Report for 1955

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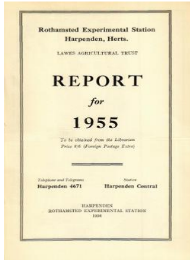
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Botany Department

D. J. Watson

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BOTANY DEPARTMENT

D. J. Watson

G. H. King was awarded the National Diploma in Horticulture; he is the first member of the assistant staff to obtain this qualification by part-time study. K. J. Witts joined the Department in May.

Plant Nutrition

Interaction between iron and micronutrient elements (K. Warington)

Chlorosis induced by excess vanadium in peas and soybeans grown in solution culture has been shown to be offset by high iron supply more readily if both elements are supplied in the same solution than if supplied separately in successive time intervals (*Rep. Rothamst. exp. Sta. for 1954*, p. 65). Similar results have now been obtained with molybdenum. They indicate that the interaction between iron and molybdenum or vanadium takes place, partly at least, outside the plant in the nutrient solution.

In these experiments the precipitation of iron that usually occurs in culture solutions was delayed for at least one day, and often longer, by addition of high concentrations of molybdenum when the initial pH was 4·6, but not when it was 6·6, whether or not plants were growing in the solution. To test whether the availability of iron in a complete culture solution is affected by molybdenum or vanadium, plants showing chlorosis induced by iron deficiency were transferred to solutions containing high iron concentrations with or without molybdenum or vanadium in high concentrations at varying times after the solutions were prepared. In the vanadium experiments on peas, the rate of recovery from chlorosis and the iron content of the shoots of the control plants were not affected by allowing the solutions to stand for 1 to 4 days before use, but the iron content of the roots was reduced after 2 days' standing. Vanadium had no effect on recovery from chlorosis nor on the iron content of shoots or roots. However, the vanadium contents of both shoots and roots decreased with increase in the interval between making up the solution and transferring the plants to it, and this suggests that vanadium interacts with some constituent of the solution, although it does not appear to affect the availability of iron.

In the molybdenum experiments on peas and soybeans, the solutions were allowed to stand up to 9 days before use, and molybdenum was supplied as sodium or ammonium molybdate. With increase in the standing time, the chlorotic test plants developed a green colour more slowly, and the iron content of the shoots of peas, but not soybeans, and of the roots of both species, was decreased. Precipitation of iron was delayed from 1 to 4 days whenever molybdenum was given, and the drift towards a higher pH was retarded. The rate of recovery of a green colour was unaffected by molybdenum if the solutions were used within 7 days of preparation, but with longer standing times recovery was more rapid when molybdenum was supplied, especially as the ammonium salt. Addition of

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molybdenum did not alter the iron content of the shoots, but increased that of the roots of both peas and soybeans.

These results suggest that molybdenum increases iron uptake by delaying precipitation of iron in the culture solution. Experiments have been done to investigate whether the delayed precipitation is a direct effect of molybdenum or an indirect result of slower change in pH, but the results are not yet complete.

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

Many attempts have been made to use leaf analysis as a measure of the supply of mineral nutrients from the soil, and as a guide to the fertilizer requirements of crops, but the method has not been generally successful. It is probable that the root reflects more precisely the mineral status of the soil in which it is growing than any other organ of the plant. Previous work on root systems excised from plants grown in solution culture has shown that the rate of uptake of a nutrient element depends on the concentration of that element in the roots and on the reducing sugar content of the roots, but is independent of the concentrations of other nutrient elements. Although the mineral composition of the root may itself be useful for diagnosis of the nutrient status of the soil, it is possible that the rates of absorption of nutrients in standard conditions by root systems removed from the soil may provide more sensitive tests of deficiencies in the soil nutrient supply.

Preliminary experiments were done to ensure that root systems recovered from the soil with as little damage as possible were capable of absorbing nutrients in laboratory conditions. Samples of wheat roots were then taken from a number of plots of Broadbalk field to test whether roots grown in the field with a wide range of nutrient supply show corresponding variation in ability to absorb nutrients. The roots were washed, centrifuged to remove surface moisture, and put in an aerated complete nutrient solution at 25° C. for 4 hours. Samples were taken before and after the absorption period for chemical analysis to determine the amounts of nutrients absorbed.

