ROTHAMSTED RESEARCH

Report for 1961

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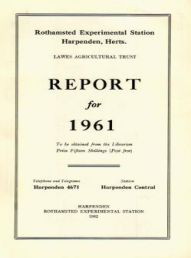

General Report

F. C. Bawden

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GENERAL REPORT

F. C. Bawden

H. H. Mann died on 2 December, a few weeks after his 89th birthday. He officially retired from the post of Assistant Director at Woburn in 1956, but he was active in our affairs until his death. With his interests undiminished and his faculties undimmed, he remained a member of the Staff Council and Field Plots Committee, and to their meetings as to our regular scientific meetings at Rothamsted he remained a valued and forthright contributor. His productive working life was as remarkable for its range and diversity as for its duration. He published his first paper, which described effects of antiseptics on yeast, in 1897, and he was writing one at the time of his death on the Woburn Market-garden Experiment. In the 64 years between he worked twice at Woburn, and had what is normally regarded as a full career in India, where he held such posts as Scientific Officer to the Tea Association, Principal of the Poona Agricultural College and Director of Agriculture for Bombay State. His work there not only established him as a world's authority on the tea crop but made him the most respected and influential person in Indian agricultural science. His first stay at Woburn was relatively brief, from 1898 to 1900, while he worked as assistant to Dr. J. A. Voelcker, Chemist to the Royal Agricultural Society of England, which was then responsible for Woburn. However, the stay gave him a lasting interest in the station and the district, and he returned there in 1928 after retiring from India. Until 1936 he was in charge of the experiments at Woburn, the lease of which had passed from the Royal Agricultural Society to Dr. Voelcker in 1921 and from him to the Lawes Agricultural Trust Committee in 1926, but from 1936 to 1946 Mann also shouldered the responsibility for running the whole farm. There is no need here to list the many subjects he successfully studied, for he summarised the work at Woburn in the Report for 1958. That article not only shows the range of his interests but the enthusiasm and activity with which he pursued them; it must be unique as an account of research achievements by someone in years far beyond any official retiring age. Even so, there was more to his life than agricultural research and, in both India and Bedfordshire, he was active in local affairs and tireless in his work to improve social conditions.

Membership of Trust Committee

Lt.-Col. R. B. Verdin was appointed to the Lawes Agricultural Trust Committee by the Royal Agricultural Society of England to replace Mr. A. H. Carter, who resigned.

Head of Entomology Department

C. G. Johnson was appointed head of the Entomology Department to succeed K. Mellanby, who left on 30 September to become

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director of a new research station of the Nature Conservancy in Huntingdonshire.

Awards

F. J. Seabrook's services were acknowledged in the Birthday Honours List by the award of the British Empire Medal. R. Hull was awarded the Research Medal of the Royal Agricultural Society of England in recognition of his work on sugar-beet diseases, particularly his success in checking yellows. The high quality of research done by B. Kassanis and A. Kleczkowski gained them promotion on merit to the grade of Senior Principal Scientific Officer. F. C. Bawden was elected to Foreign Membership of the Royal Netherlands Academy of Sciences and Letters. On the occasion of the bicentenary of the French Academy of Agriculture, the French Minister of Agriculture conferred on Sir John Russell the honour of Commander of the Order of Agricultural Merit.

In June we celebrated what will probably remain a unique occasion, when three members of staff, H. Currant, W. C. Game and F. J. Seabrook, reached almost simultaneously 50 years of continuous employment with the Lawes Agricultural Trust Committee. Regrettably Sir John Russell, who appointed them, could not attend the celebration in their honour; this was not for reasons that might have been expected for one in his 89th year, but because he had a long-standing engagement that day to inspect improved grassland on the mountain of Plynlimon.

Buildings

Some progress can be reported towards relieving our overcrowding. The new building in Rivers Lodge garden for the statisticians was finished and occupied, except for the room designed to house the Orion computer when it comes. A small extension to Red Gables to increase accommodation for the Soil Bureau was almost finished. The old Imperial College Laboratory was refurbished and occupied by members of the Botany Department, whose move freed some rooms for the library staff, who for years have had to work on the landing or in the library itself. At the end of the year builders were on the site and had dug an impressive hole where the considerable extension to the West Building should be completed by January 1963.

