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

#### Rothamsted Research

Rothamsted Research (1935) *Crops, Plant Growth, Plant Products and Action of Manures* ; Report For 1934, pp 89 - 96 - DOI: <https://doi.org/10.23637/ERADOC-1-66>

## SCIENTIFIC PAPERS

Published 1934 and in the Press.

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

(Departments of Bacteriology, Botany, Chemistry, Fermentation, Insecticides and Fungicides, Physics, and the Imperial College Staff.)

#### (a) PLANT GROWTH.

- I. E. J. RUSSELL. "*Chemical Problems in Crop Production.*" Journal of the Chemical Society, January, 1935, pp. 48-53.
- II. E. J. RUSSELL. "*Applications of Chemistry in Modern Agriculture.*" Journal of the Society of Chemical Industry, 1935, Vol. LIV, pp. 325-327.
- III. K. WARINGTON. "*Studies in the Absorption of Calcium from Nutrient Solutions with Special Reference to the Presence or Absence of Boron.*" Annals of Botany, 1934, Vol. XLVIII, pp. 743-776.

Over a nine-week period the quantity of calcium absorbed per week by *Vicia faba* increased up to the seventh or fourth week respectively, according as to whether or not a trace of boron was present, indications of periodicity in uptake being obtained in the former case. Less calcium was absorbed from solutions renewed at weekly or fortnightly intervals than from unrenewed solutions when boron was present, but the reverse was the case if boron were not provided. This difference is attributed to the fact that renewal of the solution delays the appearance of the boron deficiency symptoms, and thus prolongs the absorbing capacity of the plant.

The quantity of the calcium absorbed was approximately proportional to the calcium supplied, irrespective of the presence or absence of boron, although the total calcium taken up was much reduced under the latter conditions. No correlation was found between the calcium supplied and the nitrogen or potash content of the plant, both the latter showing a closer affinity with the production of dry matter.

Under full nutrient conditions the N/Ca and K/Ca ratios in the plant fell as its age increased, the fall being more marked in the presence than in the absence of boron. A lack of boron, therefore, reduced the uptake of calcium more than that of nitrogen or potash.

In the presence of boron, the calcium absorbed per unit of dry matter produced was higher from a pure solution of calcium chloride than from a complete nutrient medium containing a similar quantity of calcium. In the absence of boron, death ensued the more rapidly in the plants grown in the single salt solution, so that the presence of other nutrients apparently increased the requirement of the plant for

both calcium and boron. Although the evidence is not conclusive, indications of an association between boron and calcium were, therefore, obtained.

- IV. W. E. BRENCHELY. "*The Effect of Rubidium Sulphate and Palladium Chloride on the Growth of Plants.*" *Annals of Applied Biology*, 1934, Vol. XXI, pp. 398-417.

Comparisons have been made between the action of rubidium sulphate and palladium chloride on the growth of barley, wheat, oats, peas and beans in complete nutrient solutions.

Over a wide range of concentrations rubidium sulphate was not found to exercise either a beneficial or a harmful action on the growth of any of the species tested. The germination of the seed was likewise not affected.

No benefit was derived from palladium chloride, but at a comparatively low concentration a harmful action occurred which became more intense with increasing concentration. Stunting of the main root and laterals was a characteristic feature of this toxicity. With the lower concentrations the check was temporary, and the roots eventually made normal growth, as good as that in the control plants. With increasing amounts of palladium chloride the poisoning effect became more persistent, until a concentration was reached which did not allow of any root or shoot recovery.

The tolerance of palladium varies with the species, as was indicated by the measure of recovery. Barley appeared to be the least, and oats the most sensitive of the three cereals tested. Peas responded at much the same concentrations as barley, but broad beans made a complete recovery from the initial checking, and the dry weights were not reduced even by the strongest concentration tested. The effect of palladium poisoning was similar whether the seeds were germinated in the presence of palladium or whether the seedlings were not introduced to it until they were about a week old.

- V. J. T. MARTIN and F. TATTERSFIELD. "*The Effect of Environmental Conditions upon Pyrethrum (Chrysanthemum cinerariaefolium). I.*" *Annals of Applied Biology*, 1934, Vol. XXI, pp. 670-681.

