ROTHAMSTED RESEARCH

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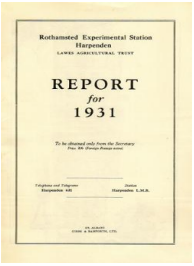

Crops, Plant Growth, Plant Products and Action of Manures

Rothamsted Research

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SCIENTIFIC PAPERS

Published 1931 and in the Press

CROPS, PLANT GROWTH, PLANT PRODUCTS AND ACTION OF MANURES

(Chemical, Fermentation, Mycological and Statistical Departments; and the Imperial College Staff.)

(*a*) CROPS

I. E. J. RUSSELL. "*The Changing Outlook in Agriculture.*" Presidential Address to Section M (Agriculture) at the British Association Centenary Meeting, September, 1931.

A survey of the chief changes in practical agriculture and of the chief movements in agricultural science during the past 100 years.

II. E. J. RUSSELL. "*Die Wirkung von Düngemitteln auf den Ernteertrag. Ergebnisse der von Lawes und Gilbert begonnenen Feldversuche an der landwirtschaftlichen Versuchsstation Rothamsted*, 1843-1930." Archiv für Pflanzenbau, 1931, Vol. VIII, pp. 1-69.

A summary of the chief results of the Rothamsted field experiments from the year 1843 to 1930. This is based on lectures delivered by the author in Denmark, Germany and Holland, and it includes discussions of many of the points raised by agricultural experts in those countries.

(*b*) PLANT GROWTH

III. W. O. JAMES, "*Studies of the Physiological Importance of the Mineral Elements in Plants. II. Potassium: its Distribution, Movement and Relation to Growth in the Potato.*" Annals of Botany, 1931, Vol. XLV, pp. 425-441.

The fresh weight, dry weight, and weight of potassium were determined at regular intervals in the leaves, stems and tubers of potato plants throughout the season of growth. From these data, relative growth rates, potassium and water contents, and rates of absorption and migration of potassium are calculated.

The relative growth rate of the whole plant is similar to those already established for maize and other plants. The curves of the individual organs show a much shorter initial lag phase than that of the whole plant. The latter is shown to be due mainly, though not entirely, to the diminishing weight of the mother tubers. The residual lag may represent the growth of the meristem, i.e. increase in the number of dividing cells.

The time curve of potassium content of the whole plant (expressed either as percentage of dry weight or of water content) shows a significant connection with the relative growth-rate curve ($r=0.9448$, $P=>0.01$). This connection disappears in the individual organs owing to the comparatively short periods of rising relative

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growth rate. In later phases growth rate declines more rapidly than potassium content, but less rapidly than potassium absorption, suggesting a heaping up of potassium in non-meristematic regions.

There is a significant positive correlation ($P > 0.01$) between potassium and water contents through the growth period and a definite connection in spatial distribution. It is suggested that the mechanism of the relation is complex, involving at least solution tension, osmotic pressure, and adsorption forces. The result is a tendency to establish an equilibrium between potassium and water at somewhere between 1 and 0.5 per cent. potassium, in the active parts of the plant, and somewhat lower in the mature tubers.

It is shown that potassium ions may move from one organ to another either with or against the average concentration gradient between them. The movements contrary to such gradients are always in the normal direction of the transpiration stream, while those with the gradients are against the stream.

These movements, together with the heaping up and final removal of potassium from the leaves, suggest that a continuous circulation of the element goes on. The upward movement probably depends mainly on mass movement in the transpiration stream, while the downward movement is due to some different mechanism, dependent upon concentration gradients, but faster than diffusion.

IV. F. G. GREGORY, AND F. CROWTHER. "*A Physiological Study of Varietal Differences in Plants. II. Further Evidence for the Differential Response in Yield of Barley Varieties to Manurial Deficiencies.*" Annals of Botany, 1931, Vol. XLV, pp. 579-592.

Further evidence is presented for the existence of a differential response of varieties of barley to various types of manuring.

Three varieties were grown, namely, the hybrid Plumage Archer and the parent forms Plumage and English Archer. Four types of manuring were used: fully manured controls, and deficiency in nitrogen, in phosphorus, and in potassium. Forty-two replicates of each variety for each manuring were used, giving 504 cultures in all.

Each set of replicates was sampled fortnightly throughout the period of vegetative growth, each harvest representing a random sample of six pots.

The resulting data were treated by the analysis of variance method, and values for differential response of significance far greater than 100 to 1 are obtained for each part of the plant.

