REPORT

A REVIEW OF TECHNIQUES FOR THE ASSESSMENT OF SOIL PHYSICAL CONDITIONS IN THE FIELD

BY

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This Report is based on field research carried out between 18th May and 6th July 1990 at Trangie, Narrabri and UNE Armidale. The primary objectives were to evaluate the SOILpak project as developed for irrigated cotton grown on cracking clays, leading on to a general evaluation of soil extension activities in NSW. Other objectives were listed in the itinerary prepared prior to the visit which are discussed in Section 3 of this Report.

CONTENTS

Introduction

Techniques for the examination and assessment of the physical condition of a soil in the field have been available for some time - Peerlkamp 1967, Strutt 1970, and MAFF 1973. Reports showing the benefits of deep cultivation to break up compact subsoil go back as far as 1852 (Johnston) with more recent research by Russell 1956 and Swain 1973. A review of soil compaction was published by Soane (1983). The techniques of soil examination are similar whatever the soil and whatever the crop: careful and systematic dissection of a soil face to reveal both natural and man-made features which can then be classified in absolute or relative terms.

Land degradation has been identified as one of the most critical environmental issues in Australia. The examination and evaluation of soils in the field has a vital role to play in the characterisation of degradation and in its prevention and control. Because sound knowledge of many sciences is involved when assessing the whole of the soil environment - physics, chemistry, microbiology, plant physiology, mineralogy, geology and soil mechanics - comprehensive examination of the soil is mainly the province of those with a qualification in soil science. However, other disciplines as well as farmers and farm staff can be trained to deal with particular aspects, for example tillage needs and effects, provided that specialist back-up is available when required.

Principal Conclusions

SOILpak: The manual is comprehensive though some simplification is recommended and a separation of field evaluation from aspects relating to management of the cotton crop should be considered. Future effort should be biased towards promotion of field examination of soils rather than further refinement of the Manual at this stage. Continued support for the SOILpak project is recommended and related research is essential to provide growers with the information needed to maintain a viable and sustainable industry.

Staffing: Bearing in mind that many soils in NSW are fragile and readily degraded, there are too few Soil Scientists either engaged in research or particularly as Advisers. This is a serious omission in the train of scientific communication. The presence of an Advisory Soil Scientist is essential to provide support to growers, District Agronomists and other disciplines and to provide a two-way link between pure researchers and those working in the field. Without this link, the Agricultural Industry is deprived of the type of support readily available in other countries. There is an urgent need for the creation of the post of Advisory Soil Scientist with appropriate career structure and support.

Research: Priority should be given to research into the measurement and significance of soil compaction on cotton farms, into the effects on compact soil of drying through crop transpiration and into soil mechanics aspects of the pressures currently applied beneath cotton pickers. Where research projects are conducted at Research Stations by recent graduates, access to a Senior Soil Scientist should be on a local day-to-day basis for their progress to be effective and to make efficient use of the facilities provided.

SECTION 1 THE SOILpak PROJECT

Following the identification of soil compaction as a major problem affecting cotton yields in the late 1970's, the need for a systematic approach to soil examination was clear. Support from the Cotton Research Council was obtained and techniques appropriate to irrigated cotton grown on cracking clays were developed. Several draft texts were prepared and the March 1990 version has been used in this evaluation.

The University of New England Department of Agronomy has collaborated with NSW Agriculture and Fisheries in developing SOILpak, particularly Dr D A MacLeod. Further research into the techniques is in progress, described in Section 1.3, and Ms S Greenhalgh is registered for a Master's Degree at UNE under Dr MacLeod's supervision.

Two seminars dealing with SOILpak were attended by the author of this Report, one at Trangie on achievements and future directions and the other at Narrabri on editorial and scientific assessment.

Additional support for the SOILpak project was given by the Soil Management Service which had been set up in the Macquarie valley by NSW Agriculture and Fisheries in 1986. In this area, soil examination has been widely used as a routine test with over half the cotton growers having had pits open though only a small number examine their soils every year. Elsewhere, the technique has been little used as yet, which may reflect the sparsity of trained personnel rather than lack of interest on the part of growers.

