Introduction

Grain growers in the low to medium rainfall zone of South Australia and Victoria face numerous challenges in their quest to improve farm profitability and sustainability. One of the largest challenges is the management of subsoil constraints to crop growth. Subsoil constraints are any soil physical or chemical characteristic located below the cultivated layer that limit the ability of crops to access water and nutrients. Subsoil constraints include salinity (either primary or transient (Rengasamy *et al*. 2002)), sodicity, high soil strength and toxic concentrations of Boron. Other factors, such as Aluminium and bicarbonate toxicity, nutrient deficiencies and water-logging may also be implicated in some instances. Subsoil constraints occur naturally throughout large sections of the Australian grain belt, but are especially prevalent in the neutral and alkaline soils of south-eastern Australia

Subsoil constraints can significantly limit farm profitability by reducing grain yields and grain quality and have also been implicated in environmental degradation such as the development of secondary salinity. In many soils, more than one subsoil constraint may be operating and this mix varies across cropping regions at paddock, catchment and regional scales. To make matters even more complicated, the impact of subsoil constraints varies with crop type/variety and seasonal conditions. Consequently there is no 'one size fits all approach' that farmers can adopt in managing this problem. To effectively manage subsoil constraints, farmers (with the assistance of their advisers) will need to identify the extent and severity of the different constraints on their property, understand how these constraints affect crop growth, how they interact with season and the likely effectiveness and financial implications of possible management responses. The particular strategy adopted by a farmer will vary according to their attitude and ability to withstand risk, the nature of their enterprise and the environment (especially rainfall). This manual aims to endow growers and their advisers with the skills and knowledge to make decisions using the latest research results and the experience (including mistakes) of other farmers, advisers and researchers.

Surveys of farmers and their advisers in Victoria have revealed that many grain growers recognise the importance of subsoil constraints and rank them in importance below only climate variability and rainfall in terms of their impact on profitability. However, the evaluation also revealed that many farmers are unsure how to effectively manage subsoil problems for their particular enterprise.

The Grains Research and Development Corporation (GRDC) funded a major national research and development initiative (SPI08) starting in 2002, involving researchers, advisers and grower groups across all major cropping regions. The initiative aimed to improve the ability of grain growers to manage subsoil constraints. This manual was developed through a collaborative project titled 'Improving the profitability of cropping on hostile subsoils' (DAV00049). The project included researchers and advisers from DPI Victoria, SARDI, and the University of Adelaide, working in partnership with Birchip Cropping (BCG), Wimmera Farming Systems (WFS) and various TopCrop groups in Victoria, and South Australia, the Eyre Peninsula Farming Systems and the Yorke Peninsula Alkaline Soils Groups, and other farmer groups. This Diagnostic Manual aims to bring together the latest information on identifying and managing hostile subsoils. It relies heavily on a similar publication compiled by a GRDC funded SPI08 project in northern Australia involving the Queensland Departments of Natural Resources and Mines, and, Primary Industries and Fisheries, the universities of Western Sydney and Queensland, New South Wales' Departments of Primary Industries, and, Planning, Infrastructure and Natural Resources, and CSIRO. That manual targeted management of subsoil constraints in the grain growing regions of Queensland and northern New South Wales. We wish to acknowledge our deep appreciation to Dr Ram Dalal and his team for allowing us to extensively use material from that document.

This manual focuses on subsoil constraints and the management of grain crops on the neutral and alkaline soils of Victoria and South Australia, although many of

the principles and recommendations may be applicable to other environments. Our understanding of how to best manage subsoil constraints is constantly evolving through continuing research and development. We know that the impact of subsoil constraints can vary markedly with soil and crop type and appears also to be heavily dependent on seasonal conditions.

Overview of this manual

This reference manual is targeted principally at advisers and growers to assist them to manage crop production in areas with subsoil constraints. This publication is the 3rd version of the Reference Manual. It differs from previous versions in that it contains information obtained from the DAV00049 project which was not available when previous versions were published. Major revisions have been made to Chapters 4, Salinity and Sodicity, to include new information on critical tolerances of different crops to salinity and sodicity obtained from a large scale survey of farmers paddocks in Victoria and South Australia; Chapter 8, Management Options, which now highlights the potential benefit of deep nutrient placement on sand over clay soils (particularly relevant to South Australia) and Chapter 9, Financial Analysis which includes a case study and financial analysis of different amelioration treatments based on data collected from demonstration trials conducted in both Victoria and South Australia over four years.

The manual commences with a Decision Support Guide that can be used to make a preliminary assessment of whether subsoil constraints are likely to be a problem in a particular paddock. This has been designed specifically for neutral – alkaline soils of south eastern Australia. This will assist the reader to proceed to the relevant chapters in the manual where they can enhance their knowledge of a particular issue rather than needing to read the entire manual.

Chapter 1 provides a detailed description of the soils, geomorphology and geology, allowing readers to gain an appreciation of the soils used for grain production in Victoria and South Australia, including the origin of subsoil constraints. The manual then provides the reader with an in depth technical understanding of how subsoil constraints impact on crop production. Technical terms are required to provide accurate and unambiguous guidance. We simply and clearly define these terms as required and also include a glossary.

Chapter 2 focuses on critical interactions between soil water, subsoil constraints and grain production. Subsequent chapters describe specific subsoil constraints, including nutrient deficiencies and toxicities (Chapter 3), sodicity and salinity (Chapter 4), and physical constraints to root growth (Chapter 5). The final section of the manual provides readers with the knowledge and skills needed to effectively manage subsoil constraints. Chapter 6 provides sampling strategies for measuring subsoil constraints and assistance with how to interpret soil test results. Chapter 7 outlines simple diagnostic tests that can be used to assess whether crops are experiencing subsoil constraints. Previously there were few proven strategies to effectively manage subsoil constraints, especially in the low to medium rainfall zones. However, Chapter 8 describes a range of potential management options that have been tested under experimental conditions.

