Report for 1957

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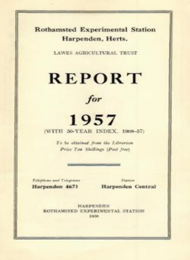

Botany Department

D. J. Watson

D. J. Watson (1958) *Botany Department ;* Report For 1957, pp 83 - 95 **- DOI: https://doi.org/10.23637/ERADOC-1-90**

BOTANY DEPARTMENT

D. J. WATSON

Dr. Katherine Warington retired on 30 September; she had been a member of the staff since 1921.

P. J. Welbank and A. W. Wheeler joined the department in October, and G. H. King transferred to the Plant Pathology Department, but has continued to supervise the Botany glasshouses.

Gillian N. Thorne was awarded a Post-Doctorate Fellowship by the National Research Council of Canada, and went to Ottawa in November to spend a year in the Botany and Plant Pathology Laboratory of Science Service, Department of Agriculture.

Joan M. Thurston prepared the material for an exhibit for the Chelsea Show of the Royal Horticultural Society in May, illustrating factors that affect the multiplication and spread of weeds.

D. J. Watson contributed a paper to a symposium on the Biological Productivity of Britain, organized by the Institute of Biology, and held in London in October.

A large Dutch-light glasshouse was erected early in the year, to enable work on effects of soil-moisture content on crop growth to be done independently of rainfall, with the whole water supply controlled by irrigation.

PLANT NUTRITION

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

Chelated complexes of iron with the following compounds were tested as sources of iron in solution cultures of peas and soybeans:

(*a*) mono-sodium ethylenediamine tetra-acetate, EDTA (Na);
(*b*) hydroxyethyl ethylenediamine triacetic acid, HEEDTA;
(*c*) diethylenetriamine penta-acetic acid, DTPA;
(*d*) ethylenediamine NN′bis (hydroxyphenyl acetic acid), CHEL 138.

(*a*), (*b*) and (*c*) were the most effective of a large number of compounds tested previously (*Rep. Rothamst. exp. Sta. for* **1956**, p. 77), and all were superior to ferric citrate; (*d*) was not previously available. All the compounds were kindly supplied by the Geigy Company Ltd. When they were added in a range of concentrations from 0·06 to 1·0 p.p.m. Fe to a nutrient solution with an initial pH of 5·5, the development of iron-deficiency symptoms in the shoots of peas (apical chlorosis and crinkling of the leaves) was prevented by 0·125 p.p.m. Fe supplied as (*d*), but 0·25 p.p.m. Fe was required if supplied as (*a*), (*b*) or (*c*). With soybeans also, (*d*) was about twice as effective as the other compounds; 0·5 p.p.m. Fe as (*d*) prevented the appearance of iron-deficiency symptoms compared with 1 p.p.m. Fe required in the other forms. Averaging all rates of supply, plants that received (*d*) had a higher dry weight than the others. In a second series of tests comparing nutrient solutions with initial pH of 5·5 or 7·5, (*d*) was equally effective in suppressing deficiency symptoms at either pH, but the other complexes were less effective in the alkaline than in the acid solution. The shoots of plants that received (*d*) usually had a slightly higher iron content than those of plants that received equivalent iron in a different form, but the roots had a much lower iron content. This is in keeping with the greater effect of (*d*) on shoot symptoms, because accumulation of iron in the roots is usually associated with iron-deficiency chlorosis of the shoots. (*c*) also decreased the iron content of the roots, but to a less extent than (*d*).

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

Chemical analyses were completed on material from pot experiments on barley and potatoes, designed to test whether variations in nutrient absorption or loss by excised roots can be used to measure soil deficiencies in the sense that they are correlated with responses to added nutrients (*Rep. Rothamst. exp. Sta. for* **1956**, p. 78). Roots from plants grown with all combinations of three levels of nitrogen, phosphorus and potassium were excised 7–8 weeks after planting and transferred to a complete nutrient solution in standard conditions. Contrary to previous experience, nearly all the excised root samples absorbed nutrients from the standard solution, even if they came from plants which had received adequate nutrient supply; in earlier experiments roots from such plants lost nutrients to the solution. It was therefore not possible to diagnose nutrient deficiencies simply by measuring gain or loss of ions by the excised roots. The relation between uptake by excised roots and the nutrient status of the plants from which they came is evidently a complex one, and is still being investigated.

