MYCORRHIZA

THE British Mycological Society met at the Imperial College of Science and Technology, London, on October 21 to discuss the subject of mycorrhiza in plants. The programme included two general papers, two papers on endotrophic infection, and four papers on the ectotrophic infection of trees.

The president of the Society, Dr. W. P. K. Findlay, called upon Dr. S. D. Garrett to open the discussion. Dr. Garrett first paid tribute to the late Dr. M. C. Rayner, whose work had been until recently a driving force behind research in mycorrhiza. He then showed in what ways work upon this subject is of importance and interest to plant pathologists. The mycorrhizal fungi seem to fall into that group of soil fungi called 'soil invaders' or perhaps, better, 'root inhabitants', which have to a great degree lost the power of competitive saprophytism, and to be restricted to local specialized substrates in the soil. They hold these properties in common with specialized root parasites. Dr. Garrett showed that cultural studies, such as those of Prof. E. Melin and his associates in Sweden, tend to confirm this view.

Dr. J. L. Harley agreed with this thesis; but he pointed out that recent work has widened the meaning of the term 'mycorrhiza', so that mycorrhizal associations are separable only with difficulty from many kinds of pathological and non-pathological associations of roots and other plant organs with soil micro-organisms. After having indicated briefly the kind of root activity that might be expected to promote the occurrence of specialized communities on their surfaces, he went on to analyse and classify the kinds of effect which mycorrhiza fungi are reported to have upon their hosts. Neither their effects upon seed germination nor upon the growth of adult hosts are properties solely theirs. In formulating working hypotheses, it is therefore necessary to consider the special case of the effects of mycorrhizal fungi against the background of the general cases of the association of plants and micro-organisms. Dr. Harley emphasized in particular that, in those examples where mycorrhizal infection stimulates the growth and uptake of materials into adult hosts, it is likely that the fungi possess a permanent external food base. Such a food base can be demonstrated experimentally in only a few cases. Hence accurate ecological observation on the part played in the soil by Basidiomycetes of ectotrophic mycorrhiza is a paramount necessity for further work. Following upon this, the crux of the physiological problems of mycorrhiza lies in an experimental determination of factors affecting uptake and loss of material by fungal mycelia on similar lines to recent work on plant roots.

Dr. J. Boursnel reviewed past work on cyclic symbiosis and described her own researches upon the Cistaceæ. The whole plant of *Helianthemum chamæcistus* is invaded by a septate fungal mycelium the hyphæ of which are 4 μ thick, or greater. Its effects, in brief, are such that the roots become differentiated into long and tuberous roots, depending upon the stage at which infection takes place. The hyphæ penetrating the aerial parts of the stem enter the ovary, where they invade the loose outer seed-coat. On germination, the embryo—until now free of the fungus—is invaded. Sterilization of the seeds has the effect of causing a weak development of young plants, which reach a stagnation phase. Dr. Boursnel has been able to demonstrate that the fungus concerned synthesizes thiamin on sugar media and that either the inoculation of sterile seeds with fungi or the addition of thiamin to the cultures promotes normal seedling development. The association seems, therefore, to be one of symbiosis between a fungus autotrophic for thiamin, and a plant heterotrophic for this substance, at any rate in its young stages.

Dr. D. G. Downie briefly summarized the existing knowledge about the germination of orchid seeds and described the results obtained by herself and by Dr. Mollison upon *Goodyera repens* and other orchids. She emphasized the need for investigating germination in media lacking sugars and in distilled water. She pointed out that under these conditions the seeds of certain species, such as the frog orchis, can germinate, whereas others, such as those of *Goodyera*, will not. The latter can be stimulated to germinate in distilled water if inoculated with the appropriate endophyte. In such a case the basal cells of the embryo are penetrated by the fungal hyphæ. Germination of *Goodyera* can also be stimulated to some degree by water extracts of the endophyte, but pure vitamins, such as thiamin, biotin and nicotinic acid, have no effect under these conditions.

A short discussion of minor points of technique and interpretation followed these papers.

In the afternoon, the set papers concerned the mycorrhiza of forest trees, and Dr. W. R. C. Handley analysed the possible factors concerned in the process of infection of tree roots by mycorrhiza fungi. The cortical tissues of coniferous roots may lack intercellular spaces, so that the initial formation of the Hartig net depends upon the dissolution of the middle lamella. He suggested that changes in the constitution of the middle lamella may afford an explanation of the delay in the infection of seedling roots until a certain growth-stage has been reached. He emphasized the lack of knowledge of the pectic enzymes of Basidiomycetes, and pointed out that many other soil fungi possess such enzymes although they do not form mycorrhiza. He then dealt shortly with problems concerning resistance to disease, and pointed out that reversible morphological changes in the hyphæ of mycorrhiza fungi which occur on penetration of the host find a parallel in other cases of fungal infection as, for example, in human skin disease.

Mr. J. Warren Wilson described an attempt at the correlation of certain morphological and physiological changes in beech seedlings with the onset of development of mycorrhizal roots. Although mycorrhiza formation follows hard upon the cessation of a primary phase of rapid root-growth, it is also associated with a phase of increase of carbohydrate concentration in the root tissues, and the attainment of a low concentration of soluble nitrogen. These results agree with the conclusions of Hatch and Bjørkman, who worked with conifers. Nevertheless, before the actual infection of the rootlets, there occurs a series of changes in those rootlets involving hypertrophy of the cortical cell and reduction of the relative size of the meristem. He pointed out that the abundance of fungi in the rhizosphere seems to be influenced in a somewhat opposite sense to mycorrhiza formation.