With the same purpose and also to investigate whether varietal differences in yield of barley (see p. 76) depend on the capacity for nutrient absorption of the roots, nutrient uptakes by excised root systems of Plumage-Archer, Kenia, Proctor and Herta barleys were compared in standard laboratory conditions. Roots were taken either from plants grown in pots of a nutrient-deficient soil, with or without addition of a complete fertilizer, at four stages of growth, or from plants grown in solution cultures with varied concentrations of N, P and K. Chemical analyses of the 1,200 samples collected in these experiments are still in progress.

Nutrient uptake from leaf sprays (G. N. Thorne)

Studies of the factors affecting the rate of absorption of ^{32}P through leaves and its rate of translocation to other parts of the plant (*Rep. Rothamst. exp. Sta. for 1954*, p. 67) were continued. When small swede plants were sprayed on one leaf with a ^{32}P-labelled phosphate solution, more phosphorus was absorbed in 3 days by plants placed under transparent or opaque covers than by uncovered plants. Most of the additional phosphorus remained in the sprayed leaf of the darkened plants, but in the illuminated ones it was translocated to the rest of the leaves and roots. In another experiment, plants under a transparent cover absorbed more ^{32}P in 6 days than shaded plants, and uptake in the dark was increased by spraying the ^{32}P treated leaf with 10 per cent sucrose solution; this additional ^{32}P moved to other leaves but not to the root. These results suggest that translocation of P from the sprayed leaves is dependent on simultaneous movement of carbohydrate.

Covering plants may increase phosphorus uptake by raising the humidity of the air. Uptake by plants placed under a cover with a drying agent was less than by plants under a cover where the air was kept moist, but even where a drying agent was used more ^{32}P was absorbed than by uncovered plants. Absorption of ^{32}P by French bean leaves from a concentrated spray applied to one primary leaf, or one leaflet of the third leaf, was greater than that from twice the volume of a spray of half the concentration applied to both the primary leaves or to 2 leaflets of the third leaf. Absorption from the concentrated spray appeared to be faster than from the dilute spray; the difference in amount absorbed was greater after 3 days than after 6 days. More ^{32}P was absorbed from spray and translocated by the third leaf than by the primary leaves.

The field experiment on the effect of combining a nitrogenous spring top-dressing for wheat with a weed-killer spray (*Rep. Rothamst. exp. Sta. for 1954*, p. 67), was repeated. Spray application of N increased the yield of grain, straw, chaff and weeds slightly less than application as fertilizer to the soil. The amounts of Mayweed (*Matricaria inodora*) and Knotgrass (*Polygonum aviculare*) were reduced by 2 : 4-D, but the yield of wheat was unaffected. The effect of 2 : 4-D on weeds was independent of the method of nitrogen application, but in this and the previous experiment the recovery of nitrogen in the crop from spray application was about half that from fertilizer applied to the soil. The reason for the low recovery of N from sprays is not known, but it makes the combination of a spring top-dressing with a weed-killer spray undesirable.

In a previous experiment to test whether sprays of organo-phosphorus insecticides affect plant growth independently of control of insect damage (*Rep. Rothamst. exp. Sta. for 1953*, p. 70), some statistically significant increases in yield by spraying with insecticide or solutions supplying equivalent amounts of inorganic phosphorus were found in plants that already had a high phosphorus supply from the soil. As these effects have no obvious rational explanation, it seems probable that they were due to chance, so the experiment has been repeated. Brussels-sprouts plants grown in pots were sprayed with " Systox ", " Pestox III " or equivalent sodium phosphate solutions. The plants were larger than in 1953 and retained more spray. The total phosphorus content of plants grown in soil deficient in phosphorus was increased by the " Pestox III " spray and by the equivalent sodium phosphate solution, which had more than five times the phosphorus content of the " Systox " spray. None of the sprays increased dry weight; " Pestox III " slightly reduced the total dry weight of plants grown with a high phosphorus supply to the roots. The results give no evidence that phosphorus-containing insecticides are beneficial to plants, either by virtue of the small amount of phosphorus that they supply or by any specific effect on growth.