The largest developments were at Broom's Barn, where, despite the appalling mud during the winter, the roads, services and farm buildings were all completed in June. By the end of 1961 the six houses were finished and three occupied; most of the laboratory and other buildings also had their roofs on. After deepening the first borehole, enough water was obtained to irrigate 2 acres at a time. The staff still at Dunholme will move to Broom's Barn in the spring, and Dunholme Field Station will close.

Visits and visitors

Many members of the staff again travelled overseas not only, or even mainly, to attend scientific congresses but as the result of invitations to lecture, to advise or to undertake specific research

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problems. In addition to travels recorded by the individual departments, F. C. Bawden visited the Sudan in January to attend a meeting of the Agricultural Advisory Committee, the U.S.A. in April to lecture at the University of California, Kenya in October to represent the Secretary of State for the Colonies at a meeting of the East African High Commission and Ceylon in December to visit the Tea Research Institute.

Visitors to Rothamsted were fewer than in 1960, but we again recorded more than 3,000. Those from overseas included delegates from the Chinese Academy of Science, H.E. Dr. Esfandiar Esfandiari, Under-Secretary of State, Iran, and Mr. Sebalu, Minister for Economic Development, Uganda. Those from the United Kingdom included Mr. Denzil Freeth, M.P., Parliamentary Secretary to the Minister for Science.

The year and farming

The year began with farm work so far behind schedule that there seemed little hope of ever catching up. However, Broadbalk was drilled on 18 January and, although the crop looked poor up to May, the yield at harvest was up to average. A dry spell in February allowed a further 20 acres to be sown with winter wheat, the potatoes to be lifted (unharmed by frost in the mild winter), and much land to be ploughed. The seed beds looked far from good, but the wheat seemed not to mind and when heavily manured yielded more than 50 cwt./acre. The unusual circumstances were used to compare winter and spring wheats sown on 15 February: Cappelle gave a mean yield of 45·8 cwt./acre and Jufy 1 43·3, so it was still worth sowing winter wheat even at this late date. The later-sown spring wheat and barley also went into rough seedbeds, and the crops looked uneven in May, but later improved, and the wheat averaged more than 40 cwt. and the barley about 40 cwt./acre. On the heavy Rothamsted land it is rare to be able to show effects of tilth or soil structure on crop yields, but this was achieved with spring beans by deliberately maltreating the seedbed. Plots, formerly in ley or fallow, were split into halves, one of which was disc harrowed when very wet and the other cultivated to get the best seedbed. Yields were 20% higher on the ley plot cultivated well than on the ley plot cultivated badly or the fallow plot cultivated well, and these yielded 20% more than the fallow plot cultivated badly.

On the lighter land at Broom's Barn tilth is more important; spring wheat and barley were particularly poor on land compacted and puddled by harvesting beet during the wet autumn, and yields averaged only 20 cwt./acre. At Woburn yields averaged 26 cwt./acre. Brown foot-rot (caused by *Fusarium* spp.) was prevalent in wheat at Woburn, and on other light land with poor structure, particularly where given large dressings of nitrogenous fertilisers.

How much the yields of cereals were affected by the virus disease barley yellow dwarf is unknown, but it was very common and must have damaged some of the late-sown spring cereals considerably. Another virus disease, motley dwarf of carrots, was so prevalent and damaging that it ruined most carrot crops sown during April and May in the south and east of England. Sugar-beet yellows, too,

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appeared early and threatened to be severe for the fifth year in succession. Spray warnings went out in some areas during the second week of May, and by the end of June they had gone out almost everywhere, and some areas had been advised to repeat the spraying. More than three-quarters of the total beet acreage was sprayed, and those who sprayed when they were warned increased yields by enough to repay many times the cost of spraying. Unfortunately, not everyone did, for there were few black aphids on the crops, and it is these farmers notice, rather than the green ones that are mainly responsible for spreading yellows. Those who delayed suffered needless loss, but even so the total yield of beet for the country was the second highest ever recorded. The prevalence of virus diseases in recent springs probably reflects the succession of mild winters; infected plants and aphids that would be killed by a protracted frost have survived, and warm dry days in spring have favoured the early movement and multiplication of the aphids. It is to be hoped that the cold spell at the end of 1961 broke the succession of years favouring aphid-borne viruses, but although intense, it was only brief.

