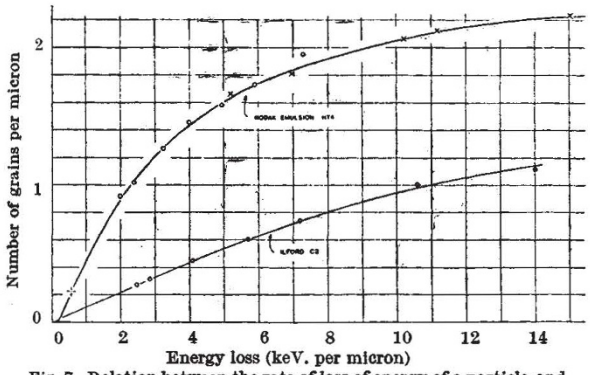

Fig. 7. Relation between the rate of loss of energy of a particle and the grain-density in the track. Points marked —o—o have been deduced from observations on the tracks of μ-particles of range greater than 2,000 μ; and those marked —×—×, from similar measurements with protons

Relation Between Grain-Density and Specific Ionization

It is a matter of great technical importance to be able to infer the specific ionization of a charged particle from the observed grain-density in its track in an emulsion. We have seen that curves of the type represented in Fig. 3 allow us to determine the grain-density in the tracks of particles of charge e, corresponding to minimum ionization. Further, from observations on the tracks of μ-mesons and protons of great range, observed in the same plate, we can determine the grain-density corresponding to a wide range of values of the specific ionization. In making such determinations, the rate of loss of energy corresponding to a given value of the residual range of a particle of known mass can be determined from the range-energy curve for protons. In this way, we have obtained the results represented in Fig. 7. The point corresponding to minimum ionization in this figure is shown thus +, the ionization having been determined in this case from the formulæ developed by Bloch, assuming the atomic composition of the emulsion to be identical with that of the Ilford plates.

Included in Fig. 7 is a similar curve for an Ilford *C* 2 emulsion. It will be seen that, as a result of the increased sensitivity of the Kodak *N.T.*4 emulsion, there is a reduction in discriminating power for tracks with a specific ionization of the order of 6 keV. per micron. In the Kodak plates, a track, in regions of high ionization, appears as an almost continuous succession of developed grains which cannot be individually resolved. This has the result that for determining the mass of particles of mass approximately 1,000 m_e, tracks of much greater length must be available for measurement than is the case with less sensitive emulsions.

In contrast with the difficulties met in the case of tracks with a high specific ionization, the calibration curve shown in Fig. 7 allows us to make estimates of the rate of loss of energy for weakly ionizing particles, a technical advance of great importance in relation to the subjects discussed in Part 2 of the present paper.

(To be continued)

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PROBLEMS AND POLICY IN PLANT BREEDING

THE second annual Conference of Plant Breeders under the auspices of the Agricultural Research Council was held during November 11–12 at the John Innes Horticultural Institution. Sixty-four members attended, including representatives of English, Scottish and Welsh plant-breeding stations, some overseas visitors, and geneticists from the universities. Prof. F. T. Brooks represented the Agricultural Research Council. Dr. C. D. Darlington was in the chair.

Demonstrations

(1) The Genetics Department of the John Innes Horticultural Institution demonstrated genetical problems in seed-growing, rogues in tomatoes, the spontaneous and induced mutation of the incompatibility gene, *Phaseolus* hybrids and the effects of selection in *Drosophila*.

(2) The Pomology Department showed new mildew-resistant tomatoes, incompatibility in pears, the breeding of sweet corn and 'bolters' in potatoes.

(3) The Cytology Department showed iso-chromosomes and heterochromatin in plants. Chromosome numbers were used to reveal the origin and development of the cultivated daffodil since 1890. In earthworms meiosis was shown in a tetraploid species —a novelty in animals—and the relations of chromosome numbers to species were illustrated in this group.

(4) The Garden Department demonstrated soil sterilization and artificial illumination as aids to the breeder.

