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### Crops, Plant Growth, Plant Products and Action of Manures

#### Rothamsted Research

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## SCIENTIFIC PAPERS

Published 1932, and in the Press

### PLANT GROWTH, PLANT PRODUCTS AND ACTION OF MANURES

(Departments of Botany, Chemistry, Fermentation, Physics and Statistics ; and the Imperial College Staff)

#### (a) PLANT GROWTH.

- I. F. J. RICHARDS. "*Physiological Studies in Plant Nutrition. III. Further Studies of the Effect of Potash Deficiency on the Rate of Respiration in Leaves of Barley.*" *Annals of Botany*, 1932, Vol. XLVI, pp. 367-388.

The part played by water content in determining the differences in the usual characteristics between leaves from barley grown under various types of mineral salt deficiency is discussed ; the conclusion is reached that differences in the ratio of dry weight to leaf area between treatments are almost wholly accounted for by differences in water content, whereas the variation of this ratio from leaf to leaf on the same plant is due primarily to variation in anatomical structure.

Results of experiments on the respiration rate of the successive leaves from plants grown at four external potash concentrations are presented. They show clearly that, in general, as the level of potash concentration is lowered, respiration rate increases, but that there is an optimum concentration below which the rate again decreases.

The positive correlation between respiration rate and amount of potash supplied, at very low concentrations, is apparently entirely due to the fact that carbohydrate concentration within the leaf is in the minimum. When abundant carbohydrate is present, the evidence is that over the complete range of manuring used there is a negative correlation between respiration rate and amount of potash supplied. A theory based on the amino-acid content of the leaf is put forward in explanation of this.

As the external concentration of potash decreases, so does the internal, but the relationship is not linear. There is strong evidence that where the amount of potash within the leaves is high, much of it may be washed out by rain, but under conditions of starvation what potash is present cannot be removed in a like manner.

- II. W. E. BRENCHLEY AND S. G. HEINTZE. "*Colonisation by *Epilobium angustifolium*.*" *Journal of Ecology*, 1933, Vol. XXI, pp. 101-102.

*Epilobium angustifolium* (Rose-bay) established itself on certain acid areas of Park Grass plots on which the herbage had been devastated by the severe frosts of 1928-9, which was followed by exceptional drought. Examination of the pH value of the soil indicated

that the varying distribution of *Epilobium* was a question of competition rather than soil reaction.

Where most *Epilobium* appeared, the return of the normal vegetation on the devastated patches was less complete than on the other plots, and the young *Epilobium* seedlings had therefore a better chance of establishing themselves. This fits in with the known facts of the habits of the species, which tends to spring up freely where areas have been cleared by fire, blizzard or similar drastic agencies, to disappear again as other vegetation reasserts itself, as has since happened in this case with the steady improvement in the grass herbage.

III. W. E. BRENCHELY AND K. WARINGTON. "*The Weed Seed Population of Arable Soil. II. Influence of Crop and Methods of Cultivation upon the Relative Abundance of Viable Seeds.*" *Journal of Ecology*, 1933, Vol. XXI, pp. 103-127.

The weed seed population of the soil is greatly influenced by the type of crop grown. Soil conditions being similar, the composition of the flora under continuous wheat and barley is very much the same, but the relative abundance of the constituent species varies greatly, some being favoured by the wheat crop and others by the barley.

When fallowing operations are carried out, most species of weeds are reduced in number, but the degree of reduction ranges over a wide percentage, while a few species may even be increased. These variations seem to depend upon the correlation between the times of the fallowing operations and the periods of maximum germination of the different species, coupled with the length of their natural dormancy. If the intervals between cultivations are too prolonged, some species are able to reach maturity and replenish the soil with so many seeds that the beneficial effect of the fallowing is entirely lost.

When land is cropped, the processes of cultivation affect the weed flora more variably than is the case with fallowing. On the same area some species may be drastically reduced, while others may be doubled or trebled in quantity. This again depends on the correlation between the date of sowing the crop, the method of cultivation, and the habits of the weed species as regards maximum period of germination and length of natural dormancy.

Some weed species respond to cropping and fallowing in the same general direction, being reduced by both methods of cultivation. Other species may be generally reduced by fallowing, but behave variably under crop, being increased or decreased in different seasons.