The behaviour of the varieties is compared with the previous results of 1927, and a large measure of agreement is found, showing that with some certainty the varieties studied may be characterised by their manurial efficiencies.

The hybrid form appears to inherit specific manurial efficiency from both parents.

V. "ALUMNUS." "*A Comparison of the Effect of Rainfall on Spring and Autumn-dressed Wheat at Rothamsted Experimental Station, Harpenden.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 101-114.

During the first twenty-four years of the Broadbalk wheat experiment the nitrogenous manures were applied wholly in the

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autumn. This paper describes an enquiry into the possibility that the large average loss of yield ascribable to winter rain on Broadbalk had been due especially to this early period. It is found that the curves of loss due to rainfall would in fact be scarcely changed had the manurial treatments been applied always as they are now.

An additional fact which attracted notice and was verified by further data is that the advantage of spring-dressed over autumn-dressed plots, though little influenced by winter rain, is considerably affected by summer rain. In fact, it appears that before a dry summer the autumn dressing is the more advantageous.

VI. J. O. IRWIN. "*On the Influence of Soil Temperature on the Germination Interval of Crops.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 241-250.

The data collected under the Agricultural Meteorological Scheme of the Ministry of Agriculture have provided information for a number of years in a number of places on the dates of sowing and appearance above ground of wheat, winter oats, spring oats, spring barley, turnips and swedes.

The present paper summarises these data, and determines the correlations and regressions of germination interval on soil temperature.

For all the cereal crops the correlations are significant, and, except for spring barley, high. The results for the winter-sown cereals are different from the spring-sown and we may summarise them by saying that the "germination interval" for winter wheat and oats is shortened by from 1.5 to 2 days for each increase of a degree F. in 4 in. or 8 in. soil temperature; for spring cereals the corresponding shortening is about a day.

VII. J. O. IRWIN. "*Precision Records in Horticulture.*" Journal of Pomology, 1931, Vol. IX, pp. 149-194.

The present study is based on observations made on apple trees planted in connection with the Ministry of Agriculture's Horticultural —Meteorological Scheme. This scheme had as its object the study of the relation between weather and the growth of horticultural crops.

A meteorological station, where one did not already exist, was set up in every station participating in the scheme and observations on apples, plums, black currants and peas were made in each place. The observations were started in 1925 and are still continuing. It was laid down that the varieties used were to be the same in each place, and a standardised programme of observations was drawn up.

In order to determine whether phenological phenomena in horticulture are capable of precise and objective measurement by the sampling method, an experimental trial was made at East Malling in the spring of 1930.

(*c*) PLANT PRODUCTS

VIII. L. R. BISHOP. "*The Practical Application of the Results of Research to the Production of Malt and Wort.*" Journal of the Institute of Brewing, 1931, Vol. XXXVII, pp. 345-359.

A study of results partly obtained by Miss E. M. Thomas under the late Professor Schryver. It is shown that about 35 per cent. of the nitrogen in the barley becomes "permanently soluble nitrogen" in the wort from the resulting malt. For six rowed barleys

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the figure is 29 per cent. Differences from this figure reveal differences in modification. The highest value is obtained at a mashing temperature of 50°C, and declines on each side of this temperature. Ammonia, amide and amino nitrogen increase slightly with increase in barley nitrogen content but, in this case and with change in mashing temperature, the main changes are due to changes in "peptide" and "undetermined" nitrogen.

The simultaneous studies of the carbohydrates showed that, other factors being constant, maltose production has a sharply marked optimum at 60°C., while the dextrinous substances in wort increase slowly to an optimum above 70°C.

IX. F. E. Day. "*Laboratory Brews with the New Hops.*" Journal of the Institute of Brewing, 1931, Vol. XXXVII, pp. 202-205.

The author's laboratory method for small scale brewing was improved in details and shown to be of value in investigations involving questions of flavour. It was successfully applied in the examination of small quantities of hops under more controlled conditions than are possible in large scale trials.

X. A. G. Norman, "*Studies on the Gums.* II. *Tragacanthin—the Soluble Constituent of Gum Tragacanth.*" Biochemical Journal, 1931, Vol. XXV, pp. 200-204.

Tragacanthin, the soluble constituent in gum tragacanth, may be separated by ordinary filtration in extreme dilution. Uronic acid units are found to be present and to constitute about one-half of the molecule. Arabinose was the only sugar found; no galactose could be detected. Hydrolysis products were prepared, the analytical figures for which give rise to the suggestion that a portion of the arabinose is united to the uronic acid to form a resistant nucleus, and the residue attached by glucosidic linkage, and therefore easily removable.