The effect of soil fertility upon the insecticidal value of the flowers has been studied in a series of pot experiments. On heavy soil the pyrethrin I content of the flowers was not increased by the application of fertilisers. The plants produced good yields of flowers, rich in pyrethrins, when grown in soil of low fertility.

Under conditions of normal growth and vitality, the extent of production of the pyrethrins in the flowers was characteristic of the individual plant and was dependent upon some factor which appeared to be genetical in character. A plant initially producing flowers of high or low percentage poison content continued to give flowers of the corresponding degree of richness in succeeding years, independently of the application of manures, or apparently of the number of heads produced. Plants derived from rooted shoots produced flowers corresponding in quality with those initially yielded by the parent plant. The insecticidal value of pyrethrum flowers may be improved by plant selection, followed by vegetative propagation.

In the fully-opened flowers, the complete disc florets contained 90 per cent. of the total pyrethrins present in the flowers, and of this the greater part was found to be located in the ovaries.

- VI. J. T. MARTIN and F. TATTERSFIELD. "*The Effect of Environmental Conditions upon Pyrethrum* (*Chrysanthemum cinerariaefolium*) II." *Annals of Applied Biology*, 1934, Vol. XXI, pp. 682-690.

The effects of light, temperature and dormancy upon pyrethrum have been studied. The partial shading of the plant during the five months preceding flowering resulted in the production of smaller flowers with a reduced pyrethrin content.

The successful flowering of the plant was largely dependent upon the relative temperatures experienced throughout the year. A dormant period, dependent upon sufficiently low winter temperatures, was shown to be necessary for the normal production of large numbers of flowers.

- VII. F. J. RICHARDS. "*On the Use of Simultaneous Observations on Successive Leaves for the Study of Physiological Change in Relation to Leaf Age.*" *Annals of Botany*, 1934, Vol. LXVIII, pp. 497-503.

Only in very exceptional cases is it permissible to use the leaves present on a shoot at one time as representative of a simple age series from which the history of single leaves at successive stages may be deduced. Included in the differences observed between the numbers are differences due to the fact that, even at comparable ages, the successive leaves constitute a series of inherently different physiological structures. To determine the effect of age on a particular leaf the corresponding leaves at various stages on replicate plants must be used, even though this involves larger errors of sampling. Further, it must be recognised that the age effect need not be uniform from leaf to leaf. Finally, it is impossible to separate effects which may be possibly ascribed to age as such from those due to change in conditions of nutrition, etc. As a leaf ages it becomes further removed from the growing point and passes successively from the position of the topmost leaf on the shoot to that of the lowest living leaf, a change which in itself must have a far-reaching effect.

- VIII. E. M. CROWTHER. "*Soil Organic Matter and Crop Rotation.*" Second Conference on Cotton Growing Problems, Empire Cotton Growing Corporation, 1934, pp. 319-329.

The experience of cotton experiment stations in different parts of the Empire on crop rotation in relation to the maintenance of soil fertility was reviewed in the light of recent investigations on the decomposition of organic matter in the soil. The effects of crop residues on the production of available nitrogen in the soil may generally be interpreted in terms of the composition of the materials added, the weather conditions, and the aptitude of the soil to store water and soluble nutrients. There is an urgent need for rotation experiments on cotton including such treatments as fallow, a leguminous crop and a cereal, tested in conjunction with different

manurings and cultivations. The report of the discussion on the paper contains a number of interesting comparisons of native and European methods of cultivation in the tropics.

- IX. HUGH NICOL. "*The Derivation of the Nitrogen of Crop Plants, with Special Reference to Associated Growth.*" *Biological Reviews*, 1934, Vol. IX, pp. 383-410.

A résumé is given of some early views concerning the forms of nitrogen supposed to be taken up by plants; the modern view which assigns pre-eminence to nitrate-nitrogen is questioned. Hitherto the manurial value of legumes has been assumed to lie in their residual effects. In this paper evidence is presented that non-leguminous plants can profitably utilise compounds of nitrogen built up by the symbiotic life of nodule bacteria within their host plants. These products of symbiosis, being excreted by the legumes, are available to other plants growing in association with them. It follows that the most economical method of manuring mixed vegetation (such as pasture) is to supply enough lime, phosphate, and potash for the legumes, which will then supply the necessary nitrogen. The importance of the double association of nodule bacteria and legumes with non-legumes has not been fully appreciated.