From the agricultural point of view it is apparent that unless fallowing operations can be carried out with a much greater degree of thoroughness than is usual, reduction of many weeds can be effected almost as well and more economically by intensified cultivation while the land is under crop. Other species, however, which tend to increase in some seasons under crop conditions, may be more effectively dealt with by fallowing if their predominance justifies the expense, which implies loss of crop as well as the cost of numerous cultivations.

- IV. R. J. KALAMKAR. "*A Statistical Examination of the Yield of Mangolds from Barnfield at Rothamsted.*" *Journal of Agricultural Science*, 1933, Vol. XXIII, pp. 161-175.

Series of yields (root weight) of twenty-five plots of Barnfield mangold field are analysed into components representing (a) deterioration, (b) slow changes other than steady deterioration, (c) annual fluctuations. The first two of these components are exhibited graphically from 1876 to 1930.

Yields are well maintained on the dunged strip, except for the last few years. This falling off does not appear in the other strips, and may be due to a falling off in the quality of the farmyard manure in the last five years.

On the strip receiving farmyard manure, and on that receiving superphosphate, the plots receiving nitrate of soda yielded more highly than any others; on the strips receiving complete minerals, and on that receiving superphosphate and potash, the two plots receiving rape cake in one case, and sulphate of ammonia and rape cake in the other, gave higher yields than nitrate of soda; on the strip receiving no minerals the result is intermediate, there being little to choose between these three plots. On all strips sulphate of ammonia is the least satisfactory of the four nitrogenous dressings tested.

In 1876 the land had been already for many years under experiment, and the deterioration from this date is not very striking. The complete minerals and the superphosphate plots Series O (without nitrogenous manure) show significant deterioration, as does the strip without minerals on Series AC (rape cake and ammonium sulphate). On the strip without minerals the unmanured plot also, and that receiving rape cake, both show a strongly suggestive deterioration.

Slow changes other than deterioration are unimportant relatively to annual variation except on the dunged plots. Change in the type of cultivation, prevalence of weeds and change in the quality of the manure, are suggested as the probable causes of the slow changes occurring on these plots.

Plots receiving organic manures or potash have shown relatively smaller annual variance. Plots receiving nitrogenous fertilisers have a large annual variation.

#### (b) PLANT PRODUCTS

- V. R. K. SCHOFIELD AND G. W. SCOTT BLAIR. "*The Relationship Between Viscosity, Elasticity and Plastic Strength of Soft Materials as Illustrated by Some Mechanical Properties of Flour Doughs. I.*" *Proceedings of the Royal Society of London, A*, 1932, Vol. CXXXVIII, pp. 707-718.

An extended significance is given to Maxwell's "time of relaxation," and this has been used in quantitatively describing the viscous and elastic behaviour of flour dough. The length of the time of application of a stress in relation to the corresponding time of relaxation determines what proportion of the deformation is elastic (recoverable) and what proportion plastic (non-recoverable). This fact is illustrated by a comparison of the behaviour of dough in the "pachimeter" and on the "rack," the behaviour in the "pachi-

meter" (rapid stressing) being paralleled by that exhibited in a ballistic experiment. The decay of internal stress in pieces of dough which had been stretched out and held stretched has been followed, and the times of relaxation and the corresponding viscosities have been evaluated for a series of stresses. Dough shows a phenomenon similar to the hardening of metals under working as a result of which the time of relaxation and the viscosity for a given stress depend on the total deformation.

The internal structure of the dough thus revealed is briefly considered.

- VI. R. K. SCHOFIELD AND G. W. SCOTT BLAIR. "*The Relationship between Viscosity, Elasticity and Plastic Strength of a Soft Material as Illustrated by some Mechanical Properties of Flour Dough. II.*" Proceedings of the Royal Society of London, A, 1933, Vol. CXXXIX, pp. 557-566.

The dependence of the viscosity of a flour dough on the shear which has taken place as well as on the shearing stress is brought out by a series of observations on the rate of shear in cylinders of unyeasted dough hung vertically and allowed to elongate under the action of gravity.

The deformations were recorded by marking a millimetre scale in enamel on the surface of the dough cylinders, and, after elongation had proceeded for a measured time, printing the deformed scale off on to a strip of duplicator paper. The print has been called a rheogram.

The conditions of test correspond closely with those ruling inside a dough distending under the action of yeast, but whether the method is capable of distinguishing the small differences which are of importance in baking has still to be determined.

