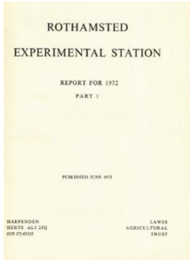
Report for 1972 - Part 1


ROTHAMSTED

EXPERIMENTAL STATION

REPORT FOR 1972

PART 1

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Physics Department

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PHYSICS DEPARTMENT

H. L. PENMAN

Introduction

The sources of limitations of crop yields may be physical, chemical or biological, and may occur in the soil, in the plant or in the atmosphere. Our task is to explore the physics of the continuum of soil, plant, and atmosphere, taking in as much of plant behaviour as seems to be amenable to measurement and theorising in physical terms. As it happens, this is quite a large part of the study, with a considerable range in scale. At the upper end is the irrigation experiment, with mixed objectives in agronomy, crop meteorology and plant physiology: next, still in the field, there are the small plot experiments, in the canopy enclosure for measurements of transpiration, assimilation and respiration above ground level, and in the soil respirometers for measurements of carbon dioxide evolution and oxygen uptake below ground level: then, in the laboratory, in growth chambers or in leaf chambers with controlled environments, there are measurements on whole plants or parts of plants, some of which come from the field. One simple sequence of ideas unifies much of the work on all scales and a short statement will help in interpretation of some of the individual sections of the report.

The water regime in the soil needs a double description, as 'quantity' and as 'quality', where quantity has its colloquial meaning, and the associated crop problems are: how much water is there, where is it, how much do plants use, where do they take it from, and what is the effect on plant growth when soil water ceases to be readily available? The last query brings in 'quality', expressed as a 'water potential' in pressure units below a reference value of zero, so that our measured values are invariably negative. As water is pulled up through the plant potential differences are established, the two most important steps being, first, a drop of $\psi_S - \psi_L$ over the path of viscous flow as liquid water from the soil outside the roots (ψ_S) to the inside of the leaves (ψ_L), and then a drop over the path of diffusive flow of water vapour from inside the leaves to the free atmosphere. Past experience indicates that $\psi_S - \psi_L$ is always small enough to neglect in the overall transpiration equation, and no mistakes have been made in such neglect. Until recently there was no consistently reliable way of measuring ψ_S *in situ*, and no method at all by which leaf water potential could be measured quickly in the field. In 1972 we were able to try—with some degree of success—psychrometer units to measure soil water potential, imported from the United States of America: ironically, the laboratory development of the instrument was done in the department by Monteith and Owen several years ago, building on the pioneer work of Professor D. C. Spanner of London University. To measure leaf water potential the so-called 'pressure bomb' was used, apparently successfully, and hence, for the first time, there was opportunity to see how conditions in the root environment, represented by a measured ψ_S, affected conditions in the leaves, represented by a measured ψ_L, and how ψ_L, in turn, affected stomatal behaviour, represented by stomatal resistance, r_s, which can be measured directly by porometer, or can be calculated from measured fluxes and appropriate potential gradients. From this more detailed knowledge of the chain of events comes better understanding of the most important variable in the physics of assimilation: the stomatal resistance is a major determinant of the rate of uptake of carbon dioxide in growth.

Much of the routine recording on the field site is on paper tape and there has been exasperation and frustration in the year's work. Breakdown is frequent, with failure of the

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tape punches as the outstanding trouble, but thanks to the vigilance of skilled supervision on the spot, only about 1% of the paper record was lost (at the expense of time that could have been used in creative activity). After making this effort it is unfortunate that some of the 1971 paper tapes were torn while being read into the computer, and early in the season some information was lost. The program for transferring information from paper tape to magnetic tape, including quality control, was written by the Computer Department. This phase of the processing works smoothly but is still very slow: at the end of 1972 the preliminary work on the 1971 records is just complete. Before the results can be combined by us to give energy, water and mass balances it is necessary to merge information from six different magnetic tapes on to a single magnetic tape. For this we need, but do not yet possess, the specialist skill to prepare the programmes.