A section is devoted to the discussion of accessory plant-growth factors, since it is thought possible that leguminous plants play a special part in the provision of such substances in addition to acting as a source of nitrogen for simultaneous and later crops.

- X. H. G. THORNTON and HUGH NICOL. "*Further Evidence upon the Nitrogen Uptake of Grass grown with Lucerne.*" *Journal of Agricultural Science*, 1934, Vol. XXIV, pp. 540-543.

This paper supplements the information given earlier (See Paper XIII, Report for 1933, pp. 66-7). Italian rye-grass grown in the presence of lucerne in sand with no added nitrogen contained, after 18 weeks' growth, more than twice as much nitrogen as did grass of the same age similarly grown but in the absence of lucerne.

- XI. H. G. THORNTON and HUGH NICOL. "*Some Effects of Clipping the Tops upon the Root Development of Lucerne.*" *Journal of Agricultural Science*, 1934, Vol. XXIV, pp. 532-539.

Inoculated lucerne was grown in pots of sand and watered with nitrogen-free food solution. In some of the pots the lucerne was clipped once, in some twice, and in some it was left unclipped. Pots were harvested on four dates at intervals of about three weeks. Counts and measurements of nodules were made and dry weights and nitrogen content of tops and roots were obtained.

Clipping did not significantly alter the nodule numbers, their mean size, or the total nitrogen contents of the plants, *i.e.*, in tops, including clippings, *plus* roots.

Clipping, however, resulted in a decrease in the nitrogen content of the roots of about 40 per cent. as compared with unclipped plants. This nitrogen was transferred to the tops where it was removed in the clippings.

In clipped plants the total yield of the tops, including clippings, was slightly increased, but that of the roots was greatly depressed. This resulted in a reduction in total dry weight of the whole plants.

- XII. HUGH NICOL. "*Yield, Duration and Drought-Resistance of Lucerne as Influenced by Frequency and Time of Cutting.*" Empire Journal of Experimental Agriculture, 1934, Vol. II, pp. 380-390.

It is recommended that lucerne should be sown early in the season, and that it should not be cut more than once in its seedling year. Neglect of these precautions induces small root growth, whence a sparse, short-lived, stand may result. If lucerne is sown in summer on soil liable to dry out, it should not be cut in the year of sowing if drought resistance and a long duration of stand are desired.

A brief discussion of the effects of clipping other plants is added.

(b) PLANT PRODUCTS.

- XIII. A. G. NORMAN and S. H. JENKINS. "*The Determination of Lignin. Part I. Errors Introduced by the Presence of Certain Carbohydrates.*" Biochemical Journal, 1934, Vol. XXVIII, pp. 2147-2159.

Some of the disturbing factors concerned in the determination of lignin by the 72 per cent.  $H_2SO_4$  method have been studied. Certain of the sugars, particularly xylose and fructose, give an insoluble residue on standing with acid of this concentration, and increase the apparent lignin figure when added to plant materials. Polysaccharides containing pentose sugars produce a similar effect. The disturbance caused by the presence of such carbohydrates increases with time of contact with 72 per cent. acid, and at 2 hours the effect is small.

In plant materials the effect of the presence of xylose in the hemicellulose may be almost excluded by a hydrolytic pretreatment with dilute mineral acid, or minimised by reducing the time of contact to 2 hours. The validity of an acid pretreatment is not yet proved, since the action of dilute acids on lignin is not known.

Because of the presence of xylose, the figures generally quoted for lignin are, in most cases, too high, and must be revised. The disturbance due to pentose is caused by the slow production of furfuraldehyde and its condensation with lignin to form an insoluble phenolfurfuran resin. Furfuraldehyde itself may give an insoluble product by dehydration and condensation, but the former reaction probably takes precedence as long as there are lignin groups unsatisfied.

