

THE ROLE OF STATISTICS IN EXPERIMENTS WITH TEA

P. Kanapathipillai

One of the most striking features of the biological and technological sciences is the great variability of its material. This characteristic is in marked contrast to sciences like Physics and Chemistry where the variability is usually very small. This situation is sometimes described by saying that the results of experiments in Physics and Chemistry are *closely* reproducible whereas those of the biological sciences, though reproducible, vary greatly.

Faced with this variation, which is outside the control of the experimenter, how is the research worker in biology to draw valid inferences? This was the problem Sir Ronald Fisher solved at the Rothamstead Experimental Station in 1920. Dr T. Eden was one of his first pupils who was associated with him in the solution of this problem. The solutions were "replication" *ie* repeating the treatment a certain number of times to reduce the variation and "randomization" to estimate the size of the variation. Further, in experiments in the pre-Fisher era, the effect of a particular treatment was evaluated by varying that treatment only, whilst keeping all other treatments constant. Fisher, in collaboration with Dr Eden, showed that this approach was not quite sound. They pointed out that it was necessary to apply the treatments *simultaneously* in addition to applying them singly. It was only then that the combined effect of the treatments would be known. Fisher summed this up in his famous dictum "Nature answers better to a questionnaire than to a question".

Dr Eden, having been schooled in these revolutionary approaches, began to lay down experiments incorporating these new ideas. The present author, who had the privilege of working under Dr Eden shortly before he left Ceylon, recalls his statement that the first Latin-Square design in the world (a design which looks somewhat like a checker board) was laid out at St Coombs. In 1929, he made a study of uniformity trial data and concluded that the size of an experiment plot should not be less than 1/18th acre. These studies were made with the best methods available at that time. Recent studies, however, have shown that plots of 1/50th acre were just as efficient. In 1930, he laid out on No 3 Field at St Coombs, what is known as a 'factorial' experiment: that is to say, three treatments N, P and K each at three different levels, were studied both singly and in combination. This experiment stands to this day although the levels of the treatments have been varied. This type of experiment was unknown at that time even to the other research stations in England. Today, there is scarcely a research station in the world where there is no factorial experiment of one kind or another. The TRI, thus became internationally famous for its experimental techniques.

Now, what does all this mean to the industry? I have to refer to the earlier statements about the reproducibility of results. Estates were able to find out the yields they could expect with given levels of N, P and K. Indeed, the results obtained at St Coombs reproduced themselves so well that there was a tendency to assume that the TRI was an oracle which could solve all the industry's problems. The fact that it took at least eight years of experimentation before firm recommendations were made tended to be forgotten.

Meanwhile great advances were made in England on experimental designs, notably by two brilliant pupils of Fisher, Dr F. Yates and Dr D. J. Finney. Dr Eden, being fundamentally a Chemist, was naturally getting a little out of touch

with the latest statistical developments. After Eden's departure in 1951, there were some experiments laid down but Dr Pearce, Statistician, East Malling Research Station who visited the Institute in 1959 did not seem to be happy about them.

Most of the newer designs for research were developed at Rothamstead in relation to annual crops. Their efficiency for perennial crops like tea were not known. However, work on citrus at California and on apples at East Malling showed that for perennial crops the simpler designs were more efficient and adaptable than the complex ones. Accordingly, at present nearly all experiments conducted by the Institute are plain randomized blocks or simple factorials.

I said earlier that the results of experiments on St Coombs were reproduced on estates. Perhaps luck too played a part. The highest level of nitrogen used by Dr Eden, it must be remembered was only 80 lb per acre. But today when 150-200 lb per acre is quite normal, and experiments have reached 300-500 lb nitrogen, it becomes dangerous to extrapolate the results obtained at St Coombs. Hence estate experiments have been started to supplement information covered by St Coombs experiments.

Until about a year or two ago, it would probably be correct to say that there were no statistically designed factory experiments. The technological recommendations hitherto given appear to have been based on empirical evidence backed by personal judgment. The difficulties of technological experiments with tea are greater than those faced with in field trials. To begin with, the batches of tea leaf that come in may vary in quality from day to day depending on the vagaries of the weather. Then there are severe limitations to the number of treatments that can be tried out with existing machinery. Also, it is essential to carry out the investigation with the minimum hindrance to normal production. Finally, the value of the end-product is judged by a tea taster at St Coombs and a panel of tea tasters in Colombo. Ideally, those tea tasters should function somewhat like scientific instruments. In practice, they have been found to be quite conflicting in their judgments. This is an unsatisfactory situation for purposes of research. Therefore, statistical tests were designed to assess their degrees of consistency and they were subjected to these tests (without their knowing it, of course!). Thereafter, incomplete block designs were used because all treatments could not be manufactured on the same day.

So far I have dealt with use of statistics to estimate effects which had a direct economic value — increased yield in the case of field trials or increased quality in those of the factory. But statistics is also being used in fundamental studies like the influence of light, temperature, rainfall *etc* on spore production in Blister Blight or the effect of temperature and wind-speed on the dispersal of the Shot-hole Borer. These studies are intended to reveal the extent of dependence of one factor on a number of other factors. Eventually, of course, they should lead to more efficient methods of controlling the pest or disease.

However, there are still several statistical methods which need investigation. We still do not know the most efficient size of plot for clonal material. Weekly records are taken in all experiments. Would fortnightly or even monthly records do for valid statistical analysis? If so there would be considerable economies in the cost of experimentation. At present, we use the pre-treatment yield records to correct the yield records of the experiment *at the end* of the cycle. What would be the effect of correcting the first, second and third-year records in the upcountry? Some of these problems are being studied and it is hoped that studies in sampling techniques of pests and diseases will also be undertaken in the future.