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Report for 1956

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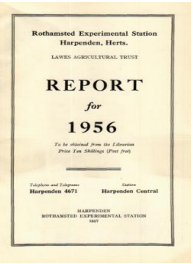
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Botany Department

D. J. Watson

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BOTANY DEPARTMENT

D. J. Watson

Mr. L. H. Fernando, of the Department of Agriculture, Ceylon, came in March to work in the department for three years, with a scholarship awarded by the United Kingdom Government under the Technical Co-operation Scheme of the Colombo Plan.

Miss Joyce Watson of the Cawthron Institute, New Zealand, spent three months in the department and visited other institutes to study methods of plant analysis.

D. J. Watson contributed a paper to the Symposium on the Growth of Leaves at the Third Easter School in Agricultural Science of the University of Nottingham. He also read a paper at the Fourth Congress of the International Potash Institute held in London in August.

J. M. Thurston, K. Warington and K. J. Witts attended the Third British Weed Control Conference at Blackpool in November, and J. M. Thurston was invited to open the discussion on the control of wild oats.

Plant Nutrition

Interaction of iron and molybdenum (K. Warington)

Addition of ammonium or sodium molybdate to a nutrient solution has been shown to delay the development of chlorosis in flax when iron was supplied as ferric citrate and the initial pH was 4·6; it also delayed precipitation of iron in the solution and greatly increased iron uptake by the plants. These effects did not occur when the initial pH was 6·6 (*Rep. Rothamst. exp. Sta. for* **1955**, p. 70). This suggests that molybdenum acts by retarding the drift of pH towards neutrality, prolonging the acid conditions in which iron is more readily available, rather than by a direct interaction with iron in the solution.

The effect of molybdenum on the rate of pH change of the nutrient solution was investigated by making daily measurements on solutions containing high or low molybdenum concentrations, started at pH 4·6, 5·6 or 6·6. Observations were made at the same times on the colour of young flax plants growing in the solutions, and on precipitation of iron. Delay induced by high molybdenum supply in the development of chlorosis and in iron precipitation occurred, as before, only when the initial pH was 4·6, though there were indications of slight effects at pH 5·6, and it was always associated with a slower drift towards alkalinity. The iron content of the roots was higher in the more acid solution, and was increased still more by high molybdenum supply.

Although the maintenance of an acid reaction partly explains the effect of molybdenum, other factors are involved. When ferric chloride was substituted for ferric citrate, high molybdenum supply failed to prevent chlorosis or precipitation of iron, although the

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drift in pH was almost negligible and the solution remained acid. When iron was supplied as FeEDTA in presence of high molybdenum in solutions at pH 4·6 there was little drift in pH, but in contrast with the solutions containing ferric chloride there was no precipitation of iron. Although no chlorosis developed in the low-molybdenum plants when iron was given as FeEDTA, in the presence of high molybdenum the shoots had a deeper green colour, suggesting that the effect of molybdenum was similar to that found when iron was given as citrate. This is supported by the fact that high molybdenum supply increased iron uptake by the plant from solutions initially at pH 4·6 when iron was given either as citrate or FeEDTA, but not when given as chloride.

Chelated iron complexes as sources of iron in solution culture (K. Warington)

Chelated complexes of iron with the following compounds (kindly supplied by the Geigy Company Ltd.) were tested as sources of iron in nutrient solutions, in comparison with ferric citrate:

(1) mono-sodiumethylenediamine tetra-acetate, EDTA(Na);
(2) di-sodium ethylenediamine tetra-acetate, EDTA(Na_2);
(3) diethylene triamine penta-acetic acid, DTPA;
(4) nitrilo acetic acid;
(5) *cyclo*hexylenediamine tetra-acetic acid;
(6) hydroxyethyl ethylenediamine triacetic acid, HEEDTA;
(7) gluconic acid;
(8) saccharic acid;
(9) *bis*-hydroxyethyl glycine.

