Agricultural Meteorology.*

THE meeting of the Commission of Agricultural Meteorology of the International Meteorological Organisation at Copenhagen immediately after the Agricultural Section of the Conference of Empire Meteorologists in London testifies to the interest now being taken in that subject.

The problems of agricultural meteorology would seem capable of division into two broad classes, macrocosmic and microcosmic. In the first, we study the influence of weather on crop yields on a large scale, seeking to fill in the general lines of a broad picture by studying recorded crop and weather data over as many years as possible and using statistical methods to determine their interrelations. In the second, the physiological reactions of the plant to the principal weather factors in plant growth—light, heat, and moisture—are considered in detail by a careful study of particular phenomena in plant growth under the completely controlled conditions of the laboratory or in a small-scale field experiment where as many conditions are controlled as possible.

The macrocosmic problem is the especial province of the statistician, and since the pioneer work of Hooker many studies have been published all over the world on the correlation of weather and crops. One might instance the work of Moore, Bradford Smith, and Kincer in America, the very fine work of Wallén, the president of the Copenhagen Conference in Sweden, and Fisher's work in Great Britain, which has effected a very great improvement in the statistical technique employed, by enabling us to relate crop yields to a continuous sequence of weather instead of merely to weather at isolated periods. The importance of this in crop-forecasting is very great.

Important as the distinction is between the two methods of approach, however, they must not be regarded as being entirely unrelated. Valuable as it is to know the degree to which crop yields depend on particular meteorological variates such as rainfall or sunshine, we cannot use our knowledge to the greatest advantage without knowing the reasons for these relations, and these can only be discovered by the microcosmic method.

The position is being rapidly reached to-day in which the statistician who has discovered the existence of interrelations by the large-scale method is also consulted on the planning of detailed experiments by which the reason for these relations may be discovered. For example, under the "Agricultural Meteorological Scheme" of the Ministry of Agriculture, "Precision Record" experiments on wheat are being conducted at several centres on two varieties of wheat. Great care has been taken to use the modern principles of randomisation and replication to ensure valid results, and each time a set of observations is taken, 256 randomly chosen $\frac{1}{4}$ metre lengths, 128 of each variety, are examined, and measurements of shoot height and counts of leaf number, shoot number, and number of emerged ears are made. In a word, accurate measurements of growth are being obtained, and it is hoped that when the data have been continued over a sufficient number of years, some of the known relations between wheat yields and weather may become explicable in terms of the previous growth of the plant. It is to be hoped that these methods will be greatly extended in the future.

While meteorological data have usually been considered accurate enough for the large-scale correlation of weather and crops, there is an influential body of opinion which considers that the meteorological data at present collected are inadequate for the intensive

and detailed study of weather effects on growth phenomena. Thus at the London Conference we find one delegate (Lawrence Balls) saying, "The meteorology recorded in the field crop, that which the plants themselves are experiencing, is not that recorded in the screen. In Egypt at night you can get as much as 5° C. lower temperature, lasting for perhaps only a few minutes, among the plants, than in the neighbouring screen. Then again the question of soil temperature is important. The temperature of the soil in fallow land is very considerably higher than the temperature of soil under the crop." Another delegate (Walter) said: "In the case of wind the effect on plant growth is evidently a function, not only of the age of the plant, but of the duration of high velocities and the change of direction during the period of specified wind velocities. None of these factors is made available for the research worker in the records of the various observatories as usually published."

Again, at Copenhagen we find Angström saying, "Measurements of temperature in the lowest layers of the air, in conjunction with the meteorologico-agricultural problems, ought, it would seem, to be primarily directed towards making clear the connexion between the nature and the quality of the vegetation on the one hand, and the distribution of the temperature in the lower layers of the air on the other". M. Angström then goes on to outline the instrumental technique necessary for this purpose. Much the same view is expressed by M. W. Schmidt: "Although plant growth depends so much on weather, there nevertheless exists to-day a huge hiatus between what the agriculturist needs and what the meteorology and climatology provide. . . . Special methods are necessary for this purpose, which relate to the whole life-environment of the plant, that is, the lowest layers of the air and the uppermost layers of the ground—fine measurements which demand a special apparatus." We find other delegates at Copenhagen expressing the same opinion.

Another point of great interest which was discussed both in London and at Copenhagen was Sir Napier Shaw's proposal that the week should be used as a time unit in meteorology. This resulted in a resolution at the London Conference that "In the opinion of the Conference the month is too long a period for the purpose of summarising, for publication, statistics of agricultural meteorology, and the Conference recommends that the week be adopted for the purpose". The Copenhagen Conference was a little more non-committal: "La Commission attire l'attention des météorologistes sur la proposition de Sir Napier Shaw et recommande d'éprouver dans certaines recherches, la valeur d'emploi de la semaine comme unité climatologique, de manière à reconnaître par l'expérience si l'emploi généralisé de cette unité est convenable".

It is probably true that while the week is a great improvement on the month, there will always be purposes for which individual research workers will require the original observations taken at daily or, it may be, more frequent intervals.

It is not possible in a short article to deal exhaustively with the whole proceedings of the Copenhagen Conference, but one should not conclude without mentioning Holdefleiss's résumé of the work done in Germany on the correlation of crop yields and weather, which seems to follow on the same lines as similar work already done in England and America, and Akerman's account of what appears to be the very fine work at Svalöf on the study of the relative resistance to frost of different varieties of wheat, a combination of field experiments and of laboratory work in which plants are subjected to cold artificially produced.

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