SOILpak is described in the Manual (Daniels and Larsen 1990) as "a soil management package for cotton production in cracking clays." It is aimed at a wide range of potential users within the cotton industry - state and private advisers, growers and researchers. The procedures concentrate on providing the skills needed to assess the physical condition of a soil in the field. This information is then used to select a rotation of crops or appropriate tillage to maintain or improve the structure of the soil and in particular to deal with soil compacted during harvest. By definition, the soil management package is restricted to use on irrigated grey and brown cracking clays of the Australian cotton industry. In this Report, it is assumed that the reader is either familiar with SOILpak or has access to the 1990 manual.

Research during this visit involved visiting some 20 properties where almost 60 soils were examined, mostly in backhoe pits, some by spade. The use of SOILpak by District Agronomists, private consultants and Company Agronomists was observed. Discussions on soil management were had with growers and their needs and interest assessed. The reaction and response of consultants and other participants attending the Namoi Valley Workshop was noted.

1.1 Evaluation of SOILpak procedures in the field

In the Section in the manual dealing with soil pit observations, 21 separate tests are given - 14 for use on soils directly in the pit, 2 on cotton plants and 5 supplementary laboratory tests on soils. Some are relatively permanent and would not need to be repeated if the same soil was examined on another occasion; most are transient and relate to changes induced by tillage or harvest ofthe crop.

All the tests are comprehensively described and are based on sound and well established methods. For them all to be done in a pit would require at least 1½ hours. In practice, experienced examiners using SOILpak take much less time then this as they go straight for the components judged necessary to assess the dominant problem in any particular soil. It would be helpful if the authors of the Manual could identify *key* components which can be identified on the face of a soil pit. These would appear to be:

* the detection of compact soil - its intensity, dimensions, location and significance

* the detection of thin smeared layers in critical positions, e.g. within the hill

* the stability of the structure, both on the surface of the hills and in the furrows

* the overall porosity and structure of soil within and beneath the hill

* the pattern of crop roots - their shape, depth and reaction to compact soil

Can these criteria be assessed directly and more simply than by proceeding stepwise through each and every test? There appears to a danger that too much detail may obscure the overall assessment. Are all the tests needed to make a sound assessment? For example, there were queries from some of the participants during the Narrabri Workshop over the value of 'shape of aggregates' and 'porosity within aggregates'.

The procedure for selecting the location within the pit for the assessment of a particular property is not always made clear. For example, the assessment of plastic limits in relation to proposed tillage should be done just below the maximum operating depth of the implement to be used.

The approach adopted by those with extensive experience in soil evaluation is less formal than SOILpak and involves very careful and delicate dissection of the soil to locate any differences created by tillage or pressure, however small. The latter technique was demonstrated by the author in all pits examined by using the pointed blade of a pocket knife. By this means, it was possible to detect narrow bands of soil which had been smeared by a single pass of a specific tillage operation. Such conditions were frequently found, which were of much interest to growers.

To assess post-harvest compaction after cotton, a trench dug with a backhoe across a number of cotton hills is necessary to make an adequate

evaluation. However, there are several situations where soil examination is required but where a backhoe is inappropriate or may be unavailable. For example, following injection of ammonia, the passage of a weeder sweep, a lister body or before or after the use of a chisel plough to break up compaction. In these situations the use of a small spade or mattock should be encouraged.

An example of the need for careful examination of soil at a shallow depth soon after planting was seen at Dunbar, Brookstead. When examined at harvest, the tap root of some 60% of the cotton plants was bent at right-angles 10 cm below the hill crest. However, by then all signs of any prior physical discontinuity in soil properties at this depth had disappeared in the classical self-mulching vertisol.

In any future workshops planned to promote SOILpak, consideration should be given to the following topics which could be dealt with indoors prior to the sessions in the field. This can be done very effectively if speakers prepare appropriate stimulating talks/demonstrations which utilize the experience of the participants.

