ROTHAMSTED RESEARCH

Report for 1953

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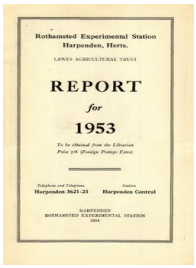

Insecticides and Fungicides Department

C. Potter

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INSECTICIDES AND FUNGICIDES DEPARTMENT

C. POTTER

Miss Pauline Smith left the department during the current year, and has been replaced by Mr. R. Bardner. Following visits by Colombo plan students to the department, Mr. Kirthisinghe of Ceylon, one of the students, arranged to work here for three months. Mr. Bernet of Switzerland is working in the department for six months.

CHEMICAL

Physical chemistry

Particle size and toxicity of suspensions of contact insecticides. This work has been continued and very nearly completed.

In the past the toxicities of colloidal and crystalline suspensions of DDT and its analogues have been compared by dipping insects in them for a few moments. After this the insects are taken from the suspensions with poison sticking to them, and are kept for a day or more till counts of kill are made. The amounts of poison retained are not necessarily the same for different types of suspension.

Methods have been worked out for washing the poison from treated insects and chemically analysing the extracts. In this way it is possible to find out exactly how much poison is retained by the insects. Retention by adult grain beetles (*Oryzaephilus surinamensis* L.) seems to be purely mechanical, depending on the size and shape of the poison particles in the suspensions, and not on any other properties. Thus, crystals of different poisons but of the same size are retained equally well. Needle-shaped crystals are retained better than plate-shaped crystals. Poorest retention is found with plate-shaped crystals of about 25 μ; particles smaller or bigger than this are retained more efficiently. With some compounds there is no method for micro-analysis. In such a case the retention can be guessed by comparison with another compound that has analysable crystals of the same size.

The results of all comparisons of toxicity already made with compounds of the DDT type have been corrected to allow for differences in retention amongst the suspensions.

When this was done it was found that, although colloidal poison was always more toxic than the same poison in crystalline form when the insects were kept cool after treatment, the size of the difference in toxicity still varied from one DDT analogue to another.

Two qualities that might influence the size of the difference in toxicity were mentioned in last year's Report. If the crystals of a compound dissolve very slowly (compared with the deposit from the colloidal poison) in the wax of the insect cuticle, or if the colloidal suspension gives a deposit on the insects that crystallizes out slowly, the compound is likely to show a large difference in toxicity between crystals and colloid.

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The corrected results of a great many tests made in the last three years have now been examined; the only compounds in the DDT series that show a large difference in toxicity between crystals and colloid are those that have *both* the above qualities. One quality or the other on its own is not enough; the reason for this is not clear.

This subject is reviewed in a special article on page 176.

Temperature coefficients of kill by volatile solid insecticides.

The temperature at which insects are kept after treatment is important in deciding the kill. With contact poisons, lower temperatures after treatment often give higher kills, i.e., the temperature coefficient of kill is often negative. With commercial insect fumigants lower temperatures of exposure sometimes give higher kills, but this is unusual.

Three volatile solid insecticides (DFDT, γ-BHC and aldrin) were tested against two species of grain beetle (*Oryzaephilus surinamensis* L. and *Tribolium castaneum* Hbst.) at two exposure temperatures (30° C. and 11° C.) in simple laboratory fumigation tests. DFDT killed both species faster at 11° C. than 30° C.; γ-BHC killed *O. surinamensis* faster at 11° C. than 30° C., but *T. castaneum* faster at 30° C. than 11° C.; aldrin killed both species faster at 30° C. than 11° C.

Biochemical

The investigation on insect esterases and their inhibition by organo-phosphorus compounds has been continued by K. A. Lord and C. Potter, with the assistance of D. Holbrook. The comparison of the relative toxicities of para-oxon, TEPP, parathion and two of its analogues, reported last year, has been completed. The inhibitor power of the five poisons has been determined on choline esterase and a general esterase that does not hydrolyse acetyl choline derived from each of the four species of insects *Blatella germanica* L. adults, *Tenebrio molitor* L. adults, *Dysdercus fasciatus* Sign. adult males and *Tribolium castaneum* Hbst. adults used in the toxicity tests.

