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Crops, Plant Growth, Plant Products and Action of Manures

Rothamsted Research

Rothamsted Research (1936) *Crops, Plant Growth, Plant Products and Action of Manures* ; Report For 1935, pp 98 - 107 - DOI: <https://doi.org/10.23637/ERADOC-1-67>

SCIENTIFIC PAPERS

(Published 1935 and in the Press)

PLANT GROWTH, PLANT PRODUCTS, AND ACTION OF MANURES

(Departments of Bacteriology, Botany, Chemistry, Physics, Plant Pathology, and Field Experiments Section.)

(a) PLANT GROWTH

- I. E. J. RUSSELL. "*The Place of Soil Science in Agriculture.*" Transactions of the Third International Congress of Soil Science, Oxford, 1935, Vol. II, pp. 1-10. (Presidential Address.)
- II. E. J. RUSSELL. "*Interactions between Roots and Soils. The Growing Plant: its Action on the Soil and on its Neighbours.*" Proceedings of the Sixth International Botanical Congress, Amsterdam, 1935, Vol. II, pp. 1-3.
- III. E. J. RUSSELL. "*La Transition d'un Art à une Science: l'Étude de la culture Agricole.*" Lecture delivered to the Academy of Sciences, Lisbon. May 23rd, 1935.
- IV. E. J. RUSSELL. "*The Future of British Agriculture.*" The Royal Institution of Great Britain, Discourse, March 8th, 1935.
- V. W. E. BRENCHELY. "*The Influence of Season and of the Application of Lime on the Botanical Composition of Grassland Herbage.*" Annals of Applied Biology, 1935, Vol. XXII, pp. 183-207.
(Figures of complete botanical analyses for this paper were published in the Annual Report for 1934, pp. 142-59.)

The botanical composition of the herbage of grassland under constant manurial treatment varies considerably from year to year. With complete fertilisers including nitrogen and minerals the relative proportions of the three main groups of species, i.e., grasses, leguminous and miscellaneous plants, are not usually much affected by season, but with unbalanced fertilisers and on unmanured areas wide fluctuations occur in the percentage of these groups. Variations of individual species, however, occur on all plots. They may be caused by direct or indirect response to season and are much influenced by the type of manuring.

The application of lime to plots with long established manurial treatment does not affect the balance of the three main groups provided the fertilisers are complete, but with unbalanced manures a definite bias in one direction appears sooner or later. Individual species usually respond to lime at once, showing a change of proportion at the first succeeding cut, but under certain soil condi-

tions a delay may occur until a second dressing has been given. It would appear that the maximum effect of liming is reached within a few years from the first application, after which fluctuations with season may again become more obvious.

Shade is also a factor which influences the balance of species in herbage, some species being more sensitive than others. In general, no correlation can be traced between the annual variations in yield and the botanical composition of the herbage.

- VI. W. E. BRECHLEY. "*The Weed Flora in its Relation to Crop and Agricultural Treatment.*" Proceedings, Zesde Internationaal Botanisch Congres, Amsterdam, 1935, Vol. II, pp. 5-7.

The weed flora of arable land consists largely of plants native to the soil, but the association of species is much modified by cultivation and crop competition, the nature of the competition depending on the type of crop. Root crops help to clean the land on account of the intense cultivation during their growth, while clover, lucerne, and similar plants act as "smother" crops, preventing the development of many weed seedlings. In the case of cereals, the time of sowing, whether autumn or spring, is a principal factor in determining the weed flora.

Rotation of crops is usually the most efficient means of controlling weeds, but sometimes fallowing is necessary, the principle of this being to encourage germination of the weed seeds and, by destroying the seedlings repeatedly, to prevent the formation of fresh seed. Most seeds need a dormant period before they can germinate and the length of dormancy is a vital factor in determining the efficiency of fallowing. Many species also germinate most freely at particular seasons of the year, a fact which decides the time of their greatest vulnerability. For successful fallowing, cultivation must begin directly after harvest and be carried out at sufficiently short intervals to prevent rapidly growing species from ripening fresh seed. Fallowing improves soil fertility, and as weeds and crop alike benefit after-care is important, for the weeds may reassert themselves with extraordinary rapidity.

