WEATHER PROBLEMS IN AGRICULTURE

FOUR papers were presented during the second morning (July 1) of the summer meeting of the Royal Meteorological Society at Queen's College, Dundee.

Introducing the session before presenting the first paper, Dr. H. L. Penman, of Rothamsted Experimental Station, stated that two of the main objectives of crop-weather studies are, first, to achieve better growth of healthy plants, and secondly, to exercise control of pests and diseases the activity of which is dependent on weather. It is essential for the agricultural meteorologist to know something of the principles of plant-growth, though two of his problems can be derived from the simple equation for photosynthesis of carbohydrate. The need for short-wave radiation made a study of solar radiation income imperative, both as physics and as climatology. The latter topic was taken up later by Mr. G. J. Day. The supply of carbon dioxide to the crop can now be treated as a meteorological phenomenon similar to heat and vapour transfer (see second paper, by Dr. J. L. Monteith), and out of it there arises a third problem. The physiological state of the plant that permits easiest uptake of carbon dioxide also provides the most favourable conditions for transpiration, and this transfer of water from soil to atmosphere presents the meteorologist with another flux problem, and with a problem in energy balance. To the micro-meteorologist it brings problems concerned with the source of the water, and the effects that it has on the immediate environment of the plant, that is, on the 'weather' experienced by the plant, its pests and its pathogens.

In the hope that the information would some day be biologically useful, Dr. Penman and Mr. I. F. Long have been collecting detailed physical measurements in various farm crops. "Weather in Wheat"[1] is a condensation of the results for three summers of temperature, humidity and wind-speed, all continuously recorded over and within the crop on a site on which many other auxiliary measurements were made. Selecting a few topics, primarily of meteorological interest, a demonstration of variability across the site at constant height provides one of the reasons for using long-period averages in the analysis of profiles. Hot spots and damp spots can persist for several hours. By plotting wind-speed against temperature, and against vapour pressure, at the four observation heights above the crop, straight lines were obtained, from which it was inferred that the aerodynamic transport constants were effectively equal for transfer of momentum, sensible heat and latent heat. Computation of the transfer of latent heat for the forty-eight 4-hr. periods in eight days of fine weather gave very good agreement with the measured values from a large transpiration gauge, continuously weighed, in phase, amplitude and in mean daily total. Both estimated and measured values showed that transpiration is a daylight phenomenon. Calculations were presented for two periods to show how the transpiration stream was built up, layer by layer, between the soil surface and the top of the crop. It seemed that all layers contributed about equally (in this particular crop). Some time in the future it may be possible to tackle the carbon dioxide problem in the same way and find out the vertical distribution of efficiency of assimilation.

Dr. J. L. Monteith, also from Rothamsted, then summarized what he and Mr. G. Szeicz had done in measuring "The Carbon Dioxide Flux over a Field of Sugar Beet"[2], work first made possible by a grant from the Rockefeller Foundation and later by the skill of the Infra-Red Development Co. in building an instrument capable of measuring to 0·1 p.p.m. of carbon dioxide. From differences of concentration at two heights 25 cm. apart above the crop, and contemporary wind data, fluxes were computed. For a period of a few weeks from August onward the flux was always downward in daylight (assimilation > respiration), the main changes following very closely behind those of solar radiation intensity. The night flux was upward, at a fairly constant rate representing plant respiration and biological action in the soil. Net growth over the period calculated from these physical measurements agreed well with direct measures by crop sampling. Later, in October, biological activity in the soil appeared to provide more than enough carbon dioxide for plant growth—the day-time flux was upward except during short sunny intervals around noon, and the crop was still growing. Though this latter behaviour raised some important problems in soil microbiology, Dr. Monteith confined his discussion to the meteorological aspects of the earlier period, giving a hint that he had since made progress in the interpretation of the interactions of radiation intensity, mixing parameters and carbon dioxide uptake, and that there was a possibility of a link-up between the field-work he and Szeicz were doing, and laboratory work on single leaves being done elsewhere. As a purely meteorological point, he suggested that the uniform upward flux at night might be exploited in the study of transfer processes in very stable conditions. In discussion, the somewhat optimistic suggestion was made that this physical technique might replace periodic sampling, to give a non-destructive method of measuring the rate of plant growth.

Although there are many stations with long records of duration of bright sunshine (n), it is only within the last few years that there has been any attempt to measure incoming solar radiation (Q) at stations in Britain other than in south-east England. There has been much use of an empirical equation $Q/Q_A = a + bn/N$, in which Q_A is the radiation that would reach the site in the absence of an atmosphere, and N is the maximum possible duration of sunshine. Under the title "Radiation Climatology", Mr. G. J. Day (Meteorological Office, Eskdalemuir) first gave the values of a and b he has derived from monthly mean values of Q/day and n/day obtained at twelve stations having records of Q for at least three years. The geographical distribution of stations was very irregular, with large gaps in northern Scotland, eastern Scotland, eastern England, the Welsh border and along the south coast. Mr. Day made reservations about the accuracy of some of the

radiation records, but by giving equal weight to all observations he found that a has a range from 0·08 to 0·19; and b varies from 0·63 to 0·95. Neither constant shows any systematic geographical variation. Having got local values of a and b from short-period records, he applied them to large neighbouring areas with long-term records of n, to derive expected mean monthly average values of Q. These were plotted together with the corresponding values given by Black[3] for twenty-eight stations in the area bounded by lat. 50–60° N., long. 5–30° E., and isopleths of mean monthly radiation drawn for north-west Europe using the two sets of estimates. The value of the twelve maps lies in their detail, and this may be modified after a re-check of some of the basic data. When published, they will be a very useful supplement to the corresponding maps of rainfall, temperature and sunshine.