Like sugar beet, potatoes yielded well, though they went into rough ground and grew slowly at first. Some areas of early varieties at Woburn never recovered from the effects of frost on 27 May, but the maincrop varieties later made good growth and were unaffected by blight (*Phytophthora infestans*) until the second half of September. Further evidence for our earlier conclusion that the fungus can spread below ground was provided by the unique event that the first record of the fungus was in a new tuber; this happened early in August when sampling a King Edward crop in which lesions could not be found above ground. Copper sprays are often said to decrease potato yields in blight-free years, but yields from sprayed and unsprayed plots killed with acid in mid-September did not differ significantly. Sprayed plots left to mature naturally yielded nearly a ton per acre more than unsprayed plots, but with the susceptible variety King Edward this gain was largely illusory: leaving the tops to mature multiplied the weight of blighted tubers twentyfold, and this loss more than offset the extra weight put on. Hence, even in this year when blight was generally thought to be unimportant, losses of tubers could be large unless the haulms were killed at a critical time.

The yield of early potatoes at Woburn was more than doubled by irrigation equivalent to 4 inches of rain, which at the higher dressing of nitrogen increased yields by 8 tons of tubers/acre. Attempts to replace traditional cultivations by weedkillers of the triazine type were not a success.

Except for one week in June and one in July, the summer was dry to the beginning of August, and the other crops tested all responded well to irrigation; the yields of grass and spring beans were more than doubled and of barley increased by about 7 cwt./acre. Grass responded little to fertilisers unless it was irrigated. August brought 18 rainy days, which delayed the cereal harvest, and most grain had to be dried, but this harvest ended early in September, after which conditions favoured the root harvest and farm work in general. The year ended very differently from 1960; not only all crops harvested, most land ploughed and winter wheat and beans all

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sown, but with 20° of frost on 29 December and 14 inches of snow on 31 December.

The ley-arable experiment

The practice of ley farming, or of taking the plough around the farm, has had many powerful advocates, and receives official blessing in the grants given to farmers who plough up pasture, but there have been few attempts to put the practice to objective test. There are those who would say the benefits are too obvious to need test, and it is true that the health of arable crops on land that has been allowed to become infested with soil-borne pests or diseases of arable crops can be strikingly improved by a period under grass. Also, the improvement after a neglected pasture is ploughed up and reseeded is usually self-evident. However, there are other methods of controlling soil-borne pests and diseases than a period under ley, and neglected pastures can be improved in other ways than by ploughing and reseeding; indeed, ploughed and reseeded pasture usually gets managed and manured in ways denied to old pasture, and benefits produced by these other changes may be being wrongly attributed to ploughing and reseeding. The apparently self-evident benefits of ley farming, therefore, fall far short of providing the evidence needed to decide whether, on any given area of land, ley farming is more productive per acre than keeping some of the land continuously under arable crops and some under permanent pasture. It is difficult to get such evidence, which requires complex experiments that continue for many years. The ley–arable experiment was started at Rothamsted in 1949 to provide some of the evidence, and some of the answers now begin to emerge. It followed a smaller experiment at Woburn, where the yields of potatoes and barley following 3 years of leys were little better than those in continuous arable cropping, even though on this light soil beneficial effects on soil structure might have been expected from the leys.

At Rothamsted the experiment is in two halves, one on Highfield, which had been permanent grass for very many years, and the other on Fosters, which had for long been under arable crops. In neither half has the system of ley farming produced arable crops that are strikingly better than those produced in the continuously arable rotation, provided only that the crops in the arable rotation were adequately manured. The one exception to this is that, on Fosters, wheat after lucerne has consistently yielded more than after any other treatment, but after grass leys yields have often been less than after arable crops. At first, potatoes yielded better in the ley–arable rotation than in the continuously arable, but since the amount of fertiliser given to the crop has been increased, potatoes have yielded similarly with all the treatments. Considering the difference in the past history of Highfield and Fosters, yields have been perhaps unexpectedly similar on the two halves of the experiment, but more fertiliser has been needed to give high yields on Fosters than on Highfield; for the first 6 years cereals did not respond to nitrogen on Highfield (though grass did), and only recently have responses become economic and approached those on Fosters.

