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The Soil

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This is one of three papers read to the Industrial and Agricultural Section of the Royal Statistical Society, with discussion. The first paper, by Dr. Irwin, describes critically the official methods of crop estimation in the United Kingdom, the United States and India and outlines the early work of the crop-weather scheme of the Agricultural Meteorological Committee. In the second paper, by Mr. Cochran, the use in crop forecasting of the correlation of yields with weather factors and with previous measurements on the crop is discussed. A prediction formula is presented for wheat, based on the results of the wheat sampling observations under the crop weather scheme. This formula is as yet unsatisfactory in forecasting variations in yield from year to year, but may be improved by the inclusion of weather effects when sufficient data become available. In general, however, much research is still needed on the possibility of crop forecasting by this method.

The estimation of crop yields at harvest by taking small samples from a number of fields is considered and the results obtained from an extension to commercial crops of the wheat sampling scheme are presented. The chief difficulties here appear to lie in the selection of fields to be sampled and in a positive bias which persists in the sampling yields as compared with the harvested yields of whole fields. The use of a fixed panel of forms for each crop is recommended as the most practicable method of organising the work.

The third paper, by Dr. Wishart, sums up several points in the first two papers and describes the system of crop estimation in China.

THE SOIL

(Departments of Chemistry, Fermentation, and Physics)

(a) CULTIVATION

- XIX. E. W. RUSSELL and B. A. KEEN. "*Studies in Soil Cultivation. VII. The Effect of Cultivation on Crop Yield.*" *Journal of Agricultural Science*, 1938, Vol. XXVIII, pp. 212-233.

The yields of wheat, barley and mangolds were not appreciably affected whether the seed beds were prepared by ploughing and harrowing, by using the grubber (or cultivator) and harrowing, or by using the Rototiller, provided that the grubber and Rototiller were used for one year only. If used for several years in succession deterioration of yield sometimes sets in, possibly due to the increased weediness of the non-ploughed plots.

There was no advantage in ploughing deeper than 4 in. but it is advantageous to use the grubber or Rototiller deeper.

For spring-sown crops, cross-ploughing, subsoiling, or heavy rolling of the seed bed were without effect on the yield.

Spring rolling and harrowing improved the yield of winter wheat but had little effect on the yield of straw. Rolling alone produced a slightly increased yield of grain. The straw yield was increased by rolling but depressed by harrowing.

There was strong evidence that intensive hoeing of sugar-beet or kale is detrimental to the yield. Two to three hoeings appear to be ample.

- XX. E. W. RUSSELL and N. P. MEHTA. "*Studies in Soil Cultivation. VIII. The Influence of the Seed Bed on Crop Growth.*" *Journal of Agricultural Science*, 1938, Vol. XXVIII, pp. 272-298.

Crops germinate faster on the looser seed bed prepared by a Rototiller than on the more compact ones prepared by a plough or a grubber. The total number of plants that germinate is, however, the same for all treatments unless the land is too foul with weeds, when higher germination is obtained on the cleaner plots.

Cereals tend to ripen a little sooner on land that has been ploughed than on land that has been either rototilled or grubbed.

The roots of mangolds were longest and thinnest on the deep-ploughed plots and were always squatter on the shallow-tilled than on the deep-tilled plots. The roots were heaviest on the deep-ploughed plots and lightest on the rototilled plots. On the rototilled and the grubbed plots the depth of tillage had no effect. The plants on the shallow-grubbed plots seemed, however, to have no reserve of strength, for they could not make better growth if given more room, while those on the deep-grubbed plots could make

some use and those on the ploughed or rototilled plots appreciable use of extra space.

Weeds tend to accumulate on the rototilled and the grubbed plots since neither grubbers nor rotary cultivators carrying tines mounted on a horizontal shaft can bury weeds and weed seeds in the way that the plough can. If the land is fairly clean and in good heart this probably does not matter for several years, but it prevents either implement from completely displacing the plough.

A subsidiary result that emerged from these experiments is that if a thin crop is given a nitrogenous top dressing, the fertiliser may benefit the weeds more than the crop.

(b) PHYSICAL PROPERTIES

- XXI. R. K. SCHOFIELD and J. V. BOTELHO DA COSTA. "*The Measurement of pF in Soil by Freezing Point.*" *Journal of Agricultural Science*, 1938, Vol. XXVIII, in the press.

