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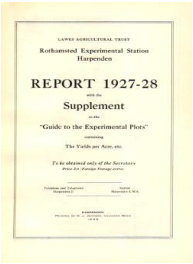
Report for 1927-28

Full Table of Content


LAWES AGRICULTURAL TRUST
Rothamsted Experimental Station
Harpenden

REPORT 1927-28

Supplement

"Guide to the Experimental Plots"

The Yields per Acre, etc.

To be obtained only of the Secretary

The Soil

Rothamsted Research

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III.—THE SOIL.

(a) Mechanical Analysis.

(Chemical, Physical and Statistical Departments.)

XXX. A Sub-Committee of the Agricultural Education Association. *"The Revised Official British Method for Mechanical Analysis."* Journal of Agricultural Science, 1928. Vol. XVIII., pp. 734-739.

A Sub-Committee of the Agricultural Education Association, with Dr. Keen as convenor, proposed in 1926 a new method of mechanical analysis that was officially adopted by the Association. (Papers XXII. and C., Report 1925-26.) At the 1927 meeting of the International Society of Soil Science an agreed international method was adopted which did not differ greatly from the New British method. In consequence, the Agricultural Education Association Sub-Committee decided to make the necessary changes in its recommended method to bring it into line with the international proposals, and the present paper contains an account of the reasons for the change and the actual alterations involved. The full details of the new method, known as the "Revised Official Method," have been accepted and published (see Technical Paper No. CXVIII).

The main differences are that the fractions are weighed as oven dry and not after ignition, and the grouping of the fractions has been altered to the Atterberg scale.

XXXI. E. M. Crowther. *"Nomographs for use in Mechanical Analysis Calculations."*...Proceedings and Papers of First International Congress of Soil Science, Washington, 1928. Vol. I., pp. 399-404.

To facilitate the more general adoption in routine work of the temperature correction for the viscosity of water in mechanical analysis, a nomograph has been prepared giving by a direct reading the times or depths of sedimentation equivalent to those desired at a standard temperature of 20° C. In a second nomograph the logarithms of the settling velocities are connected with (1) the experimental depths and times and (2) the temperature and "equivalent diameter" evaluated on the basis of Stokes' Law.

XXXII. E. M. Crowther. *"The Direct Determination of Distribution Curves of Particle Size in Suspensions."* Journal of the Society of Chemical Industry, 1927. Vol. XLVI., pp. 105-107T.

An apparatus is described for obtaining continuous size distribution curves of suspensions through measurements of the changes with time of the density at a given depth. A highly sensitive differential liquid manometer connected between two points near the base of the sedimenting column is used to secure sufficient magnification for direct readings. Since the readings are proportional to the concentration at a defined depth they may be plotted against the times, or the logarithms of the times, to give directly a summation percentage curve for particle size.

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XXXIII. E. M. CROWTHER. "*A Manometric Apparatus for the Direct Determination of Summation Percentage Curves in Mechanical Analysis.*" Proceedings and Papers of First International Congress of Soil Science, Washington, 1928. Vol. I., pp. 394-398.

See Paper No. XXXI. for abstract.

(*b*) PHYSICAL PROPERTIES.

XXXIV. B. A. KEEN. "*First Commission Soil Mechanics and Physics.*" Soil Science, 1928. Vol. XXV., pp. 9-20.

This is a critical review of recent progress in Soil Physics, partly based on the papers presented to the International Congress of Soil Science, at Washington, D.C., in 1927.

XXXV. B. A. KEEN AND J. R. H. COUTTS. "*'Single Value' Soil Properties : A Study of the Significance of Certain Soil Constants.*" Journal of Agricultural Science, 1928. Vol. XVIII., pp. 740-765.

Numerous attempts have been made to devise an experimental method that, applied to a variety or a series of soils, enables them to be placed in an order closely reflecting their field behaviour or their most important physical characteristics. Such a method is called a "single value" determination, as it endeavours to specify the soil by a single number, in distinction to the group of figures obtained, for example, from a mechanical analysis. A number of these methods are discussed in the present paper, which contains an account of a detailed investigation on 39 soils of certain single value determinations.