- XIV. A. G. NORMAN and S. H. JENKINS. "*The Determination of Lignin. Part II. Errors Introduced by the Presence of Proteins.*" Biochemical Journal, 1934, Vol. XXVIII, pp. 2160-2168.

Proteins alone give no precipitate on standing with 72 per cent.  $H_2SO_4$ , but when added to plant materials increase the apparent lignin content. The lignin residue then obtained contains nitrogen.

The magnitude of the disturbance produced is quite different if the material is previously subjected to a hydrolytic pretreatment, indicating an interaction between the hydrolysable constituents and protein, which enhances the disturbing effect of both. The protein disturbance is probably due to the linkage of protein fission products with lignin. Direct linkage between protein and lignin is unlikely, because the ratio of increment produced to nitrogen present is very variable. Small additions of protein cause a proportionately greater disturbance than do larger amounts. The magnitude of the disturbance cannot be reduced by decreasing the time of contact with the acid but may be reduced in most cases by dilute acid pretreatment.

- XV. L. W. SAMUEL. "*The Determination of Amino-Acids in Wheat Flour.*" *Biochemical Journal*, 1934, Vol. XXVIII, pp. 273-282.

The claim that proteolysis occurs in flour extracts has been studied for the few hours immediately subsequent to separation of the extract. The technique of Brown for the estimation of amino-acids by the Sørensen method has been applied to flour extracts. Proteolysis, as measured by the production of amino-acids, did not occur in the flour extracts studied.

For one flour of the four studied (a low grade) the amino-acid determinations made on the extract at varying pH values showed an increase with time if the solution were titrated to pH 9.0 before and after the addition of formaldehyde, but no increase if the titration were carried to pH 8.0 only. It is suggested that this is due to the enzymic production of substances containing carboxyl and amino-groups and having a low acid dissociation constant, which do not titrate even in the presence of formaldehyde until pH 9.0 is reached.

(c) ACTION OF MANURES.

- XVI. H. L. RICHARDSON. "*Studies on Calcium Cyanamide IV—The Use of Calcium Cyanamide and Other Forms of Nitrogen on Grassland.*" *Journal of Agricultural Science*, 1934, Vol. XXIV, pp. 491-510.

Ammonia added as sulphate of ammonia disappeared rapidly from a pasture grassland soil, while very little nitrate accumulated. Winter applications of sulphate of ammonia produced less increase in yield or nitrogen content of repeatedly mown herbage than did spring or late autumn applications. Calcium cyanamide in late autumn or early winter was on the whole less effective than sulphate of ammonia, but in spring the two were substantially equal. There was little evidence that calcium cyanamide was "slow-acting" in comparison with sulphate of ammonia. A fortnight after application there was little difference in the soil inorganic nitrogen from the two fertilisers. Dicyanodiamide was practically inert so far as the effect of winter dressings on yield or nitrogen uptake was concerned. The greatest recovery of added nitrogen in the herbage was less than 40 per cent.; part of the remainder may have been locked up by microbiological action. The response of the repeatedly mown herbage to 2 cwt. per acre of sulphate of ammonia was rapidly

exhausted and later in the year there was a marked reduction in yield through the depression of clovers in summer by the heavier growth of grass after a spring application of nitrogenous fertiliser.

- XVII. H. L. RICHARDSON and E. M. CROWTHER. "*Studies on Calcium Cyanamide V. The Utilisation of Calcium Cyanamide in Pot Culture Experiments.*" *Journal of Agricultural Science*, 1935, Vol. XXV., pp. 132-150.

In pot culture experiments with barley and mustard conducted in several soils over a number of years, the yield differences between calcium cyanamide and ammonium sulphate were generally small. Calcium cyanamide gave slightly poorer results than ammonium sulphate in soils with high responses to added nitrogen but definitely better ones in soils which contained much available nitrogen and in which calcium cyanamide greatly retarded nitrification.

The pot culture experiments confirmed the conclusion from earlier laboratory work that in normal soils calcium cyanamide was converted through urea into ammonia within a few days. Nitrate accumulation was less complete and slower from calcium cyanamide than from ammonium sulphate. In one soil the nitrogen from calcium cyanamide remained as ammonia for several weeks, the nitrate content being below that even of unmanured soil.