On Highfield ploughing up the old grass and reseeding has had

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little effect on productivity, for the old grass left in place, reseeded grass left to grow indefinitely and 3-year leys, have all given about the same weight of dry matter per acre. On Fosters, too, temporary leys have produced no more than land put under permanent grass. In other places leys may be more productive than at Rothamsted, and periods under grass elsewhere may have beneficial effects on arable crops denied to us; this information should come from tests of ley-farming now being made on some of the Husbandry Farms of the National Agricultural Advisory Service, but meanwhile we can only report that in our conditions the practice has little to recommend it, provided that the rotations of arable crops avoid major soil-borne pests and diseases and that both arable crops and permanent grass are adequately manured.

The two halves of the experiment also show how impossible it is to generalise about the effects of a given practice on the state of the soil. On Highfield the organic matter of the soil has decreased steadily since the ley–arable experiment began, not only where arable crops are taken every year but also where they alternate with leys, whereas on Fosters the ley–arable rotation is steadily increasing the amount of organic matter in the soil.

Soils and fertilisers

The manurial experiment with mangolds grown continuously on Barnfield since 1876 ended in 1959 and has left a legacy of soils with very different contents of plant nutrients. This year we summarise the effects of the various types of manuring on yield of both mangolds and sugar beet, which were introduced into the experiment in 1946, and describe the changes in responses over the years, not all of which can be satisfactorily explained. The cropping and manuring will now be altered in ways that are hoped will explain some present puzzles and provide new information about the value to current crops of residues from past dressings of organic and inorganic manures. Particularly, the separate actions of magnesium and sodium will be assessed and tests will be made to see whether increasing the amount of inorganic nitrogen given will achieve yields so far attained only by farmyard manure plus inorganic nitrogen.

Results are reported of many other manurial experiments, on grass and most of the common arable crops, testing different kinds and forms of fertilisers, and different ways and times of applying them. Applying nitrogenous fertilisers as solutions to grass seems a practice not to be recommended, for it has consistently given slightly smaller responses than applying them as solids. Urea, which is being increasingly used, is more likely than other forms of nitrogenous fertilisers to damage germinating cereal seed, and only with urea is it worth using a side-band drill. Combine drilling and broadcasting other forms give yields similar to those obtained from side placement, but to use urea efficiently requires placing it at the side of the seed, and the extra yield from placement quickly repays the cost of the equipment needed to do it.

An interesting and potentially important addition to its value as a fertiliser was found for ammonium sulphate in apple orchards in Cambridgeshire, where apple scab starts each year from ascospores of the fungus (*Venturia inaequalis*) that survive the winter in fallen

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leaves. Broadcasting 3 cwt./acre ammonium sulphate 3 weeks before the time of bud-burst destroyed more than 90% of the ascospores that otherwise would have been liberated and provided sources of infection for the new growth.

Work with Broadbalk soils shows considerable effects of mineral fertilisers on crumb structure and porosity. That these properties are improved by organic manures is generally assumed, and few will be surprised by the fact that soil from the farmyard-manure plot has a better structure than that from the unmanured plot. However, it is no better than the structure on plots 8 and 16, which get only mineral fertilisers, so the improvement seems not to be a direct effect of the farmyard manure on the soil, but indirect by its nutrients increasing plant growth, and can be produced equally by mineral fertilisers that stimulate plant growth equally.

As we have previously reported that inoculating seed with *Azotobacter* sometimes increased yields of crops, it is necessary to say that this year there was no response in five field experiments with the "bacterial fertiliser". However, the *Azotobacter* did not establish well, probably because the soils used for the tests were too acid. Conditions for getting the bacterium established in the rhizosphere of crops are beginning to be better defined, so the prospects of getting consistent results seem brighter, and then perhaps its actions will become interpretable.

The many other lines of work with soils and manures reported this year, and not mentioned here, describe new information about factors affecting aeration, the manner in which major nutrients and trace elements are held in soil, the factors that affect their availability to plants, the break-down of organic matter of different types, the effects of soil conditions on soil organisms and of soil organisms on soil conditions.

