ROTHAMSTED RESEARCH

Report for 1950

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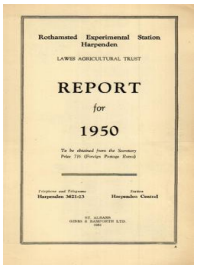

Botany Department

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BOTANY DEPARTMENT

By D. J. Watson

Dr. E. C. Humphries, Miss J. M. Thurston, Dr. K. Warington and Dr. D. J. Watson attended the VIIth International Botanical Congress held at Stockholm in July. Dr. Humphries read a paper on nutrient uptake by excised roots, and Dr. Watson on some effects of virus infection on the carbohydrates of sugar beet.

Dr. Humphries was awarded the degree of D.Sc. of the University of London.

Work done during the year followed on the lines of that described in the 1949 report, and no new investigations were started. The development of growth-analysis studies intended to throw light on the physiology of variation in crop-yield has been held up by lack of facilities for growing plants in controlled environments. Without them it is not possible to disentangle the effects of internal factors of the plant and external conditions, nor to obtain precise information on the effects of environmental factors and their interactions. These matters, which are fundamental to an understanding of the growth of crop plants, are still controversial, and until they are cleared up, it is difficult to interpret the results of previous work at Rothamsted and other places. Much time has been spent on the planning of suitable controlled-environment rooms, and it is hoped that before long it may be possible to proceed with their construction.

The results of wartime work on the storage of potatoes in clamps, previously available only in part in a report to the Agricultural Research Council, have now been published (35, 36).

Micronutrients (K. Warington)

Experiments have been carried out in solution culture to study the interaction between molybdenum and manganese in plant nutrition. Other workers have claimed that in some conditions the addition of molybdenum may increase the sensitivity of plants to manganese deficiency, and that molybdenum in high concentration may offset the toxic effect of excess manganese or other heavy metals. The two elements were supplied in varying combinations of rates ranging from those known to be adequate for normal growth (0·1 p.p.m. Mo and 1·0 p.p.m. Mn) to those liable to be toxic (20 p.p.m. Mo and 25 or more p.p.m. Mn). Oats, flax and soybean were selected as test crops. Observations made during growth showed that the tolerance of high Mn supply varied considerably between flax and soybean on the one hand, and oats on the other. Oats were unharmed by concentrations of over 100 p.p.m. Mn, whereas growth of flax and soybean was seriously affected by 10 or 20 p.p.m. All the crops responded similarly to Mo, and were unexpectedly tolerant to the high rates of supply; increase in the concentration to 20 p.p.m. did not reduce the dry weight yield. Chemical analyses of the plant material are still in progress. So far, no evidence has been found to support the claim that increased molybdenum supply mitigates the toxic effect of

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excess manganese, but this effect may occur only in restricted conditions different from those of the present experiment, and further work will be done to test this.

Nutrient Uptake by Excised Root Systems (E. C. Humphries).

Investigations of the effect of the nutrient content of excised roots on the rate of ion uptake from a nutrient solution was continued. An account of the methods used, and the results of some preliminary experiments has been published (31). Statistical examination of the considerable body of data collected has occupied much time and is not yet complete. It has been established that the rates of uptake of nitrate, phosphate and potassium all depend on the total soluble carbohydrate content of the root, but apparently not specifically on sucrose or reducing-sugar content. The rate of uptake of each of these nutrients decreases with increases in the concentration of the same nutrient in the root ; the question as to whether it is also affected by the concentration of the other nutrients is being examined, but a definite answer cannot yet be given.

Experiments have been made to study (a) the effect of sucrose added to the nutrient solution on the rate of ion uptake ; (b) the relative rates of absorption and assimilation of nitrate and ammonia by nitrogen-deficient roots, and (c) the effect of molybdenum and manganese deficiencies on the rates of absorption and assimilation of nitrate and ammonia. Chemical analysis of the material from these experiments is still in progress.

