water layer at a given relative humidity depends on the kind of cation that is present.

The fact that the number of exchangeable ions held by a clay depends upon the hydrogen ion concentration of the clay shows, as Dr. R. K. Schofield pointed out, that clay particles carry other electric charges besides those arising from isomorphous replacements. There are evidently 'spots' on the particles which are charged or uncharged according to the reaction of the medium. They are of two kinds : acidic spots, where negative charges can develop through the dissociation of hydrogen ions, and basic spots, where positive charges can develop through the combination of hydrogen ions. The process in the case of the acidic spots is probably

$$\equiv \mathrm{Si} - \mathrm{OH} \rightleftarrows \equiv \mathrm{Si} - \overset{-}{\mathrm{O}} + \mathrm{H}^{+}$$

the silicon atoms being those situated at the edges of the silicon-oxygen layer. The chemical nature of the basic spots is uncertain. They are not found in the clay minerals so far identified, but are frequent in the common clays. The equilibrium is possibly

$$- \overset{+}{\mathrm{Al}} - \mathrm{OH} \rightleftarrows - \mathrm{Al} = \mathrm{O} + \mathrm{H}^{+}$$

and may be due to an overcrowding in the octohedral layers. In certain clays the number of basic groups exceeds that of the negative charges due to isomorphous replacements. These exhibit well-defined iso-electric points.

The forces which hold the successive lattice sheets together appear to be of three kinds. In the case of pyrophyllite and talc, both the faces of the sheets consist of oxygens shared between silicons, and only very weak residual fields are available to hold one sheet to the next. In kaolinite one face consists of oxygen and the other of hydroxyls. The layers are stacked with the oxygen layer of one sheet facing the hydroxyl layer of the next. In this case, Prof. J. D. Bernal explained that 'hydroxyl bonds' must here be regarded as providing the principal linkages. When the sheets are charged, the balancing ions act as ties. In mica the attractive force is strong enough to keep water out, but in montmorillonite, with fewer isomorphous replacements, water at high relative humidities can partially separate the sheets. The development of thixotropy in clay suspensions within a certain range of salt concentration is doubtless connected in some way with this effect, but Prof. E. K. Rideal mentioned cases where this behaviour seemed to be due to a small amount of the clay that had dissolved Observations on the behaviour of clays towards water were made by Dr. E. W. Russell and Mr H. H. Macey.

Problems of Crop Production

IN devoting a session on August 22 to problems of crop production, Section M (Agriculture) was dealing with one broad aspect of a wider question—the place of science in the advancement of British agriculture. More than simple efficiency of production is implied by advancement. It means also the development and extension of farming to the fullest economic degree and, if demonstrably necessary in the national interest, to a degree beyond the limit set by financial economics. Now advancement in the industry at large, like success on the individual farm, is dependent first on policy and next on technical farming efficiency. Science can promote efficiency both by providing new knowledge and by helping farmers to make the best use of existing knowledge ; that is, by research and by education.

It must have been in the minds of those who listened to this discussion to ask whether science's contribution must be limited to technical efficiency or whether it might not have a part in making national agricultural policy. Views put forward at an earlier session, when employment on the land was discussed, plainly inclined to the idea that in applying itself to agriculture, science must take national policy as it finds it and be content to work within its limitations. But ever since the end of the Great War, protagonists, some scientific, some lay, have claimed for science a strong share in government, including the shaping of policy. It may be regretted that, when discussing the part of science in agricultural advancement, the Section did not boldly debate the question what part, if any, science could take in shaping agricultural policy.

The title under which this discussion took place is significant—the practical problems of crop production. In conferences connected with science and agriculture it is usual to deal only with current experimental work. So much is this the case that discussion as to what are the main problems of crop production very rarely occurs. Yet it is the great problems of farming practice which agricultural science is under obligation to try to solve. In its efforts it constantly has to take up special problems in pure science. But the final objective must always be to help the agricultural industry.