Varietal differences in yield

The increases in yields of most crops over recent years have many causes, improved manuring, earlier sowing and less lost to pests and diseases or to competition from weeds. With some crops, such as potatoes, the whole increase is attributable to improved methods of cultivations, for the varieties now generally grown are the same as previously, but with cereals the increased yield is partly attributable to the introduction of higher-yielding varieties. There has been little work on the factors responsible for varietal differences in yield, so we have analysed the growth differences between new and old varieties of barley and of wheat (spring and winter). One difference between the two varieties of winter wheat that affects yield is that the old one (Squarehead's Master) lodges at levels of manuring where the shorter-strawed Cappelle remains erect, but the main difference is that the ears of Cappelle photosynthesise more and contribute more to the yield of grain than do the ears of Squarehead's Master. Similarly, the new varieties of barley and of spring wheat also yield more than the old because the ears assimilate more, and not because of increased leaf area or increased assimilation rate in the leaves. Such comparisons cannot show whether intrinsic yielding capacity can be increased in other ways, but the fact that the same principle

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is operating in barley as in both winter and spring wheat suggests that this one is probably more readily changed than others.

Leaf protein

The work on producing leaf protein suitable for human consumption progressed at all stages of the process, from the selection of suitable plants to improvements in the methods of extracting the protein and of preserving it once prepared. The last is dietetically important, for the nutritive value is lowered by over-heating during drying. However, perhaps the most valuable progress was in the increasing interest shown in the work by organisations in several tropical countries where protein deficiency is a major cause of malnutrition. We have done the necessary work to establish that a nutritionally desirable protein, which would make a valuable supplement to diet, can be made, but whether it can be made economically where it is most needed can be established only by a thorough test in the countries where work is now beginning.

The use of pesticides

The use of toxic chemicals in agriculture is a subject that receives much publicity, usually emphasising hazards, real or imagined, rather than the benefits. We again record many examples of the large increases in yield that can result from using appropriate pesticides, and agriculture obviously cannot afford to forgo such increases. However, it would be foolish to expect that yield increases are their only effects and that they do nothing except kill the pests at which they are aimed. The need to assess probable other effects is the reason for much of our work on the stability of insecticides in different environments and on the different ways they act; also for our population studies, not only of pests but also of other organisms, particularly those usually described as beneficial. Increasing attention is now being given to the soil fauna and flora, for it is in rather than over the soil that residues from pesticides can be expected to accumulate and perhaps have lasting consequences. The major effects we describe of long-continued spraying with copper fungicides on the soil and soil fauna in some apple orchards show the kind of thing that can happen when residues accumulate. The need for more knowledge is urgent, because pesticides are likely to be applied to the soil much more than they have been; until now, this has been done only to control soil-inhabiting pests, but, as our report shows, there is increasing likelihood of it being done to control foliage pests such as aphids. Systemic insecticides applied to seeds, to potato seed tubers or to the soil at time of sowing can keep plants free from colonising aphids for several weeks, so protecting seedlings from pests and vectors of viruses while they are too small to be sprayed effectively; it is also cheaper than spraying, is less likely to affect predators of aphids and avoids the chance of drift or of the chemical harming anything that does not actually feed on the crop. Some of these advantages might also come by replacing spraying by dusting crops with granulated forms of insecticides, which this year was as effective as spraying in checking sugar-beet yellows, but this again would probably increase the amount of insecticide that enters the soil.

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Fortunately, most such insecticides are unstable and will soon be destroyed in soil, so any effects they have on the soil fauna are likely to be temporary only. Tests of nematicides at Woburn showed how brief effects can be from soil treatments that have immense effects on crop yields. Applying a nematicide to land heavily infested with potato-root eelworm increased the yield of Majestic potatoes from 4 cwt. to over 11 tons/acre, but the eelworm population was only temporarily made harmless. After harvest, there were as many eelworm cysts on the treated as the untreated plots, for the few eelworms remaining after the treatment, presented with abundant roots on the vigorous potato crops, multiplied abundantly and restored their initial population within a year. Similar rapid changes in population are not peculiar to eelworms, but are to be expected with all rapidly multiplying organisms when exposed to transient conditions that limit their numbers. Essentially the same phenomenon is described after spraying sugar-beet crops with organophosphorus compounds. For a time the sprayed crops were free from both aphids and their ladybird predators (which probably disappeared more because they had nothing to eat rather than because the spray killed them), but as the insecticidal action wore off, first aphids and soon after ladybirds recolonised the sprayed crops, and within a few weeks populations of both were the same in both sprayed and unsprayed crops.

