ON THE PRE-TREATMENT OF SAMPLES OF HEAVY CLAY SOIL FOR DETERMINATIONS BY THE PRESSURE MEMBRANE APPARATUS

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KROTH and JAMISON (2) have recently pointed out that the use of air-dry samples in the determination of the 15-atmosphere percentage is likely to produce misleading results for claypan soils with restricted drainage. In the author's experience, this is equally true for the heavy glacial clays in Finland. These soils are very slowly draining in the swollen condition subsequent to melting of the snow, or after a rainy season, but there is usually no distinct pan horizon. CRONEY and COLEMAN (1) have clearly demonstrated the irreversible effects of drying on the pF curve, and their paper proffers a very satisfactory explanation for the behaviour of dried samples in laboratory determinations. There is no question, that whenever possible, soil moisture studies should be made with samples not subjected to artificial drying. However, it is often essential to be able to work with laboratory-prepared, air-dry samples. This induced the author to investigate whether there might not be some suitable method of pre-treatment by which the effects of drying could be counterbalanced.

Preliminary experiments indicated that the effect of pre-treatment is most notable in the heaviest clays, while it may be quite negligible in medium clays (Table 1). A very heavy clay from Jokioinen in SW-Finland was therefore used

Table 1. The effect of air-drying and grinding on the 8-bar percentage of some medium clay soils with 34–46% material $< 2\ \mu$.

	Dried and ground to pass 2 mm	Dried and ground to pass 0.6 mm	Stored in moist condition
Topsoils, 2–3 % org. carbon	20.0	20.0	20.8–21.5
	18.4	18.8	19.2–20.7
	19.0	19.4	..
Subsoils, 30–50 cm	17.0	17.6	18.2–21.0
	15.1	16.0	15.8–16.5
	14.1	14.1	..

in the detailed studies. It contained 66% clay $< 2\,\mu$ in the topsoil, and 81% in the subsoil at 30 cms depth. The organic carbon contents were 3.0 and 1.5%, respectively.

The samples were taken in the spring, when the soil was still moist after the winter. Portions of the samples were enclosed in plastic bags and stored at about + 2°C in a refrigerator; the rest of the samples were air-dried. The air-dry samples were ground to different degrees of fineness, using the Brown mill and adjusting the distance between its plates accordingly.

The following working conditions were maintained in the determinations with the pressure membrane apparatus (Instrument Development and Manufacturing Corp., California, U.S.A.):

Temperature: + 20°C
Time under pressure: 3 days
Size of soil samples: 4—7 g
Thickness of the soil layer after pressing: 1—3 mm;
in finely ground samples: 1—2 mm
Replicates: 3 or more; in different batches
Preliminary soaking: 1 day unless otherwise stated.

Results

Figs. 1 and 2 show the effect of air-drying and grinding on a portion of the

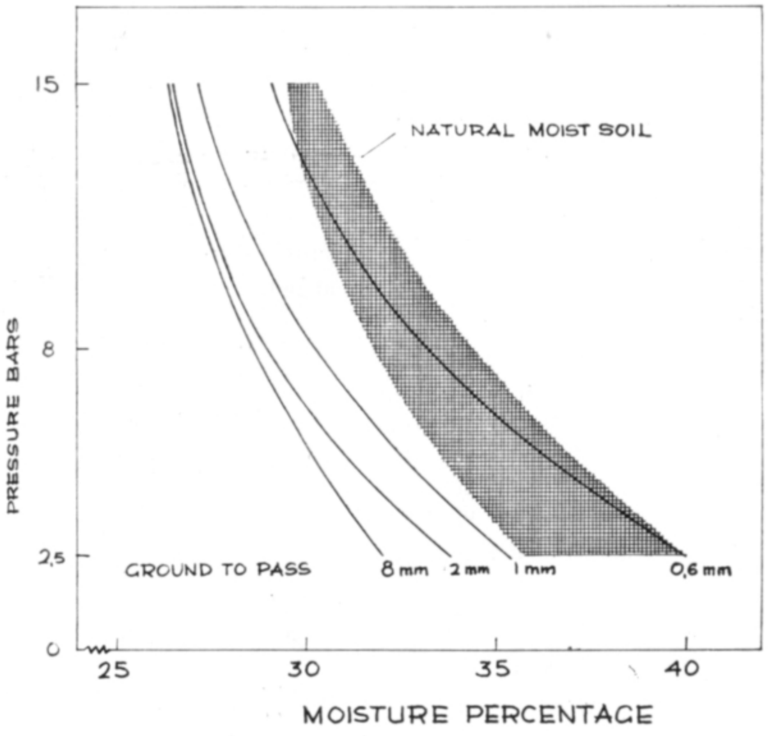

Fig. 1. The effect of air-drying and grinding on the moisture percentage at different pressures. — Very heavy clay topsoil, No. 742.