In cultures initially at pH 5·5 containing 0·1 p.p.m. Fe, (1), (2), (3) and (4) were all more effective than ferric citrate in preventing chlorosis in peas, but (2), (3) and (4) caused leaf scorch when supplied at concentrations of 0·5 p.p.m., so FeEDTA(Na) was the most suitable of these four complexes. With soybean, (6) gave outstandingly good results, but (7) and (8) were no better than ferric citrate, and (9) was ineffective at concentrations below 1 p.p.m. In later tests on peas and barley with solutions containing 0·5 or 2 p.p.m. Fe initially at pH 5·5 or 7·5, FeEDTA(Na) usually gave the best plants and was effective at either pH; (5) was superior to ferric citrate in the alkaline solution, but (4) was effective only in the acid solution. FeHEEDTA and DTPA were not included in these trials, so no direct comparison of them with FeEDTA(Na) is available.

Nutrient uptake by excised roots (E. C. Humphries)

The possibility of assessing the nutrient status of a soil from the ability of roots excised from plants grown in the soil to absorb nutrients in standard laboratory conditions has been further investigated, and the chemical analyses of material from experiments already described (*Rep. Rothamst. exp. Sta. for* **1955**, p. 71) have been completed.

Barley plants were grown in pots in a nutrient-deficient soil with or without addition of a complete fertilizer, and roots were washed

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out from sample pots at 5, 8 and 11 weeks after sowing. The remaining pots were kept for determination of the final yield of the crop. Analyses were made on excised root systems before and after they were transferred to Hoagland solution for 4 hours at 25° C. At the first sampling of plants that received no fertilizer, the excised roots absorbed a large amount of phosphorus but no potassium; at the second sampling there was a small uptake, and at the third a loss, of both P and K. At all three samplings there was a loss of nitrogen to the nutrient solution. This is in accord with the low phosphorus status of the soil, and shows that there was never any deficiency of N, or of K, except perhaps at the second sampling, relative to the low phosphorus supply.

Excised roots from plants that received the complete fertilizer lost N and K at the first two sampling times, but absorbed both at the third. There was a nearly uniform loss of P at all three harvests. It appears that both N and K supplies from the soil became deficient at the third sampling, near the time of ear emergence, and analyses of the whole plants showed that at this time 87 per cent of both the N and K added in fertilizer had been absorbed. Only 15 per cent of the added P was recovered in the plants at the third sampling, which accounts for the inability of the excised roots to absorb P. These results indicate that excised roots show variations in nutrient uptake from, or loss to, an aerated nutrient solution that reflect differences in nutrient supply from the soil, including deficiencies induced by removal of nutrients by the growing plants.

To test whether variations in nutrient absorption or loss by excised roots measure soil deficiencies, in the sense that they are correlated with responses to added nutrients, pot experiments were done with barley and potatoes grown in the same infertile soil as before, with nitrogen, phosphorus and potassium supplied in all combinations of three rates of each. At a suitable stage of growth samples of roots were washed out of the soil and preserved for analysis before and after transfer to a nutrient solution in standard conditions. Some pots were kept to measure the yield responses to the added nutrients. The chemical analyses of material from these experiments are not yet complete.

As part of the analysis of varietal differences in barley (p. 83) four varieties (Plumage Archer, Kenia, Proctor and Herta) were included in the 1955 soil-culture experiment to test whether their roots differ in ability to absorb nutrients, but no such differences were found, nor were there any significant differences in yield of dry matter. The same four varieties were also grown in solution-culture with two rates of nutrient supply. The rates of nutrient uptake by excised root systems were compared in standard conditions, but again no varietal differences in uptake per unit weight of root were found. In the solution-culture experiments the four varieties were grown together in competition in the same vessels; Kenia and Proctor produced smaller root systems than Plumage Archer and Herta, and gave smaller final yields and total nutrient contents. In these experiments plants that received the high rate of nutrient supply were given additional nutrients a few days before the roots were excised, and replicate blocks were sampled on successive days. Nutrient absorption by the excised roots showed a steady drift with

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time over the period of sampling, presumably because of slow equilibration of the roots to a sudden change in external conditions and because the composition of the nutrient solution was also changing.

Experiments were started on the effect of removing part of the root system on subsequent growth and nutrient uptake of barley, rye and tomato plants grown in solution culture. In two weeks after treatment, nutrient uptake was reduced less than proportionally to the fraction of the root system removed, e.g., when 35 or 50 per cent of the root system was excised, the amount of K absorbed was respectively 23 and 35 per cent less than that of untreated control plants. The total weight of the plants was decreased nearly proportionally to the K uptake, so the K content per cent of dry matter was almost unaffected. Removal of roots greatly decreased the growth of the tops, but no effect on the growth of the surviving roots was observed until at least half the root system was excised.

