Recent trends in rapid assessment of soil structure in the field

By Dr David McKenzie[1] and Dr Tom Batey[2]

At a recent international meeting in France (see box story) Ian Bradley from the UK National Soil Resources Institute gave a presentation that described how English farmers in the near future will be required to demonstrate achievement of a minimum standard of soil management before receiving farm payments. Rapid field procedures for soil assessment are being developed to support this scheme, with an emphasis on soil structural condition.

The soil management component of the 'Good Agricultural and Environmental Condition' initiative in England is very ambitious. All farmers receiving subsidies will have to draw up a simple risk-based soil management plan during 2006, then put it into practice from 2007 onwards. The overall aim of the program is to provide farmers with the opportunity to enhance the environment on their farms and to reward them for doing so. Also, it is anticipated that farm productivity will improve.

The French soil scientists from INRA (Hubert Boizard, Guy Richard and Jean Roger-Estrade) described their long tradition of using visual-tactile soil assessment in pits as a research tool. Their novel excavation and description techniques allow more complex procedures such as image analysis to be targeted accurately.

Following are brief descriptions of the 10 soil structure assessment methods presented at the conference.

Methods based on soil profile evaluation

- ***Whole profile assessment, Tom Batey, Scotland***

This method had two objectives — first, to determine the inherent capability of the soil and second, to identify any limitations as a result of the management of the soil. Key criteria were soil texture by hand assessment, soil colour; development, strength and stability of structure; soil compaction, degree of fissuring and the presence of roots.

- ***SOILpak method, David McKenzie, Australia***

The SOILpak scoring procedure was originally designed to assess compaction under irrigated black and grey cracking clays, but has been adapted for use on a wide range of soil types and cropping systems in a semi-arid climate in Australia.

Structural form is assessed using a systematic and detailed scoring procedure that has been correlated with soil strength, aeration and the 'non-limiting water range' for root growth.

Key criteria include the size, shape, strength and internal porosity of primary clods and aggregates. The factors are weighted and a score between 0.0 (poor) and 2.0 (good) is calculated at a number of critical depths on the face of a soil pit, down to at least 90 cm.

Over-ride factors can be applied to allow for the presence of smeared layers and inter-connected vertical macropores. The SOILpak score is used to develop tillage recommendations for each study site.

- ***Le profil cultural, H Boizard, G Richard, J Roger-Estrade, France***

This is a comprehensive and detailed method widely used in France for the field assessment of soil structure. An observation face (photo page 59) is prepared using a knife and bellows in a pit three metres wide, 0.6 metre deep cut across the direction of tillage and traffic.

Key criteria include the transition between the tilled layers; internal structural

INTRODUCTION

In May 2005, a "Visual soil structure assessment" field meeting was held in north-east France. The workshop was sponsored by The National Institute for Agronomic Research (INRA), Estrées-Mons, and The International Soil & Tillage Research Organisation (ISTRO).

The aims of the meeting were as follows:

- To compare 10 soil structure assessment methods from UK, France, Australia, Denmark, New Zealand and Switzerland under maize, sugar beet and pea crops in a long term tillage experiment on loess-derived soil. Three of the procedures were based on assessment of the whole soil profile to a depth of one metre. Seven were based on spade inspections of the topsoil.
- Possible improvements for each of the methods were discussed.
- Consideration was given to amalgamation of some of the techniques.

David McKenzie demonstrated the SOILpak "compaction severity" assessment procedures to the group (see below). This method was initially developed by the Australian cotton industry approximately 15 years ago and is part of the 'Land and Water Management' module in the Best Management Practices Manual. The workshop provided an opportunity to see how well the SOILpak assessment procedures compare with the best available practices in other countries, and allowed possible improvements to be explored.

Critical evaluation of the SOILpak scoring procedure at Estrées-Mons.
(Photograph courtesy of INRA)

'Le profil cultural' method, demonstrated by Hubert Boizard in a field that had recently been mouldboard ploughed. Photograph courtesy of INRA.

