ROTHAMSTED RESEARCH

Report for 1949

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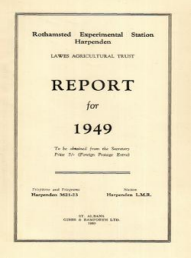

Botany Department

D. J. Watson

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BOTANY DEPARTMENT

By D. J. WATSON

P. C. Owen was transferred from the Physics Department to the Botany Department in January.

J. H. Wilson, of the Department of Agriculture, Tasmania, joined the department in January, as a temporary worker.

Miss G. N. Thorne was appointed in October to work on nutrient uptake from solutions sprayed on leaves.

MICRONUTRIENTS

The interaction of molybdenum and nitrogen supply has been studied in lettuce and red clover grown in solution culture. For the lettuce, nitrogen was supplied at three rates, in all combinations with three rates of molybdenum supply (0, 0·1 and 5 or 10 p.p.m. Mo). Samples were taken on three successive occasions for dry weight, nitrogen and molybdenum determinations. No benefit from added molybdenum was found after 3 weeks treatment ; the highest rate caused a slight reduction of dry weight and visible symptoms of toxicity in the leaves. After 5–6 weeks treatment, the dry weight of a spring variety of lettuce, Tom Thumb, increased with increase in molybdenum supply at the two higher rates of N supply, but not at the lowest rate, and the depression of dry weight by the highest rate of molybdenum supply had disappeared. The positive interaction between Mo and N persisted in the later stages and became greater. In a winter variety of lettuce, Cheshunt Early Giant, addition of molybdenum gave no increase in dry weight at any stage; the highest rate of Mo supply, 10 p.p.m., caused a reduction of dry weight especially at the higher levels of N supply.

The total N content percent of dry matter was reduced by addition of Mo. In the plants without Mo there was some evidence of nitrate accumulation, though NO_3-N never accounted for more than about 10 per cent. of total N. The results, therefore, do not wholly support the conclusion of Mulder and others that Mo-deficiency inhibits nitrate reduction.

For the experiments on clover, three rates of nitrogen supply in combination with two rates of molybdenum (0 and 0·2 p.p.m. Mo) were used, in two different types of culture solution. In one experiment the plants were inoculated with *Rhizobium* and in another they were uninoculated. The nitrogen content of the culture solution used for the inoculated plants was reduced as growth proceeded, and in the later stages the plants were wholly dependent for their nitrogen supply on fixation by *Rhizobium*. The uninoculated plants grown without added Mo showed visual symptoms of Mo deficiency in the leaves, especially when the N supply was low, but at harvest after about 6 months growth, there was no detectable effect of Mo supply on dry weight or nitrogen content. The dry weight of the inoculated plants, harvested three months later, was increased by addition of Mo, and the number of nodules was depressed. This effect of Mo supply on nodule formation confirmed the results of previous experiments.

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Nutrient Uptake by Excised Root Systems

The object of this work is to establish quantitative relationships between the rate of uptake of nutrient ions by excised roots and the concentration of these ions in the roots and in the external solution. Barley and pea plants were grown for 6–7 weeks in culture solutions, with varied supply of nitrate, phosphate and potassium. The carbohydrate content of the roots was varied by shading some of the plants for several days before the roots were taken for experiment. The root systems were cut off and held at constant temperature in a flowing aerated nutrient solution of constant composition. Samples taken at the beginning and on succesive occasions throughout a 24 hour period, were analysed for N, P, K and carbohydrates. The rates of respiration of the roots was measured throughout the period. A series of six experiments of this type has been carried out.

The analyses are not yet completed, but there is evidence that the rates of uptake of nitrate, phosphate and potassium were all dependent on the carbohydrate content, as well as the nutrient content, of the roots. Roots from plants grown with similar nutrient supply at different times of the year varied in their capacity for ion absorption ; this was probably the result of seasonal variation in carbohydrate content. Simultaneous uptake of one ion and loss of another was observed. The losses of nutrients from excised roots took place into solutions of higher concentration than those in which the intact plants were grown ; uptake was found only when the concentration of the ion in question in the solution used for growing the plants was much below that in the solution in which the excised roots were held.

The adsorption of nitrate by low-N roots was accompanied by a rise in the rate of respiration. Absorption of phosphate by low-P roots or of potassium by low-K roots did not increase the respiration rate. Low-P and low-K roots behaved like roots with a high content of all three nutrients in showing a decline of respiration rate throughout the experimental period, possibly due to falling sugar content. The rise in respiration rate associated with nitrate absorption is thought to be a different phenomenon from the " salt respiration " observed when plant tissues are transferred from water to a salt solution. It may be a metabolic effect, associated with rapid conversion of nitrate into organic nitrogen compounds.