In general, the poisons are more active inhibitors of the enzyme which does not hydrolyse acetyl choline, although this is not so in every case. The inhibition data suggests that both kinds of esterase differ from species to species. This work is being prepared for publication.

Work is now in progress on the variations in amount and behaviour of esterases on different instars and species of insects. A short publication on this subject has already been made. In addition, an attempt is being made to determine the location of the esterases in the insect tissues, and techniques are being investigated for isolation of the esterases from insect extracts and studying their properties. This work is intended to provide a basis for the study of the *in vivo* action of organo-phosphorus compounds.

In connection with the studies on the action of systemic insecticides on bees and on the use of systemic insecticides to control aphids on sugar beet, a little work has been done on the behaviour and action of organo-phosphorus compounds within the plant. This work may be extended.

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Organic chemistry

M. Elliott and P. H. Needham are continuing the work on the relationship between the insecticidal activity and the chemical constitution of pyrethrin-like compounds, and a publication is in preparation. In connection with this work two new routes to biologically active compounds of the pyrethrin type are being developed. It is hoped that it may be possible to produce toxic compounds more easily by these routes than those at present available, but the work is not sufficiently far advanced to give details at present.

In the course of this work some pure organic chemistry of general interest was carried out, of which a short account is given below.

Ultra-violet absorption of unsaturated compounds related to succinic anhydride. In the Report for 1951 (p. 117) it was stated that *iso*-alkylidene succinic anhydrides show maximum absorption at 2,350 Å. (ethanol), whereas the corresponding acids have $\lambda_{max.}$ 2,200 Å. (ethanol). The table below shows the ultra-violet absorption maxima of compounds selected to investigate this phenomenon. Since crotonic acid ($\lambda_{max.}$ 2,130 Å.) and crotonic anhydride (VIII) absorb at the same wavelength, it is improbable that conjugation is transmitted through the anhydride (—O—) oxygen in the latter compound and, therefore, in compounds (II), (IV), (VI) and (VII); moreover, $\lambda_{max.}$ for the system MeCH=CH·COR is the same whether R be (—OH) or (—O—). Again, maleic acid and maleic anhydride (VII) have almost the same $\lambda_{max.}$, indicating that an endocyclic double bond does not produce a bathochromic shift in the anhydride. To eliminate the possibility that an enolic structure, (IX), might contribute to the absorption spectrum of (II), the infra-red spectra of (II) and of (VI), which could not enolize, were compared (gratitude is expressed to Dr. L. Crombie of the Organic Chemistry Department, Imperial College of Science and Technology, for these measurements), but no bands in the hydroxyl region were found with either compound. Woodward (*J. Amer. chem. Soc.*, 1942, **64**, 76), collected data to show that αβ-unsaturated ketones with exocyclic double bonds had maxima nearer the red than corresponding compounds without exocyclic double bonds. It appears, therefore, that an exocyclic double bond conjugated with the carbonyl group of an anhydride also exerts a bathochromic effect in comparison with related αβ-unsaturated acids and anhydrides without exocyclic double bonds.

The ultra-violet absorption spectrum of a fulgide such as (VI) has not been previously determined. The very broad absorption band ($\lambda_{max.}$ 2,760 Å.) is obviously related to the phototropic properties of the fulgides with phenyl and other aromatic substituents.

The constituents of pyrethrum flowers. Work on separation of the constituents of extract or pyrethrum flowers has been continued. The technique of displacement chromatography has been applied to the problem, and by its use J. Ward has separated the four known active constituents from each other and from some inactive constituents of pyrethrum extract. The separation was achieved by adsorbing the pyrethrins on activated alumina and eluting with a solution of stearic acid in normal hexane. A note on the process has been published. Later work was directed to achieving a separation on a larger scale. Difficulties were encountered in scaling up