Graham Shepherd showed workshop participants how to apply the New Zealand VSA system.

state of clods or zones (no visible porosity, no visible porosity with cracks, or visible porosity); type of structural state (continuous, formed with clods greater than 10 cm diameter, or porous without clods less than 10 cm diameter). Field observations are complemented with photographs and image analysis.

Methods based on topsoil examination

- ***Peerlkamp score, Tom Batey, Scotland***

The Peerlkamp procedure is a long-established Dutch method for assessing topsoil structure. It is based on the manipulation of a spadeful of soil. A score is assigned using a key from one (worst) to nine (best). The method is rapid, flexible and low-cost; the results can be validated statistically. Key criteria are size, shape and porosity of clods and aggregates; stability and dispersion on the surface; actual or potential root development.

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- ***A guide to tillage management based on surface soil types, B Murphy, Australia***

The Central West Surface Soil Classification (CWSSC) applies to the soil surface and the top 10 cm of soil. Key criteria are a careful and systematic assessment of the texture and the stability and resilience of structure (including an in-field assessment of aggregate stability and dispersion). The method is used to assist with selection of the most appropriate land management practices for a particular soil.

- ***Visual soil assessment (VSA), G Shepherd, New Zealand***

VSA was developed to provide land managers (regulatory authorities, consultants and farmers) with a simple standardised method to assess and monitor soil quality quickly and cheaply on land in arable or grassland. It is based on the manipulation of a spadeful of soil from the topsoil, and if desired, from lower horizons to examine the subsoil.

Key criteria are the identification and sorting of aggregates by size (see photo page 59), shape and abundance, aggregate porosity, colour, mottles, erosion and earthworm count. Eight indicators are assessed on a scale from 0.0 to 2.0 by comparison with photographs in the Field Guide. An undisturbed reference sample is taken from under a fence or scrub cover nearby.

- ***Soil quality scoring procedure, BC Ball, Scotland***

This is a rapid, cheap and holistic method based on the extraction, manipulation and evaluation of a spadeful of soil. Key criteria include the identification of horizontal layers, their depth and thickness; structure, consistence, macropores, roots and fauna. Separate scores are given for each criteria on a scale of one (worst) to five (best).

- ***Visual soil assessment — spade analysis, LJ Munkholm, Denmark***

The Danish VSA method describes the present status of the soil tilth and relates it to past management practices. It is based on German techniques developed during the 1920s. Key criteria include soil texture, structure (layering, units, density, colour), compaction, anaerobism, root growth, soil fauna and decomposition of organic matter. A record form describing each property is completed. A heavy duty 'Gorbing Spade' and an inspection frame (photo this page) are used to extract and examine the 30 cm long mini-profiles.

Lars Munkolm used a 'Gorbing spade' to demonstrate topsoil structure and root growth.

- ***Assessment of soil structure by visual classification of soil aggregates, G Hasinger and J Nievergelt, Switzerland***

The Swiss method is based on the assessment of soil extracted using a strong spade with a blade of 45 cm. The soil is divided into layers and after fracture of the soil by a drop-test, aggregates in each layer are separated and classified according to size and type.

The diameter of big aggregates is measured directly in cm, the smaller ones are sieved into five fractions with mesh sizes between 0.2 and 20 mm. The clods and aggregates are classified with the help of a comprehensive set of pictures and key codes into 12 different types and put on a scale ranging from one (worst) to 14 (best).

Each fraction of aggregates is weighed and the mean weight diameter (MDW) and the mean weight score (MWS) are calculated for each layer.

- ***A guide to better soil structure, Ian Bradley, England***

This method is principally aimed at farmers and is based on a spadeful of soil dug out to a depth of 30 cm and laid on the ground. A second spadeful may be taken from below plough depth to examine the subsoil. Alternatively, the test can be done by removing soil from the side of a trench. Soil structures are identified by reference to a photographic guide describing good, moderate and poor structures, compaction, impeded drainage, root behaviour and other signs of structural damage.