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

Some further experiments were done on the effect of applying boron, with or without carbohydrate, to the primary leaves of dwarf French beans (*Phaseolus vulgaris*) on the formation of adventitious roots by the hypocotyl (*Rep. Rothamst. exp. Sta. for* **1955**, p. 79). They confirmed that sucrose applied in the light, but not in the dark, depressed root formation, but fructose and glucose in the same concentration had no effect. An organic boron compound (phenylboronic acid) was as effective in producing roots as sodium borate in solutions supplying equivalent boron. As reported previously, no interaction was found between boron and sucrose, so there is no evidence that boron accelerated sucrose transfer to the hypocotyl.

Effect of time of application of nitrogenous fertilizer to wheat (G. N. Thorne)

Field experiments on wheat have shown that, on the average, late nitrogenous top-dressings are as effective as early top-dressings in increasing grain yield, but in pot experiments (*Rep. Rothamst. exp. Sta. for* **1955**, p. 76) late applications of N were much less effective than early applications. The explanation suggested was that the plants grown in pots had such a low N-supply from the soil that they were incapable of responding to a late application of nitrogenous fertilizer. This implies that the response in grain yield to late N increases with increase in the supply of N available early in growth, at least over some part of its range. To test this, wheat was grown in soil in pots with 0, 0·5 or 1·0 g. N per pot applied in mid-March, and in addition, some plants had 0·5 g. N applied either in mid-March or at the time of ear emergence in late May.

Contrary to the hypothesis, the response in grain yield to the additional 0·5 g. N per pot applied late, like that to an additional early application, decreased with increase in the basal N supply in March. The response in number of ears also was smaller when the basal N supply was increased, and was similar for both times of application. Evidently further work will be necessary to explain the discrepancy between the field and pot results. With the lowest basal rate, additional late nitrogen increased grain yield mainly by increasing the number of ears, whereas at the higher basal rates the extra grain yield was produced mainly by ears already present when the late N was applied.

GROWTH STUDIES

Effect of excising roots on shoot growth of barley (E. C. Humphries)

Experiments on the effect of removing all or part of the root systems of barley, rye or tomato plants on growth in subsequent short periods have been reported previously (*Rep. Rothamst. exp. Sta. for* **1956**, p. 79). The barley experiments have been extended to measure effects on subsequent growth to maturity of removing at successive dates the whole root systems of plants grown in solution culture. When the roots were removed 40–50 days after germination while shoot number was still increasing, the number of ears produced was increased by more than 10 per cent. Later removal of roots, after shoot number had reached its maximum, had no effect on ear production. It is suggested that the increased ear number is attributable to a temporary diversion to the shoots and developing ears of carbohydrate that would otherwise be used in root growth. Root removal made little difference to the final nitrogen content of the shoot, and data for other nutrients are not available. High temperatures in the glasshouse at the time of anthesis caused very erratic grain formation, but the total plant dry weight at harvest was unaffected by removal of the roots, except that it was decreased a little when the roots were excised at the last date, near to ear emergence.

Effect of gibberellic acid and kinetin on leaf growth and net assimilation rate (E. C. Humphries)