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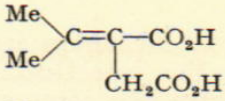
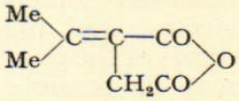
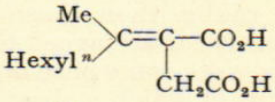
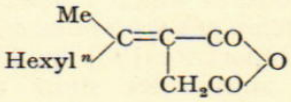
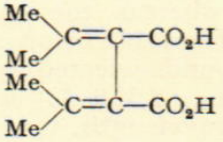
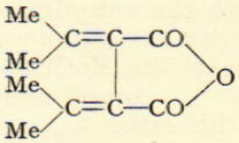
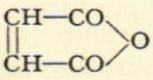
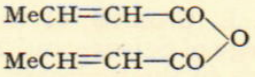
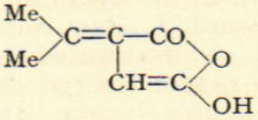
Compound	Structure	$\lambda_{max.}$ (Å.)	$\epsilon_{max.}$
I. *iso*Propylidene succinic acid		2,210	9,400
II. *iso*Propylidene succinic anhydride		2,350	12,500
III. γ-Hexyl γ-methyl itaconic acid		2,250	8,730 (methanol)
IV. γ-Hexyl γ-methyl itaconic anhydride		2,350	12,600
V. Tetramethyl fulgic acid		2,200	15,000
VI. Tetramethyl fulgide		2,190 2,760	12,110 11,500
VII. Maleic anhydride		2,130 2,130	8,900 (ethanol) 10,300 (hexane)
VIII. Crotonic anhydride		2,140	23,400 (hexane)
IX.		—	—

the process, but about 100 mg. of cinerin I and 300 mg. of pyrethrin I have now been obtained. Certain physical constants of these materials have been measured and their dinitrophenylhydrazones prepared. An automatic fraction collector is being built, and the chromatographic work will be continued as soon as this is completed. A rough assessment of the biological activity of these four compounds to mustard beetles, *Phaedon cochleariae* Fab., has been made by P. H. Needham. Their relative toxicities were as follows :

	LD 50% w/v	Relative potency
Cinerin I	0·0020	10,00
Pyrethrin I..	0·0010	2,000
Cinerin II	0·0050	400
Pyrethrin II	0·0026	769
Allethrin	0·0250	80

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Biological

Pyrethrum

(*a*) In addition to the work already described on this subject, members of the department have taken part in a collaborative study on the insecticidal activity of strains of pyrethrum. This work is in preparation for publication.

An estimation of the activity of a strain of flower collected from Aden has been made by P. H. Needham at the request of the Colonial Products Advisory Bureau, with results as follows :

Proportions of Pyrethrin I and Pyrethrin II in sample treated

Extract of flowers from Aden

	%
Pyrethrin I	0·35 w/v
Pyrethrin II	0·16 w/v.
Total pyrethrins	0·51 w/v.

Extract supplied by Cooper Technical Bureau

Pyrethrin I	13·67 w/v.
Pyrethrin II	10·99 w/v.
Total pyrethrins	24·66 w/v.

Relative toxicities against Tenebrio molitor

	Measured drop, %	Injection, %
Aden extract	0·100	0·120
Cooper's extract	0·122	0·130
Allethrin	0·950	0·480

Concentrations of total pyrethrins required to give 50 per cent kill.

(*b*) A study of synergism of the pyrethrins has been started by C. Potter, K. A. Lord and D. Holbrook. The object of this work is to investigate some of the biological and physico-chemical factors that influence synergistic action and at the same time to obtain detailed information on the performance of some particular synergists with the pyrethrins. So far, performance curves have been obtained for the synergistic action of piperonyl butoxide (technical material containing 80 per cent of 3 : 4-methylenedioxy-6-propylbenzyl (butyl) diethylene glycol ether) and Sulphoxide (*n*-octyl sulphoxide of *iso*safrole) under one set of experimental conditions using *Tenebrio molitor* L. adults as test subjects and preliminary data using *Blatella germanica* L. adults and *Phaedon cochleariae* Fab. adults.