The plan of discussion classified the problems of crop production under husbandry practices, crop varieties, and damage by pests and diseases. The question of crop varieties may seem almost wholly for the plant breeder. In fact, however, it creates producer problems wherever crops are grown under even moderately intensive conditions. The basic consideration is which variety of the crop concerned will pay best. With modifications in special cases, yield first and next quality of produce, determine remunerativeness. Many farmers still cling pathetically to the hope of finding in some new variety a means of getting higher yields without greater effort on their own part. In undeveloped agricultures it may be fairly easy for the breeder to satisfy this hope. But with crops already highly improved, like British cereals, the plant breeder can do no more than produce varieties which will give higher yields—in a way that the older varieties cannot—under a higher level of husbandry. That is, the breeder can help the farmer to raise the level of output, but cannot solve for him the problem of raising or maintaining soil fertility.

The old question of the importance of high botanical uniformity of type among the plants in a field has aroused a new, more critical, interest. Among its many farming and genetic aspects, influence on quality of produce attracts most attention. It seems evident, indeed, that the whole question of quality ought to be re-examined. The farmer may be expected to concern himself about quality, whether in choosing the variety or in husbandry practices, only in measure as he is paid for quality. But what is this measure ? Discussion revealed a feeling that modern household taste and modern processing technique are so developing as to divest quality of some of its importance in many crop products : and further, that to guide the farmer and to ensure reasonable price-recognition of quality, experimentally determined standards will have to be specified. Farmer and agricultural scientist cannot alone deal with this matter ; consuming interests have a part to play and, in some cases, an urgent problem—to find out more clearly what they themselves require in quality of crop products.

The variety problem, from a plant breeding point of view, brought up a question which, though never under direct discussion, gloomily intruded itself more than once upon Section M—the question of Britain's agricultural policy. To produce a new variety by hybridizing may take fully fifteen years. Who is to say whether in fifteen years' time mangolds, swedes, turnips, kales, beans, peas will have dropped to the small acreage their decline of the past years suggests ? Yet on this turns the wisdom of undertaking expensive breeding work on them. Their future place depends on the extent to which meat and milk are to be produced from arable land or from grass ; and this question is perhaps as big as any in the future of our agricultural policy. It involves cereals, too, in the matter both of grain and of straw, and manifestly bears fundamentally on grasses and clovers. It is thus a prime determiner of the major practical problems not only of breeding but also of husbandry, both crop and animal.

In husbandry practices the problems of urgency are recognized to be not new questions but old ones made important : by new resources, such as mechanical power ; by new conditions, such as world surplus in staples like wheat and sugar ; by economic pressure under which land drainage has fallen into decay and cash crops have displaced livestock on arable land, in some minds to the permanent detriment of soil fertility.

The readiest example of such problems is cultivations. They include ploughing, cultivating, subsoiling, harrowing, hoeing, rolling. Whether their source of power be tractor, horse, or the bullock or hand tool of tropical countries, the modern cultivator has begun to ask himself questions about them. What, exactly, is their effect on soil and crop and, thus, to what extent are they necessary ? Local custom once told a farmer how often to plough for a root crop and whether to plough fleet, medium or deep. He asks now whether anything is gained by cultivations beyond the minimum necessary to make a seed bed, bury large rubbish, and kill weeds. The tea planter in India or Ceylon, the sugar beet grower in Britain and his rival in tropical sugar cane countries, and indeed the grower of almost any crop anywhere, recognizes here a pressing question.

Maintenance of soil fertility is a problem of no less wide application but much greater gravity. Its crux is commonly held to be soil organic matter, and discussion showed sign of return to the view that the old, uncompromising rotational farming is the only sure foundation for maintaining soil fertility. Land drainage also came under review. This is overshadowed by the sorry fact that in present conditions owners and tenants cannot afford to restore or replace the old land drains which have been vital to British farming since about 1840–60. Tractor power has made a new contribution to mole draining, but there remains the great difficulty that we have but crude ideas as to the influence of depth, distance apart, and orientation of drains. It was held that the final solution of these practical problems could only be found in a full knowledge of water movement in various soils.