Gibberellic acid has been shown by other workers to increase the leaf area of some plants, and an experiment was done to measure its effects on leaf growth of potato and to determine whether it alters the efficiency of the leaves in dry matter production. Kinetin (6 furfuryl-amino-purine), a growth substance that is said to affect cell division, was tested in the same experiment. Potato plants grown from small sets, each with a single eye, were sprayed at the stage when they had eleven leaves on the main shoot and no lateral branches with gibberellic acid (50 p.p.m. in water), kinetin (0·025 p.p.m.), or both, or distilled water. The spraying was repeated a week later. When half the plants were harvested after two weeks, gibberellic acid had increased the leaf area of the main shoot by 36 per cent and of the lateral branches by 65 per cent, without altering the number of leaves. When the remaining plants were harvested after 2 more weeks the increase by gibberellic acid in leaf area of the main shoot still persisted, but the effect on the lateral branches had disappeared. Kinetin had no immediate effect on leaf area, but decreased it at the second harvest. At the first harvest, gibberellic acid had not affected total plant dry weight but had altered its distribution so that the weight of stem and leaves was increased and that of tubers decreased; the weight of roots was unchanged. At the second harvest the dry weight of stem and leaf was unaffected by the gibberellic acid treatment, but the weight of tubers was increased. Kinetin alone depressed the tuber weight, but not in the presence of gibberellic acid. The number of tubers was increased by gibberellic acid, and the tubers were longer and thinner than those of control plants, and had conspicuous scale leaves. The mean net assimilation rate for the interval between the two harvests was only slightly reduced by gibberellic acid. In the experimental period, therefore, the enlarged leaf area of plants treated with gibberellic acid had a photosynthetic efficiency nearly as great as that of untreated plants, and consequently the treated plants produced a higher dry-matter yield. As there were indications at the end of the experiment that the leaf area of plants sprayed with gibberellic acid was declining more rapidly than that of unsprayed plants, it is possible that the increase in dry-matter production caused by gibberellic acid would not persist in plants grown to maturity.

In experiments on dwarf French bean plants gibberellic acid increased the rate of expansion of leaves but not their ultimate size. Leaves sprayed with gibberellic acid wilted readily, and sometimes did not recover. Kinetin had a depressing effect on leaf growth, which was counteracted by gibberellic acid, as in the potato experiments. The depression by kinetin occurred only when the plants were placed in darkness immediately after spraying, but this result needs confirmation.

Effects of mineral nutrients on leaf growth (L. H. Fernando)

Experiments on sugar beet started in 1956 (*Rep. Rothamst. exp. Sta. for* **1956**, p. 86) to analyse the effects of the major plant nutrients on leaf area per plant, with particular reference to the stage of growth at which the effects appear, were continued and repeated on potatoes. The plants were grown in pots in a deficient soil without fertilizer, or with addition of nitrogen, phosphorus and potassium separately and in all combinations. Counts were made at intervals of the number of leaves present and the number dead, from which the rate of leaf production and the length of life of leaves was determined, and the areas of individual leaves were measured.

The effect of phosphorus in increasing the leaf area of sugar-beet plants was maximal about 6 weeks after germination; it then declined but persisted to the end of the experiment. Nitrogen had no effect on leaf area per plant during the first 6 weeks, but later caused a large increase which was maximal after 12 weeks. Potassium had much less influence on leaf area per plant than the other nutrients in these experiments; like nitrogen, it was most effective at about the 12th week. There were positive interactions between the nutrients; each had a greater effect in the presence of the others.

Phosphorus increased the rate of production of new leaves throughout the growth period, but its effect decreased with time. Nitrogen did not alter the rate of leaf production during the first two months, but later increased it, while potassium had no effect at any time.

On the average of all treatments the longevity of successive leaves increased steadily from the first to the fifteenth; leaves after the fifteenth were still alive at the end of the experiment, so their full functional duration could not be determined. Nitrogen increased the longevity of the first six leaves by 1–7 days, but shortened the life of later leaves by longer periods, up to 4 weeks for leaf 12. Potassium had only small effects that tended to increase in the later leaves, which showed severe deficiency symptoms in plants that received no potassium. It extended the life of the 15th leaf by about 1 week.

The final size of successive leaves in the age series increased to a maximum and then decreased. Phosphorus increased the size of the first ten leaves, but decreased that of subsequent ones. Nitrogen consistently increased leaf size with a maximal effect in leaves 10–20. Because of these changes, the largest leaf occurred earlier in the series when phosphorus was applied, and was delayed to a later leaf by nitrogen application. Potassium caused a small increase in the first fifteen leaves, but not subsequently.

The increase in leaf area per plant caused by phosphorus in the early stages of growth was thus attributable to a combination of more rapid production, longer survival and larger size of leaves near the beginning of the age series. At a later stage the higher number of leaves on plants that received phosphorus was offset by smaller leaf size. The effect of nitrogen was attributable to increases in both the size and number of leaves; the higher rate of leaf production was more than sufficient to counterbalance more rapid death of leaves. The increase in leaf area per plant caused by potassium was at first wholly attributable to greater leaf expansion, but later it was caused by longer survival of leaves.

Similar effects were found for potato, but the nitrogen response occurred earlier, and the effects of potassium were relatively greater than with sugar beet.