Investigations were also carried out on the synergistic properties of *Melaleuca bracteata* Nuell. oil sent to us from Kenya by Mr. Gilbert Walker, and a performance curve has been obtained, using *T. molitor* adults as the test insect. Further investigations are to be carried out on *B. germanica* and *P. cochleariae* when these insects become available.

Bioassay techniques

Measured drop and injection technique. The range of application of the micrometer syringe used for these bio-assay techniques has been increased by a modification permitting the rapid reproduction of doses down to 0·000125 ml., utilizing the clicking device

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described last year. A variety of media can be employed with this apparatus, including water, odourless distillate and acetone.

The use of the 0·000125-ml. drop enabled the aphid *Megoura viciae* Buckt, to be added to the list of suitable test insects.

Film method for contact poisons on glass-climbing insects. Contact insecticides are often tested by a film method : a surface such as paper is sprayed with an insecticidal preparation and then allowed to dry, giving an even film on the surface. Insects are allowed to run on the treated surface. This method is suitable for flat surfaces and for insects that cannot climb the smooth vertical surfaces that are often used to contain them on the film.

During the course of his work on particle size effects, A. H. McIntosh had occasion to compare a number of contact poisons as residual films, and he and Mrs. Macfarlane developed a technique for this purpose which can be used with species of insect that can climb smooth surfaces. The technique is also of general application.

An even film of insecticide is made on a 9-cm. circle of filter-paper. When the paper is dry, it is folded loosely in half and the edges fastened together with an Emgee " Multigrip " rotary paper crimper. A small opening is left at one end. Through this the insects are inserted into the paper, by way of a glass funnel if necessary. Fifty adult *Oryzaephilus surinamensis* L. are used for each paper. The opening is closed by crimping, and the paper is stored at constant temperature. The insects are quite unable to crawl off the treated surface. The method is simple to use. The papers do not take up much constant-temperature space; they can be stored flat or upright. Repeated cleaning of glassware is unnecessary. If more than one count of kill is needed, the paper can be opened and crimped again several times.

The effect of bio-assay technique on relative toxicity. During some recent routine bio-assay tests on some extracts of different strains of pyrethrum flowers, for the Colonial Products Advisory Bureau, in which " allethrin " was used as a standard reference insecticide, an interesting point arose concerning the difference in relative toxicity of allethrin and natural pyrethrins when injected and applied topically.

This is now being investigated more fully, and a note on it will be published in the near future.

Bio-assay of phosphorus insecticides. Since organo-phosphorus compounds are being extensively used in the departmental field experiments, it seemed desirable to have detailed information on their insecticidal action. A series of laboratory tests have therefore been started to investigate the relative importance of the contact, stomach poison and fumigant activity of a series of organophosphorus insecticides with systemic action including " Systox ", " iso-Systox ", schradan, " N.C.7 " and parathion.

The contact activity of these poisons has been investigated against *Phaedon cochleariae* F. and *Megoura viciae* Buckt., and it is intended to add also *Alphitobius laevigatus* F. and *Diataraxia oleracea* L. larvae.

The investigation of all three factors will be made against *Diataraxia oleracea* L. larvae with which a start has been made on stomach-poison tests.

If a suitable technique can be arranged for *feeding* known doses

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of poison to an aphid, *Megoura viciae* Buckt, will be included in the stomach-poison tests.

Toxicity and persistence of insecticidal deposits

Work on this subject was continued by J. Ward and P. E. Burt during the first half of the year. Thereafter the entomological side of the work was taken over by M. J. Way and E. M. Gillham.

Microscopical techniques were investigated in order to find a method of observing the very small crystals of DDT which have been used. It was found that the most satisfactory method was to mount them in glycerol or water and view them with dark ground illumination. In this way it is possible to follow the evaporation of the crystals on slides stored for different periods.

The deposits formed when various types of emulsion are sprayed were studied. It was found that an emulsion of 25 per cent re-crystallized DDT in xylene gave a deposit with crystals of about the same size as those in the suspensions previously used. The crystals appeared over a period of about 6 hours from the time of spraying. The toxicity of these deposits to *Tribolium castaneum* Hbst., on both glass and leaves, was of the same order as that of deposits from suspensions and the rate at which toxicity decreased when the deposits were exposed in a glass-house was also about the same.