- VII. R. K. SCHOFIELD AND G. W. SCOTT BLAIR. "*The Relationship between Viscosity, Elasticity and Plastic Strength of a Soft Material as Illustrated by some Mechanical Properties of Flour Dough. III.*" Proceedings of the Royal Society of London, A, 1933, Vol. CXXXIX, pp.

A further study of the mechanical properties of flour dough has revealed the presence of two properties in addition to hardening, both of which are well known in the study of metals: namely, elastic after-effect and elastic hysteresis.

The first necessitates the addition of a term  $d\alpha/dt$  to the Maxwell equation, which then becomes:

$$\frac{de}{dt} = \left( \frac{l}{n} \frac{dS}{dt} - \frac{d\alpha}{dt} \right) + \frac{1}{n} \cdot S$$

This term is only important when abrupt changes of stress have recently occurred.

The second property causes  $n$  to decrease steadily whenever  $dS/dt$  preserves the same sign for some time, and to increase abruptly when the sign of  $dS/dt$  is changed.

In Paper II it was shown that the viscosity, as determined from the rate of flow, agreed roughly but not exactly with that calculated as the product of the rigidity modulus and the relaxation time. It is

now clear that the value adopted for  $n$  was a mean value, and differed somewhat from that appropriate to the conditions during stress relaxation. Due appreciation of this point renders the agreement quantitative.

- VIII. F. E. DAY. "*Laboratory Trial Brews with New Varieties of Hops.*" Journal of the Institute of Brewing, 1932, Vol. XXXVIII, pp. 16-18.

Samples of several of the new varieties grown at E. Malling in 1930 were compared with E. Kent Goldings, Saaz, and Oregon hops by means of small-scale brewings. Oregon x English and German x English crosses had flavours intermediate between their parents. Manitoba seedlings gave very bitter flavour. Small-scale brewings are definitely of value in comparing hops. Bitterness of beer is not proportional to  $\alpha$ -resin addition.

- IX. F. E. DAY (in part). "*A Method for the Quantitative Comparison of the Relative Stabilities of Hopped Worts before and after Fermentation.*" Journal of the Institute of Brewing, 1932, Vol. XXXVIII, pp. 308-310.

Small-scale brewing tests gave evidence of the dependence of beer stability on hop resin content, other things being equal. Support is therefore given to the value of analyses of hops for determining their preservative strength.

#### (c) ACTION OF MANURES

- X. W. E. BRECHLEY. "*The Action on the Growth of Crops of Small Percentages of Certain Metallic Compounds when Applied with Ordinary Artificial Fertilisers.*" The Journal of Agricultural Science, 1932, Vol. XXII, pp. 704-735.

*Copper.* No beneficial effect on the growth of barley or mustard on two types of soil was obtained by the addition of quantities of copper sulphate ranging up to 4 per cent. of the total artificial fertilisers applied.

*Vanadium.* Increased fineness of grinding of basic slag in some cases brings about a certain reduction of crop, which may be due to the presence of vanadium in such slags.

*Lithium.* Barley is less sensitive to the toxic action of lithium than of copper, and a suggestion of stimulation was obtained with very dilute solutions in the presence of nutrient salts. Buckwheat is more sensitive to the action and exhibits stimulation with any concentration.

*Titanium.* The growth of mustard on two different soils was not improved by small proportions of titanium compounds added to the usual artificial fertilisers.

*Aluminium.* Barley proved to be very sensitive to the toxic action of aluminium sulphate, the harmful effect becoming more evident when the nutrient solutions were renewed, so that fresh supplies of poison were brought into contact with the roots. Peas were much less affected, remaining quite healthy in concentrations

which killed barley. No evidence of stimulation was obtained with barley, peas, or maize, with any strength of aluminium sulphate, however dilute.

- XI. E. M. CROWTHER. "*The Present Position of the Use of Fertilisers.*" *Journal of the Royal Agricultural Society of England*, 1931, Vol. XCII, pp. 16-18.

A survey of the statistics for the world's production of fertilisers from the beginning of the industry to 1930 showed that for long periods before the war the annual percentage increase in output was remarkably steady. By the time of the "nitrogen crisis" of 1931, the total world output had reached the level that would have been attained if the relative rate of increase had continued at its pre-war rate. Comparisons of the results of large numbers of fertiliser trials brought out the uniformity of the average responses to unit N, P<sub>2</sub>O<sub>5</sub>, and K<sub>2</sub>O in their effects on crops, but the wide differences in the ratios of the amounts of the fertiliser consumed in different countries.