XI. H. L. Richardson. "*The Use of Hydrogen Peroxide for Estimating Humification.*" Soil Science, 1931, Vol. XXXII, pp. 167-171.

Six per cent. hydrogen peroxide, as used for measuring "degree of humification," was found to exercise a considerable action on a wide range of unhumified plant materials, and this action was increased by the presence of soil. Consequently, the method may be useful for following progressive stages in the decomposition of a single material, but it can give only approximate results and should not be used for comparing materials of different origin.

(*d*) Action of Manures

XII. T. J. Mirchandani. "*The Effect of Summer Green Manures on the Ammonia and Nitrate Contents of Soil Cropped for Winter Wheat.*" Journal of Agricultural Science, 1931, Vol. XXI, pp. 458-468.

At the Woburn Experimental Station it was found that winter wheat after summer tares was poorer than that after summer mustard in the early years of continued experiments both when the green crops were ploughed in directly and when they were folded off by sheep. Further, after a few rotations the wheat yields in all cases

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sank to a very low level. Systematic soil analyses throughout two seasons showed very low contents of nitrate and ammonia, and small scale plot experiments within the main wheat plots gave very large responses to nitrate of soda. It is concluded that the low fertility of these plots is caused by an acute shortage of available nitrogen in late spring and early summer when the wheat has a high nitrogen requirement.

XIII. E. M. CROWTHER AND T. J. MIRCHANDANI. *"Winter Leaching and the Manurial Value of Green Manures and Crop Residues for Winter Wheat."* Journal of Agricultural Science, 1931, Vol. XXI, pp. 493-525.

It is suggested that the striking failure of winter wheat grown in rotation with two summer crops of tares or mustard on the sandy soil of the Woburn Experimental Station is due to the production of nitrate and ammonia from the green manures at times when the wheat is unable to use them efficiently and the consequent loss of nitrate in the drainage. Owing to the low C/N ratio in tares, the nitrogen nitrifies very rapidly and the loss by leaching is very great. Mustard, on the other hand, reduces the winter loss, but the nitrogen present in the mustard and that absorbed in the decomposition of the excess carbon compounds are liberated too slowly to be utilised efficiently by the wheat and much of the nitrate subsequently produced is also lost by leaching.

Nitrification experiments in the laboratory and pot experiments on wheat showed that nitrogen was made available more rapidly and more completely from materials with 13C/1N (tares, mustard+ blood, straw + blood) than from those with 26C/1N (tares + straw mustard, straw + blood). The yields in unleached pots were much higher with materials with 13C/1N, but in pots leached systematically during the winter the two types of organic matter were equally effective. The reduction of crop by leaching was closely correlated with, but not proportional to, the extent of early nitrate formation as measured by the amount of nitrate leached from the pots. It is suggested that early nitrate formation reduces the yield not only by increasing the removal of nitrate by leaching, but also by increasing the amount converted by the soil micro-organisms into forms which become available again only very slowly.

Tares material formed nitrates and mustard material removed it more rapidly and completely than equivalent mixtures. The less intimate association of the proteins and cellulosic substances in the mixtures appears to be sufficient explanation of these differences. There was no evidence of specific toxins or stimulants in mustard or tares. The bearing of these results on crop rotations and green manuring on light soils is discussed.

XIV. E. M. CROWTHER AND R. G. WARREN. *"Report on Laboratory and Pot Culture Work and Discussion of the Yields and Composition of the Experimental Crops from the Field Experiments on Phosphatic Fertilisers."* Appendix to Ninth Interim Report of Permanent Committee on Basic Slag, 1931, Ministry of Agriculture, pp. 7-31.

An account is given of a series of phosphatic fertiliser trials on grassland both for hay and with repeated mowing in partial imitation

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of grazing conditions. The herbage in all cases was analysed for nitrogen and phosphoric acid so as to assess improvement in feeding value and the recovery of the added phosphoric acid. Pot experiments on some of the more recent types of low soluble slags gave results only very slightly superior to those of the older types.

XV. E. M. CROWTHER AND H. L. RICHARDSON. "*Studies on Calcium Cyanamide. I. The Decomposition of Calcium Cyanamide in the Soil and its Effects on Germination, Nitrification and Soil Reaction.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 300-324.