Interdependence of leaves (L. H. Fernando)

The expanding leaves of a plant presumably compete for mineral nutrients absorbed by the roots, and for water if the supply is restricted. Also, carbon compounds necessary for their growth, in the early stages at least, may be provided by photosynthesis in older leaves. Thus the growth of a particular leaf is likely to be dependent on the activities of the other leaves. An investigation of the interdependence of leaves produced from the same apical meristem was begun in 1956 (*Rep. Rothamst. exp. Sta. for* **1956,**

p. 87) on sugar beet and tobacco plants. The sixth leaf was selected as the chief test object, but the growth of other leaves was also measured. Some plants had some or all of the first five leaves removed at the time when the sixth leaf was beginning to expand, and on other plants leaves 7–11, or all the leaves after the sixth, were cut off in succession as they appeared. Undefoliated plants were kept as controls.

The size of the sixth leaf of sugar-beet plants with a low nutrient supply was increased by removing the first five leaves, but the same treatment decreased the size of the sixth leaf of plants with a high nutrient supply. On plants from which leaves 1–5 were removed the sixth leaf died sooner than on undefoliated plants. Removal of leaves 3–5 had similar but smaller effects on leaf 6. The growth of many leaves produced after the sixth was affected by removal of leaves 1–5 in a similar way to that of the sixth leaf.

Removal of leaves 7–11 consistently increased the size of leaf 6, and also of leaves produced subsequently to the eleventh. When no leaves were allowed to develop after the sixth the first six leaves grew larger, and survived and continued to expand for a longer period.

Similar results were obtained with tobacco, except that loss of leaves 1–5 had no effect on the growth of leaf 6, but decreased the size of subsequent leaves with a maximal effect at leaf 10.

In another experiment the same defoliation treatments were applied to plants with varied supply of nitrogen, phosphorus and potassium to find out which of the major nutrients was involved in the interaction with the effect of removing leaves 1–5. Chemical analyses are being made on material from this experiment to determine whether the effects of defoliation on leaf growth can be related to changes in mineral content of the leaves, and in the distribution of nutrients between leaves, but these are not yet complete.

Varietal differences in barley (G. N. Thorne)

Although Plumage Archer barley produces more tillers than Proctor, a smaller proportion survive to form ears, so that Proctor has more ears at harvest (*Rep. Rothamst. exp. Sta. for* **1956**, p. 83). This fact is probably significant in relation to yield, because the higher grain yield of Proctor in field cultures has been shown to result from additional photosynthesis in the ears. The causes of this difference in tiller survival were investigated in several experiments. In one of them the two varieties were grown in soil in pots with or without additional nitrogen, and each tiller was labelled as it appeared. At fortnightly intervals pots were harvested, the plants dissected and the stage of development of the apical meristem of each shoot was determined. All the main shoots survived to form ears. In plants that received no nitrogenous fertilizer, about half the first primary tillers of both varieties survived; almost all the second primary tillers of Proctor also survived, but none of Plumage Archer. At the higher rate of N supply nearly all the first and second primary tillers survived for both varieties, and the varietal difference occurred in the secondary tillers; 85 per cent of those produced by Proctor survived, but only 14 per cent in Plumage Archer. These results suggest that in Proctor there was a relaxation of apical dominance compared with Plumage Archer, rather than a general change in the ability of tillers to survive.

Death of tillers usually occurred shortly before ear emergence, and at earlier harvests no differences in development were detected between apices of shoots destined to survive to maturity or to die without producing an ear, in comparisons either between or within varieties. The dry weight and leaf area of each shoot were also determined, and the samples kept for nitrogen estimation, but these results are not yet complete. The survival of a larger proportion of shoots of Proctor was associated with a higher ear : shoot dry weight ratio at the time of ear emergence.

Another experiment tested the effect of removing ears from some older shoots on the survival of the rest. Shortly before the ears emerged, or two weeks later, ears on the main stem and the first two primary tillers of Plumage Archer and Proctor plants were cut off. To determine whether the apices of the older shoots influence the development of lateral shoots by auxin production, as in vegetative shoots, lanolin paste containing 100 p.p.m. IAA was placed on the cut ends of the shoots in half of the pots from which ears were removed.