Agricultural meteorology

Equipment and crops. The Great Field site was fully instrumented, where desired, with some additions. There were field beans on the macro plots (irrigated on Mn, unirrigated on Ms) and, in addition to the sensors for temperature, humidity and ventilation, above, within and below the crop canopy, set up on both sites, other instruments were installed for biological and physical observations. Most of the information was recorded on paper tape by six Kent–Harrison loggers: we await delivery of the last two to complete the system as it was planned five or six years ago. (Long)

On the conventional irrigation experiment there was kale and wheat, and on all three areas there were regular measurements of soil water content using the neutron meter (20 access tubes in total), and plant measurements for growth analysis, supplemented by occasional experiments in the leaf canopy enclosure, field measurements of stomatal resistance, leaf water potential and laboratory measurements on plant material from the field. (Many workers—see later)

A Stogate logger came into service late in June and, apart from one minor breakdown, it turned out faultless paper tape records of air flow measurements. In preparation for its arrival, the sensing equipment was modified and all of the pulse discriminator circuits redesigned and rebuilt. Some had been in use for more than 20 years. (Long)

New equipment to sample water vapour and carbon dioxide in the atmosphere was working from early June: the system of automatic calibration of the associated gas analysers worked well. That for water vapour was very stable—it is new—but the carbon dioxide analyser was unstable—it is very old and replacement is overdue. (Legg)

Radiation measurements were wide in scope and, as a preparation for a model of crop growth, included regular measurements of the intensity of visible radiation at several levels within the canopy of the bean crop. (Szeicz)

Irrigation and crop growth: Rothamsted

***Beans* (*Maris Bead*).** The crop was irrigated four times (40 mm in June, 45 mm in July). Growth analysis (Pike) showed little difference between the two plots until the first week in July when the calculated deficit under the unirrigated plots was about 60 mm. The irrigated crop continued to grow well thereafter but the unirrigated crop was retarded and its leaf area index soon decreased. Before harvest, the average pod populations per plant were near 11 (irrigated) and 7 (unirrigated), but at harvest the order was reversed: the dry matter yields of grain were, respectively 2·7 and 3·5 t ha^{-1}. Some good records of carbon dioxide and water vapour profiles were obtained from the new equipment (see above), and when processing problems are solved it should be possible to fill in short period details of growth rates between the botanical samplings.

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***Wheat* (*Maris Ranger*).** Autumn-sown and spring-sown plots had spacing and nitrogen fertiliser contrasts, without and with irrigation (65 mm in June, 50 mm in July). All autumn-sown plots gave better yields than those spring sown, the averages being 5·1 and 4·4 t ha^{-1} for grain, and 5·0 and 4·6 t ha^{-1} for straw. Extra nitrogen increased straw yield a little, but had no effect on grain yield: decreased sowing rate (to quarter normal) decreased both grain and straw yields by about 20%, with no interaction with irrigation. Irrigation had no effect on the straw yield of the autumn-sown crop, it increased the straw yield of the spring-sown crop from 4·2 to 4·9 t ha^{-1}, and decreased grain yields from both: 5·4 to 4·7 t ha^{-1} (autumn) and 4·6 to 4·2 t ha^{-1} (spring). Some plants were severely infected with mildew, but there were no measurements of relative intensity.

Growth anlaysis on the irrigated plots showed that dry matter gain, divided by the potential evaporation of the period was linearly related to fractional ground cover: at the maximum it was 0·7 t ha^{-1} cm^{-1} at 80% cover. This value differs little from that obtained in 1971 for potatoes. It would be very helpful to establish, at least for an irrigated crop, that the rate of accumulation of dry matter is a linear function of the product of potential evaporation rate (calculated from routine weather observations) and fraction of ground cover. The latter needs measurements on site, and it is pleasant to record that the accuracy of this measurement was greatly improved by an innovation suggested by M. Dell, a student worker.