These studies were undertaken as an investigation of the modern standardised form of Calcium Cyanamide. Its rates of decomposition by various powdered minerals and in a number of soils were compared. In different soils the rate varied considerably, but given thorough mixing, most of the cyanamide was converted to urea or ammonia within a few days. The rate of disappearance in a soil was found to follow a logarithmic law, being proportional to the concentration of cyanamide in the soil solution.

The toxicity to germinating seeds was examined in laboratory experiments, and was found to be caused by the cyanamide itself, not by impurities or products of decomposition of the fertiliser. It fell off rapidly as the interval between applying Calcium Cyanamide and sowing the seeds increased, in accordance with the rapid disappearance of the cyanamide.

Ammonification and nitrification were studied in pot and field experiments; within a few days the soil ammonia content was practically the same whether nitrogen was added as sulphate of ammonia or as Calcium Cyanamide, but the final stage of nitrification was often slower with the latter. The extent of the retardation depended on the type of soil and on environmental conditions, showing a reduction with improved aeration in the pot experiments, and being very slight in the field experiments.

The effect of Calcium Cyanamide on soil reaction was consistently good as compared with the acidifying action of sulphate of ammonia, and it was shown that the use of Calcium Cyanamide was equivalent to the addition of its own weight of quicklime with a corresponding dressing of sulphate of ammonia.

XVI. B. K. MUKERJI. "*Studies on Calcium Cyanamide. II. Microbiological Aspects of Nitrification in Soils under Varied Environmental Conditions.*" Journal of Agricultural Science, 1932, Vol. XXII, pp. 335-347.

Extensive series of bacterial counts and determinations of CO_2 production showed that under laboratory conditions both of these were increased by the addition of Calcium Cyanamide to soil. Bacterial numbers were also increased in pot experiments. The ammonification and nitrification of Calcium Cyanamide in soil were studied in the laboratory, and the degree of aeration was found to influence considerably the rates of disappearance of urea, and of production and disappearance of ammonia, as well as the rate of nitrification. In solution cultures Calcium Cyanamide was more

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toxic than dicyanodiamide to nitrifying organisms, although in soils the toxic action of the former is relatively less because of its much more rapid disappearance.

XVII. H. L. RICHARDSON. "*Studies on Calcium Cyanamide. III. Storage and Mixing with Superphosphate.*" Journal of Agricultural Science, **1932**, Vol. XXII, pp. 348-357.

There was no appreciable loss of nitrogen from Calcium Cyanamide during storage under good farm conditions for two years, and only slight changes in the forms of the nitrogen present. Less than 1 per cent. was converted to dicyanodiamide after one year. Mixing Calcium Cyanamide and superphosphate caused changes that varied greatly with the conditions ; in a farm mixture spread in a thin layer after mixing, one-sixth of the nitrogen was changed to dicyanodiamide within a day, and one quarter in a month. In a series of laboratory mixtures the proportion of nitrogen converted to dicyanodiamide varied regularly with the composition, a maximum of 50 per cent. being reached in the mixture containing 20 per cent. of Calcium Cyanamide.

Both this paper and the first in the series contain appendices describing the special analytical methods used in the investigations.

STATISTICAL METHODS AND RESULTS
(Statistical Department)

(*a*) MATHEMATICAL THEORY

XVIII. R. A. FISHER. "*The Moments of the Distribution for Normal Samples of Measures of Departure from Normality.*" Proceedings of the Royal Society of London, A, **1930**, Vol. CXXX, pp. 16-28.

Two methods are given for discussing the distribution of the ratios of the symmetric functions k_3, k_4 . . . obtained from samples from a normal distribution to the powers of k_2 of the same degree.

The first method consists in the development of recurrence relations expressing the ratios from a sample of n in terms of the corresponding ratios from a sample of n—1 observations, and of a parameter distributed independently in a known distribution. Theoretically, all the properties of the general distribution could be obtained from these relations in conjunction with a study of samples of 3, 4, 5 . . . observations.

The relations are used to derive the exact values of the first three even moments of the simplest ratio γ, and of the simpler non-vanishing moments of the simultaneous distribution of all the ratios. It is observed that these moments are very simply related to the corresponding moments of the distribution of k_3, k_4 . . . given in a previous paper.

The second method is an application of the method of symbolical operators developed by the author, which confirms the generality of the relationship found. The moments of the one distribution may thus be inferred directly from that of the other for which the combinatorial procedure is available.

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