- XII. E. M. CROWTHER. "*The Loss of Lime from Light Soils (an Examination of the Woburn Barley and Wheat Soils).*" *Journal of the Royal Agricultural Society of England*, 1932, Vol. XCIII, pp. 199-214.

The exchangeable calcium contents of soil samples taken from the Woburn Experimental Station in 1927 after 50 years of continuous cultivation for wheat and barley and again in 1932 after two years of fallow and three years of cropping without manure are discussed in relation to the recovery of the lime added and the effects of farmyard manure, nitrate of soda, ammonium sulphate, and mineral manures. The conclusions are used in order to interpret past and present practices in light land farming and to show the type of field experiment now urgently required at a number of representative centres.

- XIII. E. M. CROWTHER AND R. G. WARREN. "*Report on Field, Pot and Laboratory Work. Appendix to Tenth Interim Report of Permanent Committee on Basic Slag, Ministry of Agriculture,*" 1932, Vol. X, pp. 4-21.

This report gives (a) the yields and chemical composition of hay in a series of field trials on four phosphatic fertilisers, mostly in the second year of experimentation; (b) the results of a similar trial on pasture grazed by cattle and sheep except for a short period in the season when the produce was mown, weighed and analysed. A series of such separate experiments with interrupted grazing and one with repeated mowing without grazing has shown high effects from the more soluble fertilisers. Over 16 per cent. of the phosphoric acid added in superphosphate was recovered in the first year; (c) the results of a repeated mowing experiment for three years in Devon; (d) the results of pot experiments for three years on barley.

- XIV. H. L. RICHARDSON. "*The Behaviour of Nitrogenous Fertilisers in Grassland Soils.*" *Agricultural Progress*, 1933, Vol. X, p. 160-163.

Systematic determinations of ammonia and nitrate nitrogen in grassland soils showed that the ammonia level was generally higher

than the nitrate level. There was a very rapid disappearance of added nitrate and a rather less rapid removal of added ammonia. The rate of removal of the latter, however, was such as to suggest that some of the ammonia might be taken up directly without nitrification. This was made practically certain by a study of the rate of nitrification, which was very low in certain soils from which ammonia was rapidly removed.

The equilibrium between ammonia and nitrate production in these soils is discussed.

- xv. J. G. SHRIKHANDE. "*The Degree of Humification in Manures Measured by the use of Hydrogen Peroxide.*" *Soil Science*, 1933, Vol. XXXV, pp. 221-228.

It is known that humified organic matter can be distinguished from non-humified by the action of hydrogen peroxide. The action of three per cent. hydrogen peroxide has been used for measuring the degree of humification which appears to be a useful measure of the decomposition undergone by any one kind of plant material under different treatments. The loss after extraction with peroxide is not an infallible guide to the value of organic manures in general. A comparison has also been made between the extractive properties of water and peroxide.

## STATISTICAL METHODS AND RESULTS

(Department of Statistics)

### (a) MATHEMATICAL THEORY

- xvi. R. A. FISHER. "*Inverse Probability and the Use of Likelihood.*" *Proceedings of the Cambridge Philosophical Society*, 1932, Vol. XXVIII, pp. 257-261.

An explanation of the distinction between these two methods of reasoning from experience, with a correction of some allusions to likelihood in which they are confused.

- xvii. R. A. FISHER. "*The Concepts of Inverse Probability and Fiducial Probability Referring to Unknown Parameters.*" *Proceedings of the Royal Society, A*, 1933, Vol. CXXXIX p.p. 343-348.

The argument of Jeffreys in favour of a particular frequency distribution *a priori* for the precision constant of a normally distributed variate rests on the fallacy that the probability of the last of three observations, lying between the previous two, should be one-third, *irrespective of the distance apart of the two previous observations.*

The apparent simplicity of the results of assuming this particular distribution *a priori* rests on the fact that the *inverse* and the *fiducial* probability statements about the unknown parameter are thereby made to coincide, though logically they are entirely distinct. This particular distribution *a priori* is, however, not only hypothetical but unacceptable as such, since it implies that all ranges of values of the parameter covering finite ratios, however great, are infinitely improbable.

F