Similar experiments were made with barley and pea roots dug from small field plots. The dry season made it difficult to remove the root systems from the soil without serious damage and loss of the finer branches, but in more favourable weather conditions it should be possible to obtain satisfactory field material for nutrient absorption studies.

Uptake of Sugar and Mineral Nutrients by Leaves

An investigation has been started on the effect of spraying plants with solutions of sugar or mineral nutrients. American workers have reported that when tomato plants growing at high temperatures and in low light intensities (*i.e.* the conditions in a heated glasshouse in winter) were sprayed with sucrose solution, the rate of stem elongation and the dry weight of the plant was increased. This result was confirmed, but the effects on growth were not such as would be expected merely from an increased carbo-

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hydrate supply. For example, the increase in dry weight was restricted to the leaves, the part of the plant that would be least expected to suffer from carbohydrate deficiency, the dry weight of the stem was not affected although its length was increased, and the dry weight of roots was reduced. Further work on this is now in progress.

Work on the uptake of mineral nutrients by plants from solutions sprayed on the leaves was not begun until October. Its immediate object is to test a report that small amounts of potassium nitrate applied in overhead irrigation water to horticultural crops have a marked beneficial effect on growth and yield. Preliminary experiments were made to find out what concentration of nutrient salts can be used without scorching the leaves, and to determine whether appreciable amounts of nutrients can be absorbed from spray deposited on the leaves. In an experiment on young sugar beet plants, the amounts of N, P and K present in the leaves of plants sprayed daily for 6 weeks with a complete nutrient solution, was 15–40 per cent. higher than in the leaves of control plants sprayed with water. Experiments are now in progress comparing rates of uptake through the roots and through the leaves in different species. The rates of uptake of nitrogen from solutions containing equivalent concentrations of ammonium or nitrate are also being compared. Experiments to study the effects on growth of nutrients supplied through the leaves will be started in the spring when growing conditions are more favourable.

Water Relations of Germination

In collaboration with the Physcis Department, a study is being made of the dependence of germination of wheat seeds on moisture potential. The seeds are held close to the surface of a salt solution of accurately known vapour pressure, in a system kept at constant temperature ($\pm$ about 0·001°C), so that water is supplied to the seed through the vapour phase at a known moisture potential.

The first experiments, continued for 4–5 days, indicated that there was a sharply defined critical moisture potential below which seeds were unable to absorb enough water to germinate. Further work showed that the rate of germination was reduced by reducing moisture potential ; for example, at 20°C in an atmosphere saturated with water vapour, which we take as zero potential, wheat germinates in about 3 days, while at a moisture potential of –250 metres of water, it takes about 10 days. Seeds have been kept for 20 days at lower moisture potentials, and some have germinated in this time against a potential of –300 metres of water, *i.e.* a pF of nearly 4·5, considerably above the permanent wilting point (pF 4·2, equivalent to –150 metres of water). If there is a critical moisture potential below which germination cannot take place, it must be much lower than the first experiments suggested.

In the more prolonged experiments it has been found difficult to prevent fungal infection. Several methods of sterilizing the seeds have been tried, but none has been completely successful.

Biology of Wild Oats (*Avena fatua* and *A. ludoviciana*)

Work on wild oats was concerned with their growth and nutrition

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in comparison with cereal crops, and various aspects of the dormancy of the seeds.

Susceptibility to manganese deficiency

The susceptibility of wild oats to " grey speck " disease, caused by deficiency of manganese, was compared with that of two varieties of cultivated oat,—Scotch Potato, which is said to be relatively resistant, and Star. Plants were grown in pot culture in a manganese-deficient Fen soil, without added Mn, and with Mn added at three rates, the highest rate being fixed at a level estimated as adequate to correct the deficiency. *A. ludoviciana* showed the greatest response to Mn supply in total dry weight, shoot number and shoot height, and was the first to show chlorosis at the lower rates of Mn supply. The leaf symptoms of Mn deficiency in this species were different from the characteristic grey-speck lesions found in the cultivated oats and *A. fatua* ; they consisted of interveinal chlorotic stripes which later became necrotic. The effect of Mn supply on dry weight at harvest did not differ greatly in Star and Scotch Potato, but Mn deficiency caused more severe leaf symptoms and greater delay in ear production in Star. *A. fatua* was the least affected by varying Mn supply. Mn-deficient wild oats showed a smaller per cent. reduction of seed number, but a greater per cent reduction in weight per seed than cultivated oats.