Two procedures are described for ascertaining the relationship between the freezing point and moisture content of a soil. As the process of freezing dries the soil sample, it is necessary to estimate how much water has been frozen out of the soil at the moment when the freezing temperature is recorded.

One procedure embodies all the precautions which appear desirable when the greatest accuracy is required. The other is simple and rapid and yet accurate enough for routine estimation of the wilting coefficient.

- XXII J. V. BOTELHO DA COSTA. "*A Critical Survey of Investigations on the 'Wilting Coefficient' of Soils.*" *Journal of Agricultural Science*, 1938, Vol. XXVIII, in the press.

The experiments of Briggs and Shantz led them to conclude that the "wilting coefficient" is a soil "constant" which is (a) independent of the kind of plant used as indicator; (b) independent of the conditions under which the plant was grown and (c) directly related to several other soil constants.

Subsequent research as well as an examination of their own results has shown that (c) is untrue, while (a) and (b) are substantially correct for hygrophytes and mesophytes. Earlier writers have been led to wrong conclusions regarding (a) and (b) through assuming (c) to be correct and through disregarding the particular nature of "permanent wilting" as defined by Briggs and Shantz.

The fact that considerable variation is to be found between the osmotic pressure in different plants, in different parts of the same plant and in the same part under different conditions, is not at variance with conclusions (a) and (b) when properly understood.

An important factor making for the substantial constancy of the "wilting coefficient" for a given soil is the extreme steepness of the curve connecting suction pressure and soil moisture content, in consequence of which differences of suction pressure of unquestionable significance from the standpoint of plant physiology give rise to differences in soil moisture content that are too small to be detected.

- XXIII. J. V. BOTELHO DA COSTA. "*The Indirect Determination of the 'Wilting Coefficient' by the Freezing Point Method, and the Influence of the Salts upon the pF at that Critical Moisture Content.*" *Journal of Agricultural Science*, 1938, Vol. XXVIII, in the press.

The results obtained in the preliminary investigation were entirely confirmed, the pF at the "wilting coefficient," as measured by the modified freezing point method, varying from 4.0 to 4.4 (round figures), with an average of 4.2.

The variation observed bears no relation to the soil texture, neither can it be explained by uncertainties in the freezing point determinations which have proved to be accurately reproducible. Freezing point measurements after leaching, conductivity measurements and freezing point determinations in saturated soil and at the moisture equivalent proved that part of the variation is due to the presence of soluble salts, the more saline soils having a higher pF at the "wilting coefficient." When the salt content does not exceed about 500 p.p.m. the influence of the salts is hardly detectable, and the pF at the

"wilting coefficient" lies between 4.0 and 4.3. Besides unavoidable errors in the wilting experiments* several other factors may account for this variation. They are all the factors that have any rôle in the "history" of the soil. In view of these uncontrollable sources of error a variation of 0.3 ρF units can be considered very small.

It can therefore be confidently concluded that in ordinary agricultural soils with a salt content of less than about 500 p.p.m. permanent wilting occurs when a critical ρF value lying between 4.0 and 4.3 is reached.

This knowledge affords a new indirect method of determining the "wilting coefficient" by freezing point measurements in soils having less than about 500 p.p.m. of soluble salts. Both procedures described in Paper XXI above, are equally satisfactory for this purpose. As the ρF curve is practically straight in the neighbourhood of the "wilting coefficient," two freezing point measurements (round about 1-2°C. freezing point depression) are enough for the indirect determination of the "wilting coefficient."

The method is incomparably less laborious than the direct determination by wilting experiments and highly accurate.

- XXIV. G. W. SCOTT BLAIR. "*Compressibility Curves as a Quantitative Measure of Soil Tilth.*" Journal of Agricultural Science, 1937, Vol. XXVII, pp. 541-556.

A preliminary account is given of experiments on the compressibility of soils in field condition, and two methods for obtaining compressibility curves, one for the field and one for the laboratory, are described. The laboratory apparatus automatically draws a curve relating deformation to the square root of the load built up. The theoretical relationship between load and deformation is discussed, the conclusions reached being at this stage semi-quantitative. Laboratory compression curves indicate the characteristics of soils in various states of tilth, and the effects of drainage condition, frost action, etc. Such factors as size of soil crumb, depth of layer tested, and moisture content of soil samples for laboratory studies are considered.

Preliminary field experiments are described in which the effects of simple cultivation processes on soil compressibility were measured.