PROBLEMS

Quantitative Inheritance and Selection

Prof. K. Mather, in the opening talk, gave an outline of the methods available in the study of quantitative inheritance. The Mendelian method of experiment, he pointed out, can be applied only to differences caused by genes of large effect. Biometrical methods can be used with all differences, including quantitative variation which is controlled by polygenes. Mendel's principles apply to nearly all heritable variation in higher organisms, and therefore have been used as the basis for biometrical analysis.

On this basis methods had been developed of measuring polygenic variation; of partitioning such variation into non-heritable, heritable and fixable, and heritable but depending on dominance and therefore unfixable; of testing for residual genic interaction and for linkage; and of finding the number of effective units of segregation. By these means the magnitude and speed of progress under selection could be predicted in some circumstances, and the progress of inbreeding could be measured experimentally.

Most of the variability was normally hidden, and its exposure to the action of selection depended on crossing, segregation and recombination. These processes were controlled in Nature by the natural breeding system and by the frequency of chiasma formation.

Control of the breeding system is a regular tool of plant breeding; and the control of recombination by adjustment of the environment may become another.

Correlated responses in characters other than those under direct selection, Prof. Mather suggested, might also be useful as a means of splitting up stabilized

polygenic complexes and as markers for selection in the juvenile stage. A possible example of correlated responses in adult plant characters to selection of seedlings with abnormal cotyledons was described by M. G. M. L. Haskell.

From hybrids and varieties of sweet corn brought back from the United States, Mr. Haskell said that he had selected seventy-seven and compared them with Canada Gold and Extra Early Bantam, the best varieties so far known in Britain.

The geographical origin was of considerable importance. Hybrids from Connecticut, in some instances, were early and promising, those from Wisconsin too late. Those from Ottawa varied in potentiality; but all had the sweetest flavour.

From observations of inbred lines obtained from Connecticut, Wisconsin and Indiana, it is clear that good ones for Great Britain can only be obtained by producing them here. Inbreeding had begun on selected cold hardy lines of Canada Gold and other material in order to obtain cold-hardy inbreds which would produce good hybrids.

Dr. S. C. Harland, in a talk on the inheritance of seed weight in *Ricinus communis*, showed that in the F_1 and F_2 the mean seed weight is close to the geometric mean of the parents. Successive back-crosses to the small parent approached the latter by a series of geometric means. It was not clear whether this would continue until the frequency distributions are indistinguishable from that of the recurrent parent or whether bimodal curves began to occur, indicating monogenic segregation. Results were not inconsistent with about eight factors for seed weight, one of which was linked with waxy bloom.

Rogues and Cytoplasmic Inheritance

The next two speakers dealt with the problem of aberrant plants which continually occur in tomatoes and potatoes. Dr. D. Lewis described the rogue tomato as an old mystery to the geneticist and a source of loss to the grower. Normal plants produce rogues in a percentage varying according to the variety; rogue plants produce rogue and normal offspring. As tomatoes are pure lines, only an elaborate and improbable genic control can be postulated. Working on Darlington's hypothesis that the rogue was mainly controlled by a plasmagene, it was found that, as with other plasmagenes, their activity was subject to environmental conditions. For example, temperature at germination had a profound effect; with the variety Ailsa Craig at 13° C. there are only 1·7 per cent rogues, at 26° there are 12·9. Intermediate types of rogue plants are produced when short periods of high temperature are given during germination. The number of rogues produced also varied with the inflorescence from which the seed was obtained. The proportion was low from the first and second, high from the third and fourth, and low again in the fifth.

Although the breeder did not often have to work with characters controlled by plasmagenes, Dr. Lewis suggested that bolting in beet, brassicas and onions were examples. It was clear that the breeder must take care when selecting for such characters to do it in relation to a controlled environment.

Mr. S. H. Revell described the widespread and sporadic occurrence of 'bolters' in potatoes. The breeding behaviour indicated that there was not a simple genic control of the bolter characters. Frequent somatic mutation could explain most of the facts. The expression of the normal and bolter characters could be altered by the application of different day-lengths. Normal plants under long days appeared to be bolter in character, while bolters under short days appeared more normal in character.