***Kale* (*Maris Kestrel*).** Treatments included two sowing rates, two dates of sowing, two fertiliser rates, all without and with irrigation (50 mm in July, 25 mm in August). As has happened before with kale, though irrigation helped the early growth, at the December harvest there was no detectable difference in yields with and without irrigation. Nor was there a clear response to any of the other treatments, including, most surprisingly, no difference between crops sown on 18 April and 30 May. The mean yield, as fresh weight, was 80 $\pm$ 2 t ha^{-1}. (Lake, French, Pike and Legg)

Irrigation and crop growth: Woburn

***Potatoes* (*Nematology experiment*).** The applications advised were 50 mm in June and 50 mm in July. Responses were good with the usual complex interactions caused by current treatments and past history. On series I (Pentland Crown—nematode susceptible), irrigation increased the best plot yields from 32 to 39 t ha^{-1}, and the worst from 12 to 18 t ha^{-1}. On series IV, the irrigation increased the yield of Maris Piper (nematode resistant) from 32 to 41 t ha^{-1}, and of Pentland Dell (nematode susceptible) from 25 to 31 t ha^{-1}. (Legg—as adviser) (see also under 'Plant respiration', p. 39.)

Exchanges in crop canopies: whole crop. Some of the very detailed measurements in wheat (1969) were reported in 1970: a complete survey and analysis (1.1) includes many points of interest in detail, and an important answer to the technical problem the research was designed to resolve. In the mixture of physics and plant physiology that determines growth rates (and transpiration rates) the net assimiltion rate depends on the concentration of carbon dioxide in the air around the leaves, on the efficiency of atmospheric mixing and transfer processes in carrying the gas to the leaf surfaces, on the surface properties of the leaves in imposing a resistance to entry (referred to several times in this report), and on the complex biophysics and biochemistry when the gas comes into contact with the liquid phase of the water content of the leaf. In previous work we had occasionally found that short period assimilation rates could be large enough to produce significant depletion of ambient carbon dioxide concentration—but it was not detected in 1969. In general, by day and by night, the atmospheric mixing and transfer processes in the

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crop canopy are always sufficiently active to impose no limitation on net assimilation rates (positive or negative)—the source of limitation is in the plant.

Some of the details show parts of the background. Large eddies in the air above the crop can penetrate the canopy, and, near the soil surface, where leaves are fewer, ventilation can be more efficient than higher up in the denser part of the canopy. The physical effects of this ventilation are more dependent on scalar wind speeds than on vector wind speeds, and at times the former may be as much as 30% greater than the latter. (A pendulum bob moves a long way in a day—scalar—but its net movement is zero—vector.) This is for the horizontal flow, but, particularly on calm nights, there can be vigorous vertical mixing because of a vertical temperature gradient in the canopy, most vigorous in the calmest conditions above. (Legg and Long)

The ambient horizontal and vertical movement of air in a crop canopy could be of importance in plant pathology and entomology too, and eight new miniature anemometers were designed, built and run successfully in late summer—except when a dog ran through the plot and a week's work in repair was needed. (Long)

Plant Physics

Exchanges: crop canopy enclosure. An equation, given a year ago, related net assimilation rate to ambient carbon dioxide concentration and incident light intensity: it was known that it fitted some of the observations made on the 1971 kale crop. Since then more of the kale results have been processed, and they too fit, including—for the first time on a field site—measurements made with the ambient oxygen concentration at 0·42 cm^0. This year the enclosure was used on the unirrigated beans. The apparent photosynthetic efficiency was close to that obtained otherwise by micro-meteorological estimates, at about 1 g of carbon dioxide fixed for $1{\cdot}2 \times 10^5$ calories of incident visible light. From one set of readings, the value of $r_s + r_a$ was 0·6 sec cm^{-1} and, because the air in the canopy was vigorously stirred, the atmospheric component, r_a was probably negligibly small. The time chosen was when the soil was moist.

For the kale, changing the oxygen concentration from 0·21 to 0·42 cm^0 had the effect expected from leaf chamber measurements on other species: there were increases in the apparent mesophyll resistance, and in the carbon dioxide compensation point concentration. Results from the leaf chamber experiments show that the mesophyll resistance varies linearly with oxygen concentration, and the extrapolated value at zero concentration is thought to be a measure of resistance to transport in the cytoplasm. When applied to the kale results, the extrapolation gave no more than order of magnitude, because of scatter in the estimates of mesophyll resistance. (Lake)

Theoretical study of root growth. Measurements in several laboratories, made either in uniform soil or in culture solution, suggest that the extension and branching of the root system of cereals proceed at constant rates for long periods. The measurements can be interpreted through a simple set of concepts that could form part of a later physiological model of plant growth.