The work described in the Annual Report for 1952 had suggested that the main cause of loss of toxicity of DDT deposits under our experimental conditions was volatilization of the DDT. Further evidence that this was so was obtained by exposing sprayed plates in a still atmosphere and in a draught from an electric fan. It was found that the plates in moving air lost their DDT more than twice as rapidly as those in still air. An attempt was made to reduce the rate of evaporation of DDT by mixing it with a resin. An emulsion was made of a solution in xylene of equal weights of DDT and of "Arochlor 5460", a chlorinated polyphenyl resin. This formulation produced a deposit consisting of droplets of a viscous liquid which did not crystallize even after several weeks. On exposure to high temperatures and to sunlight, however, DDT was lost at least as rapidly as from crystalline deposits. It is thought that a mixture containing a larger proportion of resin may prove more successful, and this will be tested in due course.

The mechanism of selection of strains of insect resistant to insecticides

F. Tattersfield and J. Kerridge have continued their work on this subject. Two papers giving an account of work carried out in previous years have been published in the *Annals of Applied Biology*. A number of issues arising out of previous work have been examined.

Problems arising from the CO_2-sensitivity of the strain of *Brosophila melanogaster* Meig. used have been investigated.

(*a*) A preliminary series of tests showed that these insects could be "conditioned", i.e., by administering sub-lethal doses of CO_2, the insect for a period showed an increased resistance to the toxic effects of this gas.

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A more elaborate experiment on a stock of insects which, however, were not of the highest susceptibility, in which successive increases in concentrations of CO_2 were administered at 24-hour intervals for four days showed on statistical analysis that the average proportion surviving was significantly greater than in the case of fresh insects. M. J. R. Healy of the Statistical Department confirmed this finding by the use of a more rigorous analysis. Certain other points emerging from our analyses, and those of M. J. R. Healy, will need further investigation.

(*b*) A series of respiration experiments with strains of *D. melanogaster* sensitive and non-sensitive to CO_2 at temperatures of approximately 15° C. have not indicated any difference between them in rate of respiration of sufficient significance to account for their marked differences in sensitivity to CO_2. The investigation, however, showed up grave imperfections in the several techniques employed.

Tests were undertaken to ascertain whether *D. melanogaster* could be " conditioned " to the effects of insecticides. The work is in progress, and data obtained by the application of DDT and BHC to the adults are being examined. So far, the results do not indicate that such is the case.

We are being compelled to undertake experiments on the effects of certain environmental factors such as food, etc., upon the viability of *D. melanogaster* adults and on their resistance to DDT. Preliminary investigations have shown that some of these factors are of considerable importance, and it is proposed to extend the investigations.

At Professor L'Héritier's suggestion we undertook during the autumn to examine *Drosophila melanogaster* Meig. captured in different localities to ascertain how widespread was their susceptibility to CO_2. Dr. H. Kalmus, of the Galton Laboratory, who kindly undertook to arrange the trapping, and Miss J. Kerridge have found that such sensitivity is widespread with this insect, confirming results obtained by Professor L'Héritier.

Insect rearing

Fourteen species of plant-feeding insects and eleven species of stored-products insects were reared during the year. Four species were added to the previous year's list: the " Khapra " beetle, *Trogoderma granarium* Everts.; the willow aphid, *Tuberolachnus saligna* Gmel.; the ladybird beetle, *Coccinella septempunctata* F.; and the wheat bulb fly, *Leptohylemyia coarctata* Fall. *C. septempunctata* is being reared in connection with the field experiments on the pests of field beans, and the wheat bulb fly is being reared in order to provide material for insecticide tests on the control of the insect.