Removing ears on the first occasion increased the number of ears at harvest in both varieties, but more for Proctor than Plumage Archer. However, this increase was entirely due to production of more tillers after the ears were removed; the survival of shoots already present at that time was unaffected. Removal of ears on the second occasion, or auxin application at either time, did not influence the production or survival of tillers. Removing ears had no effect on the dry weight of the treated shoots, but increased the dry weight and grain yield of the other shoots. Auxin had no effect on shoot dry weight, but grain yield was apparently decreased by the first auxin application and increased by the second.

An attempt was made to determine how the shoots of a barley plant influence each other's survival, by comparing the behaviour of intact plants grown in solution culture with that of plants divided up into their constituent shoots and returned to grow in the same vessels as the intact plants, but unfortunately this gave erratic results, and needs to be repeated with an improved technique.

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

Previous work has shown that pot cultures are unsatisfactory for studying effects of soil water supply on plant growth, because conditions of water stress can be maintained only for short periods compared with what occurs in the field (*Rep. Rothamst. exp. Sta. for* **1956**, p. 85). Instead of pot cultures, small field plots protected from rain by a Dutch-light structure so that the whole water supply was under control were therefore used for a continuation of this investigation. Sugar-beet were grown with uniform watering until the beginning of June. Then the soil water content on all plots was brought to field capacity (about 28 per cent water) and three treatments were compared:

(*a*) Minimal water stress, with the water content of the soil maintained near field capacity by frequent watering; a total of 5·4 inches of water was applied.

(*b*) The mean soil water content to a depth of 12 inches was allowed to fall to 13 per cent in early July; this is a little above permanent wilting percentage (about 10 per cent for this soil); it was then restored nearly to field capacity by a single application of 1 inch of water, and subsequently allowed to fall steadily to 14 per cent in August.

(*c*) Five waterings, totalling 1 inch, were given at intervals in July and August; the water content varied between 12 and 20 per cent.

The large expenditure of water needed for treatment (*a*) gave a high yield, over 6 tons total dry matter per acre by late August. When only 1 inch of water was applied in treatments (*b*) and (*c*) the total dry-matter production was less, but was still 80 per cent of that on the heavily watered plots. This contrasts with the result of the pot cultures—in which short-period fluctuations over a similar range of water potential had no effect on growth or yield. Plants receiving treatment (*a*) had a higher leaf area than the others throughout, and this accounted almost entirely for the greater dry-matter production, because net assimilation rate was only slightly affected, though immediately after the water applications in treatments (*b*) and (*c*) it was consistently a little higher than for treatment (*a*). This was similar to, but much less than, the effect of a small amount of rain on the net assimilation rate of an unirrigated crop following prolonged drought reported previously (*Rep. Rothamst. exp. Sta. for* **1955**, p. 77), and in spite of it the rate of dry-matter production after the waterings of treatments (*b*) and (*c*) was always less than for treatment (*a*). Contrary to present horticultural opinion, small frequent applications of water (treatment (*c*)) gave a slightly higher yield than the same amount given in one large application (treatment (*b*)).

Dependence of net assimilation rate of barley on leaf-area index (D. J. Watson and S. A. W. French)

The net assimilation rate (E) of thousand-headed kale decreases rapidly with increase of leaf area index (leaf area per unit area of land; L) presumably because mutual shading of leaves becomes more intense (273). Consequently, the crop growth rate (rate of dry-matter production per unit area of land; C) reaches its maximum when L is comparatively small, between 3 and 4, and decreases with further increase of L. Values of L well above the optimum, between 5 and 6, were found in the later stages of growth of the kale crops used for the experiments. For sugar beet, E decreases less rapidly with increase of L than for kale, and so maximum C was not attained within the range of L tested, up to 6, but may be within the range on very fertile soils, as in the Fens, where sugar beet have very large tops.