Breeding Apomicts

Dr. D. G. Catcheside showed how variation in apomicts could be expected through changes which arose either by mutation occurring somatically or by a limited kind of segregation occurring through diplospory. The variations were likely to be rare and relatively slight in amount on any occasion. It sometimes happened, as in the composite rubber plant, guayule, *Parthenium argentatum*, that facultative sexual reproduction provides a method for obtaining numerous definitely known recombinants for testing.

In apomictic 72-chromosome guayule, a reduced egg in the embryo sac could form a 36-chromosome embryo. The resulting 'haploid' plants were usually apomictic. As in other guayule apomicts, the unreduced eggs were sometimes fertilized to give an apomict with a higher chromosome number. In the production of pollen in a 72-chromosome apomict there was nearly always reduction in the chromosome number and generally genetic segregation. If a 'haploid' with 36 were pollinated by a 72-chromosome plant, the resulting progeny would contain a small proportion of 72-chromosome plants, each the result of a distinct fertilization, and each could form the foundation of a new selection test-line. Segregation in the pollen parent would be demonstrated by greater variation among these progeny than among the apomict progeny of the male parent. This was the basis of a method of readily finding small variations in apomict stock, and it could be developed by searching for élite 'haploids' giving superior offspring in crosses, analogous to the élite inbreds in corn.

Experimental Design

Dr. F. Yates, speaking on the best methods of selecting and testing varieties, said that the design of field trials had progressed to a stage where satisfactory designs could be recommended for a wide range of requirements. But there was a serious lack of information on the optimum degree and accuracy of selection at each stage in a breeding programme. In the use of 'control' varieties as standards from year to year it was important to use more than one, as this overcomes differences of any one variety in response to different conditions and allows for changing the controls in the middle of a long-term experiment if any variety becomes obsolete.

It was generally agreed that the subject was of such importance that a whole session of next year's conference should be allotted to it, in the hope that, by that time, more information would be available.

POLICY

Seed Growing

Dr. A. J. Bateman pointed out that the maintenance of varieties produced by the breeder was of vital importance to him. Seed-growing presented many problems which required scientific study. With inbred crops: the degree of heterozygosity after single plant selection, the importance of mutation, and the degree of uniformity desirable. With cross-bred crops: the effects of natural selection, the prevention of undesirable cross-pollination and the size of populations necessary to maintain a variety properly. There was therefore a need for knowledge on the genetical aspects of stock seed maintenance

and for a greater control by plant-breeding stations over the maintenance and multiplication of their products. In the discussion, Dr. G. D. H. Bell pointed out that, at Cambridge, the National Institute of Agricultural Botany collaborated to maintain seed stocks. Dr. O. H. Frankel urged that co-operation with private seed firms would greatly improve the position, and Dr. J. Philp thought that breeders could obtain this co-operation only by concentrating for a time on certain crops and showing by a good example.

Prof. T. J. Jenkins and Mr. G. Evans stressed the importance of reducing in cross-pollinated crops the number of generations between the basic plants of a strain and the seed as it reaches the user. When seed growers have gained more experience, they may be able to grow two generations from the seed released by the breeders rather than one as at present.

Mr. W. J. C. Lawrence asserted that, owing to piecemeal breeding with horticultural crops in the past, only some four instances could be cited where introductions by the research stations had materially affected crop production. What was needed was a policy of breeding and co-ordination which integrated the breeding with other aspects of production, such as climate, husbandry, markets, the consumer and future developments.

In the absence of Dr. P. S. Hudson, a talk on the Food and Agriculture Organisation Scheme for Cataloguing and Maintenance of Stocks was given by Dr. O. H. Frankel. The scheme provides for: (1) a catalogue of genetic stocks starting with self-fertilizing crops; (2) each country to be responsible for assembly, description, maintenance and distribution of its types; (3) descriptions to be collected by the Organisation, recorded on punched cards and published in lists. Points of detail in the scheme were criticized by Dr. Frankel, who stated that it made no provision for world collections, and by Dr. Harland, who pointed out that the most needed material came from primitive countries without plant breeders and that these would not be included in the scheme. Dr. Bell proposed the motion, which was carried unanimously, that although the Conference appreciated the deficiencies of the scheme it welcomed these steps towards making a world wheat catalogue.