Effect of boron on production of adventitious roots (E. C. Humphries)

Production of adventitious roots on the hypocotyl of French-bean seedlings (*Phaseolus vulgaris*) is known to depend on boron supply; it occurs if the cut hypocotyl is placed in a solution containing boron, but not in distilled water, and increases with increase in the boron concentration. As there is evidence that boron is involved in translocation of carbohydrate in plants, it seemed possible that the failure of boron-deficient bean hypocotyls to form roots might be due to restricted transport of carbohydrate from the leaves. If so, it should be possible to increase root production by increasing the carbohydrate supply.

Seedlings of dwarf French bean (var. Prince) were raised in sand and transferred to nutrient solution with or without addition of boron until the primary leaves were fully expanded. The primary leaves of boron-deficient plants were larger than those of normal plants, presumably because of reduced transport of metabolites from them, associated with the death of the apical growing point. The root and base of the hypocotyl was cut off 5 cm. below the cotyledons, and the cut hypocotyls were placed in dilute nutrient solution free from boron. The plants were kept in daylight or in complete darkness, and the primary leaves were painted daily with water, or a solution of sodium borate, or a sucrose solution, or a solution containing both boron and sucrose. The experiments are still continuing, and the results cannot yet be fully interpreted. So far, they show that boron applied to the leaves of boron-deficient seedlings increased the number of roots and root initials formed on the hypocotyls, both in the light and in the dark. Sucrose alone increased root formation in the dark, but decreased it in the light. There was no evidence that application of boron and sucrose together had a greater effect than separate applications. Plants kept in light formed roots mainly on the upper part of the hypocotyl and on the epicotyl, while in the dark most of the roots were formed on the lower part of the hypocotyl.

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Weed Studies

Wild oats (J. M. Thurston)

A few seedlings of *Avena fatua* appeared in 1956 on plots where seed was sown in October 1950 at a depth of 6 inches (*Rep. Rothamst. exp. Sta. for* **1955**, p. 73), but none from the shallow sowing. For the second successive year, no seeds of *A. ludoviciana* germinated. The results indicate that *A. ludoviciana* can survive for not more than four years in Rothamsted soil, but seeds of *A. fatua* persist longer. The experiment will be continued for another year to find out whether any viable seeds of *A. ludoviciana* remain, and whether *A. fatua* seeds continue to germinate.

Observations on the longevity of wild oats seeds in land put under temporary ley were continued on three field experiments (*Rep. Rothamst. exp. Sta. for* **1955**, p. 73). In the Northampton experiment, where the soil population of a mixture of *A. fatua* and *A. ludoviciana* seeds is so high that it can be estimated by washing out the seeds from soil samples, the number of seeds recovered and presumably viable after the third year of the experiment was as great as after the second. In the previous year the number had nearly halved. The much smaller population of viable *A. fatua* seeds in the soil of the Boxworth experiment, measured by ploughing up part of the ley each year and counting the number of seedlings that appear, did not decrease during the year, the 5th under ley; in the previous year it had fallen by 75 per cent. It is possible that the population of dormant seeds in these experiments has become nearly stabilized and is now decreasing only slowly through germination or death. This must be tested by counts in future years, but the results raise doubts about the efficacy of a period in temporary ley as a method of eradicating an infestation of wild oats. In the Rothamsted experiment 3 plants of *A. fatua* per sq. yd. appeared in the spring on plots ploughed after one year under grazed ley, compared with 9 per sq. yd. in the spring of 1955 before the ley was sown. A similar reduction occurred on plots not sown with the ley, but fallowed to avoid reinfestation with wild oats seeds.

Germination tests on seeds of *A. ludoviciana* from the experiment on competition with wheat, barley and rye (*Rep. Rothamst. exp. Sta. for* **1955**, p. 74) showed the percentage of viable seeds was unaffected by the treatments. Dormancy of the first seeds was unusually high, but was slightly reduced by increased competition with the cereal crops, especially when sown early with low nitrogen supply. Nearly all the second seeds from all treatments were dormant.

