peer-reviewed and 'grey' literature where claims could be substantiated, and analysis of the results of a grower survey which benchmarked grower perceptions and management of non-wetting sands. These report components were utilised for the development of a set of research priorities and the associated hypotheses that could be tested to address these priorities.

Additional information

Unkovich M, McBeath T, Macdonald L, Gupta V, Llewellyn R, Hall J, Tonkin D and Baldock J (2015). Management of Water Repellent Sands in the GRDC Southern Region, Project Technical Report to GRDC, CSIRO, Australia.