Experiments were done on barley to test whether there is a similar dependence of E and C on L for cereals, which differ greatly from kale and sugar beet in size, shape and distribution of leaves. In the kale and sugar-beet experiments, L was varied by removing different fractions of the plant population, by pulling up individual plants distributed in a systematic pattern through the crop. This was not possible in a barley crop, because plants cannot be distinguished except in the early stages of growth, and instead L was varied by removing either whole rows of crop, or 1-foot lengths distributed systematically along the rows; the two methods gave the same results. From different plots, 0, $\frac{1}{4}$, $\frac{1}{2}$ or $\frac{3}{4}$ of the plants were removed in this way, and from their dry weights and leaf areas, the dry weights and leaf-area indices of the plants remaining on the plots were estimated. After a fortnight, the remaining plants were harvested, and E and C were calculated for each plot from the initial and final dry weights and leaf areas. Leaf sheaths were included in the measurements of leaf areas as well as laminae, and on this basis L for the unthinned crop in the second experiment was about 9.

E decreased nearly linearly with increase of L throughout the range from 2 to 9. The rate of decrease of E per unit increase in L, expressed as a percentage of the value of E for $L = 1$ obtained by extrapolation, was 6·9 per cent in the first experiment and 7·2 per cent in the second. The comparable average values previously found for kale and sugar beet were 16 and 6 per cent respectively. Thus, E for barley was affected by increase in L to about the same extent as that of sugar beet, and much less than that of kale. Maximal C for barley occurred when L was about 8 or 9, near the upper limit of the experimental range. The results confirm the previous conclusion that there is little if any scope for increasing total yield of dry matter by increase in L at its maximum, and that improvement in yield depends rather on increasing L at the times in the growth period when it is small. But the grain yield of cereals depends on photosynthesis after ear emergence, when L has declined from its maximum, and it may be possible to improve grain yield still further by increase in L at this time.

Photosynthesis of leaves at different levels in a crop (D. J. Watson and S. A. W. French)

The lower leaves of a crop are shaded by those above, and so should be less effective in photosynthesis than the upper leaves that are fully exposed to sunlight. Also the fall in rate of photosynthesis from the top to the bottom leaves of a crop should be greater when the leaf-area index (L) is higher, because mutual shading of leaves should be more severe, and this may explain the fall in mean net assimilation rate (E) of the whole crop with increase in L.

An attempt was made to measure differences in rate of photosynthesis between groups of leaves at different levels in a kale crop, by comparing the dry-matter production in a period of 2 weeks by unit area of intact crop having an average of eleven leaves per plant with that by crops from which either the four lowest leaves or the seven lowest leaves of every plant were removed. These defoliation treatments were applied both to unthinned plots and to plots from which alternate plants had been removed before the experiment began; the initial values of L for these were about 5 and 2·5 respectively.

Removal of the four lowest leaves decreased the leaf area of the plants by 40 per cent, but decreased dry matter production per unit area of crop by only 13 per cent. Similarly, the seven lowest leaves, which represented 71 per cent of the leaf area, accounted for only 34 per cent of the dry-matter production. The mean net assimilation rates for the three groups of leaves at different levels of the crop in g./sq. m. of leaf area per week, were: four lowest leaves, 23; three middle leaves, 48; upper leaves (usually four), 112. Unfortunately, the experiment was not sufficiently precise to detect differences in the effects of defoliation between the crops with high and low L, but the results suggest that the reduction of E by increase in L occurred in leaves at all levels. As the lower leaves are older than the upper leaves, the difference between them in E may be partly an effect of ageing.

Measurement of leaf area (P. C. Owen)

A method for constructing a measuring grid from which the areas of elliptical leaves may be read directly, described by Freeman and Bolas (*Rep. East Malling. Res. Sta. for* **1955**, p. 104), has been modified so that leaves which have irregular geometric shapes, and which may be asymmetrical about one axis, can be measured. A grid based on slightly different principles is being developed for the measurement of the leaf areas of cereal crops and grasses.

WEED STUDIES

Wild oats (J. M. Thurston)

In the experiment on survival of wild oats seeds in a cultivated soil (*Rep. Rothamst. exp. Sta. for* **1956**, p. 80) only two more seedlings of *Avena fatua* appeared in 1957, and none of *A. ludoviciana*. The number of seedlings recorded in all the years of the experiment accounts for only about 20 per cent of the seeds sown in October 1950. Soil samples representing in all 60 sq. ft. of land to ploughing depth were taken in September 1957 and washed through sieves to see whether any viable but dormant seeds remained. Only two were found, both third seeds of spikelets of *A. fatua*, out of 3,000 sown. Evidently the 80 per cent of sown seeds, not accounted for as seedlings, are no longer present in the soil, but have been destroyed probably mainly by rotting, though some are known to have been taken by birds in the early years. The experiment has now been terminated.

