PROJECT CS12L: PHYSICAL DEGRADATION OF CLAY SOILS IN RELATION TO MANAGEMENT FOR COTTON PRODUCTION - FINAL REPORT

AIMS

1. To determine the mechanical and physical consequences of land preparation and harvesting on the soils and to relate these effects to soil water content.

2. To develop and assess methods for ameliorating undesirable physical conditions in heavy clay soils.

3. To develop and assess methods for predicting and classifying clay soils with relation to susceptibility to deformation, consolidation and shear under load during cultivation and harvest.

PROJECT FINDINGS

The cornerstone of this project has been to provide a sound, physically based description of the manner in which soil deforms in response to applied stresses, such as those due to heavy vehicles. It has been shown that the "critical state" description of soil behaviour is applicable to unsaturated soils; previously it was applied mainly to saturated soils. This description explains both the compression and shear behaviour of the soil. It has been found possible to establish the main features of compression and shear behaviour from a relatively small number of soil mechanics tests.

The main conclusion drawn from this is that soils that are sufficiently wet to be compressed are also sufficiently wet to be sheared under wheels. Potentially shear may be more damaging to infiltration and drainage than compression alone. An important outcome is to demonstrate that shearing of the soil is always likely, and for irrigated cotton soils will often be the main process of physical degradation. (Note: a saturated soil will not compress beneath a tyre but will shear.) This is important for a number of practical reasons.

1. It provides a soundly based physical explanation of the effects, observed in the field by McGarry and others over recent years, of physical degradation of the soil with little change in bulk density. This type of research can now be much better focussed on the correct manifestations of the problem. This is also true of laboratory investigations, which should not be directed solely at investigating volume change effects.

2. It has lead to the establishment of straightforward rules regarding the likelihood of damage beneath tyres and tracks. These rules follow from observations that; firstly, much damage results from shear deformation when the ground contact pressure of the vehicle approaches the bearing capacity of the soil (i.e. the maximum pressure that the soil can withstand); secondly, that the bearing capacity of the soil is directly related to the shear strength; and thirdly, that the shear strength is strongly dependent on moisture content. Thus, the damage can be related to the moisture content, and it turns out that for most vehicles the ground is trafficable with little degradation provided that the soil is drier than about the plastic limit (a readily measured soil property).

The project has addressed the aims by showing how soil deforms in response to traffic and how this is affected by moisture content (aim 1). This has led to the suggestion of the use of the plastic limit to predict and classify clay soils with relation to susceptibility to deformation, consolidation and shear under load during cultivation and harvest (aim 3). Aim 2 has not been addressed directly because all soil can be degraded when wet irrespective of any amelioration. Rather, it is suggested that degradation be avoided through sound knowledge of when degradation may happen.

RECOMMENDATIONS FOR FURTHER WORK

The main shortcoming of this work is that it has concentrated on soil types from a very limited number of sites (Myall Vale Research Station and Auscott, Warren). The extension to a wider range of soil types is important.

Another shortcoming, allied to the first, is that the variability of soil mechanics properties and soil moisture content has been found to be quite large. Future work should study this variability over a range of soil types. Without such work the reliability of management rules cannot be assessed.

PUBLICATIONS ARISING FROM THE PROJECT

1 Kirby, J.M.,1986. Some comments on The determination of best fit 1inear failure envelopes to Mohr circles, discussion. J. Agric. Engng. Res., 35: 287-8.

2 Kirby, J.M., 1986. Stress-strain relations in soils and the process of compaction. Australian Soil Science Society Inc. Symposium on Compaction and Engineering Properties of Soils. 10-11 Apr., Brisbane. Summary published in Soils News, 68 (July): 9.

3 Kirby, J.M., 1987. Soil management and soil mechanics: the effect of one upon the other. In National Workshop on the Effects of Management Practices on Soil Physical Properties. Eds. Coughlan, K.J. and Truong, P.N. Toowoomba, Queensland, 7 - 10 Sept., 154-157.

4 Kirby, J.M. Measurements of the critical state and yield surfaces of some unsaturated agricultural soils. J. Soil Sci. (In preparation).