* further scientific background to the growth of plants and roots

* a discussion on the factors concerned with the development and stability of soil structure

* training in the assessment of soil texture when a full range of moist soils of standard textures can be demonstrated. It takes a relatively long time in the field to demonstrate the technique and to identify one or two soil textures, when there are no other soils available for comparison.

It must be remembered that while some participants may have received formal training in soils they may have had little subsequent opportunity to gain experience and that some revision of basic principles can be beneficial.

1.1.1 Quantitative assessment of soil physical conditions in the field.

During examination of backhoe pits it became apparent that compact zones of soil detected by visual and tactile means could vary in their degree of compaction. A numerical method of evaluation was therefore devised specifically for the conditions found under cotton, shown in Appendix 1. This was based on earlier methods of similar type (Batey 1988, Peerlkamp 1967, Boekel 1963) and was demonstrated to several Agronomists. If the method proves useful, further refinement may be made to improve the categories designated. For example, to make an adjustment in the procedure to deal with soils of differing water content.

1.2 Editorial and scientific assessment of the SOILpak manual

Only broad aspects concerning the principles are discussed here. Detailed comments on the text or on the techniques have been made direct to the authors and the dialogue can continue as further refinements are introduced.

The strength of SOILpak lies in the formal approach, wealth of detail and logical progression from test to test. The science is sound throughout and comments in this Report are concerned mainly with the balance and the means of achieving the overall objectives.

The project leaders must consider what is the primary objective and to keep it in perspective. This would appear to be that: *field examination and evaluation of the physical state of the soil must be done regularly by cotton growers to enable an economic and sustainable sequence of tillage and cropping to be established and maintained.* If this is correct, the primary objective should be borne in mind and it is felt that promotion should now take precedence over further refinement of the manual. However detailed a text is provided it does not seem practical to cover every eventuality; there will always be exceptions and variations to take into account. It is also necessary to establish sound methods of soil examination prior to the computerization of SOILpak; the former will determine the success of the latter.

Within the manual, emphasis is correctly placed on the identification of compact soil as its presence initiated the project. However, this approach must be balanced by examination and assessment of good soil too, particularly within and beneath the hill, and between and below any damaged zones.

The SOILpak form used to record observations on soil properties was well designed and straightforward to use.

Is the detail given on soil tests excessive? The answer to this question may lie with the proposed users of the manual. For growers or their consultants who may have no background in soil science, the descriptions of soil tests, particularly those in Chapter C3a, may be too detailed. To overcome this difficulty, more attention should be paid in the Workshops to the basics of soil science. Where qualified and experienced soil scientists were involved, much less detail would be needed and the use of the manual would be mainly for training and education or the revision of dormant skills.

The length of the text can detract from its ready acceptance. As well as giving comprehensive details on soil tests, it includes a detailed approach to the management of cotton, covering rotations, tillage and water use. Should management aspects be separated from soil examination? On balance, a separate field user handbook restricted to the examination and diagnosis of soil conditions would have advantages, possibly of the type noted in the paragraph below. This could also be developed for much wider use on any soil and for any crop. An accompanying and more comprehensive book on soil management for cotton could be prepared for consultation/discussion, based on the information obtained in the field. The latter may be adaptable to computer use.

The manual is unwieldy for direct use in the field. One suggestion made by Dr MacLeod was to provide only the pages needed to assess soil properties in the field, in the form of a small multi-paged plastic wallet; an example was shown to the authors of SOILpak.

1.3 Evaluation of method refinement research

A pilot project began in February 1989 and further funding from the Cotton Research Council was obtained to support the work until 1993. The objectives are to develop methods to measure physical properties of soils which can be reliably and rapidly used to support and quantify the assesment made in a backhoe pit using the SOILpak technique.