J. Kenten has continued her work on the factors influencing the production of the various forms of the aphid *Acyrthosiphon pisum* (Harris), and has made observations throughout the year on an unidentified species of *Phaenobremia* (Cecidomyidae) which causes considerable damage to the laboratory cultures of the aphid *Macrosiphoniella sanborni* Gill. The following is a short progress report on the observations and experiments on the biology

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of the four species (a) *Cocinella septempunctata* F., (*b*) *Phaenobremia* sp., (*c*) *Acyrthosiphon pisum* Harris, (*d*) *Leptohylemyia coarctata* Fall. :

(*a*) *Coccinella septempunctata* F. An attempt was made to rear *Coccinella septempunctata* F. in the laboratory for use as a test insect for the study of insecticidal action. It was found difficult, however, to rear the large numbers that would be required for this purpose owing to the large quantities of aphids necessary for food. It was also found that the adults were very erratic in their egg-laying habits when kept under greenhouse conditions, which suggests that it might be difficult to ensure an all-the-year-round supply. However, P. Forbes has been able to rear a series of six generations throughout the year by keeping some insects at constant temperatures of 20° C. and 24° C. and under continuous illumination. It is considered therefore that should this insect be required it could, if necessary, be reared in moderate numbers throughout the year, but that it would not be practical to rear it as a test insect for general purposes.

(*b*) *Phaenobremia* sp. Observations have been made throughout the year on an unidentified species of *Phaenobremia* (Cecidomyidae), a predator of the aphid *Macrosiphoniella sanborni* (Gillette), which causes considerable damage to the laboratory cultures of this aphid. The midge larvae were first observed attacking the aphid culture during May, and from an initial stock of about twenty larvae, five generations of midges were reared in the laboratory, the last midges emerging during October. A complete life cycle took from four to five weeks, of which (very approximately) the egg stage took four to five days, the larval stage eight to fifteen days, pupal stage thirteen to sixteen days. The length of life of the adults was very variable (probably due to an imperfect rearing technique) and many died after one to two days ; a number, however, lived from fourteen to seventeen days, and on one occasion an unfertilized female lived for twenty-three days. This particular female was dissected after death and found to contain 116 fully developed eggs. No larvae was ever obtained from unfertilized females.

It was not found possible to induce midges to lay their eggs on bean plants bearing aphids *Acyrthosiphon pisum* Harris or *Aulacorthum circumflexus* Buckton. They would, however, lay their eggs on chrysanthemum leaves bearing no aphids, and on cotton-wool strands, and the resulting larvae fed readily on *A. pisum* and *A. circumflexus*, and in both cases adult midges were obtained.

(*c*) *Acrythosiphon pisum* Harris. Experiments to test the effect of different photoperiods and temperatures on the reproduction and production of various forms of the aphid *A. pisum* have been discontinued. It was found that this aphid will readily produce sexual forms at temperatures below 20° C., if parent apterae are given a daily photoperiod of 8 hours during the period from birth until the last imaginal moult. If, however, parent apterae received a daily photoperiod of 16 hours during this period they produced only parthenogenetic forms. In both instances the treatment the parent aphids received after their last imaginal moult had no effect on the proportion of sexual offspring they produced. The temperature which favoured the optimum production of males differed from that which favoured the optimum production of females. The largest numbers of male offspring were obtained at 19–20° C. (20–30 per

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cent), of females at 11–13° C. (50–80 per cent). No sexual forms were obtained at temperatures above 25–26° C.

The length of life of the aphids increased with decrease in temperature from approximately twenty-two days at 29–30° C. to approximately 140 days at 5–9° C. Maximum reproduction occurred at 19–20° C., where an average of seventy-seven to eighty-six offspring were produced per parent. Above and below this temperature the reproduction dropped to none to sixteen per parent at 29–30° C. and twenty to thirty-four per parent at 5–9° C. The offspring produced by aphids kept at 29–30° C. from birth were abnormal, in that their nymphal period was frequently prolonged and that when mature they were considerably smaller than was usual.