On old grassland the vegetation itself constitutes the crop, the less desirable species being regarded as weeds. The flora is much influenced by soil fertility, manuring and methods of cultural treatment. Grazing has a direct influence on the weed flora as the various animals eat down the herbage differently, and alternate grazing and taking off crops of hay is a valuable method of weed control.

- VII. K. WARINGTON. "*The Effect of Constant and Fluctuating Temperature on the Germination of the Weed Seeds in Arable Soil.*" Journal of Ecology, 1936, Vol. XXIV, pp. 185-204.

Germination of all species was definitely inhibited if the soil was kept in an incubator or cellar where the temperature was practically constant, and light wholly or partially excluded. Some weed seeds were more adversely affected than others, *Alopecurus*

agrestis being the least and *Papaver rhoeas* the most sensitive of the more important species encountered. Removal of the same samples of soil to a glasshouse after one or two years in the incubator or cellar resulted in a rapid germination of a variety of weed seeds, showing that their failure to appear sooner was due to unfavourable conditions in the previous circumstances. This inhibiting effect on germination is attributed to a lack of sufficient fluctuation in temperature rather than to any reduction in light intensity, though with certain species this may also have played a part. Too long an exposure to the constant temperature resulted in loss of seeds by death, the capacity for survival varying with the different species, *Alopecurus agrestis*, for example, generally failing to survive one year, whereas *Alchemilla arvensis* and *Papaver rhoeas* remained viable after two years.

- VIII. E. M. CROWTHER AND F. CROWTHER. "*Rainfall and Cotton Yields in the Sudan Gezira.*" Proceedings of the Royal Society of London, B., 1935, Vol. CXVIII, pp. 343-370.

The relationships between seasonal yield and weather fluctuations for cotton grown under irrigation in the Sudan Gezira were analysed for periods up to 23 years.

The analysis confirmed the generally recognised bad effects of high rainfall about the period of sowing cotton, but showed that this effect was not universal. An unsuspected but apparently general effect was discovered. Cotton yields were negatively correlated with the amount of early—May and June—rainfall. In some areas yields were negatively correlated with late rainfall and with the total rainfall in the preceding year. The differences between areas in their responses to weather could be partially interpreted in terms of their situations and agricultural histories.

The progressive decline in yield at the oldest trial farm could be largely accounted for by a significant increase in total rainfall during the period of cotton cultivation. The total annual rainfall in the Sudan Gezira exhibited a significant seven-year periodicity, which was reflected in cotton yields, dura exports, and recorded famines. It happened that the first trial of irrigated cotton and the first use of the Sennar Dam coincided with minimal rainfalls on this periodicity. The early promise and rapidly increasing difficulties may well have been due in part to the recurrence of unfavourable weather conditions and not necessarily to soil deterioration and pests.

Uniformly treated record areas could easily be established on a normal commercial basis in irrigation projects under central control, and would provide valuable material for research in agricultural meteorology, and a surer background for determining both experimental and commercial programmes.

- IX. E. M. CROWTHER. "*Rainfall and Cotton Yields in the Sudan Gezira.*" Empire Cotton Growing Review, 1936, Vol. XIII, pp. 110-119.

The conclusions from the preceding paper (No. VIII.) were summarised, and extended by testing the rate of change of the

rainfall effects with time. In no set of data examined was there evidence that the effect of unit rainfall had increased or decreased significantly over the period of cultivation. It is not, therefore, possible to use the striking agreement between actual and forecasted yields in some of the recent years as support for the view that soil deterioration was being manifested in greater sensitivity to the harmful rainfall.

- X. D. J. WATSON. "*The Effect of Potassium Chloride on the Diurnal Changes of the Carbohydrates of the Potato Leaf.*" *Annals of Botany*, 1936, Vol. L, pp. 59-83.

The effect of application of potassium chloride on the diurnal changes of carbohydrates in potato leaflets was studied on five plots of the Six-Course Rotation. The changes in composition were all expressed on the basis of 100 gm. initial dry weight, by using a method of sampling which utilises the correlation between opposite leaflets, so that the effect of changes in other constituents was eliminated.