Past experiment on cultivations and on the control of fertility by fertilizers, manures and farming systems, reveals a conception of problems not acceptable from the point of view taken in this discussion. It was formerly the object of experiment to find out the effect of any treatment on the immediately following crop and on that alone. Now the practical problem is widely accepted to be the cumulative effect of these methods and treatments on the soil and on the yield of all the crops throughout a rotation.

Science cannot solve the exact problems which confront the farmer. It has to ascertain the scientific questions by which the practical problem is made up and to deal with these. In the case of cultivations and maintenance of fertility, the simplest kind of investigation would be field trials to measure the effect of various treatments on crop yield. Such measurements would not give understanding or point the way to further progress. Here the questions for science are how each cultivation or other treatment influences the soil and directly, or through the soil, the crop. These influences can only be measured by the plant itself. That is, a developmental study must be made to determine how at each point in plant life treatment influences growth and development and thus, ultimately, final yield. To make developmental studies under field conditions is exceedingly difficult. Plant physiology could do a service to agricultural experimentation by devising measures or indexes of growth and development suitable for field use.

In dealing with pests and diseases of crops, the natural tendency towards vigorous offensive may overcome business common-sense. Prominence was given in the discussion to the need for careful estimates of extent and nature of damage to crops. To find a method of control or prevention is not the full solution of the practical problem ; how much can profitably be spent in applying the method remains, in many cases, a problem also.

Of plant parasites—insect, fungus or other—the types most to be dreaded are those capable of lingering in the soil for several years. Examples are 'take all' (*Ophiobolus graminis*) of wheat and eelworm of potatoes or sugar beet. No direct means of destruction is known in any of these cases, though indirect methods, sometimes biologically fascinating, are coming within view. Safety lies at present in avoidance ; in a policy of temperance. In fact, what was said from the husbandry point of view in the discussion, about the merits of uncompromising rotation, was effectively reinforced by considerations of disease. The apparently steady increase of take-all, foot root and similar diseases in cereals, in many parts of the world, was declared to arise from the tendency to lessen the interval between one corn crop and the next. Correspondingly, the tendency and the temptation to grow successive crops of early potatoes or sugar beet has already created a problem of geographic extent and of gravity which few realize. Restriction on freedom of cropping—in the past a matter of statute law and leases—has its severest importance as a matter of biologic law and herein lie, perhaps, the greatest problems of plant pathology.

Present Aspects of Plant Virus Research

THE discussion on present aspects of plant virus research, held on August 23 by Section K (Botany) at Cambridge, covered the whole range of plant virus work, from the properties of purified virus proteins to the propagation of healthy potato stocks.

Recent work by Dr. Kenneth M. Smith and Mr. W. D. MacClement, on the natural modes of dissemination of plant viruses, has shown that the old idea of an insect vector as essential for the spread of a virus from plant to plant is true only to a limited extent. Some of the best known viruses apparently have no insect vector and other means of dissemination must exist. *Solanum* virus I spreads by the contact of diseased and healthy leaves, especially when agitated by wind. *Solanum* virus II, which is found in the roots of apparently healthy glasshouse plants and does not normally enter the aerial organs, is disseminated in at least two ways. It has been isolated from the sludge in glasshouse tanks and may be introduced to the soil during watering. Experiments with plants grown in air-proof chambers have shown that it also spreads from pot to pot by air-borne particles of infected plant material. This virus and *Nicotiana* virus I have both been recovered from the air one hour after being atomized into it. When the former has been atomized into the air of an air-proof chamber, the plants grown in it under sterile conditions have become infected, while those in an adjacent chamber which was not atomized remained healthy. *Lycopersicum* virus 4 could be recovered from the air only for 5–10 minutes after atomizing, while *Solanum* virus I could not be recovered from the air at all.

The problem of multiplication of adequate stocks of healthy potatoes has occupied Dr. R. N. Salaman's attention for many years. At present, only a third of the potato acreage in England is planted with approximately clean seed, and this leads to a reduction in actual yield, as compared with possible, of some two tons per acre for the