Analysis of growth and response to nitrogen of wild and cultivated oats

One way in which weeds reduce crop yield is by competition with the crop for the supply of nutrients, especially nitrogen, in the soil. Pot experiments are in progress to test whether wild oats differ from cereal crops in their ability to take up nitrogen. An experiment comparing the two species of wild oat with barley at three levels of nitrogen supply has been completed, and a second one, comparing wild oats with cultivated winter oats and winter wheat was set up in November. Samples were taken at intervals for determination of nitrogen content, and the usual measurements required for growth analysis (dry matter, leaf area, shoot counts etc.) were made to see whether there are any attributes of growth other than nitrogen uptake that may give wild oats a competitive advantage.

Dormancy of the seeds

In a field experiment on potatoes on Rothamsted Farm, wild oat seedlings were found only in the ridges where dung was applied. This observation suggested either that the dung had contained viable wild oat seeds, or that it had broken the dormancy of seeds already present in the soil. To test these possibilities, samples of dung, unfortunately not from the same bulk as was used for the potato experiment, were brought to the laboratory, spread in pans with and without the admixture of sand, and kept watered to induce non-dormant viable seeds to germinate. Seeds of *A. fatua* or *A. ludoviciana* were added to similar pans of dung and equal numbers of seeds were sown in wild-oat-free soil. The added seeds have begun to germinate both in dung and soil, but so far no seedlings have appeared from the dung without added seeds.

Dormancy in *A. fatua* is apparently due to impermeability of the seed-coat to oxygen, for germination can be induced at any time by pricking the seed with a needle. Seeds of *A. ludoviciana*, however, cannot consistently be made to germinate by pricking, and evidently

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this species exhibits dormancy due to factors in the embryo or endosperm, as well as dormancy due to impermeability of the seed-coat. Some time has been spent in developing a technique for growing excised embryos of wild oats on nutrient agar, with the intention of using it to study the causes of dormancy of the embryo.

An anatomical and microchemical examination showed that the seed-coats of *A. fatua* and *A. ludoviciana* are very similar in structure.

Physiological Effects of Virus Infection

Seed-certification schemes for the control of virus diseases in potatoes depend on the recognition of infected plants in field crops by inspection. It is, therefore, important to know whether the presence, or the intensity, of visible leaf symptoms depends on the conditions of growth. A pot experiment was set up to determine the effect of varying nutrition and light intensity on the symptoms of leaf-roll infection. Small sets cut from healthy or infected tubers of Craig's Defiance, were grown with varied supply of N, P, and K with full daylight or under muslin shades which reduced the light intensity to about half that of full daylight. Some of the plants grown from healthy tubers were infected by means of aphids soon after the shoot appeared. It was found that high N supply and shading both tended to mask the leaf-rolling and yellowing symptoms. The same experiment provided material for a growth analysis study, the object of which was to determine the changes in growth caused by infection that lead to a reduction of yield, and to study the interaction of infection, nutrient supply and shading. Samples were taken at fortnightly intervals during the growth period for the measurement of dry matter in the different parts of the plant, and the total leaf area. Other attributes of growth including the number of leaves, lateral shoots and tubers and shoot height were also measured, and samples were kept for determination of nutrient content. The data obtained are now being analysed.

In collaboration with the Plant Pathology Department work on the effect of infection with yellow virus on the carbohydrate metabolism of sugar beet has been continued. This confirmed previous experiments in showing that the accumulation of starch and sugars in the leaves of infected plants is not attributable to an inhibition of translocation, as earlier workers thought.

Field Work

Samples of hay for botanical analysis were taken from twenty plots of the Park Grass experiment, selected because no analyses of the herbage on them had been made in recent years. When these analyses are completed, information on the present composition of the flora of all the plots will be brought up to date. Dr. Brenchley has continued to work on the revision of her book " The Manuring of Grassland for Hay," which describes the changes induced in the flora of these plots by long continued difference in manuring.

The usual routine observations were made on the weed flora of Broadbalk and Hoos fields.

A growth analysis study to compare the effects of nitrogenous fertilizer on spring sown wheat, barley and oats and to analyse the responses in yield, was carried out on small field plots. Samples were taken at fortnightly intervals from the end of April to early

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August for the determination of dry weight, leaf area and nitrogen content. An attempt was made to estimate the dry matter contributed by photosynthesis in the inflorescence of each species, by measuring the dry matter increment over short periods of plants from which the ears were removed, in comparison with intact plants. Nitrogen determinations on the samples, and the statistical analysis of the data, have not yet been completed.

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