The methods evaluated in the field during the first growing season 1989/90 included:-

* soil bulk density using cylindrical cores

* macroporosity using rhodamine dye

* soil resistance using a recording penetromter

* cotton root morphology

Comprensive statistical analysis of the first year's results is not yet complete. Extensive discussions were held with Ms S Greenhalgh, Dr D A MacLeod and Mr D C McKenzie on the results obtained to date and on possible future tests which may be incorporated. These included a hand-held penetrometer to measure in the horizontal plane the resistance of visually compact layers, piezometers to measure water infiltration and shear vane measurements for soil strength as well as those already listed in the proposals.

One of the unavoidable difficulties inherent in this type of research is to create a range of comparable physical conditions within the limits likely to be found in practice and within a range to which the test crop, cotton, can show a suitable response.

This research program is an important and essential support both to the SOILpak project and directly in its own right to the understanding of the physical state of cotton soils.

1.4 Conclusions and recommendations

The SOILpak project is unique and continued support is fully justified. The enthusiasm and skills of those involved was evident and their work should be strongly supported. The manual is comprehensive and sound, though simplification of some tests could help its progress. In its present form it is not suitable for direct use in the field and crop management aspects should be separated from the techniques of field examination of soil pits. There was a need to stress the properties of good soil as well as that which had been damaged. Sound records of soil descriptions must be kept in order to follow changes in the soil over time and thus to enable management decisions to be evaluated.

Supplementary techniques for the examination and evaluation of soils in the field were demonstrated whereby thin smeared layers created by the passage of tillage and other implements could be detected. These have important

implications for management and these techniques could be incorporated into the manual. Further work on the means of quantifying compact soil was required.

Suggestions for improving training workshops were made, by undertaking more of the work inside using soils that clearly illustrate the characteristics of specific conditions.

The overriding recommendation is to increase the use of soil examination by cotton growers. Judging by the condition found in many soils, the need for its use is unequivocal and greater promotion is justified.

SECTION 2 FUTURE SOIL RESEARCH AND EXTENSION ACTIVITIES

2.1 In the Australian cotton industry

Sound techniques for the assessment of soil physical conditions in the field are now well established. While it is accepted that compaction is common, many growers do not use these techniques and some effort should be made to find out why they are not used more widely. Certainly soil examination has a mystique that is not always dispelled by its proponents. Specialised skills in communication are involved as well as the direct evaluation of the soil condition. It is also important to follow up each evaluation with a written report which describes for future comparison the condition found as well as recommendations based on the soil properties. As many growers use neutron moisture meters to schedule irrigation, an attempt should be made to link the data obtained to the evaluation of soil conditions.

Confidence in the techniques of soil examination can only be established, and also maintained, if the condition of soils can be linked to both the costs of production and to yields of cotton. An input of research into this type of 'near-market' project is just as important as fundamental work. More needs to be known about the direct and indirect costs of compaction. For example, it may be possible to still achieve reasonable yields on compacted soils in some seasons by increasing the frequency of irrigation and the rate of N application but we need to have information on the extra costs involved.

Recent research into soil compaction has lead to recommendations that axle weights should be restricted to a maximum of 6 t where traffic on moist soils is unavoidable (Hakansson 1989), otherwise there is the possibility of compaction being so severe that it is irreversible. This weight is much less than that of the drive axle on a 4-row cotton picker which may be as much as 13 t when fully laden with crop and fuel. The significance of this research to cotton production should be further evaluated.

Much emphasis within the SOILpak manual is placed on the fracturing potential of smectite clays when they dry; hence the use of the expression 'biological ripping'. Bearing in mind the comments on soil compaction in the foregoing paragraph, it would seem unwise to base important management decisions on the expectation of the complete fracture of compacted soil,

without confirmation of the phenomenon by direct examination. Further research into 'biological ripping' is justified.

If the present proposals to train District and Company Agronomists, consultants and growers in the techniques of soil examination are fully implemented, there will be an increased need for back-up support by qualified and experienced soil scientists. This specialist input is required to provide any update of techniques, to run refresher courses and also to train new entrants. In addition, experience has shown that the skills and enthusiasm of non-specialists for soil examination tends to wane because of the workload of their mainstream interests. There are risks if the latter are left unsupported and the technique of soil examination may lose credibility and confidence amongst growers. There is a strong case for the creation of Soil Science Advisers, one of whose roles would be the examination and evaluation of soils in the field.