The methods selected for study were chosen because (i) they required only simple apparatus, and (ii) they appeared to be related to some distinct characteristic of the soil.

The list of measurements was as follows :—

(*a*) percentage of clay ; (*b*) moisture content of soil in equilibrium with atmosphere of 50 per cent. relative humidity (the ordinary "air-dry moisture content" which was also determined, is close to this value) ; (*c*) ignition loss of the dried soil ; (*d*) moisture content at the "sticky" point, which is defined as the point at which a thoroughly kneaded plastic mass of the soil is just about to stick to the fingers or to a knife.

An important feature of the present investigation was the repetition of the above measurements after the soils had been treated with hydrogen peroxide. Our present knowledge indicates that this removes the humified and non-structural part of the organic matter without exercising more than a small solvent action on the mineral portion of the soil. Comparison of the single-value results for the original and peroxide treated soils thus gives an opportunity of approximately comparing the relative contributions of the organic and mineral parts of the soil. The main results are set out below :—

Correlation coefficients obtained for the various pairs of quantities examined express the general fact that the heavy clay soils have the highest ignition losses, moisture contents and sticky points.

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An increased correlation between clay and sticky point for the peroxide treated soils suggest that the sticky point value is controlled both by the organic matter and some property related to the clay content.

When the associations are further examined by partial correlation coefficients, the sticky point is shown to be largely controlled by the colloidal and inorganic colloidal material, while the moisture content at 50 per cent. relative humidity is largely controlled by the actual clay content. There is independent evidence that this moisture is held in the minute interstices between the clay particles.

The sticky point approaches a lower limit of about 16 per cent. moisture content with very sandy soils containing little organic matter. This value is close to 14.6 per cent., which is the saturation moisture content of an ideal soil in closest packing, and it is shown that the pore space of this ideal soil and of the kneaded blocks of actual soil have approximately the same value. Hence the value of the sticky point moisture content is made up of (*a*) 16 per cent. of water held in the pore space, unassociated with colloidal material, and (*b*) water associated with colloidal material. The division of the latter quantity into water associated with organic matter and inorganic clay colloids can be very approximately effected by assuming (i) that the difference between ignition losses of original and peroxide treated soil measures the effective organic matter, and (ii) that the ignition loss of the peroxide treated soil (less the organic matter still present) represents the clay colloid. On these assumptions it appears that the organic colloid takes up about 4.4 times its own weight of water, and the inorganic clay colloid 2.7 times its own weight. The approximate nature of the comparison must be emphasised, owing to the limitations in the assumptions on which it is based. If the actual clay content be taken instead of the ignition loss of the peroxide treated soil, as a measure of the inorganic colloid, the clay on a unit weight basis is only one-ninth as effective as the organic matter.

A comparison is made of the variation of sticky point determinations made by different workers, and it is shown that satisfactory agreement can be secured after a little experience of the method.

The importance is stressed of introducing single value methods as an adjunct to the modern system of soil classification, and into soil physics.

XXXVI. B. A. Keen. *"Some Comments on the Hydrometer Method for Studying Soils."* Soil Science, 1928. Vol. XXVI., 261-263.

Bouyoucos has developed an empirical method of studying soils, based on the reading of a hydrometer placed in a suspension of the soil in water that has stood for 15 minutes to allow the coarser particles to settle. In Paper No. XXXIV., it was pointed out that the method was essentially qualitative, since an appreciable density gradient must exist in the suspension between top and bottom of the long hydrometer bulb after so short a period as 15 minutes. Later, Bouyoucos (Soil Science, 1925, 25 pp. 365-369) claimed that this statement was not justified, and gave some

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results to support his claim. The present paper consists of an examination of these figures, which show, as would be expected, that there is an appreciable density gradient, and the actual technique employed by Bouyoucos is then stated in exact physical terms: it consists in measuring at an arbitrary time the average density of a layer of suspension several centimetres in length whose density is continually changing both with depth and time in a manner depending on the particle-size distribution curve of the soil, and therefore varying from soil to soil. The method is therefore essentially qualitative, although in the present state of our knowledge it has some value as an empirical determination.

