ROTHAMSTED RESEARCH

Report for 1937

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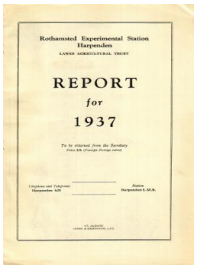

Crops, Plant Growth, Plant Products and Action of Manures

Rothamsted Research

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SCIENTIFIC PAPERS

(Published 1937, and in the Press)

PLANT GROWTH, AND ACTION OF MANURES.

(Departments of Botany, Chemistry, General Microbiology, Plant Pathology and Field Experiments Section).

(*a*) PLANT GROWTH

I. E. J. RUSSELL. "*La Station Experimentale de Rothamsted ; Son Organisation et Ses Resultats.*" Transactions of the Seventh International Congress of Tropical and Sub-Tropical Agriculture, Paris, 1937.

II. E. J. RUSSELL. "*The Restoration of Soil Fertility.*" Symposium, Chartered Surveyors' Institution Conference of Agricultural Members. Journal of the Chartered Surveyors' Institution, 1938, Vol. XVII, pp. 479-486.

III. E. J. RUSSELL. "*Report on the Work of the Imperial Council of Agricultural Research in Applying Science to Crop Production in India.*" Published by the Manager of Publications, Delhi, 1937.

IV. D. J. WATSON. "*The Estimation of Leaf Area in Field Crops.*" Journal of Agricultural Science, 1937, Vol. XXVII, pp. 474-483.

It is shown that the leaf area : leaf weight ratio decreases with increasing leaf weight. The relation between the leaf area : leaf weight ratio and leaf weight is well fitted by a linear regression equation. A method of estimating the mean leaf area per leaf or per plant of a field crop by means of this regression is described. The mean weight per leaf is determined by a large sampling, and the leaf area : leaf weight ratio and its regression on leaf weight are estimated on a small subsidiary sample. Alternative methods of estimation from the mean leaf weight and either the unweighted or the weighted mean leaf area : leaf weight ratio are shown to give positively biassed estimates of mean leaf area. It is emphasized that the small sample, from which the leaf area : leaf weight ratio and its regression on leaf weight are determined, must be a strictly random selection from the whole population.

V. K. WARINGTON. "*Observations on the Effect of Molybdenum on Plants with Special Reference to the Solanaceae.*" Annals of Applied Biology, 1937, Vol. XXIV, pp. 475-493.

In view of the similarity between certain cytological changes induced by virus disease and treatment with molybdenum, pot- and water-culture experiments were carried out to determine further the effect of this element on plant growth. Sodium molybdate was used throughout.

Toxic symptoms were produced with the larger dressings of molybdate, injury being shown at much lower concentrations in solanaceous species than in barley. The shoots of tomato and *Solanum nodiflorum* turned a golden yellow, and potato tubers a reddish yellow colour when the plants were grown with the larger quantities of molybdate. These colour changes were shown to be due to the presence of yellow globules of a tannin-molybdenum compound which had formed within the tissues. Blue granular accumulations occurred in large numbers in molybdenum-treated plants. Their distribution was confined to tissues that contained anthocyanin pigment, and their composition was apparently of an anthocyanin-molybdenum nature.

The formation of these compounds does not appear to be the cause of the injury which results from the stronger doses of molybdenum, as toxic effects occur in plants where no such compounds are found. Conversely, granules may be present to a quite considerable extent in apparently healthy plants.

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Molybdenum, therefore, evidently plays a part in the cytological and morphological behaviour of the plant, although its precise function remains to be determined.

VI. W. E. BRENCHLEY and D. J. WATSON. *"The Influence of Boron on the Second Year's Growth of Sugar Beet Affected with Heart-Rot."* Annals of Applied Biology, 1937, Vol. XXIV, pp. 494-503.

Heart-rot of sugar beet occurred on experimental plots at Rothamsted during 1935, the severity of the attack decreasing steadily with later sowing, but the effects of spacing of the rows and of treatment with sulphate of ammonia were not significant. Where the number of affected plants per row was high, a higher proportion of affected plants showed severe symptoms.

Unaffected sugar beets and others showing slight and severe symptoms of heart-rot were transplanted to sand cultures and treated with light and heavy dressings of boric acid or with none In the absence of boric acid the characteristic signs of boron deficiency appeared in the shoots, the apices of the stems and the flower buds blackening and dying. This occurred even when no symptoms were present before transplanting. In the presence of boric acid all plants produced healthy shoots, with no deficiency symptoms. Where heart-rot was originally present and the main axis killed, a number of healthy, lateral shoots was produced.