In ideal conditions, with no check to growth, a given root axis extends at a uniform rate (v_a mm day^{-1}), and at time $t = t_f$ first order laterals begin to emerge at uniform density: their number at any later time is proportional to $t - t_f$, their total length is proportional to $(t - t_f)^2$ and they grow longer at a uniform rate, v_f. Similarly, second order laterals begin to emerge at some time t_s, in number and length proportional to $t - t_s$ and $(t - t_s)^2$ respectively, and with a growth rate v_s. Higher orders can be neglected. With some assumptions, the treatment yields a spatial distribution of the roots dependent on simple relations among the characteristic values of t and v. It agrees well

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with experimental results from the ARC Letcombe Laboratory and from the Waite Institute, Adelaide, and permits a clarifying synthesis of some of the generalisations about root growth now current (1.5).

A first use of the model was to examine the observation, from experiment, that during the vegetative phase of the growth of barley the average length of root members (total length ÷ total number) changes very little. Using those values of the variables that gave the best fit with the results of an experiment, the numbers were altered, one at a time, to see which variable had most effect on the mean root member length. The general conclusion emerged that the plasticity of root form, so often a subject of comment, arises from quite small ranges of variation in a large number of variables (1.6). (Rose—with Australian colleague)

Plant respiration. The results of the 1971 experiments on beans in the controlled environment chambers (briefly reported a year ago—*Rothamsted Report for 1971*, Part 1, 48–49) were analysed in detail. The summary conclusion then was that changing the ambient oxygen concentration in ratio 5/21 produced a growth ratio of 2/1, at constant carbon dioxide concentration. The calculated efficiencies of photosynthesis had a ratio of more than 2, because the leaves on the bigger plants (at the smaller oxygen concentration) drooped more from the horizontal and so intercepted less radiation per unit leaf area. The contrast was very obvious during the experiment, and will probably repay further study that might explain a puzzle from 1971 and 1972 field results of growth analysis. Within the range of variation permitted by the growth and development of the crop there is no sign whatever of a limiting value to the ratio of dry matter accumulation/potential evaporation for the period. (See under 'Irrigation . . . wheat', p. 37.) (Parkinson and Penman)

As a step towards a model to simulate plant growth the chambers were used with about eight hours of light at four concentrations of carbon dioxide, so giving four different rates of net assimilation, and then about 16 hours of darkness during which respiration was measured. The unit experiment lasted a week. For wheat seedlings the dark respiration rate was not very dependent on the preceding treatment and was almost constant: for white clover seedlings the rate decreased rapidly with time (to about half the initial value in about seven hours), with previous treatment clearly a determinant of the initial rate, but not dominant, so that it seems unlikely that the dark respiration rate can be inferred from the preceding day's rate of net assimilation.

Using the growth chambers in a new way, experiments were done on field beans in the earliest stages of growth when the field canopy equipment is not good enough. Results are processed to yield the total resistance to uptake of carbon dioxide uptake, and the first of them indicates a large decrease in resistance, per unit leaf area, as the leaf area increases from about 45 to 120 cm² per plant. (Parkinson and Derry)

In collaboration with the Nematology Department stomatal resistances were measured, by porometer, on potato plants at Woburn, at weekly intervals (Physics) with simultaneous measurements of leaf water potential (Nematology), plus sampling, at three-week intervals, for dry weight and leaf area. There is clearly a general trend in the relationship (r_s increases with $-\psi_L$) but in detail there is a contrast between the relationships for the extreme conditions of greatly infected plots not irrigated, and lightly infected plots, irrigated: it may be possible to sort out the biological effects of damage produced by the nematodes, and the physical effects of shortage of soil water. (Evans, Trudgill and Parkinson) (See also under 'Irrigation . . . Woburn', p. 37.)