It was found that the rate of formation and removal of starch was not affected, which confirms the work of James and Maskell. The sucrose content was depressed but only during the middle of the day, and there was no effect on reducing sugars.

Significant diurnal variations of starch, sucrose and reducing sugars were found. There was evidence of rapid starch hydrolysis with formation of sucrose at sunset, and of the reverse effect at sunrise.

It has been suggested that "residual dry matter," (dry matter—total carbohydrate) might be used as a constant basis of reference for changes of carbohydrate content. Significant changes of residual dry matter were found, however, during the course of the day, so that this method of expressing the results would have led to erroneous conclusions.

- XI. H. G. THORNTON and HUGH NICOL. "*Reduction of Nodule Numbers and Growth, produced by the Addition of Sodium Nitrate to Lucerne in Sand Culture.*" *Journal of Agricultural Science*, 1936, Vol. XXVI, pp. 173-188.

A sand culture experiment with inoculated lucerne was made to test the effect of increasing doses of sodium nitrate upon the yield and nitrogen content of tops and roots, and upon the number and development of nodules.

There was no correlation between yield or nitrogen content of the lucerne, and the dose of nitrate.

The number of nodules, though unaffected by 1 gm. of sodium nitrate, was progressively decreased by the stronger doses.

The length of nodules was reduced about 30 per cent. by 1 gm. of sodium nitrate, and decreased progressively with stronger doses.

Nodules were found to show a definite relationship between their overall length and the volume of contained bacterial tissue. Using this relation, the mean volumes of bacterial tissue per nodule and per pot for each series were calculated. The reduction effected by nitrate was far greater when measured in this way, owing to the

small contribution of bacterial tissue derived from nodules less than 1.5 mm. in length.

Increasing doses of nitrate also progressively decreased the nodule numbers, and the content of bacterial tissue, per gram of root. The effect of nitrate was thus not due to reduced root growth.

- XII. H. G. THORNTON and J. E. RUDORF. "*The Abnormal Structure Induced in Nodules on Lucerne (Medicago Sativa L.) by the Supply of Sodium Nitrate to the Host Plant.*" Proceedings of the Royal Society of London, B, 1936, Vol. CXX, pp. 240-252.

Lucerne seedlings carrying very young nodules were transplanted into and grown in an agar medium (1) with no nitrate, and (2) containing concentrations of sodium nitrate ranging from 0.05 to 0.2 per cent. The presence of nitrate greatly reduced the growth of the nodules.

The following abnormalities were associated with the supply of nitrate to the host plant :

(1) The cell-walls of the distal cap were very much thickened, the cell-wall material often projecting into the cells in the form of concretion-like lumps. These thickened walls and the lumps gave the same micro-chemical reactions as did the thin cell-walls of the normal tissue. The cell-contents were usually reduced and the nuclei greatly shrunken.

(2) The endodermis that surrounds the central tissue of the nodule and also that which ensheathes the vascular strands were abnormally thickened by a deposition throughout the cell-walls of material giving the suberin reaction.

(3) There was an increased tendency towards necrotic decay of the central bacterial tissue and, where this did not occur, the cell-contents were usually much reduced.

(4) In the younger portions of the bacterial tissue, the bacteria occurred principally in the coccus stage of their life-cycle, a stage usually associated with food deficiency.

- XIII. H. G. THORNTON. "*The Action of Sodium Nitrate upon the Infection of Lucerne Root-hairs by Nodule Bacteria.*" Proceedings of the Royal Society of London, B, 1936, Vol. CXIX, pp. 474-492.

The actions of living nodule bacteria and of sterile filtrates containing their secretions were tested upon root-hairs of lucerne grown in agar medium in the presence and absence of sodium nitrate and ammonium sulphate.

Sodium nitrate at initial concentrations of from 0.1 to 1.0 per cent. prevents infection of the root-hairs.

Sodium nitrate at the above concentrations, and ammonium sulphate at a concentration of 0.1 per cent., check the deformation of the root-hairs by the nodule bacteria. This deformation is a necessary prelude to infection and the checking of it accounts for the absence of infection by the nodule bacteria.