2.2 On other soils and other crops in NSW

Taking a detached and objective look at the organisation of soil science within the NSW Agriculture and Fisheries, the position of Advisory Soil Scientist appears to be missing. This has been highlighted by the present project on SOILpak. The techniques being promoted have been used in Britain and elsewhere for over 30 years. In England & Wales, for example, there are at present 44 Advisory Soil Scientists within MAFF; the minimum qualification is a good Honours Degree in soil science and many have Higher Degrees. Their role is not only to examine and evaluate soils in the field but to advise on all aspects of soil science including pollution and the environment, to determine research needs and priorities and to plan and execute field experiments.

Land degradation is considered to be Australia's most critical environmental issue. Soil examination and evaluation has a vital role to play in the characterisation of degradation and its prevention and control. Field examination should be a technique available for any crop and for any soil. With the major contribution made by crops and livestock to the GNP and the highly fragile nature of many soils in NSW, the creation of the post of Advisory Soil Scientist must be considered as an urgent priority.

T Batey 14.09.90

SECTION 3 OTHER TOPICS STUDIED

The topics discussed in this section are based on those described in the itinerary prepared prior to the visit.

While Based at Trangie

3.1. Use of the α-α' dipyridyl test for ferrous ions to assess the degree of waterlogging.

This test was demonstrated to research staff at Trangie and its use discussed; the bright red colour indicative of the presence of ferrous ions was found when a compacted and waterlogged soil taken from a stock trackway was added to the solution. Problems that had been experienced earlier when cotton soils were tested were due to the absence of ferrous ions in the soils analysed, possibly linked to the lack of an adequate substrate for the multiplication of the microbial population. The method is useful for field use to detect anaerobic pockets of soil as described by Batey and Childs (1982) and Batey and Killham 1986). One such pocket was located under cotton in Block 19 at Auscott Warren and the presence of ferrous ions confirmed by the dipyridyl test.

3.2. Comparative effects of cotton picker tracks and wheels on soil physical conditions.

A four-row picker fitted with half-tracks was seen working on Mr Tony Quigley's property. The tracks were fitted over normal-width tyres on the driving wheels and round a smaller diameter idler wheel. Considerable extra traction was obtained; the tracked picker could travel under almost any soil conditions and was seen traversing the field without difficulty when a 2-row picker was getting bogged. Its use under very wet and soft conditions was self limiting as ruts were formed up to 15 cm deep; severe soil damage was obvious as the hills were pushed out from 1.0 to 1.15/1.18 m. The degree of sinkage suggested that soil compaction was not likely to be significantly less than under a wheeled picker used under equivalent conditions.

3.3. Delivery of a guest lecture at a soil assessment and land preparation field day.

Dr Batey was principal speaker (with Adam Kay) at a 'Soils Field Day' organised by Col Mullen at Gilgandra. Six backhoe pits were exposed, described to farmers and their management discussed.

3.4 Provide input at a 'Dryland Red Soil Management' research planning meeting.

This was held at ARC Trangie on 4th June; a summary was prepared and circulated by Ms P Commins. Several discussions were held subsequently with the staff involved.

3.5. Visit saline/sodic clay management experiment at Condobolin.

Due to rain curtailing visits to cotton properties at the beginning of the programme, it was not possible to visit Condobolin.

While Based at Narrabri

3.6. Editorial and scientific assessment of SOILpak manual development.

A report was presented to the Project Committee and Editors at an evaluation meeting held at Auscott Narrabri on 18th June.

3.7. Discussions about nitrogen and other plant nutrients with researchers in cotton nutrition.

A meeting with Dr A Hodgson was held on 18th June when he described his work on nitrogen and iron nutrition. Casual discussions took place with other researchers, including the Engineering Group at Trangie.

3.8. Participate in 'Namoi Valley Cotton Soil Management Workshop'

Assistance was given to participants as needed and their comments and reaction are incorporated within this Report.