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Weed Studies

Wild Oats (J. M. Thurston)

In the fifth year of the field experiment on survival of wild oats sown at two depths in October 1950, on plots that subsequently received different cultivations (*Rep. Rothamst. exp. Sta. for 1954*, p. 67), all the plots were treated alike; they were dug by hand at the end of March and in October to encourage germination of surviving viable wild oat seeds, and to control other weeds. No more *Avena ludoviciana* seeds germinated, but a few *A. fatua* seedlings appeared on plots of all treatments. Where the seed was sown 6 inches deep on plots that had only surface cultivations for 4 years, there were more *A. fatua* seedlings than elsewhere, indicating that prolonged undisturbed burial induced dormancy in some seeds. The number of seeds germinating in 1955 was a very small fraction of those sown in 1950, the great majority of which have still not produced seedlings.

In the experiment in Hoosfield comparing the effect of winter and spring cereals on the establishment and growth of *A. fatua* (*Rep. Rothamst. exp. Sta. for 1954*, p. 68) barley was sown in spring on all plots, to compare the numbers of viable seeds remaining after the different crops in 1953 and 1954. The mean numbers of wild oat seedlings per square yard in 1955 were 4·9 after winter rye, 2·9 after winter wheat, 2·2 after winter barley, 1·5 after spring barley and 0·6 after fallow. The total was only about one-quarter of the number that appeared in 1953, and the treatment differences in 1953 and 1954 tended to be reversed in 1955. Thus, fewer wild oat plants appeared in winter wheat and rye in 1953 and 1954 than in barley or fallow, but in 1955 there were many more in barley after winter rye than elsewhere. This suggests that cropping with winter rye may have prolonged the dormancy of some of the wild oat seeds. The barley crop after fallow was much heavier than on other plots, and the growth of the wild oat plants was correspondingly reduced by more intense competition.

Soil samples taken in May from the plots of the experiment in Northamptonshire on survival of wild oat seeds under temporary ley (*Rep. Rothamst. exp. Sta. for 1954*, p. 69) showed that after one-year ley the number of potentially viable seeds was nearly halved, but there were still about 6 million per acre. The species of many of the seeds could not be identified, because of rotting of the husks, but there is no doubt that the number of viable seeds of both *A. fatua* and *A. ludoviciana* was greatly decreased since the previous year.

In the experiment at Boxworth Experimental Husbandry Farm, plots ploughed in autumn 1954 after 4 years under ley produced an average of 2 plants per square yard in May 1955, compared with 7·5 on plots ploughed and counted one year earlier. Unfortunately, the numbers and species of seeds in the initial infestation of this experiment and the numbers capable of germination in the earlier years are not known. A similar experiment was started at Rothamsted in spring 1955 on a field that had an average of 9 plants of *A. fatua* per square yard at the time of sowing of the ley. Plots will be ploughed up annually and cultivated to encourage germination of wild oat seeds so that the infestation surviving after varying periods under ley can be measured.

An experiment on competition between *Avena ludoviciana* and wheat, barley or rye sown together in pots in autumn gave similar results to that done in 1954 on *A. fatua* competing with barley or wheat sown in spring (*Rep. Rothamst. exp. Sta. for 1954*, p. 69). As before, barley was a more effective competitor than wheat; rye was intermediate. When the wild oats were sown two weeks after the cereal, they produced only 60 per cent of the number of seeds produced by plants sown at the same time as the cereals. No inhibitory effect of rye on the growth of wild oat seedlings was found.

Freshly-harvested seeds of 10 selections of *A. ludoviciana* and 6 of *A. fatua*, of distinctive types not found at Rothamsted (*Rep. Rothamst. exp. Sta. for 1952*, pp. 69 and 71), were sown in soil in a cool glasshouse in September. In 7 selections of *A. ludoviciana* most of the first seeds in the spikelets germinated within one month, and all within two months, and many of the second seeds also germinated. This lack of dormancy supports the theory that these types are hybrids between *A. ludoviciana* and non-dormant cultivated oats. The other 3 selections shewed much longer periods of dormancy in the same period, 0–7 per cent of the *A. fatua* seeds germinated, and a few more seedlings appeared in the third month. Thus these types resemble the Rothamsted *A. fatua* in showing high dormancy.