- XXV. G. W. SCOTT BLAIR and G. H. CASHEN. "*Compressibility Curves as a Quantitative Measure of Soil Tilth. II.*" Journal of Agricultural Science, 1938, Vol. XXVIII, pp. 367-378.

The method described in an earlier paper for measuring the compressibility of soils *in situ* has been used to study the gradual consolidation of soil following digging with a fork, and a new method is described in which the rate of flow of water through rubber tubes buried in the soil gives a measure of compression.

By means of this latter method some measure can be obtained of the changes that take place in the soil after it has been loaded and trampled.

The results of the experiments confirm and amplify the earlier conclusions. At present it is hard to distinguish quantitatively the effects of moisture and time; but it appears that differences in moisture for the range of stress used hardly affect the compressibility of newly dug soils, whereas in soils which have rested for some time since cultivation the compressibility is much increased by an increase in moisture content.

- XXVI. J. R. H. COUTTS. "*The Measurement of Soil Colours.*" Soil Research, 1937, Vol. V, pp. 295-307.

Four means were used to obtain quantitative measures of the colours of a group of Natal soils: (1) the Ostwald colour atlas; (2) the Ridgway colour atlas; (3) the Maxwell spinning disc; and (4) the Lovibond tintometer. The relative advantages of the different methods are discussed. A direct comparison with the colour atlases gave the least dependable results. The Maxwell disc in the form recommended by the Soil Colour Committee of the American Soil Survey Association does not enable all soil colours to be matched. The Lovibond tintometer is convenient, and no failures to obtain a match with it have been found. It is suggested that the suitability of the tintometer should receive further consideration.

* A difference of 1 per cent. moisture content corresponds to a difference of 0.1 to 0.2 ρF units in the neighbourhood of the "wilting coefficient."

(c) ANALYSIS

- XXVII. G. NAGELSMIDT. "*X-Ray Investigations on Clays, Part III. The Differentiation of Micas by X-Ray Powder Photographs.*" *Zeitschrift für Kristallographie*, 1937, Vol. (A) XCVII, pp. 514-521.

In using the X-ray powder method for studying the minerals in soil fractions it is desirable to know the variability of the powder diagrams of minerals which vary in chemical composition but belong to one mineral family. Powder diagrams of eight micas of different chemical composition, including two lithium micas and sericite, are recorded. They all belong to either of two types, muscovite and phlogopite-biotite. From powder diagrams it should be possible to recognise mica in mixtures with either quartz or kaolin, and, if the mica forms half or more of the mixture, to distinguish between the two types of mica.

- XXVIII. L. A. DEAN. "*An Attempted Fractionation of the Soil Phosphorus.*" *Journal of Agricultural Science*, 1938, Vol. XXVIII, pp. 234-246.

Soils were extracted by sodium hydroxide and colorimetric methods employed to estimate the organic and inorganic phosphorus in the extract. The amount of phosphorus soluble in sodium hydroxide solution is influenced by the active soil calcium and it is suggested that sodium-saturated soils should be used when studying the alkali-soluble phosphorus. Relatively large amounts of organic phosphorus were found in most soils and generally followed the carbon contents of the soils. The acid-soluble phosphorus remaining after alkaline extraction appears to be similar to apatites. The largest fraction of the soil phosphorus was not dissolved by the sodium hydroxide and acid extractions. This fraction was not influenced by the long-continued use of phosphatic fertilisers at Rothamsted and Woburn.

- XXIX. E. B. KIDSON. "*Some Factors Influencing the Cobalt Contents of Soils.*" *Journal of the Society of Chemical Industry*, 1938, Vol. LVII, pp. 95-96.

Evidence has been obtained to show that the cobalt content of a wide variety of soils is in general related to the magnesium contents of their parent rocks: e.g., serpentine, rich in magnesium, gives soils with high cobalt contents and soils derived from granite have low cobalt contents. Manurial treatments for long periods on the Rothamsted and Woburn continuous wheat and barley plots have negligible effects on the cobalt contents of the soils. Soils from the Dartmoor area, on which sheep suffer from "pinning" disease, have low contents (3-4 p.p.m.) of cobalt whereas healthy soils contain 11-30 p.p.m. This series of soils forms an interesting comparison with soils from New Zealand on which "bush sickness" occurs.

- XXX. C. N. ACHARYA. "*Determination of the Furfuraldehyde Yield of Soils and of Plant Materials admixed with Soil.*" *Biochemical Journal*, 1937, Vol. XXXI, pp. 1800-1804.