Where the ammonia from calcium cyanamide remained for several weeks, tillering of barley was more rapid and the final yields and nitrogen contents were higher than with ammonium sulphate. It is suggested that the young barley plant utilises ammonia nitrogen more readily than nitrate, provided the ammonia is thoroughly distributed through the soil. It is clear that the amount of nitrate obtained in nitrification tests should not be used as a measure of the relative values of calcium cyanamide and other nitrogenous fertilisers.

- XVIII. H. L. RICHARDSON. "*Field Experiments on the Action of Calcium Cyanamide on Germinating Seeds and on Charlock in Barley.*" *Empire Journal of Experimental Agriculture*, 1935, Vol. III, pp. 41-49.

Field experiments on the effect of time and method of application of calcium cyanamide to seed-beds showed that there was no interference with germination by dressings up to 3 cwt. per acre, given one week or more before sowing. The interval between sowing the fertiliser and the seed might safely be reduced to a few days, or even in favourable conditions to a few hours, for moderate applications, provided that the fertiliser was cultivated into the soil before the seed was sown. A moderate application two days after sowing the seed was found to be safe if the fertiliser was left undisturbed on the surface of the soil.

In a replicated field trial on charlock-destruction in barley, with comparisons under different weather conditions, calcium cyanamide proved much less efficient in destroying the charlock than kainit or a solution of copper sulphate. Both the barley and the weeds that survived the cyanamide treatment responded to the added nitrogen.



- XIX. E. M. CROWTHER. "*Comparative Field Trials on Calcium Cyanamide and Other Nitrogenous Fertilisers on Arable Crops*". *Empire Journal of Experimental Agriculture*, 1935, Vol. III, pp. 129-144.

In a series of 22 field trials at Rothamsted and other centres on spring crops—barley, potatoes, and sugar beet—calcium cyanamide and sulphate of ammonia gave similar yield increases in 11 of the 15 experiments in which there were significant responses to added nitrogen, and calcium cyanamide was less efficient than sulphate of ammonia in the other four.

In five experiments at Rothamsted on winter cereals there was no clear difference between autumn and spring dressings of nitrogenous fertilisers or between calcium cyanamide and sulphate of ammonia, except with repeated small applications during winter and spring when calcium cyanamide was worse than sulphate of ammonia. Autumn dressings of dicyanodiamide, either alone or mixed with calcium cyanamide, gave good results on winter wheat.

- XX. E. M. CROWTHER. "*Basic Slags and Mineral Phosphates*." *Journal of the Royal Agricultural Society of England*, 1934, Vol. XCV, pp. 34-53.

The production and use of basic slags and mineral phosphates are discussed in relation to (a) recent work on the constitutions of their phosphatic compounds, and (b), the results of comparative trials on a number of phosphates in grassland experiments and pot cultures. It is suggested that the comparatively poor results from low-soluble slags may be due not merely to the circumstance that most of the phosphorus is present as an insoluble fluorapatite, but also to the associated basic calcium silicate which tends to neutralise the acids in the vicinity of the apatite crystals and so protects them from attack. The poor results generally obtained from mineral phosphates on recently limed or calcareous soils may also be explained by the very low solubility of apatites in nearly neutral solutions of calcium salts.

- XXI. E. M. CROWTHER and R. G. WARREN. "*Report on Field and Laboratory Work*." Appendix to Twelfth Interim Report of Permanent Committee on Basic Slag, Ministry of Agriculture, 1934, Vol. XII, pp. 4-13.

This report summarises the results of field trials of two basic slags, superphosphate and mineral phosphate for five hay trials over four years, and for two repeated manuring trials for three and four years respectively.

## STATISTICAL METHODS AND RESULTS.

(Department of Statistics).

(a) MATHEMATICAL THEORY.

- XXII. F. YATES. "*Some Examples of Biased Sampling*." *Annals of Eugenics*, 1935, Vol. VI.

It has long been known that the choice of representative samples by deliberate selection on the part of the observer is extremely difficult. In order to avoid conscious or unconscious bias the observer