Soil water and plant water. On 11 mornings during July and August the vertical profile of leaf water potential (ψ_L) was measured in the bean crop. The average gradient was smaller

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in the irrigated crop ($-$ 2·7 bar m^{-1}) than in the unirrigated crop ($-$ 3·7 bar m^{-1}), it was linear for both, and, extrapolated to the soil surface the respective potentials were $-$ 1·2 and $-$ 3·4 bars. These values agreed well with average measured values of soil water potential (ψ_S) in what seemed to be the regions of active root activity—near the surface of the irrigated soil, and at about 30–50 cm depth in the unirrigated soil. Within the average behaviour there were great variations from day to day, unrelated to transpiration rates estimated to be between zero and 0·36 mm h^{-1}. Nor was there any detectable correlation in the day to day variations of ψ_L and ψ_S, possibly because of a time lag in the response of the soil water potential sensor. (Szeicz, Lake, Dell, Pike and Goodbody)

Other measurements on sunny days from June to August sought relationships among ψ_S, ψ_L, and stomatal resistance, r_s. Typically, values of ψ_L for the irrigated and unirrigated plants differed by about 2 bars (cf. $-$ 1·2 and $-$ 3·4, above), the stomatal resistance was only slightly smaller for the irrigated plants, in a range from 1 to 8 sec cm^{-1}, and the correlation between ψ_L and r_s was very poor, apart from a steep increase in r_S when ψ_L decreased below $-$ 10 bars. First attempts at curve fitting suggest that there may be an exponential relationship associated with the steep rise, perhaps indicating that the relative humidity of the air in the sub-stomatal cavity is an index or a determinant of stomatal opening and hence of stomatal resistance. As noted elsewhere, similar measurements on potatoes at Woburn had a great scatter too. (Lake, Dell, Pike and Goodbody)

For various reasons, it was not possible to get constant and reliable simultaneous measurements of soil water potential under the beans and of leaf water potential in the beans, but there were indications that the difference, $\psi_S - \psi_L$ might be somewhere near 5 bars, and relatively conservative. (Szeicz)

From skilful experimenters elsewhere there has come evidence that 'conservative' should read 'constant'—independent of the rate of transpiration—and this is a severe jolt to current ideas. Calling the resistance in the liquid path of the water from outside the roots to the leaves r_p, we set E, the transpiration rate, as $(\psi_S - \psi_L)/r_p$ (in appropriate units, unimportant here). If $\psi_S - \psi_L$ is even approximately constant as E varies, then r_p must decrease as E increases, which is a preposterous idea flatly contradicting reasonable expectation that r_p should be constant (depending on internal geometry of roots, stems and petioles) and negligibly small anyway (see introduction). Physics and Botany Departments have combined in experiments in controlled environment cabinets using plant species with contrasts in growth habit (*Trifolium repens*, *Lolium perenne*, and *Lysimachia numularia*), measuring or otherwise estimating soil water potential, leaf water potential, stomatal resistance, and evaporation rate, with the last modified either by changing light intensity or ambient water vapour pressure. Although digestion of results is incomplete the first impression is unlikely to be changed—the preposterous seems to be true. (Lawlor and Lake)

Soil Physics

Soil water: 1962 to 1971. The survey of all our experience with the neutron moisture meter, nearing completion a year ago, is in Part 2 of the current report (p. 5). It is in three sections, each with its own summary. Part I uses the results for 1970 as an exhaustive test of the meter, Part II continues the testing, almost as exhaustively on results for 1969 and 1968, and Part III brings in all the dependable information from 1962 onward, plus results for 1971, which were not complete while Parts I and II were being written. In Part III there is a brief synthesis of all results for the ten years 1962 to 1971, and to avoid excessive duplication in the two parts of the Station Report only the summary of Part III appears under departmental publications (1.3). A few points can bear re-statement. In the Rothamsted clay soil, cereals, sugar beet and kale take out water from at least the