The study of dormancy and periodicity of germination of types of *A. ludoviciana* and *A. fatua* distinct from those found at Rothamsted (*Rep. Rothamst. exp. Sta. for* **1955**, p. 74) was continued. As in the Rothamsted types, germination of *A. ludoviciana* ceased about the end of March (except for two selections of one type that started and finished a month later than the rest) and began again in late October. Six selections of *A. fatua* gave a spring peak of germination, like the Rothamsted type, but two selections of *A. fatua*, similar in appearance, gave a winter peak corresponding in

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periodicity to the late-germinating types of *A. ludoviciana*. Thus, types of wild oats selected because they differed most widely in appearance from the Rothamsted types, usually resembled them in periodicity of germination.

The investigation of the effect of temperature on germination of seeds of *A. ludoviciana* was continued, using first and second seeds from spikelets collected in 1950, which had lost most of their natural dormancy during storage. Over 90 per cent of the first seeds germinated without pricking when kept moist at 7° or 15° C., but very few germinated at 27° C. One day or one week at 27° increased the rate of germination on subsequent transfer to 7°, but one month at 27° decreased it, and reduced the number germinating by 5 per cent. Second seeds behaved differently; 27 per cent, 17 per cent and 2 per cent germinated at 7°, 15° and 27° respectively. The initial rate of germination was higher at 15° than at 7°. Exposure to 15° or 27° for a week before transfer to 7° increased the rate of germination and raised the percentage germination to 47 per cent. The highest germination, 74 per cent, was found in second seeds held at 27° for one day and then at 7°.

Seeds of *A. ludoviciana* were collected from different positions in the panicle to determine whether their germination behaviour varies with position. Their viability and dormancy have been tested, and an anatomical examination is to be made to see whether structural differences in seed-coat or embryo can be correlated with differences in germination.

Weeds of Broadbalk (K. Warington and J. M. Thurston)

Another set of soil samples was taken from Section I of five plots of Broadbalk to compare changes in the weed-seed population on the part that is to be continuously cropped with those on the part that remains in the five-year fallow cycle (*Rep. Rothamst. exp. Sta. for* **1955**, p. 74). The species germinating in these and the previous year's samples have been recorded at regular intervals.

Broadbalk Wilderness (J. M. Thurston and K. J. Witts)

In view of a proposal to introduce grazing by sheep on part of the "meadow" section of Broadbalk Wilderness, where the growth of trees and bushes is prevented, a survey of the existing flora has been made to help decide whether the proposal is practicable and how best to divide the area, and to provide a base-line from which the changes in the flora induced by grazing could be measured. The species present and the percentage area covered by each were recorded on six occasions between April and December on quadrats distributed over the area, and the boundaries of sharply differentiated plant communities were mapped. Very few species with any grazing value were found, and useful grasses account for only a small fraction of the herbage until after the dicotyledonous weeds have died in the autumn. There are also several poisonous species, of which the most abundant is *Mercurialis perennis*. Since the last detailed description of the flora was published in 1915, the large patches of ivy that then occupied much of the area have disappeared, and so have 3 species of grasses, 9 of legumes and 19 other species; 9 species not recorded then are now present.

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Physiological Effects of Virus Infection

Effects of infection on respiration and photosynthesis of tobacco leaves (P. C. Owen)

Unlike tobacco mosaic virus (TMV), which increases the rate of respiration of tobacco leaves within an hour of inoculation (*Rep. Rothamst. exp. Sta. for* **1955**, p. 75), a virulent strain of tobacco etch virus does not affect the respiration rate until the leaves show visible symptoms after 6 days or more. When tobacco plants were inoculated with tobacco etch virus, the respiration rates of inoculated or systemically infected leaves showing etch symptoms were up to 40 per cent greater than those of comparable leaves of healthy plants. This is three times the increase produced by TMV. The effect on respiration is evidently not related to the concentration of virus because the maximum concentration of tobacco etch virus in tobacco leaves is known to be only about one-thousandth of that reached by TMV. The increase in respiration caused by infection with tobacco etch virus continued throughout the life of the leaves, and occurred at all times of the year.

There was no difference in total dry weight or leaf area between healthy plants and plants infected with TMV until the second week after inoculation. After 3 weeks, when symptoms of systemic infection were visible, the dry weight of infected plants was 25 per cent less than that of healthy plants and there was a similar reduction in leaf area. The loss of dry weight caused by infection was the result of nearly equal effects on net assimilation rate and leaf area; mean net assimilation rate and mean leaf area per plant for the three weeks after infection were respectively 16 per cent and 19 per cent less for infected than for healthy plants.