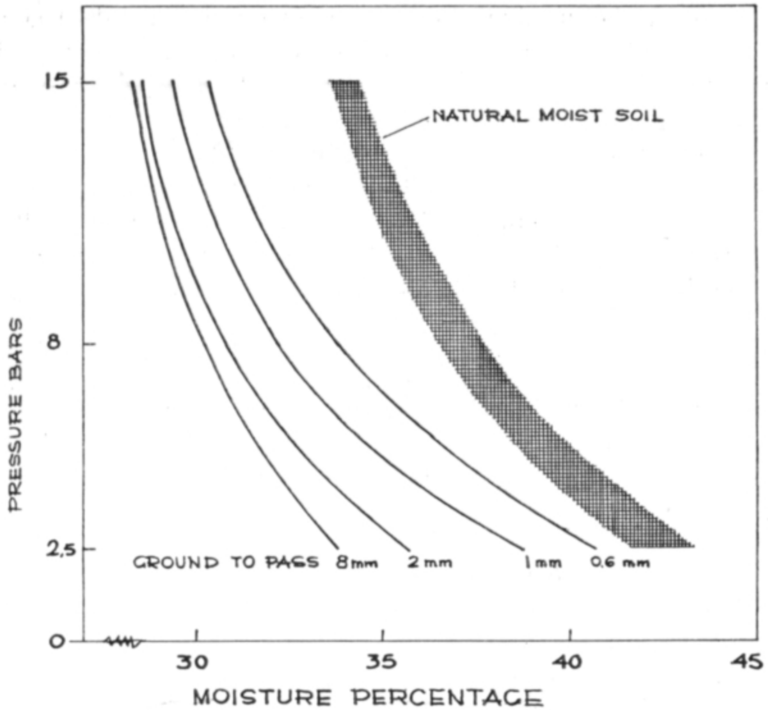

Fig. 2. The effect of air-drying and grinding on the moisture percentage at different poessures. — Very heavy clay subsoil, No. 744.

tension vs. moisture curve. The results referring to natural moist soils have been indicated as a belt instead of a single curve, as the moisture content at a given pressure displayed a tendency to creep towards higher values in the course of the prolonged time of storage (between 1 and 8 months in this instance) of the moist samples. The following principles emerged from these experiments:

— The moisture-retaining characteristics are highly sensitive to the intensity of grinding, especially in the range below 1 mm. Reproducible results are conditional on strictly standardized treatment.

— Unless very finely ground, the air-dry samples yield low results, particularly those of the subsoil.

— The effect exerted by the fineness of grinding is highest with the least pressures, but it is in evidence over the entire working range of the pressure membrane apparatus.

— If it is desired to make a direct determination, grinding to 0.6 mm appears to be a reasonable treatment for topsoils.

— It was not possible to bring heavy clay subsoil rapidly into a state of dispersion, in which its moisture-retaining characteristics would have approximated those of the undisturbed moist soil. Dry grinding (even down to 0.4 mm) was not sufficient, while serious over-dispersion easily resulted from the puddling of wet samples.

Since obviously the grinding procedure is unable to provide a good solution, at least when the subsoil of heavy clays is concerned, another series of tests was undertaken with the same samples, in which the effect of pre-soaking time, and fineness of grinding on the 8-bar percentage was studied. The results (Figs. 3 and 4) reveal that the effects of grinding are gradually levelled out with increasing time of preliminary soaking. The differences have practically vanished in three weeks, and the normal preparation (ground to pass 2 mm) then produced results coinciding with the central part of the »natural range» for the topsoil, falling just slightly below this range for the subsoil.

Discussion

A characteristic feature of the wetting pattern of heavy Finnish clay is its *slow reversibility*. Under these circumstances it is exceedingly difficult to label any one method of investigation as definitely superior to all others. The choice of method is only possible in each case, after the object of investigation and the formulation of questions have been precisely defined. The solution of the problem would be easier if the changes caused by drying were as irreversible as they are in the soil investigated by Croney and Coleman (1). One of the consequences of slow reversibility is that sampling at »field capacity» is not sufficiently specific. It is necessary to also take into account the preceding moisture conditions. (In most cases a period of one year is likely to be sufficient.)

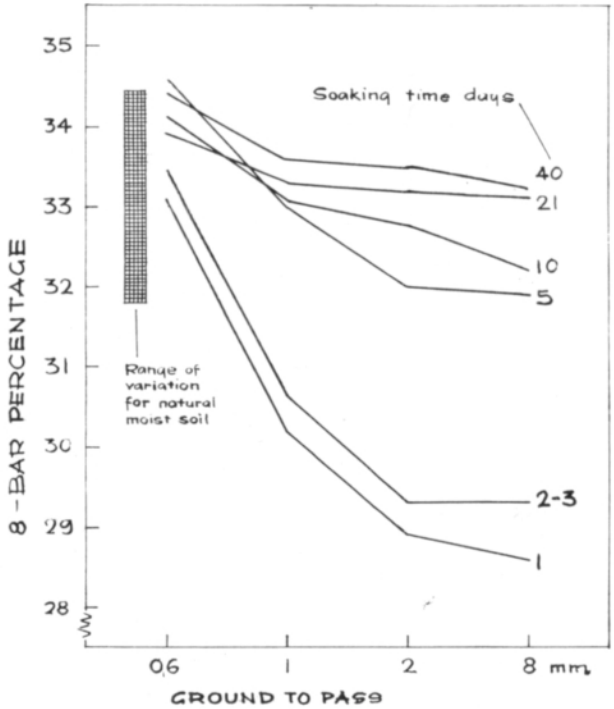

Fig. 3. The effect of soaking time and grinding intensity on the 8-bar percentage of Topsoil No. 742.