Dr. F. A. L. Clowes showed that the basic pattern of cell and tissue arrangement in beech roots is not different in mycorrhizal and non-mycorrhizal roots. He has observed in large mycorrhizas of adult beech trees no evidence of hypertrophy such as Mr. Wilson has found in seedlings; nor has he been able to find evidence of hyperplasia. The greater diameter of

infected roots can be ascribed in great measure to the increase of size of the cells in a radial plane, and there is, on the whole, a reduction in longitudinal elongation which more than compensates for this increase, so that cell volumes are reduced. Correlated with such changes, xylem development and endodermal thickening occur nearer the apex of mycorrhizas. He is of the opinion that the area of surface of individual mycorrhiza rootlets is less than that of uninfected rootlets. He emphasized the point that this observation does not necessarily imply a reduction in the area of surface of the whole root system. Dr. Clowes referred to the recent work of Slankis on pine roots in culture, but pointed out that colchicine tumours are as similar to mycorrhizal structures as are the growths produced by heteroauxin. A degree of caution is therefore required, for several equally attractive hypotheses could be formulated to guide future work on causal anatomy of mycorrhizal roots.

Dr. Ida Levisohn described several examples of pseudomycorrhizas found on pine and spruce roots. She uses the term 'pseudomycorrhiza' for structures superficially similar in general form to mycorrhizas but lacking sheath or Hartig net, or showing obvious evidence of parasitism. She outlined the diagnostic features of three important types, illustrating her account with photomicrographs and other slides. The ecological distribution and importance of each was particularly emphasized, and she concluded by asking for any available information upon the haustorial type of pseudomycorrhiza which is particularly prevalent in arable soil and worn-out nurseries.

Dr. John Ramsbottom opened the general discussion. He remarked that the variability of mycorrhizas in form and occurrence indicates that no single explanation of their effects upon their various hosts is likely to be found. Each particular example requires detailed study on its own. He showed slides of orchid mycorrhizas and demonstrated a specimen of the interesting saprophytic liverwort *Cryptothallus*. He believes that the Basidiomycetes associated with ectotrophic mycorrhizas possess a habitat in the soil apart from the root surface.

The discussion which followed was characterized by its friendly but very controversial spirit, and it centred particularly upon the ecology of root infection and of mycorrhizal and root-infecting fungi.

J. L. HARLEY

VELOCITY OF SECOND SOUND IN LIQUID HELIUM II

IN a letter to the *Physical Review*[1] (September 15 issue), Dr. J. R. Pellam and R. B. Scott, of the United States Bureau of Standards, give the results of their experimental observations on the qualitative behaviour of the velocity of second sound in paramagnetically cooled liquid helium II in the temperature range below 1° K. The helium was cooled by the demagnetization method using hydrated iron-ammonium-alum crystals immersed in the liquid. The remainder of the bath contained the apparatus for the generation and detection of the second sound by the pulse method, and the velocity of the second sound was determined from oscillographic observations of the transit time. Accurate determinations of the temperatures of the liquid helium corresponding to the velocity values obtained could not be made, but it was established that the second sound velocity increases markedly with decrease of temperature below 1° K. reaching nearly twice its value for 1° K. at the lowest temperature attained. As the helium bath warmed up, the velocity minimum of 18·4 m./sec., observed originally by Peshkov[2], just above 1° K., was verified.

Tisza formed a theory of helium II in 1938 which was based on F. London's interpretation of the λ-point transition of helium as an Einstein–Bose condensation, and which predicted that the velocity of second sound should decrease with decrease of temperature below 1·5° K. (Both Tisza and London have discussed this theory recently in *Nature*[3,4].) On the other hand, Landau, who denied the relevance of Einstein–Bose statistics, predicted a strong increase in the velocity below 1° K. It would appear, therefore, that Pellam and Scott's results are direct evidence in favour of Landau's assumptions, though, as is pointed out in the letter, this does not necessarily weaken the original Einstein–Bose hypothesis but only the interpretations that have been given to it. In fact, the recent experiments of D. Osborne and co-workers[5], which show non-superfluidity in helium-3, are exceedingly strong evidence in support of the condensation theory.

In the October 1 issue of the *Physical Review*, R. D. Maurer and M. A. Herlin[6] describe experiments, similar to those of Pellam and Scott, in which they have measured the second sound velocity down to 0·86° K. They also verify the rise in velocity below 1·1° K. observed by Peshkov, but their values for the velocity below 1·2° K. are slightly higher than Peshkov's most recent evaluations. Qualitative indication that the thermomechanical effect in helium II remains strong down to the lowest temperature reached was obtained. They conclude that it is likely that a more refined form of the two-fluid model should contain elements of both the Tisza and Landau theories.

[1] *Phys. Rev.*, **76**, 869 (1949).
[2] *J. Exp. Theor. Phys., U.S.S.R.*, **18**, 951 (1948).
[3] *Nature*, **163**, 102 (1949).
[4] *Nature*, **163**, 694 (1949).
[5] *Phys. Rev.*, **75**, 988 (1949).
[6] *Phys. Rev.*, **76**, 948 (1949).

TRAINING OF TRADES UNION OFFICIALS

AT one of the sectional meetings of the conference of the British Institute of Management which was held at Cliftonville in May 1948, Mr. E. P. Harries, secretary of the Organisation Department of the Trades Union Congress, introduced a discussion on whether special facilities are required for the training of trades union officials in the principles and practices of management.

Mr. Harries stated that most trades union officials who had given any thought to the subject would unhesitatingly reply that such training is necessary. The General Council of the Trades Union Congress has already deliberately undertaken the task of re-orientating the attitude of mind of trade unionists to the problem of production and, since time is short, believes that the process could be considerably speeded up if trades union officials are given some insight into the nature of management.