Direct determinations of the rates of photosynthesis of comparable healthy and infected leaves attached to the plant and kept in daylight were made by enclosing them in perspex vessels through which air was drawn, and the CO_2 concentration of the air was measured with an infra-red gas analyser, before and after passage over the leaf. The rate of photosynthesis of leaves inoculated with TMV was decreased by 15–20 per cent of that of control leaves, and the decrease was detectable from the first hour after inoculation, at which time the virus is currently believed to be still confined to the epidermis. It also occurred from the first hour after inoculation when a purified preparation of TMV was used instead of infective sap, and when the upper epidermis (on which the inoculum was rubbed) was covered with a film of vaseline, so the effect was not due to some constituent of infected sap other than virus, nor to closure of stomata on the inoculated surface of the leaf. The rate of photosynthesis was unaffected when the virus preparation was inactivated by ultra-violet irradiation before use. These results imply that the entry of virus into the epidermis produces an effect on deeper chlorophyllous tissues within an hour, long before movement of virus out of the epidermis has been detected or inferred.

The rate of photosynthesis of uninoculated leaves of plants systemically infected with TMV 3 weeks after inoculation was about 20 per cent less than that of healthy leaves. There was a decrease

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of similar magnitude in leaves infected with tobacco etch virus and showing visible symptoms.

Growth Analysis

Photosynthesis of leaf sheaths of cereals (G. N. Thorne)

In growth analyses of cereal crops it has been customary to measure leaf area as that of the laminae only, ignoring the leaf sheaths. The exposed parts of the sheaths are small compared with the laminae in the early stages of growth, but by the time of ear emergence the green area of sheaths is about equal to, and later may exceed, that of the laminae. Net assimilation rates expressed on the basis of lamina area may, therefore, be serious overestimates of the photosynthetic efficiency of the leaves to an extent depending on the relative photosynthetic rates of laminae and sheaths.

The rates of photosynthesis of single leaves and of portions of sheaths of barley plants grown in pots were measured in daylight with an infra-red CO_2 analyser. The rate of CO_2 absorption per sq. cm. of sheath was about half that per sq. cm. of lamina. Young leaves had a higher rate than old leaves; the rates of CO_2 uptake per sq. cm. of lamina or sheath of a particular leaf were about 70 per cent of those of the next higher leaf on the stem.

The rate of respiration, measured at night in one series of experiments, was two to three times greater per unit area of sheath than of lamina. This difference was due mainly to the greater dry weight per unit area of the sheaths, but respiration per g. dry weight was slightly greater for sheaths than for leaves. The difference between sheath and lamina in respiration rate per sq. cm. was of the right order to account for the difference in apparent photosynthesis.

Varietal differences in yield of barley (G. N. Thorne)

In the 1955 field experiment comparing Plumage Archer, Herta and Proctor barleys with and without nitrogenous fertilizer (*Rep. Rothamst. exp. Sta. for* **1955**, p. 76), the total dry weight yield, leaf-area index and net assimilation rates were similar for all varieties throughout the growth period. The higher grain yield of Proctor and Herta was therefore not due to increased size or efficiency of the photosynthetic system, but to a difference in the distribution between ears and shoots of the products of photosynthesis after ear emergence. In the early stages of growth, Plumage Archer had more tillers than the other varieties, but many of them died while the other varieties were still producing ear-bearing shoots. Consequently, Proctor and Herta had more ears at harvest than Plumage Archer, and this accounts for their higher grain yield, though the difference was partly offset by the larger ear and grains of Plumage Archer. Whether the tendency for a higher fraction of assimilate to move to the ears is causally related to the development of more ears is not known. Increased photosynthesis by the larger number of ears probably contributed towards the higher yield of grain. The progress of nutrient uptake throughout growth was similar in all varieties, but Herta took up phosphorus more slowly than the others.