Sodium nitrate at a concentration of 0.1 per cent. also checks

the deformation of root-hairs by sterile secretions of the nodule bacteria.

Both the living bacteria and their sterile secretions not only cause deformed growth of the root-hairs but in addition stimulate an increase in their number and length. Sodium nitrate also checks this growth-stimulation.

These effects of nitrate in inhibiting the action of the bacterial secretions upon root-hairs are mitigated by the addition of dextrose, together with the nitrate, to the medium surrounding the roots. This suggests that the nitrate interferes with the carbohydrate supply to the piliferous layer of the root.

- XIV. L. HAVAS and J. CALDWELL. "*Some Experiments on the Effects of Animal Hormones on Plants.*" *Annals of Botany*, 1935, Vol. XLIX, pp. 729-748.

Present knowledge on the effect of animal hormones on plants is examined; and experiments described in which a number of glandular extracts was administered to plants. On the whole the effect was small.

- XV. J. CALDWELL. "*Occurrence of Copper Poisoning in a Glasshouse Crop.*" *Annals of Applied Biology*, 1935, Vol. XXII, pp. 465-468.

Small traces of copper may produce in cucumbers a disease simulating virus diseases, and care is necessary in commercial practice to avoid any chance of copper contamination, e.g. in sterilising pots.

(b) PLANT PRODUCTS.

- XVI. A. G. NORMAN. "*The Hemicelluloses. Part I. Alcoholic Sodium Hydroxide as a Pretreatment to Extraction.*" *Biochemical Journal*, 1935, Vol. XXIX, pp. 945-952.

As a pretreatment to the preparation or direct determination of hemicelluloses, an extraction of the material with 1 per cent. NaOH in 50 per cent. alcohol has been advocated as a delignifying agent. The effect of various concentrations of alcoholic soda has been studied.

When hot, 1 per cent. NaOH in alcohol concentrations up to 90 per cent. extracts in addition to lignin a considerable amount of polyuronide material, the amount increasing as the alcohol concentration is decreased. When cold, the action is less drastic in 70 per cent. alcohol and higher concentrations, but is still appreciable in 50 per cent. alcohol and lower concentrations. Alcoholic soda is not a very effective delignifying agent in any of these concentrations.

The polyuronide hemicelluloses of different materials vary in the degree of susceptibility to alcoholic soda. Those of immature tissues seem to be more easily removed than those of older lignified materials. No indication has been obtained that the material removed by alcoholic soda represents a special group or type of polyuronide.

- XVII. A. G. NORMAN, and (in part) J. G. SHRIKHANDE. "*The Hemicelluloses. Part II. The Association of Hemicelluloses with Lignin.*" *Biochemical Journal*, 1935, Vol. XXIX, pp. 2259-2266.

The removal of polyuronide hemicelluloses from plant materials by extraction with hot sulphite solution is affected by previous chlorination to almost the same degree as that of lignin, for which the process was especially designed. Some form of association or combination between lignin and this type of hemicellulose is probable since the extraction of the latter depends on a treatment effecting the solution of the former. Aqueous extractions following chlorination are nearly as effective in the removal of the hemicelluloses as sulphite treatments, once the linkage has been ruptured. The possibility arises that both lignin and hemicellulose may be present in two forms in plant materials, attached and unattached, dependent on the relative quantities of each present.

- XVIII. W. T. ASTBURY, R. D. PRESTON, and A. G. NORMAN. "*X-Ray Examination of the Effect of Removing Non-Cellulosic Constituents from Vegetable Fibres.*" *Nature*, 1935, Vol. CXXXVI, p. 391.

X-ray studies of the progressive removal of the xylan associated with the cellulosic fibres of manilla hemp support the view that the incorporation of xylan in cellulose is a form of mixed crystallisation. The effect of purification of common fibres by removal of lignin and encrusting hemicelluloses was also studied. Improved definition through sharpening of the crystallite orientation was observed, without reduction of intensity.

- XIX. A. G. NORMAN. "*The Composition of Crude Fibre.*" *Journal of Agricultural Science*, 1935, Vol. XXV, pp. 529-540.