Germination tests were made on seeds from two trials in which wild oats were sprayed with maleic hydrazide after the panicles emerged to prevent the formation of viable seeds. In a field trial done by the National Agricultural Advisory Service in Dorset, 1½ lb. maleic hydrazide per acre decreased the number of viable seeds by 45 per cent, but germination of barley grain from the crop in which the wild oats grew was decreased by 28 per cent, and many of the seedlings were deformed. Application at ¾ lb./acre had no effect on the barley, but decreased the number of viable wild oat seeds by only 17 per cent. Pot-grown plants of *A. fatua* and *A. ludoviciana* were sprayed with maleic hydrazide by the Unit of Experimental Agronomy, Oxford, at three stages of development ranging from just before the panicles emerged until they were fully expanded. The later sprayings decreased the number of viable seeds to less than one-third of those produced by unsprayed plants, and a smaller proportion of the surviving seeds were dormant.

Other species (J. M. Thurston)

In the wet summers of 1953 and 1954, *Polygonum persicaria* became abundant in one field of Rothamsted, and some work has been done on dormancy of its seeds. High temperatures favoured germination; more seeds germinated at 27° C. than at laboratory temperatures, or at 7° C., or with alternations between 27° C. and lower temperatures. Germination percentage and rate of germination were increased by chipping or removing the seed coats, or by soaking in tap-water or 2 per cent KNO_3 solution before sowing. Dormancy decreased after 3 or 4 months' storage in the laboratory.

Broadbalk field (K. Warington and J. M. Thurston)

Soil samples taken from all sections of five plots of Broadbalk field were reduced in bulk by washing through sieves, and the residues put in pans in the glasshouse, to determine the numbers of viable weed seeds present by counting and identifying the seedlings as they germinate. The results will show what changes have occurred in the weed-seed population since the last sampling in 1945, and will also provide a base line to measure changes in the weed flora that follow reversion in 1956 to continuous wheat growing on part of Section I after 25 years of the fallowing cycle.

Physiological Effects of Virus Infection

Effect of infection on the respiration rate of tobacco leaves (P. C. Owen)

The effect of infection with tobacco mosaic virus (TMV) on the respiration rate of tobacco leaves has been shown to vary with environmental conditions, with the time elapsed since inoculation, and with the stage of development of the leaves used (*Rep. Rothamst. exp. Sta. for 1954*, p. 70). In a new series of experiments leaves of tobacco plants inoculated with TMV were divided into three groups : (*a*) the inoculated leaves; (*b*) younger leaves present at the time of inoculation but not themselves inoculated; (*c*) leaves formed since inoculation, and the respiration rate of each group was compared with that of similar leaves from healthy plants during the period between inoculation and development of systemic infection. The respiration rate of inoculated leaves was increased above that of the controls within one hour of inoculation, long before virus multiplication can be detected. The proportional increase in respiration rate remained approximately constant for three weeks until the plant showed systemic symptoms, at which time inoculated leaves contained their maximum amount of virus, and the respiration rate then fell below that of healthy controls. This implies that the increase of respiration rate is not related to the quantity of virus in the leaf; it may reflect changes in infected cells preparatory to virus synthesis. The decreased respiration rate per g. dry weight after three weeks is possibly due to accumulation of material inactive in respiration.

There was never any detectable effect of infection on the respiration rates of non-inoculated leaves in group (*b*). Although symptoms appeared on these leaves, they probably did not contain appreciable amounts of virus. Their metabolism was evidently not affected in the same way as that of the inoculated leaves during the establishment of systemic infection in the plant. The respiration rate of leaves formed on infected plants after inoculation (group (*c*)) was 10 per cent below that of comparable healthy leaves. Presumably all the cells of these leaves were fully infected before their respiration was measured, and had completed the initial metabolic change that causes the increased respiration of inoculated mature leaves. The total virus content of systematically infected leaves accounts for about 10 per cent of the dry weight, and if it makes no contribution to respiration, it could account for the 10 per cent reduction in respiration rate per g. dry weight.

Severe etch virus in tobacco leaves attains only about one-thousandth of the concentration reached by TMV, but it produces very severe symptoms. The effect of this virus on the respiration of tobacco leaves is therefore being compared with that of TMV. Preliminary experiments showed that the immediate effect of infection is smaller than that of infection with TMV, and measurements are being made at later stages of infection.

