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The problem of cementation

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1 *Summary*
Under certain soil conditions, cotton strips may become 'cemented' and this may increase their measured tensile strength from its 'true' (uncemented) value. Two kinds of cementation, concretion (cementation by fine solids) and biotic cementation (resulting from microbial growth), are recognized, and some suggestions are made for dealing with the problem when comparing different soil types.

2 *The problem*
In some soil types, or with particular conditions or treatments, cotton strips may become 'cemented', ie some external agent acts on the fibres to bind them together, thereby possibly increasing their aggregate tensile strength (TS) over the uncemented state. Also, some of the features of fabrics listed by Sagar (1988) as having an effect on tensile strength (particularly yarn strength and effects of crossing threads) could be influenced by external agents in soil.

French (1984) distinguished 2 kinds of cementation:

i. concretion — cementing by fine solids, eg clay or lime;
ii. biotic cementation — cementing by a variety of biotically produced bonding agents, eg microbial polysaccharides and root exudates; resins may also be involved, but are often only a superficial deposit.

The first is an essentially abiotic 'physical' process, often not easily detectable without uncemented strips for comparison, but its effects can be measured by assessing the effect of artificial cementation with the relevant cementing agent (eg Figure 1). However, care

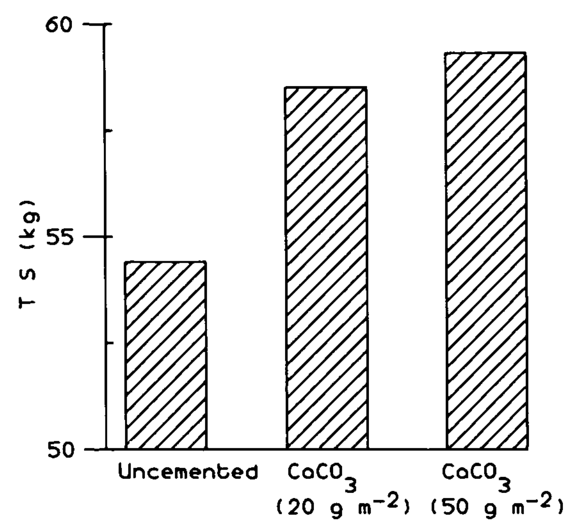

Figure 1. Effects of artificial cementation (concretion) with $CaCO_3$ on tensile strength (TS) of unrotted cotton strips. TS in both treatments is significantly higher than uncemented TS ($P<0.001$, t-test)

is necessary to ensure adequate mimicking of the field conditions, especially the processes involved in impregnating the cloth with the cementing agent; compare the attempts to cement cloth with calcium salts by French (1984) and Latter *et al.* (1988) using different methods. Occasionally, an experienced cotton strip handler may be able to detect from the 'feel' of a strip whether it is cemented in this way.

Biotic cementation, conversely, is usually easily detectable from the 'feel' of a strip and its fraying behaviour. Symptoms include:

i. observable coating of the threads (under a low-power light microscope);
ii. perceptible thickening of the cloth;
iii. a tendency to a felted texture;
iv. sticky or slimy coatings, especially when still wet, often hardening on drying;
v. cloth not cutting as cleanly as uncemented cloth;
vi. threads tending to stick together when test segments are frayed.

This list of indicators is not exhaustive, and all these features may not be present together, even in a heavily cemented strip, but, using these or similar criteria, it is possible at least to rank strips as uncemented, cemented or heavily cemented. However, while biotic cementation is easily detectable, it is not easy to induce it artificially under controlled conditions, especially in combination with normal activity of soil microflora. Further, because it is usually only present on partly decayed strips, it may not be possible to measure its effects on the TS of the cloth. There are some indications (Latter *et al.* 1988) that the potential effect may be at least as great as that of concretion, and Figure 2 shows that some effect was probably present in at least one field study (French 1988).