The number of seeds of *A. fatua* that germinated in 1957, on plots ploughed in autumn 1956 out of temporary ley established in spring 1955 on an infested site at Rothamsted, was about the same as that found in 1956, on plots ploughed in autumn 1955; the large decrease that occurred in the first year under ley did not continue in the second year. This agrees with results previously found for a much heavier mixed infestation of *A. fatua* and *A. ludoviciana* in a field in Northamptonshire which showed that the infestation decreased more rapidly in the early years than later. The number of seeds recovered by washing through sieves from soil samples taken from the Northamptonshire field in 1957 was slightly less than in 1956, but over 4 million seeds per acre still remained after 4 years under ley, compared with about 15 million per acre in 1954, when the first counts were made after 1 year under ley.

A study of the development of seeds of *A. ludoviciana* at different positions in the panicle (*Rep. Rothamst. exp. Sta. for* **1956**, p. 51) was continued and showed that many seeds were fully developed and already dormant 15 days after anthesis. The percentages of viable and dormant seeds increased between the 15th and 25th days. The percentage of non-viable seeds was higher in small than in large panicles, and was highest in the lowest whorl of the panicle. Dormancy, as percentage of viable seeds, was always lower in first than in second seeds of the spikelets, and reached a maximum of 80 per cent for first seeds 25 days after anthesis, when almost all second seeds were dormant. First seeds taken at a later harvest when fully mature had less dormancy, but this may have been partly the result of a short period of storage in the laboratory before testing. Large panicles had a smaller proportion of dormant seeds than small ones, but dormancy did not vary with position in the panicle.

Further work on the temperature relations of germination of seeds of *A. ludoviciana* which had lost their primary dormancy during 7 years' storage, showed that exposure to 23° or 25° C. did not induce dormancy in first seeds, but as before (*Rep. Rothamst. exp. Sta. for* **1956**, p. 81) very few germinated at 27°, though they did so when transferred to 7°. Dormancy was induced at lower temperatures in second seeds; 25 per cent became dormant at 25° and 4 per cent at 23°. More second seeds germinated when held continuously at 7° after they were imbibed than at 23° or 25°, and germination at 23° or 25° was increased by previous exposure to 7° C. for 1 day or 1 week, though not up to that of seed held continuously at 7°.

In a badly infested field near Bishop's Stortford stubble-burning was observed to have stimulated germination of wild oats seeds (mainly *A. fatua*); counts showed that there were about ten times as many seedlings per unit area where the stubble was burnt as on a few small unburnt patches. However, when ungerminated seeds were recovered by washing from soil samples it was found that for every seed germinated on the burnt patches, about ten remained dormant and presumably viable in the soil. Thus, the stubble-burning was not an effective method of controlling wild oats, because it eradicated only a small fraction of the population of seeds.

Effect of competition with Agrostis gigantea *on response of wheat to nitrogenous top-dressings* (K. J. Witts)

In a field experiment on winter wheat at Woburn in 1956 the response in grain yield to a nitrogenous top-dressing in May was much less than to applications in March or April, and this was thought to be due to competition with *Agrostis gigantea*, which had multiplied in three successive wheat crops on the site to become a serious infestation. On thinly sown plots, where the growth of *Agrostis* was most dense, the late top-dressing failed to produce any increase in the yield of wheat. To test whether the effects of competition with *Agrostis* are more severe when the supply of nitrogen is delayed, winter wheat was grown in pots alone or with variable numbers of *Agrostis* plants, and receiving either no top-dressing or an application of ammonium nitrate on one of three occasions between February and May. Even in the absence of *Agrostis* the late top-dressing was less effective on the wheat than the earlier ones, and in the presence of *Agrostis* the responses to top-dressings at all three times were decreased. The effect of *Agrostis* was, proportionally, a little greater for the late top-dressing than for the earlier ones, but the explanation suggested for the field results was not wholly substantiated. The weight of *Agrostis* was increased by the nitrogen dressings nearly equally for all times of application. A full interpretation of the results depends on nitrogen analyses of the plant material which are not yet completed.