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Growth Analysis

Effect of time of application of nitrogenous fertilizer and of mildew infection on yield of wheat (G. N. Thorne and F. T. Last, Plant Pathology Department)

The data from the pot experiment done in 1954 (*Rep. Rothamst. exp. Sta. for 1954*, p. 71) have now been examined, but the experiment was unsuccessful because the effects it was designed to analyse did not occur. The mildew infection was not severe enough to affect the final yield significantly, and had only small and temporary effects on growth early in the season. Contrary to previous experience with field crops and pot cultures, nitrogenous fertilizer applied at the time of ear emergence had a much smaller effect on grain yield than when applied at sowing or in April. The reason for this is not clear. The late N application increased leaf area after ear emergence more than the earlier applications, but the extra leaf area was apparently ineffective in adding to grain yield, possibly because it was produced mainly by increasing the length of life of leaves on sterile tillers. The plants that had no nitrogenous fertilizer were very N-deficient, and this may account for the lack of response in grain yield to the late N application, because other experiments suggest that late N applications are less effective on plants that previously have had a very low N supply.

Varietal differences in yield of barley (G. N. Thorne, S. A. W. French, K. J. Witts and F. V. Widdowson, Chemistry Department)

Proctor barley, bred by Dr. G. D. H. Bell at Cambridge, is the successful outcome of an attempt to combine the good malting qualities of the old varieties Plumage-Archer and Spratt-Archer with high yield. In field trials it has yielded on the average some 15 per cent more grain than the old varieties, and has proved to be comparable in yield with the best Scandinavian varieties, such as Herta. The extra grain yield of Proctor compared with Plumage-Archer must be the result of physiological changes induced by breeding and selection, the nature of which is not yet known. Experiments were therefore started to investigate by growth analysis the physiological basis of the differences in grain yield between Proctor, Herta and Plumage Archer. The three varieties were grown in a field experiment, with and without nitrogenous fertilizer, and samples were taken at fortnightly intervals from soon after germination until harvest to determine dry weight, leaf area, plant and shoot number, and other appropriate measures of growth.

At the end of the experiment part of each plot was harvested by combine, giving the following exceptionally high mean yields :

Grain, cwt./acre

	Plumage-Archer	Proctor	Herta	S.E.
No N	43·9	51·0	48·5	1·00
0·5 cwt.N/acre ..	40·6	52·7	55·6	
Mean	42·3	51·8	52·0	0·71

The results show the expected superiority of Proctor and Herta over Plumage-Archer; at the higher N level it was partly attributable to lodging of Plumage-Archer. The same varieties were grown in

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a pot-culture experiment with two rates of nitrogen supply. The variety Kenia was also included because Proctor originated from a Kenia × Plumage-Archer cross. In the pots, Proctor was superior in grain yield to Herta and Plumage-Archer at the low N level, but with high N supply Herta gave the highest yield. The chief object of this experiment was to find out whether the varieties differ in respect of the contributions made by photosynthesis in different parts of the plant to the total dry matter entering the grain. The ears of some plants were covered with opaque shades, other plants had the awns removed or the lower leaves and stems shaded, and the effect of preventing photosynthesis in these parts was measured by the loss of dry matter in comparison with untreated plants. Measurements of growth before ear emergence were also made as in the field experiment. Samples were kept from both experiments for chemical analysis to determine whether there were varietal differences in nutrient uptake and distribution. Statistical analysis of the growth data and chemical analyses are not yet completed.

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

A series of experiments was done in the glasshouse to determine whether variations of soil moisture content within the range from field capacity to near wilting point, but avoiding wilting, affect plant growth and dry-matter yield. Three water regimes were compared in which the soil moisture content was allowed to fall repeatedly from field capacity to three different levels before the soil was saturated again. Broad beans, sugar beet and lettuce were grown. There were no significant effects on dry weight in any of the crops. The water content of the lettuce, but not of the other crops, was decreased by the driest conditions. In the sugar-beet crops there were no detectable effects on net assimilation rate or leaf area.

Some preliminary work was done on effects of irrigation on plant growth with material from the sugar beet crop of the Woburn Irrigation Experiment. The unirrigated plots and the plots that were irrigated throughout the growth period, with and without additional nitrogenous fertilizer, were used, and only three samplings at fortnightly intervals were possible because most of the crop had to be kept for estimating yield at the final harvest. No rain had fallen for 3 weeks before the first sampling on 27 July, and the estimated water deficit on the unirrigated plots was 4 inches; on the other plots it was kept below 1 inch by appropriate irrigation. The dry weight and leaf area index (L; ratio of leaf area to land area) of the irrigated crop were already much above those of the unirrigated crop. There was no rain in the following fortnight, and the effects of irrigation were greatly increased. In the interval between the 1st and 2nd samplings relative leaf growth rate was lower on the unirrigated plots than on the irrigated ones, so that at the 2nd sampling, L was more than doubled by irrigation. Net assimilation rate (E) was also lower on the unirrigated plots, and this, combined with the lower L, gave a much smaller dry-weight increment than on the irrigated plots. These results confirm pot-culture experiments by other workers in showing that severe and prolonged water stress decreases yield by decreasing both net assimilation rate and leaf area.