Although many of these management strategies are yet to be validated under commercial conditions, it is hoped that this will stimulate interest amongst growers to experiment with these strategies on their own properties. Farmers account for a number of factors when making management decisions including lifestyle and environmental implications. However, in order to remain viable in the long term, these decisions must have a sound financial basis, and so the final chapter (9) provides some simple economic tools and calculations that will assist in assessing the possible economic consequences of different management strategies that can be used to manage crops growing in areas with subsoil constraints.

Contributing authors

This manual is based on the publication 'Subsoil constraints to crop production in north-eastern Australia: A reference manual' (2004) compiled by the Northern Australia GRDC Subsoils Project SPI08.

However many of these chapters have been modified or, in some cases, completely rewritten. Contributors to this process have been:

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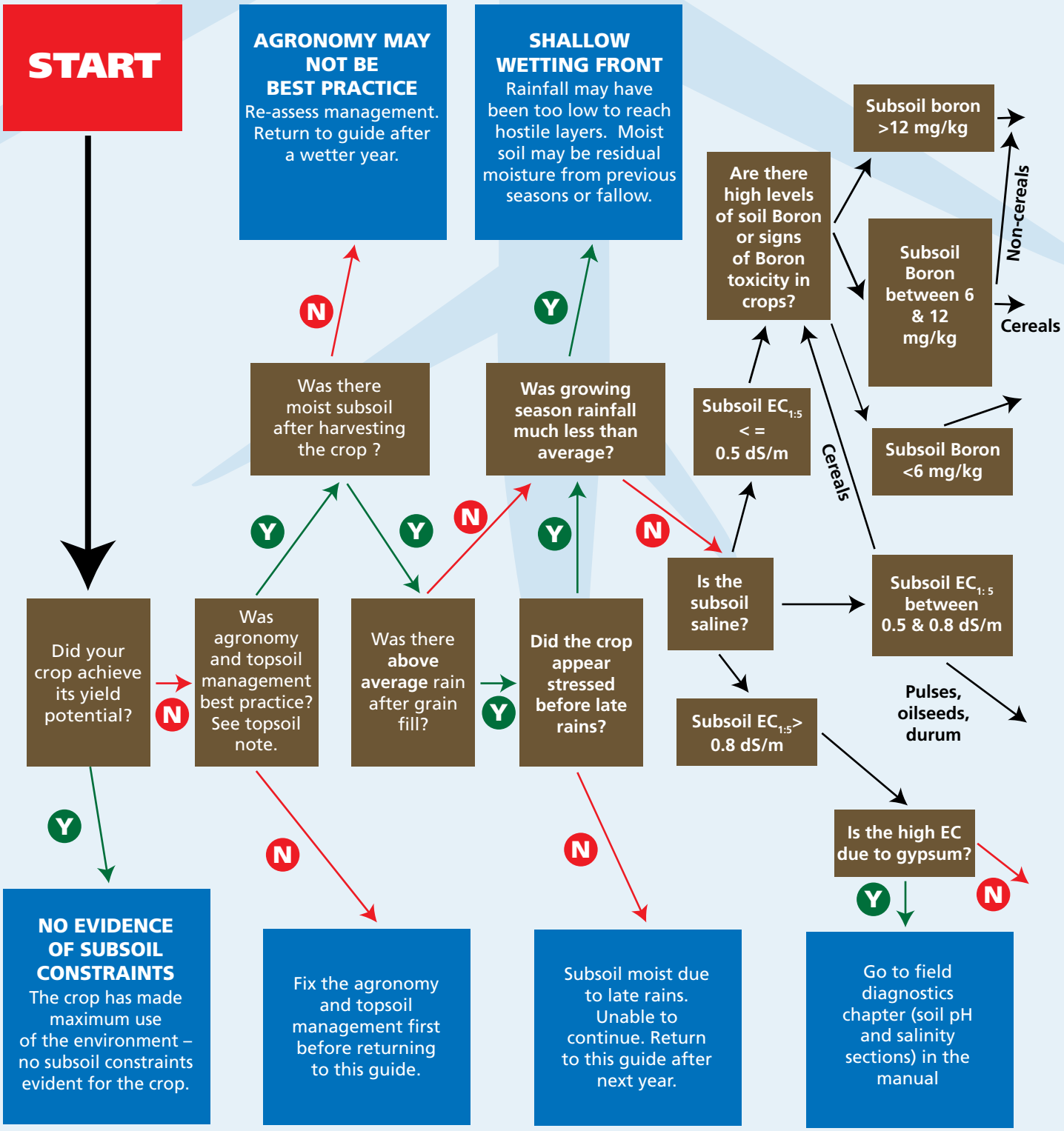
Diagnostic guide to identify the primary subsoil constraint present in neutral/alkaline soil profiles of south-eastern Australia and to suggest appropriate management responses. This guide is designed such that the constraint in the uppermost subsoil layer is identified first, if that should be ameliorated, then the guide could be re-used to identify a constraint in the next lower subsoil layer (and so on). In order to use this guide, the user will require sound knowledge of crop performance on the soil profile being examined, the chemical characteristics of the subsoil in the profile and whether the subsoil is moist after harvest of the crop. The logic of the guide flows from left to right. The subsoil has been defined as the soil below the cultivated layer.



TOPSOIL NOTE: Topsoil management includes all aspects of crop establishment; weed, disease and pest control; variety choice; time of seeding; management of acidity and frost.

Second page of the diagnostic guide to identify the primary subsoil constraint present in a soil profile and to suggest appropriate management responses.