In connection with these nutrition studies attention has been given to the problem of rapid estimation of the chief cations normally present in plant ash. For this purpose a flame-photometer has been constructed. A number of difficulties in its use have been encountered, the principal one being the mutual excitation of potassium by sodium and *vice-versa*, but satisfactory methods for estimating potassium, sodium and calcium are now in sight. The sensitivity and accuracy of the instrument have been increased by the use of interference filters and photomultipliers.

Uptake of Mineral Nutrients by Leaves (G. N. Thorne).

Work on the uptake of mineral nutrients from solutions sprayed on leaves, started late in 1949, has been continued. It is not yet possible to report on the results fully, as many chemical analyses on the plants grown in the 1950 experiments remain to be done. Uptake of nitrogen, phosphorus and potassium through the leaves in appreciable amounts compared with normal uptake through the roots has been confirmed with cabbage, sugar beet, french beans and barley. No difference was detected between the amounts of nitrogen taken up, when it was supplied as ammonium or nitrate ions, in solutions of equal concentration.

The effect of spraying leaves with nutrient solutions on growth and yield has been studied in a pot experiment on sugar beet with varied nutrient supply to the soil. Plants sprayed with nutrient solution showed a significant increase in leaf area after 4 weeks, and in root weight after 7 weeks, compared with control plants sprayed with water. The final yield was also substantially increased ;

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in the extreme case, with low nutrient supply to the soil, the final dry weight per plant was increased by 75 per cent by spraying with the more concentrated of the two nutrient solutions tested. The effect on yield increased with increase in the concentration of the spray solution, and decreased with increase in nutrient supply to the soil. Nutrient uptake from the spray solution was greater at the higher level of nutrient supply to the soil, presumably because the leaves were larger and held a greater volume of spray. Daily spraying produced greater increase of yield than spraying once or twice weekly.

The dry weight of brussels sprouts plants was also increased by spraying, but other species showed no response. Tomato plants showing symptoms of nitrogen and potassium deficiency were apparently unaffected by spraying, either in yield or in the severity of the deficiency symptoms. It is not yet known whether they absorbed any nutrients from the spray solution. Similarly, the growth of french beans was not improved by the nutrient spray.

Water Relations of Germination (P. C. Owen).

The study of the dependence of germination and water uptake of wheat seeds on water potential, in collaboration with the Physics department (1949 Report, p. 49) has been continued. Data on the progress of water uptake with time have been obtained for both living and dead seeds over a range of water potential from zero (saturated atmosphere) to —250 metres of water. In the initial phase, the curves of water uptake by seeds, held in an atmosphere with constant water potential, plotted against time have an exponential form approaching an asymptotic water content (y′), and are well fitted by the equation :

$$y' - y = (y' - y^{\circ})e^{-at}$$

where y° is the initial water content, and y the water content at time t. The water content of dead seeds comes to equilibrium at the asymptote, but with the onset of germination in living seeds there is a second phase of water uptake, also exponential in form, fitted by the equation :

$$y - y' = (y' - y^{\circ})e^{bt}$$

Work is being continued to confirm and interpret these relationships. Curves of water uptake by seeds held in atmospheres with different water potentials give values of a in the first equation that increase, apparently linearly, with decrease in potential over the range from zero to —250 metres. It has been shown that change in the width of the air gap between the seed and the salt solution over which it is held has no effect on the rate of water uptake, indicating that the resistance to water movement in the gas phase is very small compared with that within the seed.

The similarity of the first phases of water uptake in living and dead seeds suggests that this phase is a physical rather than a physiological process. The second phase of uptake in living seeds is presumably associated with growth and water absorption by the embryo.

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Biology of Wild Oats (J. M. Thurston).

The responses of *Avena fatua*, *A. ludoviciana*, winter oats and wheat to added nitrogen were compared in a pot experiment, to find out whether there are differences in the efficiency of utilization of the available nitrogen supply that may account for the ability of wild oats to compete successfully with cereal crops. No marked differential response in final dry weight was found; analysis of the data for earlier growth stages is not yet completed. Seeds from this experiment are being used to test whether the nitrogen nutrition of the plant affects the dormancy and viability of the seeds it produces.