In the next fortnight before the 3rd sampling, 0·6 inches of rain fell, but the estimated water deficit on the unirrigated plots increased to nearly 6 inches. Nevertheless, the unirrigated plants had a higher relative leaf-growth rate than the irrigated plants in this period, so that at the 3rd sampling the effect of irrigation on L was proportionally much less than at the 2nd sampling, causing an increase of only 60 per cent instead of 120 per cent. An even more surprising result was that E for the unirrigated plants was nearly three times that of the irrigated plants, so that in spite of their smaller L they produced a larger dry-matter increment. The mean values of E in g./sq. m. per week for the two periods were :

	27 July–10 Aug.	10–24 Aug.
Not irrigated	53	96
Irrigated	83	34
S.E.	±8·3	±14·5

Similar results were found at both levels of N supply. The reason for the decrease in E between the first and second periods on the irrigated plots is not known. Presumably, it was due to change in some external factor other than water supply; it cannot be attributed to the higher L of the irrigated plots, because the greatest value of L on the irrigated plots with high N supply at sampling 3 was only 3, and variation of L over the even wider range between 1 and 5 had much smaller effects on E of sugar beet than those shown above (*Rep. Rothamst. exp. Sta. for 1954*, p. 72).

The results suggest that rainfall after prolonged drought in amounts small in comparison with the soil moisture deficit may, temporarily at least, have very large effects on leaf growth and photosynthetic efficiency, perhaps through direct uptake of water by the leaves. The work needs to be repeated, and the duration of the effect of small amounts of rain determined. If the results are confirmed they may have an important bearing in the economic use of irrigation water.

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

Previous work has shown that the net assimilation rate (E) of a kale crop decreases as leaf area index (L; leaf area per unit land area) increases (*Rep. Rothamst. exp. Sta. for 1954*, p. 72). Consequently the rate of dry matter production per unit area of land increases with increase in L, reaching a maximum when L lies between 3 and 4, and falling again at higher values of L. The total dry matter production per unit area of land over the whole growth period, i.e., the dry matter yield, should therefore be increased if L were held near the optimum and not allowed to rise above it, and this could be accomplished by repeatedly removing an appropriate fraction of the plant population.

This procedure was applied to a kale crop grown on a fertile soil with a liberal fertilizer dressing to produce as large leaf area as possible. Successive samplings showed that by the middle of July L had risen to approximately 4, and on half the plots a quarter of the plants were removed to reduce L to about 3. On the remaining plots the crop was left unthinned. There was little growth in leaf area during the following 3 weeks because of lack of rain, and at the beginning of August and again in September the crop was irrigated

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with an overhead spray. By the end of August L for the unthinned crop had increased nearly to 6. On the thinned plots the thinning was repeated three times in August and early September, L being reduced from near 4 to about 3 on each occasion. Nearly two-thirds of the plants initially present were removed in the four thinnings. The unthinned plots, and the remaining crop on the thinned plots, were harvested at the end of September. Measurements of E based on samples taken fortnightly, usually at the same time as the thinning, showed in accordance with the previous results that E was consistently higher for the thinned crop, where L fluctuated between 3 and 4, than for the unthinned crop, where L rose to between 5 and 6 in August and September. However, the total yield of dry matter on the thinned plots, including the plants removed at the successive thinnings, was only about 6 per cent greater than on the unthinned plots, and the difference was not significant. The reason may be that the thinning was sometimes too severe, because the preliminary samplings to estimate L, from which the proportion of plants to be removed was determined, gave erroneously high values, and in some plots L was reduced to about 2·5. The drought in July and August may also have affected the result. Less drastic thinning and more accurate control of L might give larger increases in dry matter production, but even if the procedure is successful there are many obvious difficulties in the way of its practical application.