A comparison is given of the bromine titration method of Powell & Whittaker and the gravimetric phloroglucinol method for the estimation of the total furfuraldehyde yield of soils and plant materials admixed with soil. In the absence of soil, the two methods were found to give concordant results. In presence of soil, however, low results were obtained by both methods, owing to the presence of oxidizing agents such as ferric and manganese compounds and nitrate in the soil, which apparently oxidize a portion of the furfuraldehyde during the course of distillation with 12 per cent. HCl. The addition of stannous chloride in regulated amounts reduces the oxidizing agents and prevents their interference.

It is concluded that for soils and plant materials mixed with soil estimation of the furfuraldehyde by precipitation with phloroglucinol, followed by extraction of the precipitate with boiling alcohol, is preferable to the bromine titration method of Powell & Whittaker.

- XXXI. S. G. HEINTZE. "*Readily Soluble Manganese of Soils and Marsh Spot of Peas.*" *Journal of Agricultural Science*, 1938, Vol. XXVIII, pp. 175-186.

Marsh Spot disease of peas in the Romney Marsh area is more closely related to soil reaction than to soil series or soil texture. It was not found on any acid soil but on most of the alkaline ones in a representative set of 35 samples. Most of the soils contained appreciable amounts of free oxides of manganese and of salt-soluble manganese. The soils with Marsh Spot contained less salt-soluble manganese than the soils on which peas were healthy, but this relationship depended essentially on the contrast between acid and alkaline soils. Peas grown in pot cultures in manganese-deficient soils and in a sand-bentonite mixture developed Marsh Spot. Addition of manganese sulphate increased the manganese content of the seeds and controlled the disease.

Soils on which oats suffered from Grey Speck disease and sugar beet from "Speckled Yellow" contained little or no salt-soluble manganese.

THE PLANT IN DISEASE: CONTROL OF DISEASE

(Departments of Entomology, Insecticides and Fungicides and Plant Pathology)

(a) INSECTS AND THEIR CONTROL

- XXXII. C. B. WILLIAMS. "*The Migration of Day-flying Moths of the Genus Urania in Tropical America.*" Proceedings of the Royal Entomological Society of London, 1937, Vol. XII, pp. 141-147.

A number of new records of migration of *Urania leilus* and *Urania fulgeus* is given, and it is shown that the latter species is known in nearly all the central American countries from Mexico to Panama, and also in Columbia, Ecuador and Peru in western South America. There appear to be two flight seasons, and there is some evidence that the flights are more or less to the north in March and April and more or less to the east or south-east in June to September.

- XXXIII. K. J. GRANT. "*Some Recent Migrations of the Silver-Y. Moth.*" Transactions of the South Eastern Union of Scientific Societies, 1937, pp. 1-8.

An account is given of the evidence available on the migrations of *Plusia gamma* in 1932 to 1936. In 1936 there was a remarkable immigration and the species was seen as far north as the Shetland Islands. Immigrant swarms arrived in May and June and extensive damage was done to the sugar beet fields of Norfolk and Lincolnshire by the resulting larvae. During August and September migrations on a large scale were noted to both south and west.

The effect of wind on the flights is discussed and also the evidence that the Silver-Y. moth may survive the winter.

- XXXIV. K. J. GRANT. "*An Historical Study of the Migration of Celerio lineata lineata Fab. and Celerio lineata livornica Esp. (Lepidoptera).*" Transactions of the Royal Entomological Society of London, 1937, Vol. LXXXVI, pp. 345-357.

The distribution and outbreaks of the sub-species *Celerio lineata lineata* in America and *Celerio lineata livornica* in the Old World are described. It is suggested that both sub-species originate in semi-desert areas, and this idea is supported in the case of the American sub-species by the fact that a correlation exists between outbreaks of moths and a certain sequence of direct rainfall.

The main occurrences and outbreaks of both races in the past century are listed, and it is shown that a correlation exists between years of unusual abundance and unusual absence in the two continents. Outbreaks tend to occur simultaneously, and therefore their causes must be sought in some factor common to the two continents.

- XXXV. C. B. WILLIAMS. "*The Use of Logarithms in the Interpretation of Certain Entomological Problems.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 404-414.

It is found that where catches of insects in a light trap are being examined statistically more consistent results are obtained if the logarithm of the catch