During recent years there has grown a demand for more information about the effects of shelter on plants and on animals. Much of the resulting field work has the active co-operation of the Meteorological Office in Edinburgh, and in a paper entitled "Windbreaks—Some Physical Effects", Dr. R. W. Gloyne of that Office considered some purely aerodynamic aspects of air flow over a barrier. Summarizing world experience, he listed the three distinct flow regions that arise: (1) the up-wind boundary layer; (2) the down-wind disturbed region; and (3), overlying these, the undisturbed flow. The disturbed region can be subdivided into: (2a) a space, immediately behind the obstacle where there may be strong eddies—it is here where it is most difficult to reconcile field and wind-tunnel studies; (2b) a region, farther down-wind, of turbulent motion, approximately conforming to a logarithmic profile, which, with distance, becomes in fact the logarithmic profile of the original undisturbed flow. The sizes of the regions (as multiples of the barrier height h) vary with the permeability (φ) of the barrier. In brief (with winds of normal incidence): for dense barriers ($\varphi < 40$ per cent) the original profile is re-established at about $30h$, though a logarithmic profile may re-appear at $20h$, and the original mean direction is re-established at about $15h$. For open barriers ($\varphi > 60$ per cent) the re-establishment of speed profiles is much as for dense barriers, but that of mean direction occurs much nearer the barrier, perhaps as close as $2\frac{1}{2}h$ behind a very open mesh. The width of the affected area depends on the length (L) of the barrier. When $L > 20h$, the system behaves almost as a portion of an infinite barrier; a shorter barrier has relatively larger edge effects so that the affected area varies roughly as L^2, approximating to a parabola with its vertex perhaps $1\frac{1}{2}L$ down-wind.

Dr. Gloyne concluded with a brief reminder that there is a pressure excess up-wind and a pressure deficiency down-wind of an obstacle placed in an air stream, and he suggested that pressure measurements, similar to those made in wind tunnels, might be useful in wind-break studies. H. L. PENMAN

[1] Penman, H. L., and Long, I. F., *Quart. J. Roy. Met. Soc.*, **86**, 16 (1960).
[2] Monteith, J. L., and Szeicz, G., *Quart. J. Roy. Met. Soc.*, **86**, 205 (1960).
[3] Black, J. N., *Archiv. für Met., Geophys. und Biokl.*, B**10**, 2 (1960).

TUBERCULOSIS IN ANIMALS

TUBERCULOSIS in animals was the subject of the fourth symposium of the Zoological Society of London, held on May 24. Mr. J. N. Ritchie, who organized the meeting, presided at the evening session. Dr. R. E. Glover was chairman at the morning session, and in the afternoon Dr. J. M. Ross filled this position.

Dr. Glover explained that the subject was appropriate for discussion at this particular time because of the progress that had been made in the eradication of tuberculosis from the cattle in Great Britain. With this advance, it was useful to review the position among other animals.

The first paper was by Dr. J. T. Stamp, who dealt with the comparative pathology. In calves, the incidence of tuberculosis is low, and infection enters mainly by inhalation or is congenital. Hæmatogenous dissemination is frequent. The fact that the incidence of tuberculosis increases considerably with age shows conclusively that tuberculosis of the adult is not merely a slow progression of lesions acquired in calfhood. In the older animals, the site of the primary complex is predominantly pulmonary and it is very obvious that advanced pulmonary tuberculosis develops as a result of bronchial dissemination following cavitation of the primary lung focus. The pathology of tuberculosis of the udder shows that there is always extensive involvement of the milk ducts.

In the pig, the chief route of infection is by the alimentary tract, and this gives rise to an incomplete primary complex in the regional lymph glands. In bovine-type infection in this species, hæmatogenous dissemination is common, but chronic pulmonary tuberculosis occurs only infrequently.

Horses have a high resistance to tuberculosis. Primary infection is almost entirely by ingestion. Hæmatogenous dissemination is frequent and gives rise either to miliary tuberculosis or to large tumour-like swellings, not unlike those of sarcoma.

The tuberculin test and the laboratory diagnosis of tuberculosis were discussed by I. W. Lesslie, who gave a brief history of the methods of preparation of tuberculin and the ways in which it had been used.

The general objective of research on tuberculin is to obtain a preparation which will give a maximum response in the infected animal at all stages of sensitization and a minimum response in the non-infected or non-specifically sensitized animal. He described the procedure necessary for the characterization of tuberculins.

The intradermal comparative tuberculin test has been developed for use in cattle. It consists in the injection of 0·1 ml. of avian and mammalian tuberculins in selected sites in the neck. The reaction at each site is measured, and the test is interpreted on each animal with reference to the results recorded in the whole herd and having regard to the herd history and clinical findings. *P.P.D.* tuberculin is used (mammalian 2·5 mgm./ml., avian 0·5 mgm./ml.). The relative strength of the *P.P.D.* tuberculins resulted from somewhat empirical decisions based on the strength of the tuberculins formerly used in this test.