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first 120 cm of the profile, and sometimes from the first 150 cm: beans rarely extract water from below 90 cm, and potatoes likewise, when not irrigated. On irrigated plots, potatoes take most of their water from the ridge and a little more down to 60 cm, but inferences from the measurements (confirmed by observation on site) is that the sloping surface of the ridge plus the umbrella-like action of the plants steer rain and irrigation water to the bottom of the furrow and much of it is wasted. Ridging, however excellent as a technical device for planting, 'cleaning' and harvesting potatoes, seems to be a rather poor way of managing crop water needs. It was probably introduced to circumvent difficulties of too much water, and it hardly seems to be the best way of dealing with too little. The depth of measurable root activity may have implications for nutrient availability and uptake, with another aspect that may be relevant. For nearly all crops in all years there was evidence of continued extraction of water from deeper layers while surface layers got wetter because rain (or rain plus irrigation) exceeded total water extraction. Often by inference, and several times quite clearly revealed, there was evidence of rain or irrigation water penetrating deeply into the profile without bringing all the wetted layer to field capacity first. This phenomenon (not unexpected) too has some relevance to the nutrient problem, but it is probably more important in the trafficability of the soil and our ability to move and work on it fairly soon after heavy summer and autumn rain. Finally, in the context of total water use, though irrigated plots never used less water than unirrigated, they rarely used very much more. (French, Long and Penman)

Soil water: 1972. Fifty of the imported sensors for soil water potential (see Introduction) were shared between the Rothamsted micro-meteorological site and the Woburn cultivation site. The units exploit the Peltier effect, with the thermo-junctions in ceramic cups 10 mm long and 5 mm outside diameter. Laboratory calibration demands a carefully maintained constant temperature and avoidance of leaks: in the Rothamsted soil placement was difficult because of the flints, and nearness of flints may have produced distortions in readings. Whatever the cause—instrument itself, or the environment—neither the precision nor the accuracy was adequate for estimation of potential gradients in the soil, but both were quite adequate for a general measure of soil water potential in the root zone, with a rough indication of layer to layer differences at a given time, and somewhat better indication of changes with time in a given layer. As one example, adding to a comment made earlier, under the irrigated beans the water potential in the 10 to 30 cm layer always had only a small negative value—adequate to maintain unchecked transpiration—yet there was a period in mid-July when the change in measured potential showed some drying in the 40 to 50 cm layer. (Szeicz) (See also 'Soil water and plant water', p. 39)

Soil respiration. In the third full season for the soil respirometers the previous history of different treatments made it a little difficult to devise a scheme for cropping and management that will permit confident comparisons. Those used were 'wet' *v.* 'dry 'soil, and cropped *v.* uncropped soil. Not surprisingly, respiration was more vigorous in the first of each pair.

Tanks 4 and 8 have been fallow for three years, with Tank 8, undisturbed throughout, showing a near constancy in volumetric water content (0·35 to 0·34 cm^0)—a tribute to the water tightness of the fibre glass and the efficiency of the seal at the lid. Over the three years the annual total of carbon dioxide evolved has decreased, but there may be a weather factor additional to the exhaustion of reserves of organic matter. In contrast, Tank 4 has had water added at times, the latest in May 1972, and thereafter, for a while, the rate relative to Tank 8 was 1·25, but it gradually decreased to unity by the beginning of November.

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Of the six tanks cropped in 1970 and 1971 two (2 and 6) were left uncropped in 1972, with dwarf beans on the remainder. Of these, two (3 and 7) were brought to field capacity in May, and the others (1 and 5) had just enough water applied locally near the seeds to permit germination and to establish the plants. There were seasonal cycles in the respiration rates, not always in phase, so that the maximum values that follow are not all contemporary. Averaged over a week, the maximum outputs of carbon dioxide in g m^{-2} day^{-1} show the scale of contrasts—with + R indicating where a residual effect from 1971 and 1970 cropping might be looked for.

	Cropped	Uncropped
Dry	4·7 (1)	+ R 2·7 (2)
Dry	4·1 (5)	2·6 (8)
Wet	11·1 (3)	+ R 5·6 (6)
Wet	8·6 (7)	3·4 (4)

Two noteworthy contrasts are that the effect of residues was not detected in the dry treatment (compare 2 with 8), but it was in the wet treatment, where the rate exceeded those in the cropped dry treatments (compare 6 with 1 and 5).

A complete three-year analysis of the dependence of respiration rate on soil-water content may not be possible: there is evidence that three of the tanks now have pin-hole leaks near the base, and though this has no effect on gas exchange rates, the inward leakage during the winter dictated that these three should be 'wet' treatment tanks, and the neutron meter measurements of summer drying may include a drainage component. (Currie)

Soil structure. Making a fresh start was not retarded as much as it might have been, because Dawe Instruments Ltd. kindly let us have an ultrasonic generator on loan for a few weeks, and the ARC made possible an early purchase of a suitable light-scattering photometer.