However, not all the chemicals used to protect plants are unstable, and it is the stable ones that are mainly applied to soil. If, as our preliminary tests suggest, some of the chlorinated hydrocarbons are also fungicidal and may affect such diseases as take-all, their use might increase still further. To assess the consequences, we are studying their effects, not only in checking pests and diseases, but on the whole soil fauna, and are measuring the rates at which they disappear in soil. That they change the fauna greatly is already clear, but whether residues will accumulate and produce lasting changes, and, if so, whether these will be harmful or beneficial to crops, remains to be discovered. So, too, does much of the biological knowledge that is needed before pesticides can be used most economically and with the least risk of side effects, whether of killing organisms other than those the pesticide is aimed against or of producing forms of pests that resist current insecticides. Without this knowledge, which we seek from our work on the factors that determine the multiplication and behaviour of pests, pesticides will be used as a routine insurance against possible losses and not only where benefits from their use are assured. The epidemiology of some pests and diseases is already sufficiently understood to forecast when and where pesticides are needed, and for the control of these anything but discriminate use is clearly imprudent, but this is not yet generally true. Until it is, farmers cannot know when they can safely dispense with a pesticide and thereby save its cost, and most will consider it as improvident not to use a cheap and effective pesticide routinely as they would not to insure against losses from fire.

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Bees

That the use of insecticides does have undesirable results is evident enough from the poisoning of bees; of forty-five samples sent to us this year suspected of being poisoned, thirty-two contained insecticides and one had probably been killed by a fungicide containing mercury. To what extent these poisonings happen when pesticides are being used as recommended, it is impossible to tell, but that misuse and carelessness sometimes play a part is more than suggested by finding that one hive in which bees had died had been "protected" by being covered with a sack that had contained insecticidal seed-dressings.

Tests with synthetic queen substance show that this is not the only chemical that queen bees produce to inhibit workers from rearing new queens; another is volatile, seems to be produced by glands in several parts of the body, and both it and the queen substance are needed to stop queen rearing completely. Neither seems to be the scent whereby a queen attracts bees over a distance, and it is obvious that identifying queen substance is only a start towards understanding the full chemical mechanisms whereby queen bees rule their workers.

Pollination studies suggest that pollination is increased by feeding colonies syrup before taking them to the crop to be pollinated and that they should not be taken there until the crop is flowering; also, methods currently recommended for arranging pollinator varieties in orchards of self-sterile fruit trees seem not those likely to give the maximum set of fruit.

An unwelcome catch

Insect and spore traps are operated regularly to give quantitative and qualitative information about the biological contents of the air. In two previous years a few spores were caught of *Pithomyces chartarum*, a fungus not previously reported in Europe, which in New Zealand produces a toxin, sporidesmin, responsible for the serious disease of sheep known as facial eczema. This year portable spore traps were used to sample air in several places, and high concentrations of spores were found in some, which were then searched and the fungus found growing on the remains of cut grass. Whether the British strains produce sporidesmin is being tested in collaboration with workers in New Zealand.

A welcome gift

We gratefully acknowledge the gift from Elliott Brothers of a 402 computer, which will not only relieve the over-burdened 401 but will ease the transition in 1963 to the Orion with its much greater capacity than the 401. The 402 will be used mostly to analyse surveys, and the General Survey Programme has already been transcribed for it. A General Experiments Programme to analyse replicated experiments of many different designs is now almost complete. The amount of computation in the Statistics Department increased by more than a third over that of 1960, and was concerned with problems about as diverse as they possibly could be. Most, of

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course, were agricultural; these ranged from surveys of fertiliser practice and cattle fertility to forecasting cocoa yields in Ghana for the next 10 years and analysing long-term experiments on coconuts in Ceylon; but they obviously did not tax the versatility of our statisticians, whose other work extended to studies on the capture and recapture of bats and intelligence tests in children, to the planning of motorways and the age of menarche in Bantu girls.

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