The determination of crude fibre is one of the oldest of routine agricultural analyses and is widely used in checking the composition of commercial feeds and similar materials. For research purposes or digestibility studies its use may be misleading because the crude fibre fraction obtained does not bear any definite or constant relationship to the structural constituents of the material or to the crude fibre of any other material. The cellulose is partially attacked, and the lignin extensively removed in the process of its isolation. Much variation is found in the lignin contents of crude fibre fractions, highly lignified materials not necessarily yielding a crude fibre high in lignin.

Since the presence of lignin exercises a direct effect on the digestibility of the material, any empirical method of determination of "fibre" should include all the lignin and to achieve this any alkaline treatment must be avoided. Acid hydrolysis may be a possible alternative method, if a correction for protein be made in the case of materials high in nitrogen and the lignin content subsequently determined.

- XX. L. W. SAMUEL. "*The Amino-Acid Content of Wheat Flour Dough.*" *Biochemical Journal*, 1935, Vol. XXIX, pp. 2331-2333.

In an unyeasted flour dough the amino-acid content increased steadily with time.

In a yeasted flour dough the amino-acid content increased slightly for about an hour and then decreased to an almost constant value.

The rate of utilisation of amino-acid by yeast in a solution similar to the dough liquid indicates that in a yeasted dough the protein is decomposed about twice as rapidly as in an unyeasted dough.

- XXI. L. W. SAMUEL AND R. K. SCHOFIELD. "*The Binding of Glacial Phosphoric Acid by the Proteins of Wheat Flour.*" *Transactions of the Faraday Society*, 1936, Vol. XXXII, pp. 760-769.

Making use of the fact that glacial phosphoric acid is a protein precipitant, measurements have been made of the capacity of the proteins of wheat flour to bind this acid by shaking them up with an excess of the acid and determining the amount remaining in solution by back titration on an aliquot.

Solutions of potassium chloride, hydrochloric acid and trichloroacetic acid are slightly diluted by shaking with wheat starch, but there is no appreciable change in the concentration of a solution containing about 8 gm. of glacial phosphoric acid per litre, owing to the balancing of a very small uptake of acid by a "binding" of some water by the starch. The concentration change caused by adding flour is therefore due to acid taken up by the protein.

The capacity of thirty-seven flours to bind glacial phosphoric acid varied from 6.7 to 10.1 milliequivalents per 100 gm. of flour. The uptake tended to be greater for the flours of higher nitrogen content, but the acid bound per gram of nitrogen varied from 3.52 to 4.82.

Although electrometric titrations revealed differences in the proportions of the constituent metaphosphoric acids in different batches of glacial phosphoric acid, determinations of the binding capacity of a gluten with eight different solutions gave a variation of only 5 per cent. between the highest and lowest values.

The uptake per gram of a gluten varied only slightly with the concentration of the acid between 0.02 and 1.0 normal, and was independent of the amount of gluten added, provided not more than a quarter of the acid was removed from the solution. In confirmation of a theory of the molecular structure of the metaphosphoric acids, put forward in an earlier paper (No. LXI, Report for 1934), it has been found that protein removes certain metaphosphate ions from solution in preference to others. It has further been found that different proteins are selective to different degrees showing that their basic groups can be differentiated as regards their action on glacial phosphoric acid.

Reasons are given for thinking that the uptake of trichloroacetic

acid by gluten from a 0.5*N* solution is a measure of its hydrion binding capacity; if so, the additional titratable acid bound (roughly 30 per cent.) when glacial phosphoric acid is used, must be in the form of hydrions associated with polybasic anions.

The lowest *pH* at which the materials could be washed free of anions (the isoelectric point) was found by Loeb's ferrocyanide method to be: the gluten, *pH* 6.1; the gliadin, *pH* 6.85; the glutenin, *pH* 5.5; and one of the flours, *pH* 5.95. The *pH* values were in each case close to those of the materials as procured, and a correction of a few per cent. only had to be applied to the acid uptake to obtain the acid binding capacity.