Before these came there was a study of the effect on soil structure of the liquor obtained as a by-product of the protein extraction in the Biochemistry Department. They had noted some interesting effects by chance, and as the liquor contains some likely bonding substances, such as polysaccharides, the effect was measured on three Rothamsted soils—Barnfield headland, unstable; Highfield permanent pasture, very stable; and Geescroft. Crumbs of each were treated at two intensities of wetting by the liquor and then the dispersion ratio was measured. Compared with the untreated controls neither the Barnfield nor the Highfield soil showed any change, but the Geescroft soil had its dispersion ratio decreased to about half that of the control. It may be relevant that this soil has a much smaller clay and silt content than the other two.

In the expectation that we may someday use the technique of ultrasonic dispersion as a routine, the short period loan was exploited to study how it might be standardised. Using 10% soil suspensions (from Highfield permanent pasture) dispersion was measured for a range of input power, duration of input, and of additions of sodium hexametaphosphate (calgon). Working at the fixed frequency of 20 kHz an input of 45 W cm^{-2} was chosen as convenient: it gave complete dispersion in water in three or four minutes. Addition of calgon shortened the time to two minutes, at an optimum concentration of 3×10^{-3}. Tests on other soils must wait.

First action with the photometer has been to work out a handling regime that provides uncontaminated sample cells and dust-free water-based solutions—essential for reliable light scattering measurements. (North)

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Tillage and soil properties. The site of the experimental plots is changed every year, and the 1972 site was on a slope that would not matter in ordinary weather. However, after a very heavy storm on 31 July, monitoring showed that there had been lateral movement of water across the site, and later results will need cautious interpretation. Rather more important—in that some later results vanished—the storm water penetrated and saturated parts of the buried equipment under the barley plots and put them out of action completely. The loss is not too serious because it is the early stages of the experiment, while the barley is germinating and establishing its root and leaf systems, that are more important. So far, only a few of the water content (neutron moisture meter, twice a week) records to 50 cm depth have been processed, and these show some small differences in contemporary water contents of cultivated and uncultivated plots. At all times before 31 July, and perhaps still real after the storm, the cultivated plots contained *less* water down to about 15 cm, which was the depth of the treatment cultivation, by 5 mm on 19 May, and by 2 mm on 28 July at about the date of maximum soil dryness before the storm—with and without crop. From 15 to 50 cm there were differences not obviously associated with cultivation, so that on 28 July the whole cultivated barley profile contained 3·5 mm *more* water than the uncultivated (at a net extraction near 80 mm of water), while the whole cultivated fallow profile contained 2 mm *more* than the uncultivated (at a net extraction near 20 mm, which may contain a drainage component.) As a first impression, the cultivation seems to have slightly decreased the water holding capacity of the cultivated layer, without detectable effect on the available water capacity: other differences mentioned are no bigger than the uncertainty in the measurements, suggesting that once the plants are through the ground the preceding management of this sand soil has no important effect on crop water use.

The yields of grain in 1972 were: cultivated, 3·8 t ha^{-1}; uncultivated, 3·1 t ha^{-1}. In 1971 they were 4·7 and 3·9 t ha^{-1}, respectively. (Brown)

Staff and visiting workers

Professor J. P. Quirk, University of Western Australia, arrived in December, for six months. Dr. R. Tabamo (Philippines) was here for three weeks in September. D. Whitehead (York) came in September as an ARC research student for three years. There were two sandwich course students: M. Pike (Brunel), and M. Derry (Hatfield), and two university vacation workers: M. Dell (Cambridge) and S. Goodbody (Salford).

Several members of the department contributed, formally or informally, to technical and scientific meetings. In January, an ADAS three-day conference on soil physical conditions and crop production preceded an ARC two-day discussion group meeting on methods for measuring physical properties of soils. Papers were read at and demonstrations prepared for the Silver Jubilee Meeting of the British Society of Soil Science in September. J. V. Lake transferred to ARC as a scientific adviser for Plant Physiology, but will spend about one-fifth of his time in the department for the first year of his new job.

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