While based at the University of New England

3.9. Preparation of a Report containing recommendations about future soil research and extension activities in the Australian cotton industry, and presentation of a seminar outlining its content at Head Office, NSW Department of Agriculture and Fisheries.

The seminar was presented on 6th July

3.10. A summarised version of the Report to be prepared for publication in the Australian Cotton Grower magazine.

Discussions were held with Dr D A MacLeod and an article has been drafted 'Know Your Soils - the Key to Success and Profit'; consideration was also given to the preparation of an article for submission to the Journal of Soil and Water Conservation.

3.11. Examination of soil conditions and cotton management in the McIntyre, St George and Emerald districts, Queensland.

These visits were not made but black vertisols on one cotton property were examined in Queensland (Dunbar, Brookstead) on 10th June during the holiday weekend.

SECTION 4 DIARY OF VISIT

Incorporating properties visited, seminars given and other activities.

17th May Arrive Sydney from UK.

18th May BCRI Rydalmere - meeting with Senior Staff to discuss the background to the visit and tour of the Chemistry Branch.

19th May Travel to ARC Trangie (D C McKenzie)

21st May a.m. Seminar at Trangie to discuss achievements and future directions of SOILpak, and soil management research at Narrabri and Trangie.
p.m. Visit to Auscott, MacQuarie Farm, Warren to inspect cotton picking and the gin in operation.

22nd May Visit to Ellengarah - machinery for cotton tillage and injection of AA (J Smith, A Bell); too wet for fieldwork.

23/24th May Review of current soil projects -too wet for fieldwork.

25th May Soil pit examination - J O'Brien, Bellevue; report on 4 pits and review of soil management subsequently sent to A Kay, Warren.

28th May Preparation of reports on soil evaluation.

29th May Further examination and photography of soil pits at Bellevue; soil examination at ARC Trangie.

30th May)
31st May) Soil pit examination - Auscott, MacQuarie Farm, Warren which
1st June) was restricted because of rain and wet ground conditions; report on 10 pits subsequently sent to A Kay, Warren.

4th June Participate in planning meeting on 'Dryland Red Soil Management', minute subsequently prepared by P Commins.

5th June Examination of red soil backhoe pits at Trangie Cemetery.

6th June Examination of backhoe pits at Ellengarah, including one dug behind innovative tillage and AA injection equipment (J Smith); report subsequently sent to A Kay.

7th June Preparation of soil reports.

8th June Soils Field Day, Gilgandra.

(9-11th June: Holiday weekend)

9th June Examination of black vertisols under soybean and cotton, courtesy of S Leadbeater, "Dunbar", Brookstead, Queensland; report subsequently prepared.

12th June Examine effects of 4-row cotton picker fitted with halftracks, A. Quigley, Warren.

13th June Discussions with Engineering section, ARC Trangie (A Palmer, N Gould, R Lund).

14th June a.m. Present seminar, VIC Trangie 'Soils: their use and misuse'.

p.m. Examination of soil pit at C Quigley, Warren.
Travel to Narrabri (S Greenhalgh)

15th June Discussions with research staff at ARS Narrabri - A Hodgson, I Daniels, D Larsen.

18th June a.m. Review of SOILpak presented at Auscott Narrabri.

p.m. Present seminar, ARS Narrabri 'Soil Management in Practice'.

19th June Prior inspection of soil pits, Narrabri and Wee Waa.

p.m. Recording of 15 min talk for ABC radio, broadcast on 20th.

20/21st June Participate in Namoi Valley Cotton Soil Management Workshop.

p.m. 21st Travel to Armidale (Dr D A MacLeod).

22nd June) Meet UNE Staff, preparation of reports.
25th June)

26th June Visit with Dr D A MacLeod and Max Woods to grazing properties to examine soils and grass utilization, discussions on application of lime to basaltic soils: C Munsie, 'Lombardy', Furracabad, Glen Innes and G Munsie, 'Gerri', Glencoe. Reports later prepared.