XXXVII. W. B. Haines. *"Studies in the Physical Properties of Soils, IV. A Further Contribution to the Theory of Capillary Phenomena in Soil."* Journal of Agricultural Science, 1927. Vol. XVII., pp. 264-290.

This paper examines in detail the manner in which the moisture in soil is distributed over and between the soil particles. The usual conception of an ideal soil (an assemblage of equal sized spheres in regular packing) is employed, and experimental measurements are made with various materials approximating to this definition. It appears from considerations of the pressure deficiency produced by curvature of the water film surfaces, that there are two possible stable positions for a film of given pressure deficiency: one in which the water exists as an open tunnel, and the other in which the tunnel is filled and closed by a concave film at each end. The fact that these interchangeable forms are possible implies that over a wide range of moisture content the pressure deficiency remains constant, falling rapidly to zero at saturation, and rising theoretically to an infinite value at the dry end of the scale. The experimental results conform this conclusion when allowance is made for the impossibility of packing the material in the regular manner postulated for the ideal soil.

The curve connecting pressure deficiency with percentage of pore space occupied by water is shown also to represent the relation between height above the water table and moisture content at that height for a column of soil whose lower end stands in water.

The suction or pressure deficiency which is necessary to draw an air-water interface into the pores of the soil characterises the capillary behaviour over a considerable moisture range, and the term "entry value" is suggested for it.

XXXVIII. R. A. Fisher. *"Further Note on the Capillary Forces in an Ideal Soil."* Journal of Agricultural Science, 1928. Vol. XVIII., pp. 406-410.

The new observations of Haines on the pressure deficiency of liquid in a soil-like aggregate confirm the theoretical deduction that the pressure deficiency falls off with increasing water content, but do not justify his belief in a high static stress as saturation is approached.

A theorem is established connecting the static stress at any water content with the pressure deficiency and the dry area of the surface. This, together with general considerations of the

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energy conditions of physical equilibria, appears to dispose of the two assumptions from which the high values for the cohesive stress at saturation have been deduced.

XXXIX. E. M. CROWTHER. "*Some Physical Properties of Heavy Alkaline Soils under Irrigation (in the Sudan Gezira).*" Proceedings and Papers of First International Congress of Soil Science, Washington, 1928. Vol. I., pp. 429-433.

The value of some extremely simple physical methods of studying soil texture is illustrated by measurements on the heavy alkaline soils of the Sudan Gezira. The field density of the soil shows a marked maximum at a depth of 80 cms., but the impermeability to water of the soil at this depth is not entirely due to the closeness of packing, since sieved soil samples, uniformly packed in glass tubes, show a pronounced minimum in the rate of water movement at this depth. The rate of capillary rise of water into sieved soils in glass tubes affords a simple measure of soil texture which is useful for soil survey purposes. In good cotton soils, the rate of capillary rise was about 50 per cent. higher than in bad soils.

XL. B. A. KEEN. "*The Limited Rôle of Capillarity in Supplying Water to Plant Roots.*" Proceedings and Papers of the First International Congress, 1927. Vol. I., pp. 504-511.

The pore space in soils may be regarded as consisting either of an assemblage of small cellular units or of irregular thread-like capillary tubes. The latter conception is the one customarily employed in text-books when the movement of soil moisture is under consideration. It leads, however, to values for the capillary rise of water in soils that are much higher than those found experimentally.