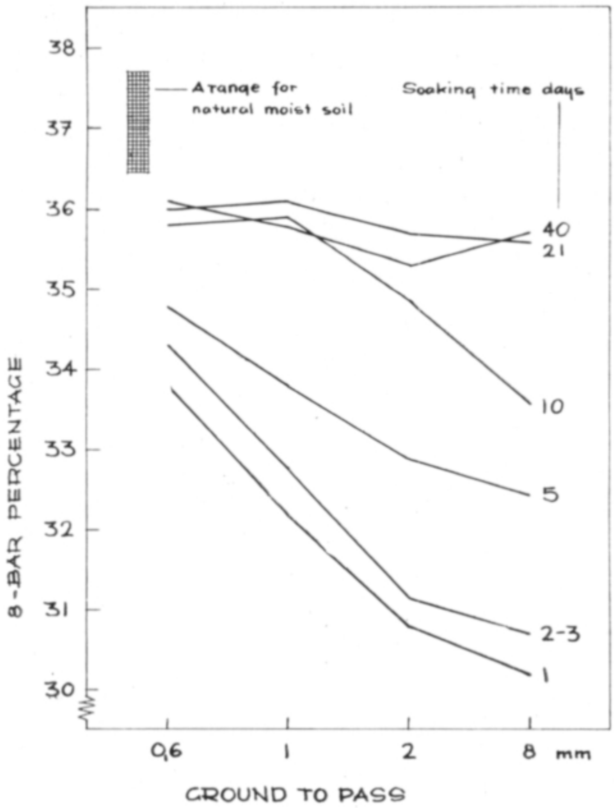

Fig. 4. The effect of soaking time and grinding intensity on the 8-bar percentage of Subsoil No. 744.

Comparison of Figs. 3 and 4 reveals that the effect of grinding is somewhat different for the topsoil and the subsoil. In connection with short-duration preliminary soaking, the 8-bar percentage of the subsoil decreases fairly linearly in the inter-plate distance 0.6—1—2 mm, and at somewhat lesser rate in the distance 2—8 mm. These changes in the 8-bar percentages are in direct correlation with the calculated increments in the surface area of the fragments when the massive soil was ground.

On the other hand, an unexpectedly large increase in moisture content occurs in the topsoil between 1 mm and 0.6 mm. This shows that cementation, which delays the wetting, has occurred in the course of drying particularly in the granules of less than 1 mm diameter. Furthermore it was shown that the difficulty of air displacement plays no role in the process of wetting, this being confirmed by a test, in which the behaviour in normal soaking and in vacuum soaking was compared. Vacuum soaking did not increase the wetting in the least, as it should have done, if the displacement of air had any contribution in the said effect.

Conclusions

The method of pre-treatment of soil samples should be chosen in each case according to the purpose of study, keeping in mind the slow reversibility of the wetting undergone by heavy glacial clay. In general, it is recommended that the air-dry samples ground to 2 mm should be soaked for three weeks prior to determinations by the pressure membrane apparatus. If it is desired to make direct determinations, grinding to pass 0.6 mm appears to be conducive to good wetting, in the case of topsoils.

REFERENCES

(1) Croney, D. & Coleman, J. D. 1954. Soil structure in relation to soil suction (pF). J. Soil Sci. 5:75–84.
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SELOSTUS:

JÄYKÄN SAVEN ESIKÄSITTELY PAINEKALVOLAITTEESSA TEHTÄVIÄ MÄÄRITYKSIÄ VARTEN

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Kun kuivattujen näytteiden käyttö painekalvolaitteessa johtaa helposti liian alhaisiin kosteuspitoisuuksiin, otettiin tutkittavaksi, voitaisiinko hienompaa jauhatusta tai pitempää esiliotusta hyväksikäyttäen saada luonnonkosteata näytettä vastaavia tuloksia. Suositeltavimmaksi osoittautui sellainen menettely, että kuivatun ja alle 2 mm:iin jauhetun näytteen annetaan liota n. 3 viikkoa ennen määritystä. Multakerrosta edustavan aitosavinäytteen osalta päästiin luonnonkosteata näytettä vastaavaan tulokseen myös 1 vrk:n esiliotuksen jälkeen, kun näyte jauhettiin Brown-myllyllä, jossa jauhinlevyjen väli oli asetettu 0.6 mm:ksi.

Jäykille saville ominainen vettymisen hidas reversiibelisyys aiheuttaa myös sen, että luonnonkosteilla näytteillä työskenneltäessä on pakko ottaa huomioon pitkähkön ajanjakson kosteusvaihtelut; esim. »kenttäkapasiteetti» ei sellaisenaan ole riittävän täsmällinen kosteustilan ilmaisu.