27th June Preparation of seminars; review of S Greenhalgh's project.

28th June Meeting with Mick Duncan, District Agronomist, Armidale, and Assistant Agronomist Ruth Barclay in Office, field visits were not possible due to wintry weather.

29th June) Preparation of seminars and report.
2nd July)

3rd July Present seminar to the Department of Agronomy and Soil Science, UNE, Armidale 'Evaluation of Soil Problems in the Field'.

Travel to Inverell; attend seminars presented by Soil Conservation Service Staff:- Adrian Harte: 'Overview of research on soil structure and erosion studies in the North, with an emphasis on cracking clay soils' and B Murphy: 'Tillage practices, soil structure and productivity on Red Brown Earths'. Overnight at Inverell.

4th July Field visit with SCS Staff and Dr D A MacLeod; examination of soil physical conditions and discussions on soil management problems in Warialda, North Star, Boggabilla and Moree Districts.

5th July Travel to Sydney.

6th July Present concluding seminar at McKell Building: 'A review of techniques for the field assessment of soil physical conditions'

7th July Depart Sydney, return to UK.

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APPENDIX

NUMERICAL ASSESSMENT OF SOIL STRUCTURE AND COMPACTION
(Revised version of 07.06.90)

Tom Batey

How compact is compact?

While layers of compact soil can be identified by careful dissection of a soil face, it is often necessary to qualify the degree of compaction before decisions on tillage and cropping can be made. The factors involved include the position of the compact layer below the surface, its thickness and its density. In order to aid the assessment of the density and strength, a numerical scale has been devised.

The scale has been designed specifically for irrigated cotton grown on clay soils though it may be adapted for other soils and for other crops.

Soil strength is strongly dependant on moisture content so the test has been based on an assessment of moist soils, at or close to field capacity, and for a soil face exposed to a depth of at least 1.0 m in a back hoe trench.

When handling and assessing soil the question to keep in mind is how suitable is this soil as a medium for root growth and the entry of air and water.

Method

Begin at the surface and by probing and flicking with a pointed knife, work downwards and remove any loose or smeared soil to expose the natural face.

Observe whether the soil is loose or has been combined into a distinct layer. Note the upper and lower depths of each layer identified.

If the layer of soil is made up of separate aggregates, use the first part of the key to assign to it a category, C1, C2 or C3.

To assess compact layers, test their relative strength by flicking pieces out and by probing. For thick layers, stand back above the edge of the pit and with a spade, carefully push off all loose soil above the compaction into the pit for a distance of about 20 cm behind the edge.

Now firmly push the spade vertically into the compact soil, also about 20 cm behind the edge, deep enough to enable an entire block of the compact layer to be levered off. Lift this block out and place it on the surface nearby for assessment of its strength and the nature of the fracture planes. The relative pressure required to insert the spade and the force needed to loosen the block also gives an indication of the strength of the compact layer.

KEY

Loose Soil

C1 Comprised wholly of natural aggregates with round, subrounded or subangular shapes; a range of sizes may be included appropriate to the depth from the surface; note the size range of the dominant fraction.

C2 As C1 but at least half present as larger compound aggregates which can be broken up by hand into their constituent natural aggregates; note the size range of the dominant fraction.

C3 As C2 but where some of the larger units are dense and massive clods; note the size range of the dominant fraction.

Firm layer of soil, usually horizontally orientated but if not, indicate the angle.

C4 Breaks up readily into porous sub-units along natural fracture planes which may have a smooth and shiny face, or the fractured edges may be rounded and with the exposed internal surfaces rough and with sub aggregates protruding.

C5 Some planes natural but distinct force needed to break blocks apart, fracturing taking place mainly across the line of the force applied to produce angular corners and mainly non-porous internal surfaces.

C6 Difficult for spade to penetrate; lumps of soil levered off made up of large tight-fitting blocks which fracture across the lines of force applied in any dimension into units with sharp right-angled corners, finely grained and even internal surfaces and with no pores visible or sub aggregates projecting from the fractured surface.