The attainment of equilibrium conditions of moisture in a soil column is a slow process, and moisture distribution conditions in the field are therefore essentially dynamic. The present paper is a preliminary account of the relation between evaporation factors and the daily level of the ground water table in large cylinders of soil exposed to field conditions and kept uncropped. From the data, which included the period of the great drought in 1911, it is possible to construct curves showing how the free water level would fall in an initially water-logged soil during a continuous and unbroken drought. It is found that after the water table has receded some 70 cms. below the surface in a heavy loam soil, the subsequent fall is very slow, and in a further six months the level falls only an additional 20 cms. This slow movement shows that capillary action is practically ineffective in raising water through a higher distance than 60-80 cms. in a heavy soil under field conditions, and the result emphasises the importance of those cultivation methods intended to protect the moisture supply in the soil from evaporation at the surface.

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XLI. G. W. Scott Blair and E. M. Crowther. "*The Flow of Clay Pastes through Narrow Tubes.*" Journal of Physical Chemistry, 1929. Vol. XXXIII., pp. 321-330.

Laboratory studies of the physical and physico-chemical factors concerned in the production of soil tilth in the field can be made in a variety of ways. This paper gives an account of the behaviour of clay and soil pastes when they are forced through a capillary tube under pressure. The experimental method has been used by a number of workers and for a wide range of plastic materials, but neither the apparatus nor the theoretical treatment can be regarded as completely satisfactory. Improvements were therefore introduced in the design of the apparatus: a bulb is provided at each end of the capillary and the paste is sheared alternatively from one bulb to the other; the apparatus is bodily tilted during the experiment to keep the level of the paste in the two bulbs the same, so that no correction is required for hydrostatic head; the amount of flow under given constant pressure is measured by a calibrated flowmeter consisting of a sensitive inclined alcohol manometer that records the pressure of the displaced air as it escapes through one of a series of capillaries, selected as convenient for the velocity of paste flow under measurement.

It is known that the relationship between the amount of material flowing in unit time and the pressure applied is not the simple proportionality obtained with true fluids under the same conditions for which the Poisuille equation holds. Numerous attempts have been made to obtain a modified Poiseuille equation for the flow of pastes. The one here considered is due to Buckingham who predicted that with increasing pressures the material would flow successively as (*a*) a solid plug, (*b*) a solid plug moving in an outer stream line sheath, (*c*) entirely stream line flow. These conclusions are shown experimentally to be correct, but in addition there is a stage that precedes the plug flow, in which no movement at all occurs until the pressure reaches a certain minimum value; the necessary modification of the Buckingham equation to include this effect is given. When the volume of flow in unit time is plotted against the pressure employed, the points for the plug flow and the complete stream line flow lie on straight lines. A constant independent of the diameter of the capillary can be derived from the slope of each line, and the ratio of these constants is independent of the concentration of the material used over a wide range. The value of the ratio appears to depend on the nature and geological origin of the material.

XLII. G. W. Scott Blair. "*Ueber die Geschwindigkeitsfunktion der Viskositat disperser Systeme.*" (On the speed-function of Viscosity in disperse systems), "Kolloid Zeitschrift," 1929. Vol. XLVII., pp. 76-81.

Ostwald and his school have for some years been collecting a great mass of data relating the amount of material passing through a capillary tube in unit time and the pressure applied to the material. For colloidal materials which are not true fluids

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many other workers have found that for a certain region of pressures a straight line is obtained by plotting the pressure direct against the flow per unit time, though this straight line does not pass through the origin.

Ostwald's treatment, however, is more elaborate and involves the logarithms of the pressure and flow. This necessitates the friction coefficient (equivalent to viscosity in a pure fluid) having dimensions dependent on the material used and on the conditions of experiment.

In this paper it is shown that much of the data obtained by Ostwald and others can be equally well interpreted on the simple relationship already mentioned. This has the further advantage that the friction coefficient is of normal dimensions.

(*c*) Soil Cultivation.

XLIII. W. B. Haines and B. A. Keen. *"Studies in Soil Cultivation, IV. A New Form of Traction Dynamometer."* Journal of Agricultural Science, 1928. Vol. XVIII., pp. 724-733.

The original form of dynamometer (Report 1925-26, Paper XXX.) has now been replaced by a new type described below that has many advantages.

