PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

General Discussion

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General discussion

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In this discussion doubts have been expressed about the wisdom of farmers using heavier and heavier equipment. However, there are two points which I should like to make. The first is that larger tractors, etc., do not necessarily put heavier loads on the soil. If they are fitted with suitable tyres then the ground pressure under them should be no higher than under the smaller tyres of smaller tractors, etc. The difficulty is that farmers often have smaller tyres fitted because they then make a small initial saving in cost, but if they will fit the largest tyres which the manufacturer makes available they will almost certainly get 5–10 % more tractive efficiency from tractors, and they will improve the timing at which they do their field work, as well as actually improving the efficiency of power transmission of the tractor. Furthermore, the ground pressure will be no higher than with smaller tractors. I need hardly add that considerable effort has been made to try to ensure that this information is given to farmers.

There is, however, an even more important point which concerns the rôle of engineers working in agriculture. We have passed through many decades when trying to save labour was of paramount importance. The criteria which engineers use for their work may very well have changed. The difficulty is that tradition in agriculture is a very strong force, and we do not always have in this industry engineers who are flexible enough to keep the main goal clearly in view. Certainly we want to reduce drudgery and unnecessary hard work, but we want no less to improve the efficiency of the industry. The use of more powerful equipment frequently saves the farmer money in the long run but a good engineer always wants to use the simplest tools which are cost effective. An example of this may be found in the traditional approach to cultivation of the land which tends to lead farmers to using bigger and bigger tractors and bigger and bigger mouldboard ploughs. We have tried to analyse this problem and we have put forward what we believe is a more intelligent solution, i.e. to avoid imposing on the tractor high draught forces which can only be transmitted by large heavily loaded wheels. Instead, we have taken the power for cultivation through the power take-off in a rotary motion; because the rotary digger does not need high draught forces we have found that we can cultivate twice as many hectares per day as with a mouldboard plough. Not only does the rotary digger use the power of the tractor in a more intelligent way than the mouldboard plough but it also results in less soil compaction and smearing.

Engineers are as opposed as biologists to ‘using a sledgehammer to crack nuts’. For farming to be a progressive and prosperous industry it is essential that engineering products used in agriculture be used as intelligently as possible. Engineers will always be interested in reducing hard work and drudgery but they are no less concerned with many other aspects of farming. A good example of the non-traditional view of engineering is that we are heavily engaged in trying to use farmyard manures so that full benefit may be obtained from the crop nutrients in them, and we are no less seriously engaged, for example, in studying the environment in which young animals are kept. There is always a tendency to suggest that engineers want to see heavier and heavier equipment on farms; for enlightened engineers this is far from being the whole truth.

A. R. Ubbelohde, F.R.S. (*Department of Chemical Engineering and Chemical Technology, Imperial College, London, SW7*). In making forecasts about improvements to be looked for to British agriculture from engineering, hopeful pointers and obstructions can both be foreseen.

With regard to hopeful developments, as agriculture becomes progressively more intensive, in respect of the output per agricultural worker and perhaps also per kilojoule of energy, it seems certain that chemical engineering science will have a greater part to play even for operations within the farm gate. Many of these operations depend in some way on successful control of heat transfer and of mass transfer. When the scale on which they have to be carried out is increased, stricter attention needs to be paid to optimization of the different factors involved. Chemical engineers are trained to meet problems of optimization and will, it may be hoped, turn increasing attention to the needs of agriculture. Special requirements for crop and forage drying, for the effective insulation and proper ventilation of farm buildings, and for sterilization of milk can probably be met by applications of existing knowledge. There is scope, too, for research as well as development into bioengineering situations, such as the transformations in silage, the treatment of farm waste, the production of proteins and other foodstuffs from lower cost materials, and so on.

With regard to obstructions, the well known gap between innovative research and effective commercial development into mechanical engineering products applied to agricultural needs shows no signs of narrowing, in regard to British agriculture. There is no lack of British manufacturing capacity in agricultural engineering, and its annual production remains impressive. But risk capital on the scale needed to commercialize promising mechanical innovations is not ordinarily available for the special needs of British agriculture. It is arguable that our varied soils and climate call for more flexible though not necessarily bigger mechanical equipment, to permit optimum use of our expensive manpower. When the larger centres of design of agricultural machinery are (as at present) overseas, optimum response to British requirements can hardly be expected.

G. D. H. Bell, F.R.S. (6 *Worts Causeway, Cambridge*). It is not stretching the interpretation of the title of this discussion meeting too far to include the genetic status and the performance of the crops which are available to the farmer. Crop improvement is a potent means of providing more efficient basic material for producing plant products and as such can be regarded as an input of far reaching significance in any consideration of biological productivity. Indeed, certain assertions and remarks that have been made by speakers during the past 2 days have recognized the contribution of new crop varieties to the very considerable improvement in yield potential in some of our major crops and also in the quality of the end product for various consumer requirements.

The choice of the most appropriate variety for any particular farming enterprise may legitimately be considered, therefore, as a significant aspect of the management of inputs for improving yield and efficiency. The criteria for such choice by the farmer are, of course, well recognized and are made available by official trials and publicized by the recommended lists of major crops published by the National Institute of Agricultural Botany. It is thus possible to make critical assessments of relative performances of individual new varieties and take full advantage of the most recent introduction by plant breeders if they are included in the trials.

Agricultural systems have, of course, a major ecological component and plant breeding may be similarly regarded in terms of an ecological exercise in matching as effectively as possible

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the genotype to the environment. It is for these reasons that the breeder has to understand and appreciate the major environmental constraints agriculturally and in the natural environment. In other words, making the most of the environment, and measuring environment/genotype interaction, are primary considerations.

There have recently been considerable advances in these respects and we have almost grown away from the generalized implication of the term 'varietal adaptation'. It has been necessary to be much more precise, in spite of the extension of the concept to specific and general adaptation when characterizing agricultural varieties. We have argued for many years whether the future for maximum exploitation of the environment lay with the greatest practicable refinement of specific adaptation or whether more generalized forms can be equally effective. For myself, there has always been a tendency to specificity while accepting the necessity to define degrees of such specificity, or indeed the limits of general adaptation; now at last the stage is being reached when fitting genotypic models to quantified environmental models is practical politics.

Plant breeders have been busy developing their crop plant models in terms of physiological, developmental and morphological characters for raising productivity levels. Considerable elucidation of the environmental parameters has also been possible as we have heard from Professor Monteith. It should be practicable to devise more effective matching of genotypic models to environmental models on a quantitative basis and thus improve still further the contribution of the crop variety as an essential input for raising productivity and efficiency.

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