ASSESSMENT OF THE RESULTS

The soil used for the investigations was of high quality. It had a high content of silt and was water retentive, deep and well drained. Roots were found to depths exceeding 1.2 metres. The land was capable of producing 10 tonnes per hectare of wheat.

Each of the methods under test had been developed for a specific purpose. The results from this unique comparison showed that all the methods classified the soil structure in a similar order, although the degree of detail varied. The best structure was recorded where the primary tillage was based on mouldboard ploughing. The soil which had been surface tilled was less well aggregated and residues of wheel compaction were found within the top 30 cm.

In summary, although the study site was shown to have good structural condition, there was evidence from several methods that the soil structure was not robust and prone to degradation. In general, it appeared from an evaluation of all the methods tested that the information obtained was roughly proportional to the effort put in.

For example, Method 3 (France) produced a highly detailed visual section across the land which was able to locate the effects of each individual tillage operation. But the section took several hours to prepare. The quickest was Method 4 which took less than three hours to complete a total of 30 numeric assessments across the three sites.

In the same time, other numeric procedures could complete only a total of between four and nine tests. But it was considered that the Peerlkamp classes were not well enough defined — modifications were proposed which are undergoing further evaluation.

Do the soil structure assessment procedures in SOILpak need to be improved?

The SOILpak method was well received. It is regarded as an excellent tool for clay soils. But some improvements are being considered for use on the less common soil types that are utilised for cotton production.

A limitation of the SOILpak scoring procedure is that it becomes more difficult to use as the sand content of the soil increases. Dr Paul Blackwell (WA Department of Agriculture) has suggested that more value should be placed on penetrometer resistance under moist conditions in sandy soil.

The application of "moderate" hand pressure to a loamy soil sample prior to assessment of aggregate/clod size and shape is a poorly defined concept for novices, particularly in situations where the soil is dry and extra pressure needs to be exerted on a sample. Rather than break soil samples apart by hand pressure prior to clod/aggregate assessment, it is recommended that a moist sample be dropped onto a wooden board in a plastic crate (as per the NZ VSA system) from a standard height of one metre. Dry samples perhaps should be dropped from a height of 1.5 metres — research is needed to improve this recommendation.

Better photographic standards are required by users of the SOILpak system, particularly on light textured soil. Recent booklets from UK (Bradley) and New Zealand (Shepherd) provide good examples of what is possible with eye-catching illustrations.

The over-ride factor definitions need to be refined, for example via the use of reference images that can be compared with paint-impregnated soil.

Soil processes other than root growth — such as water movement and greenhouse gas emission — need to be correlated with the SOILpak scores.

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HISTORY OF THE STUDY SITE — AN AUSTRALIAN CONNECTION

The workshop delegates stayed in the town of Péronne on the Somme River. It was reconstructed after being badly damaged in World War I. This town and the nearby Mont St Quentin were liberated from the Germans in early September 1918 by the 166,000 strong Australian Army Corps, led by General Sir John Monash.

It was at times an eerie experience, digging and examining pits in a landscape that once was covered by extensive networks of trenches and fortifications. Fortunately we did not strike any unexploded shells during the workshop and lived to see another day.

There are many other fascinating WWI sites within 20 kilometres of Péronne. They include the village of Villers-Bretonneux near Amiens where the course of the war was changed in favour of the allies by the innovative tactics of Monash's troops and their associates on Anzac Day 1918. Further north are the cemeteries and memorials that remind visitors of the massive casualties associated with earlier battles of the Somme in 1916.

The achievements of the Australians 87 years ago still are strongly remembered by the appreciative locals. It is a very friendly, advanced and surprisingly scenic part of the world.

A chalky clay soil profile in World War I trenches near Hamel.