New Tools

Mr. H. L. Fyfe made a plea for work on polyploidy and induced mutation in plant breeding. Much work had been done in Sweden to exploit these possible tools in plant breeding. But, apart from reduced fertility in polyploids, no predictions of the kind of effects produced could be made. It was too early to assess their value. But unless work was started in Britain we might find that we should be far behind. Mr. M. B. Crane emphasized the valuable results that could be obtained, quoting work done on horticultural crops in Denmark and on forest trees in Sweden. Dr. Catcheside pointed out that most X-ray mutations were deleterious loss changes; Dr. Lewis, confirming this, stated that X-radiation was the ideal tool to destroy a gene of which the breeder wished to rid his material. Examples were self-incompatibility in fruit, vigour in rootstocks and fertility in some ornamental crops. Dr. C. D. Darlington suggested that new polyploidy was more likely to be of value in previously unselected plants.

Dr. P. T. Thomas urged the need for cytological guidance in plant breeding, pointing out with examples how the cytologist can help the breeder. Diploid types had been found in the tetraploid wild white clover, and these might be of great value for synthesizing new types. In oats the segregation of sterile dwarf plants was correlated with changes in chromosome number. The cytologist was also of assistance when dealing with improvement by intraspecies crossing and with crop plants which were already high polyploids in resynthesizing polyploids from wild types.

Resolutions

Oil Crops. Considering that in the attempt to acclimatize new oil crops in Great Britain, the full extent of natural genetic diversity is a first condition of success; and considering that such possible crops as sunflowers and soya beans manifest a diversity so far unknown in Great Britain, the conference recommended the Agricultural Research Council to make provision for the establishment of world collections of these and other important economic crops.

This was proposed by Prof. K. Mather, seconded by Mr. E. S. Bunting, and carried unanimously.

Forestry. Considering that with the use of modern genetical technique the productivity of the forest trees could be raised in Great Britain by at least 20 per cent; and considering the increasing scarcity of timber in this and other countries and that many other countries (such as Sweden, Denmark, South Africa and the United States) have already established first-class institutes for the study of tree breeding, it was recommended that the Agricultural Research Council should establish a forestry genetics institute for the improvement and acclimatization of forest trees by genetic methods.

This was proposed by Mr. M. B. Crane, seconded by Colonel F. C. Stern, and carried unanimously.

Teaching. Since there is a lack of persons in Great Britain with the training in pure and applied genetics necessary for the immediate and future tasks of plant breeding, and considering that this lack is due to the inadequacy of facilities for university teaching, most universities still having none whatever, many years after the need has become evident, the Conference urged that the Agricultural Research Council and the University Grants Committee should combine in taking steps to establish adequate genetics departments in all universities and university colleges.

This was proposed by Dr. J. Philp, seconded by Dr. G. D. H. Bell, and carried unanimously.

Seed Distribution. Considering the importance of the way in which new varieties of seed are distributed from plant breeders, the Conference recommended that the Agricultural Research Council should convene a joint meeting of plant breeders under its control, representatives of seed firms and the National Institute of Agricultural Botany to consider their common interests in this field.

This was proposed by Dr. A. J. Bateman, seconded by Mr. J. L. Fyfe, and carried unanimously.

Soviet Biology. Considering that world science needs the co-operation of gifted men of science in all countries, and that in the past the Soviet Union has made contribution to genetics of value to the whole world, the Conference deplored the dismissal of leading Soviet geneticists during the last ten years which has culminated in the official repudiation of the established principles and practices of genetics by the Soviet Government.

This was proposed by Dr. S. C. Harland, seconded by Dr. O. H. Frankel; it was carried by fifty-four to one.

D. LEWIS