The proportion of plants failing to survive transplanting was greatest with the heavy dose of boric acid, with which one-half of the plants died. This suggests a possible toxic action of the heavy dose which did not come into play if the plants were constitutionally able to withstand the initial poisoning and start away into growth. The later addition of boron did not improve the condition of the roots of affected plants, as irremediable damage had been done before transplanting.

From the point of view of seed production, small amounts of boron compounds may thus enable affected roots to produce healthy shoots in the second year which will set seed.

VII. A. NOWOTNÓWNA (NOWOTNY). *"An Investigation of Nitrogen Uptake in Mixed Crops not Receiving Nitrogenous Manure."* Journal of Agricultural Science, 1937, Vol. XXVII, pp. 503-510.

Experiments on the nitrogen uptake of mixed crops not receiving nitrogenous manure were carried out at Pulawy, Poland, and at Rothamsted, with rye grass. The total yield, the nitrogen percentage and the total yield of nitrogen were much increased when peas, clover or serradella were grown in association, peas giving the highest, and serradella the lowest, amount of assimilated nitrogen.

With barley, peas were the only crop which produced a beneficial effect, red clover and lucerne having no influence. This was probably due to the fact that the period of most vigorous fixation of nitrogen by clover and lucerne nodule bacteria almost coincided with the period of ripening of barley, and at this stage of growth barley was unable to utilize the available nitrogenous compounds. Also, barley made less use than rye grass of the nitrogen provided by peas grown in association.

An extensive root interpenetration in the clover-rye grass pots was noted. There was little or no root interpenetration in the other series of experiments with barley.

VIII. J. CALDWELL and J. MEIKLEJOHN. *"Observations on the Oxygen Uptake of Isolated Plant Tissue. I. The Effect of Phosphate and of added Carbohydrate."* Annals of Botany, 1937, New Series, Vol. I, pp. 477-486.

The oxygen uptake of thin slices of tomato stem tissue was measured in Barcroft respirometers, and found to be maintained at a constant rate over a six-hour period. The highest values for oxygen uptake were observed in presence of M/20 potassium dihydrogen phosphate ; measurements in distilled water gave slightly lower values, and stronger solutions of phosphate produced a marked depression of oxygen uptake. Tissue from very young plants, in

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the fifth leaf stage, showed a lower level of oxygen uptake than tissue from slightly older plants, up to the twelfth leaf stage. A low level of oxygen uptake was also observed in tissue from old plants that had flowered.

The small oxygen uptake of tissue from very young plants was markedly raised by the addition of glucose or fructose, but no such rise was observed on adding sugar to tissue from very old plants. It is concluded that the oxygen uptake is limited in old plants by the activity of the respiratory enzyme system, and in very young plants by the amount of available respiratory substrate.

IX. J. CALDWELL and J. MEIKLEJOHN. *"Observations on the Oxygen Uptake of Isolated Plant Tissue. II. The Effect of Inhibitors."* Annals of Botany, 1937, New Series, Vol. I, pp. 487-498.

Substances known to inhibit enzyme action were added to slices of tomato stem tissue, and their effect on the oxygen uptake of the tissue was measured. All the substances showed an inhibiting action which increased with their concentration. Concentrations lower than those which inhibited oxygen uptake were found to have no stimulating effect. Cyanide (M/300) produced a reversible inhibition of about 85 per cent. of the total oxygen uptake; no greater inhibition was produced by M/30 cyanide than by M/300. Sodium fluoride and iodoacetic acid had an irreversible inhibiting action, and sodium azide a reversible one stronger in acid than in alkaline solution. Malachite green was effective in very small doses, but the urethanes only in high ones. Amyl alcohol was ineffective at 1/3,000, but produced almost complete inhibition at 1/30.

(*b*) ACTION OF MANURES

X. H. L. RICHARDSON. *"The Nitrogen Cycle in Grassland Soils: with Especial Reference to the Rothamsted Park Grass Experiment."* Journal of Agricultural Science, 1938, Vol. XXVIII, pp.73-121.

A three years' examination of Park Grass soils and shorter studies of other grassland soils showed that fresh soil always contained more ammonia than nitrate. Both levels were low and sufficiently constant to suggest equilibrium conditions in the nitrogen cycle. "Mineralizable" nitrogen, produced by incubating the fresh soils under standard conditions, showed a seasonal rhythm the opposite of the annual temperature rhythm. This was related to the addition and decay of organic residues in the soil. An extremely acid soil produced as much mineralizable nitrogen on incubation as more normal plots. Soils with pH values below 6.0 produced chiefly ammonia while the less acid soils produced chiefly nitrate on incubation.