The instrument consists of (*a*) an hydraulic link weighing 16lb., and placed in the hitch, (*b*) a recording mechanism weighing 15lb., carried on any convenient part of the implement, and (*c*) a control box weighing 4lb., carried by the operator. When packed in a stout box for transit, and with all accessories, the total weight is less than 100lb. The instrument is of robust construction, and has a minimum number of moving parts. Adjustments for stylus pressure, etc., are provided, but the necessity for using them hardly ever arises.

The instrument operates by recording the amount of movement in a Buordon tube filled with oil and connected by narrow bore copper tubing to the oil in the hydraulic link. A number of Bourdon tubes is provided, of different strengths. These tubes are easily interchangeable so that the instrument can be used, with the same percentage accuracy for all types of work from the lightest to the heaviest.

XLIV. W. B. Haines and B. A. Keen. *"A New Dynamometer, suitable for all types of Horse and Power-Drawn Implements."* Proceedings and Papers of the First International Congress of Soil Science, Vol. I., Part II., pp. 405-411.

See Paper No. XLIV. for abstract.

XLV. B. A. Keen. *"The Value of the Dynamometer in Cultivation Experiments and in Soil Physics Research."* Proceedings nd Papers of the First International Congress of Soil Science, 1927. Vol. I., pp. 412-428.

This Paper summarises the work already described in Papers XXX., XXXI., and XXXII., of the 1925-26 Report. In addition an account is given of later work in which variations in the resist-

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ance of the subsoil were recorded by the dynamometer during the operation of mole drainage. The field in question was known to have an irregular subsoil, patches of gravel occurring in the clay. The boundaries and extent of these patches were sharply defined by the dynamometer results, and it was therefore possible to construct a map giving their positions in detail. Without the dynamometer this information would only have been obtained—and only then in a very approximate form—by laborious digging or boring of many holes.

(*d*) Organic Chemistry.

XLVI. H. J. Page and C. E. Marshall. "*The Origin of Humic Matter.*" Nature, 1927. Vol. CXIX., p. 393.

Fractionation of humic material by sulphurous acid gave substances resembling lignosulphonic acids. The possible relationship between lignin and natural humic acids is discussed.

IV.—THE SOIL POPULATION AND ITS BEHAVIOUR.

(Bacteriological, General Microbiology, Mycological, and Entomological Departments.)

(*a*) Bacteria.

XLVII. E. J. Russell. "*The Present Status of Soil Microbiology and its Bearing upon Agricultural Practice.*" Proceedings and Papers of the First International Congress of Soil Science, June, 13-22, 1927, Washington, D.C. Vol. I.

XLVIII. P. H. H. Gray and H. G. Thornton. "*Soil Bacteria that Decompose Certain Aromatic Compounds.*" Centralblatt fur Bakteriologie Abt. II., 1928. Vol. LXXIII., pp. 24-96.

Many types of soil bacteria have been isolated that can decompose the aromatic compounds phenol, meta-cresol, and naphthalene, which are used as soil sterilising agents. Several of them can also utilise one or more of the following compounds: ortho-cresol, para-cresol, phloroglucinol and resorcinol. One organism has been isolated that can utilise toluol. Pure cultures of the bacteria use these compounds as sole sources of energy in mineral salts media containing inorganic nitrogen. Organisms without spores grew in media containing 0.1 per cent. phenol, but were killed by a concentration of 0.2 per cent. The bacteria are widely distributed in Great Britain, and have been found in soils from Norway, the Tyrol, and from islands in the South Atlantic. They are most often found in arable soil and, in the Rothamsted plots, rarely occur in unmanured soil. One species (*Mycobacterium agreste* n.sp.) is more abundant in dry than in wet districts. Out of 245 soil samples examined, 146 yielded the bacteria, and from these 208 strains were isolated that attack either phenol, meta-cresol, or naphthalene. From a study of their morphology and growth characters the strains have been classified into seven genera and 25 species, which are described. A new genus, *Mycoplana*, has been formed to include an aberrant