In the pot experiment (*Rep. Rothamst. exp. Sta. for* **1955**, p. 77),

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Plumage Archer produced more leaf area and total dry matter than Proctor, Herta or Kenia; the reason for this difference from the results of the field experiment is not known. But, as in the field, Plumage Archer transferred a smaller fraction of total dry matter to the grain, and so the yield of grain was similar for all varieties. The main point of the experiment was to determine whether the contributions made by photosynthesis in different parts of the plant to the dry matter that enters the grain vary with variety. Photosynthesis in the ears of some plants was prevented by covering them with opaque shades, and other plants had the awns cut off, or the lower leaves and stems shaded. The results were independent of variety or nitrogen supply; about 25 per cent of the dry matter in the grain was produced by photosynthesis in the ears, including 10 per cent from the awns, while photosynthesis in leaves and stem below the flag leaf supplied about 15 per cent. The balance, some 60 per cent, must have come from flag leaf and peduncle, and these are evidently the most important sources of dry matter entering the grain in all the varieties tested.

Effect of time of application of nitrogenous fertilizer to barley (G. N. Thorne and S. A. W. French)

A pot experiment on wheat (*Rep. Rothamst. exp. Sta. for* **1955**, p. 76) indicated that late nitrogen applications are ineffective on plants that previously had a very low N supply. To test whether this is true for spring cereals, barley was grown in pots with the following treatments: no N, single dose of N applied at sowing or at ear emergence, double dose of N applied at sowing or equally divided between sowing and ear emergence. Plumage Archer and Proctor were included in the experiment, to confirm and extend previous work on the physiology of their differences in growth and yield. Ears on half the pots were covered with opaque shades immediately after they emerged, to test the effect of early and late N supply on photosynthesis by the ears.

The single dose of N at sowing greatly increased the grain yield of both varieties, but when given at ear emergence it had no effect. This is similar to the results for wheat. In pots that already had the single dose of N at sowing, addition of the second dose at sowing increased the grain yield of Proctor, but not of Plumage Archer, but when the second dose was given at ear emergence it had no effect on the grain yield of Proctor, but increased that of Plumage Archer. As in earlier experiments, Plumage Archer had more shoots than Proctor early in the growth period but subsequently more died, so that Proctor eventually had more shoots and ears. The first dose of N increased the number of ears of both varieties whether applied early or late; the second dose at either time increased the shoot and final ear number of Proctor but caused only a small temporary increase in shoot number of Plumage Archer. Evidently response in grain yield to late N applications does not depend on increased shoot or ear production. The difference between varieties in response to N requires confirmation, and the separate contribution to grain yield of shoots produced before and after the time of late N application needs to be determined in future experiments. Shading the ears decreased the grain yield of both

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varieties by 27 per cent on the average of all treatments. The percentage varied with time and rate of N supply, but the analysis of these results is not yet completed.

Effect of varying soil moisture deficit on plant growth (P. C. Owen)

In two more experiments on sugar beet, grown in Mitscherlich pots, the moisture content of Rothamsted soil was either kept near field capacity by frequent watering or allowed to fall to about pF 4 before return to field capacity. The results confirmed that variation within this range had no effect on total dry matter production (*Rep. Rothamst. exp. Sta. for* **1955**, p. 77). The drier conditions slightly decreased leaf area per plant and the amount of water transpired per plant, but did not affect water loss per unit leaf area. Twice-daily wetting of the leaves with a fine spray was tested in one experiment but had no effect on growth.

It has become apparent that pot cultures are unsatisfactory for this work, because the total amount of water available from the soil is small compared with that available to a plant of a field crop, and conditions of water stress can be maintained only for short periods before the plants must be watered to survive. Pot cultures have therefore been abandoned, and future work will be done on small plots under a glass roof to protect them from rainfall.

Further work on the effects of irrigation on the growth of sugar beet in the Woburn Irrigation Experiment was planned, but abandoned after the first sampling on 10 July. At this time the early irrigation had had no effect in spite of the dry spring. No further irrigation was done because of heavy rainfall during the next two months.