Weeds of Broadbalk (J. M. Thurston)

Soil samples were taken for the third successive year from five plots of Broadbalk field, to compare changes in the weed-seed population on Section 1a, which has reverted to continuous wheat, and on Section 1b, which remains in the fallowing cycle. The total numbers of seedlings of all species that germinated in the glasshouse in the soil samples taken in 1956, compared with those from the 1955 samples, shows that the weed-seed population almost doubled where the fallow was omitted, but was decreased by one-third after one year's fallow.

Geescroft Wilderness (J. M. Thurston)

This area, which has been left undisturbed since arable experiments on the site ceased in 1867, was surveyed to see how the vegetation has changed since it was last described by Brenchley and Adam in 1913–14. The area has reverted to woodland, consisting chiefly of elm, ash and oak. The largest tree is an oak 81 inches in circumference at 4 feet from the ground, growing near the middle of the area that was cultivated until 1867. Of the forty-six species of angiosperms present in 1957, thirty-two had been recorded previously and fourteen, including eight woodland species, had come in since 1913. In the same period fifty-five species, all characteristic of grassland, had disappeared. All the arable weeds had already gone by 1913.

Weed surveys (J. M. Thurston and K. J. Witts)

The usual records were made of the weed flora of Broadbalk field in May, July and after harvest, and of the flora on the Park Grass plots. The infestation of *Vicia sativa* on plots 3, 5 and 6 of Broadbalk was exceptionally heavy, and on section 4 of plot 5 it nearly suppressed the wheat and caused it to lodge. On this area the vetches produced approximately 300 seeds/sq. ft. and shed them long before harvest. General surveys of the Rothamsted and Woburn farms in May and June showed that the numbers of annual weeds were unusually small, presumably because the spring drought prevented many seeds from germinating. Perennial weeds were less affected by drought, except that *Agropyron repens* at Rothamsted and *Agrostis gigantea* at Woburn received a severe check on sites where spring cultivations had exposed their rhizomes.

PHYSIOLOGICAL EFFECTS OF VIRUS INFECTION

Respiration and photosynthesis of infected leaves (P. C. Owen)

When tobacco leaves were infected with potato virus X, the rates of respiration and photosynthesis were unaffected until the leaves showed symptoms; the respiration rate was then increased by more than 30 per cent and the photosynthesis rate decreased by 20 per cent. The rates of respiration and photosynthesis of leaves of *Nicotiana glutinosa* were unaltered by infection with tobacco mosaic virus (TMV) until local lesions appeared; the respiration rate was then increased by an amount which varied with the number of local lesions, and the rate of photosynthesis was decreased by 20 per cent. With neither of these virus/host combinations was there any effect on photosynthesis or respiration for several days after inoculation. These results differ greatly from those previously reported for tobacco leaves infected with TMV, the respiration and photosynthesis rates of which were affected from within 1 hour of inoculation. Similarly, the water content of tobacco leaves inoculated with TMV and then kept for 20 hours in a saturated atmosphere was less than that of comparable uninfected leaves held in the same conditions, but no such effect on water content during the first day after inoculation was found in tobacco leaves infected with potato virus X or tobacco etch virus, nor with *N. glutinosa* leaves infected with TMV. Thus, in respect of the immediate physiological effects of infection, TMV in tobacco leaves is unique amongst the virus/host combinations yet studied; the validity of extrapolating conclusions based on results obtained from one combination to another is therefore questionable. The results imply that TMV affects tissues below the epidermis earlier in tobacco leaves than in other leaves, and earlier than other viruses in tobacco leaves.

MISCELLANEOUS

Effect of ultra-violet radiation on respiration rate of tobacco leaves (P. C. Owen)

During an investigation of the effect of ultra-violet irradiation on the establishment of virus infection in tobacco leaves, it was found that exposure for 5 minutes to radiation of 2,537 Å. with an intensity of 870 μW/sq. cm. increased the respiration rate of uninfected leaves kept in darkness by 20 per cent. If, after ultra-violet irradiation, the leaves were exposed to sunlight for 2 hours, there was no increase in respiration rate. This phenomenon is similar to the " photo-reactivation " or " photo-reversal " that occurs with other effects of ultra-violet radiation on viruses, fungi and higher plants.