Nitrogen added in the field as sulphate of ammonia or nitrate of soda disappeared rapidly, one-half being removed in a few days in late spring or in a week or two in winter or early spring. The rapid disappearance of ammonia, even on plots in which nitrification was poor or lacking, suggested that it was taken up directly by the herbage. When the herbage was removed, added ammonia remained in the soil for several weeks.

Under Rothamsted soils laid down to grass from arable, about twenty-five years are required for the total nitrogen content to reach half that of very old grassland.

The number of worm casts was greatest on plots with organic manures, and limed plots usually had more than unlimed. Worms were absent from the extremely acid matted plot and the formation of mat appeared to depend on the effect of acidity on the worms rather than on the microbiological decomposition of the organic matter.

XI. W. E. BRENCHLEY. *"Correlation of Manuring and Botanical Composition of Continuous Hay Crops."* Report of the Fourth International Grassland Congress, Aberystwyth, 1937, pp. 441-445.

The botanical composition of herbage varies widely in different seasons. Moreover, seasonal and manurial effects need careful discrimination.

Repeated treatment with the same fertilizer affects the botanical composition and the relative proportions of species present, the latter effect often

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being the more striking. On heavy clay loam at Rothamsted, although the qualitative composition is not seriously altered by mineral manures, some species are much encouraged and others are considerably reduced, the relative variation being influenced by season. The addition of nitrogen eliminates many species, and with heavy dressings a few grasses develop strongly at the expense of the rest. Nitrate of soda and ammonium sulphate do not encourage the same association of species on account of the difference in soil reaction. The acidity induced by heavy doses of ammonium sulphate much favours *Holcus lanatus*, but the addition of lime brings *Alopecurus pratensis* and *Arrhenatherum avenaceum* into predominance, leguminous and other plants being drastically reduced. With the neutral reaction induced by sodium nitrate *Alopecurus* and *Arrhenatherum* flourish without lime, shade being here more effective than liming in changing the proportion of species.

With organic fertilizers the yield may be reduced by heavy dressings of lime without very marked alterations in herbage composition. The response to lime is rapid, as the species affected usually show a variation in their relative proportion at the first cutting, although in some conditions the change may be delayed.

Certain species afford some indication of soil and manurial conditions. *Taraxacum vulgare* is prolific on well manured soils with a tendency to alkalinity; *Scabiosa arvensis* flourishes where potash is deficient and no nitrogen is applied; *Rumex acetosa* is possibly associated with scarcity of phosphate on soil which is otherwise well manured; while Leguminosae may form a third of the herbage where minerals without nitrogen are given.

STATISTICAL METHODS AND RESULTS

(Department of Statistics)

(*a*) Design of Experiments

XII. F. Yates. "*The Gain in Efficiency Resulting from the Use of Balanced Designs.*" Supplement to the Journal of the Royal Statistical Society, 1938, Vol. V, pp. 70-74.

The comparative efficiency of a balanced design, which was actually used in a nutritional experiment on human beings, and other alternative and simpler designs, is assessed. It is shown that the balanced design is considerably more efficient than the others.

XIII. W. G. Cochran. "*Note on J. B. S. Haldane's paper 'The Exact Value of the Moments of the Distribution of* χ^2.'" Biometrica, 1938, Vol. XXIX, p. 407.

A discrepancy noted by Haldane between his and the writer's values for the mean and variance of χ^2 in a $2 \times$ n-fold contingency table with known expectations is shown to be entirely due to a difference in the definition of χ^2.

(*b*) Analysis of Data

XIV. F. Yates and W. G. Cochran. "*The Analysis of Groups of Experiments.*" Journal of Agricultural Science, 1938, Vol. XXVIII, in the press.

When a set of experiments involving the same or similar treatments is carried out at a number of places, or in a number of years, the results usually require comprehensive examination and summary. In general, each set of results must be considered on its merits, and it is not possible to lay down rules of procedure that will be applicable in all cases, but there are certain preliminary steps in the analysis which can be dealt with in general terms. These are discussed in the present paper and illustrated by actual examples. It is pointed out that the ordinary analysis of variance procedure suitable for dealing with the results of a single experiment may require modification, owing to lack of equality in the errors of the different experiments, and owing to non-homogeneity of the components of the interaction of treatments with places and times.

XV. W. G. Cochran. "*Some Difficulties in the Statistical Analysis of Replicated Experiments.*" Empire Journal of Experimental Agriculture, 1938, Vol. VI, pp. 157-175.

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