An attempt to increase yield by controlling leaf area index (D. J. Watson, S. A. W. French and G. H. King)

An attempt was made in 1955 (*Rep. Rothamst. exp. Sta. for* **1955**, p. 78) to increase the total dry matter yield of a field crop of kale by preventing the leaf area index (L; leaf area per unit area of land) rising above the optimum for dry matter production by thinning the crop at intervals from mid-July onwards. Previous experiments had shown that the rate of dry matter production per unit area of a kale crop was maximal when L lay between 3 and 4; for the unthinned crop in 1955 L rose nearly to 6 in August. On the thinned plots, the total dry matter yield, including thinnings, was only 6 per cent higher than on the unthinned plots. As it seemed possible that the thinning had been too severe, the experiment was repeated in 1956 with two thinning treatments, aimed at holding L between 3 and 3·5 or between 3·5 and 4, but with both the range of L achieved was slightly wider. Although as before the thinned plots had a higher net assimilation rate than the unthinned, it was only just sufficient to offset the decrease in L, so that eventually thinned and unthinned plots gave almost identical total dry matter yields. Part of the explanation for the lack of response to thinning may be that L of the unthinned crop was smaller for the 1956 crop, and did not exceed 5 until the end of August, so the effect of thinning on L was relatively smaller than in 1955. But the reason for the precise

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compensation for decreased leaf area index by increased net assimilation rate is not clear, and further examination of the data is needed.

Net assimilation rate of cultivated and wild beets (K. J. Witts)

Although net assimilation rate has been shown to vary within species, present knowledge suggests that there is little hope of increasing the efficiency of the photosynthetic process by selection or breeding. If it is possible, it might reasonably be expected to have occurred during the development of cultivated sugar beet by selection from its wild ancestors, which were probably types of *Beta vulgaris* subsp. *maritima*. An opportunity to test this was provided by the collection of wild beet made by J. W. Blencowe, of the Plant Pathology Department, and grown from seed on the Garden Plots in 1956, in comparison with Kleinwanzleben E sugar beet.

Three wild types were selected, one from Pembroke, where there is little chance of crossing with cultivated beet, and two from Norfolk. Samples of plants of these three types and of Kleinwanzleben E sugar beet were taken on three occasions in July and August, and measurements were made of total dry weight and leaf area from which the net assimilation rates for the two intervals between samplings were calculated. Two of the wild types had mean net assimilation rates nearly identical with that of Klein E. The third wild type, one of the two from Norfolk, had a net assimilation rate equal to that of Klein E in the first period, but significantly less than Klein E in the second period. The reason for this difference is not known, but the results show that some wild beet plants have as high a net assimilation rate as the highest-yielding commercial strain of sugar beet, indicating that prolonged selection for high yield in this species has not increased the photosynthetic efficiency of the leaves.

Leaf growth (L. H. Fernando)

A pot-culture experiment on sugar beet was done to investigate the effect of nitrogen, phosphorus and potassium on leaf growth. Previous work on several crops has shown that while nitrogenous fertilizer increases leaf area per plant throughout the growth period, phosphatic fertilizer is effective mainly in the early stages, and may subsequently decrease leaf area, in contrast with potassic fertilizer, which increases leaf area in the later stages of growth. The object of the experiment was to analyse these effects of nutrient supply on leaf area per plant in terms of the rate of leaf production, the longevity of leaves and the rate of expansion and ultimate size of individual leaves.

In another series of experiments on sugar beet and tobacco, factors that influence the size of a particular leaf (usually for convenience the 6th) in the series produced from the apical meristem were studied, with particular reference to the influence of neighbouring leaves and its interaction with nutrient supply. Analysis of the results of these experiments is not yet completed.

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Methods

Measurement of soil pF by means of the Peltier effect (P. C. Owen in collaboration with J. L. Monteith, Physics Department)

A method of measuring the suction pressure of plant tissue based on the Peltier effect has been described by Dr. D. C. Spanner of Bedford College (*J. exp. Bot.* **2** (1951), 145–168). Some preliminary work to adapt the principle for measurement of soil pF was done in the Physics Department by P. B. Flegg (*Rep. Rothamst. exp. Sta. for* **1955**, p. 40), and an instrument has now been assembled that can determine very accurately the Relative Humidity of the atmosphere in equilibrium with a sample of soil in a small sealed vessel. From this the total water potential and pF of the soil can be computed. Some calibration problems and investigation of the cause of irregularities probably due to stray e.m.f.s in the system remain to be dealt with, but the method was sufficiently reliable to be used for determining the soil-moisture limits representing the prescribed pF range in the experiments on the effect of varying soil-moisture deficit on growth (p. 38). The instrument could be used in other biological work that requires very precise measurement of Relative Humidities between 98 and 100 per cent, or of small changes in total osmotic concentration of solutions.