(c) ACTION OF MANURES

- XXII. E. M. CROWTHER (with D. N. MCARTHUR). "*Report on Swede Experiments in 1934.*" Appendix II. to Thirteenth Interim Report of Permanent Committee on Basic Slag, Ministry of Agriculture and Fisheries, 1935.

A series of eight 6 x 6 Latin square field experiments on swedes in Scotland was carried out to compare two medium-soluble slags against low- and high-soluble slags and mineral phosphate. At two centres the crops without phosphate failed completely. On the average of the six experiments with highly significant responses low-soluble slag doubled and high-soluble slag trebled the yield. The medium-soluble slags gave intermediate results, but the difference between them was greater than would be expected from their citric acid solubilities.

- XXIII. E. M. CROWTHER and R. G. WARREN. "*Report on Field Experiments in England and Pot Culture Work and Laboratory Work at Rothamsted.*" Appendix I to Thirteenth Interim Report of Permanent Committee on Basic Slag, Ministry of Agriculture and Fisheries, 1935.

A series of pot culture experiments on eleven basic slags, including two new medium-soluble slags, showed that the yield of perennial rye-grass and its phosphoric acid uptake followed very closely the amount of citric soluble-phosphoric acid supplied in both single and double dressings of all of the slags. Mineralogical analyses on the ground slags showed that two medium-soluble slags had different assemblages of crystals. One contained the two silicophosphates commonly found in high-soluble slags, and the other contained a new form of silicophosphate. The medium-soluble and the low-soluble slags contained apatite, often intergrown with a calcium silicate.

- XXIV. E. M. CROWTHER. "*The Manuring of Sugar Beet.*" British Sugar Beet Review, 1935, Vol. IX, pp. 71-73 and 105-6.

The results of over 100 manuring experiments on sugar beet during 1928 to 1934 are reviewed and compared with those for similar experiments on potatoes. The sugar beet gave significant

responses to nitrogen in half the experiments, to phosphoric acid in one-tenth and to potash in one-fifth. Potatoes were much more responsive, significant effects being obtained in about five-sixths of the experiments with nitrogen and in one-half of those with phosphoric acid and potash.

STATISTICAL METHODS AND RESULTS (Department of Statistics)

(a) TECHNIQUE

- XXV. F. YATES. "*Incomplete Latin Squares.*" *Journal of Agricultural Science*, 1936, Vol. XXVI, pp. 301-315.

A description is given of the statistical procedure appropriate for the analysis of a Latin square having missing the whole of one row, one column or one treatment, or one row and one column, or either and a treatment. These are the only types of incomplete Latin squares (except those which can be dealt with by the missing plot technique), of which a neat statistical analysis is possible.

It is shown that incomplete Latin squares of these types give unbiased estimates of error and are therefore valid experimental arrangements. They are consequently likely to be of use when the experimental material is such as to preclude the use of a complete Latin square owing to the fact that numbers in one or both of the natural groups is one less than the number of treatments to be tested.

- XXVI. F. YATES. "*A New Method of Arranging Variety Trials involving a Large Number of Varieties.*" *Journal of Agricultural Science*, 1936, Vol. XXVI, pp. 424-455.

A new method of arranging variety trials involving a large number of varieties is described. This type of arrangement, for which the name "pseudo-factorial" arrangement is proposed, enables the block size to be kept small without the use of controls.

Various possible types of pseudo-factorial arrangement are discussed in detail and the necessary formulae developed. The appropriate methods of computation are illustrated by numerical examples based on the results of a uniformity trial on orange trees. It is shown that pseudo-factorial arrangements are likely to be more efficient than arrangements involving the use of controls. In cases where there is considerable soil heterogeneity they are also markedly more efficient than randomised blocks containing all the varieties. In the chosen example gains in efficiency ranging from 26 to 57 per cent. were obtained.

- XXVII. F. YATES and I. ZACOPANAY. "*The Estimation of the Efficiency of Sampling, with Special Reference to Sampling for Yield in Cereal Experiments.*" *Journal of Agricultural Science*, 1935, Vol. XXV, pp. 545-577.

The estimation of the yields of the individual plots of replicated experiments on cereals by sampling methods has been practised since the year 1929 at Rothamsted and its associated outside centres.