Field observations (1949 Report, p. 50) have suggested either that viable wild-oats seed may survive in farmyard manure, or that farmyard manure may break the dormancy of seed present in the soil. Some samples of dung have been tested for the presence of viable wild-oats seed, but none have been found. Evidence in support of the second possibility, that farmyard manure may shorten the period of dormancy, has been obtained. In a glasshouse experiment, 50 per cent more seeds of both species germinated in the first season when sown in farmyard manure than when sown in soil. To confirm this result for field conditions, the effect of farmyard manure applications on the number of seeds germinating is being tested in a field known to be heavily infested with *A. ludoviciana*.

A field experiment has been started to give information on the seasonal germination and on the period of survival of *A. fatua* and *A. ludoviciana* seeds in the soil and on the effect of depth of sowing and of varying intensity of cultivation. A uniform infestation has been established by sowing equal numbers of seeds per plot on a site free from natural infestation. The time course of germination will be followed over a period of years.

A start has been made in collecting information on the distribution of *A. fatua* and *A. ludoviciana* in England. Of thirty-two samples of seed, mostly from the eastern counties, all but one contained *A. fatua*, the grey-husked var. *pilosa* and the brown-husked var. *pilosissima* being commoner than the yellow-husked var. *glabrata*. A small quantity of *A. ludoviciana* was present in two samples in addition to *A. fatua*. Only one sample, from Oxfordshire, consisted entirely of *A. ludoviciana*. These results suggest that *A. fatua* is much commoner in eastern England than *A. ludoviciana*, but it is possible that in some cases seed of the latter may have been shed before the samples were collected. In co-operation with the National Agricultural Advisory Service it is hoped to arrange for systematic collection of samples over a wide area in 1951.

Physiological Effects of Virus Infection (J. H. Wilson).

The pot-culture experiment carried out in 1949 (1949 Report, p. 51) showed that infection with leaf-roll virus greatly reduced the dry matter increments of potato plants at all stages of growth. This was partly due to a reduction in leaf area, but the net assimilation rate was also decreased, indicating that the rate of photosynthesis of infected leaves is less than that of healthy leaves. An experiment was made to find out whether the effect of infection on photosynthesis is due directly to the presence of the virus and

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occurs in all leaves of infected plants, or whether it is a secondary effect associated with the rolling of the leaves. Three groups of infected plants were set up (a) with the unrolled upper leaves removed ; (b) with the rolled lower leaves removed ; (c) intact plants, and there were three corresponding groups of healthy plants with the same leaves removed or retained as in the infected groups. The net assimilation rate of infected plants was reduced, compared with the healthy controls, only in the two groups which retained the rolled leaves. The net assimilation rate of infected plants carrying only unrolled leaves differed little from that of the corresponding healthy plants. It follows that assimilation by infected leaves is not reduced until the rolling of the leaves develops.

In a further study of the influence of nitrogen supply on the expression of leaf-roll symptoms, Up-to-date, a variety tolerant to leaf-roll, was compared with the intolerant variety, Craig's Defiance, previously used. With low nitrogen supply, both varieties showed very severe symptoms. Addition of nitrogen appreciably reduced the severity of symptoms in Craig's Defiance, but in Up-to-date symptoms were completely suppressed almost until the time of flowering and were then of only mild intensity.

The 1949 experiments indicated that the transport of dry matter from infected tubers to the developing shoots is slower and less complete than from healthy tubers. To test this, setts of three different sizes cut from healthy and infected tubers were planted in gravel culture, and estimates of the loss of dry matter from the setts during the early stages of shoot growth were obtained by harvesting replicates at intervals after shoot emergence. From a preliminary examination of the results it appears that leaf-roll infection retarded transport from the tubers of intolerant varieties such as Craig's Defiance, but had little effect in tolerant varieties such as Up-to-date.

Field Observations

Records of the weeds present on the Broadbalk and Hoosfield plots, and of the flora of the Park Grass plots, were made as in previous years.

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