However, TS increases are not all due to cementation. The early TS increase observed by Holter (1988), for example, is more likely to be an effect of removal of lubricants, as noted by Smith and Maw (1988). The large increases in TS observed in field control strips in moss turves on Signy Island (Wynn-Williams 1988; Heal *et al.* 1974) do, however, seem to be related to the extremely high quantities of mucopolysaccharides found in those sites (D D Wynn-Williams pers. comm.), so this example may be an extreme case of biotic cementation. Latter *et al.* (1988) were not able to reproduce this effect with mucopolysaccharides alone in pure culture, but there could be many possible interactions of such potential cementing agents with other soil constituents, greatly increasing the overall degree of cementation.

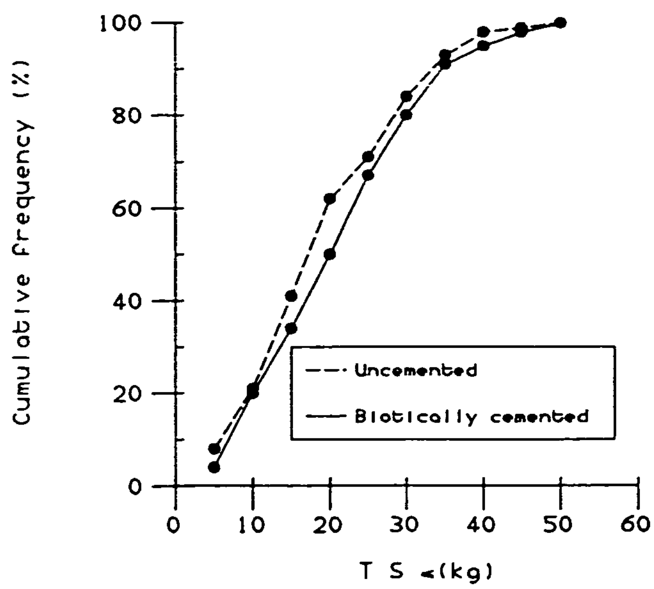

Figure 2. Cumulative percentage frequencies of TS of uncemented and detectably biotically cemented strips from a field experiment. Cemented strips have higher TS than uncemented ones (Kolmagorov–Smirnov test, $n1 = 213$, $n2 = 207$, $X^2 = 5.36$, $0.05 < P < 0.1$). Difference in TS at 50% frequency = 3.5 kg, maximum difference = 4 kg

3 *Some partial remedies*

3.1 In any given study, if all strips are in the same type of soil, and nearly all strips are cemented or uncemented to a similar extent, then no correction is needed for intra-experiment comparisons, but cementation should still be noted, if present.

3.2 Where different types of soil are being compared, especially if some are likely to contain concreting agents (all clay or limestone soils so far tested do appear to cement cotton cloth) and others not (eg sandy brown earths), or where a potentially concreting soil treatment, eg liming, has been applied, then an appropriate correction factor should be derived, along the lines suggested by French (1984), and applied to all strips in the concreted batch, as either all or none will be affected.

3.3 Biotic cementation can usually be ignored if detectable only in a few strips or test segments, but, if present in more than approximately 10%, all cemented substrips should be noted. Then, either an appropriate correction should be applied *only* to substrips with detectable cementation and its effects tested on the final result (see French 1984), or the uncorrected data should be interpreted with care.

3.4 If the TS of a cemented batch of strips is significantly less than that of an uncemented batch, the difference is 'real', ie it may confidently be concluded that the cemented sample is more decayed. If TS of cemented strips is more than uncemented, a test of probable cementation effects is essential. That is, explicit corrections for cementation, appropriate to the sample, should be applied, and the relevant comparisons calculated both with and without that correction. Because even a 1% or 2% correction may make the difference between a statistically significant and a non-significant result if the variation is small enough, or the sample large enough, great care is needed in interpretation, and generally both corrected and uncorrected data should be presented.

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