(*d*) *Leptohylemyia coarctata* Fall. An attempt is being made to rear *Leptohylemyia coarctata* Fall., the wheat bulb fly, in the laboratory on a large scale. Pupae were obtained from Dr. H. C. Gough of the National Agricultural Advisory Service, Cambridge, shortly before the flies emerged at the beginning of June; of these approximately 50 per cent produced adult flies. These flies were kept in the laboratory under a variety of temperature conditions in two types of cages, muslin-covered cages (2 feet × 2 feet × 2 feet) and in cages made from hurricane lamp-glasses. The majority of the flies received a diet of three foods: honey, condensed milk and blood, a number, however, were given other diets, i.e., Bovril and honey, Bovril and condensed milk, condensed milk and honey, blood and honey, honey, blood; these flies were kept in lamp-glass cages. Egg-laying commenced at the beginning of July, and continued, in some instances, until October. The eggs were collected every two to three days and counted. It was found that the flies in the lamp-glass cages receiving a diet of the three foods (honey, condensed milk and blood) produced many more eggs than either the flies kept in the large muslin cages receiving the three foods or the flies kept in the lamp-glass cages receiving the other diets, i.e. :

Eggs per female	
115–242	for flies in lamp-glass cages fed on three foods
0–19	for flies in lamp-glass cages fed on other diets
10–35 (approx.)	for flies in muslin cages fed on three foods

The eggs obtained from these flies and from other flies caught in the field, were placed at a number of conditions of humidity and temperature to find the conditions necessary for optimum survival. So far, it has been found that at temperatures of 20° C. and above the eggs soon become infected with mould, and at 30° C. the eggs did not develop at all. At relative humidities of 96 per cent and below (at 20° C.) eggs became desiccated and collapsed. Some of the eggs are receiving a variety of temperature treatments in an attempt to break the diapause of the egg.

The effect of plant-protective chemicals on pollinating insects

D. Glynne Jones and J. Connell have continued their work on this subject at Seale-Hayne Agricultural College. The bio-assay of various chemicals has been continued, and those tested include

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melathon, " Pyrolan ", endrin, " Systox " and " N.C.7 " (Peat Control Ltd.). The results may be summarized as follows :

Stomach poison	mg./bee
Malathon (LD50/24 hours)	$31{\cdot}6 \times 10^{-5}$
" Pyrolan "	$137{\cdot}6 \times 10^{-5}$
Endrin	$141{\cdot}3 \times 10^{-5}$
" Systox " (active ingredient)	$147{\cdot}8 \times 10^{-5}$
" N.C.7 "	$359{\cdot}3 \times 10^{-5}$
Contact poison	mg./sq. cm.
Malathon (LD50/24 hours)	$107{\cdot}2 \times 10^{-5}$
" Pyrolan "	$454{\cdot}3 \times 10^{-5}$
Endrin	$495{\cdot}7 \times 10^{-5}$
" Systox " (active ingredient)	$512{\cdot}3 \times 10^{-5}$
" N.C.7 "	$1230{\cdot}0 \times 10^{-5}$

No fumigant or residual contact effect is to be expected when these chemicals are used at normal field concentrations.

The possibility of the active ingredient of " Systox " contaminating nectar following foliar applications has been investigated using radio-tracer techniques in collaboration with Dr. Thomas of the Long Ashton Research Station. The rate of translocation from treated to untreated leaves was shown to be much slower than for schradan, and the amounts appearing in nectar are very small. The investigations into the action of dusts on the waterproofing mechanism of the honeybee and other adult hymenoptera has been continued, and are now being prepared for publication.

Evidence has been offered to the Zuckerman Working Party considering the effect of toxic chemicals on wild life.

Field Experiments

Control of Aphis fabae *on field beans*

M. J. Way assisted by P. H. Needham continued the work on this subject. As a continuation of the 1950–52 trials, an account of which has been sent in for publication, a more ambitious experiment was laid down to compare parathion, " Systox " and DDT sprays for control of bean aphid, *Aphis fabae* Scop., on field beans. Replicated plots of spring and autumn sown beans were planted, and tractor-drawn farm spraying machinery was used to apply the the insecticides. Unfortunately the aphid infestation did not develop. Only one insecticide treatment was applied, and this showed that the spraying machinery, comprising a spray boom with drop bars, gave satisfactory coverage of the crop. The experiment is to be repeated during 1954.

A small-scale replica of the main field trial was laid out on the Garden Plots. Shrubs of spindlewood, the winter host of *A. fabae*, were planted near by. These were attacked by the aphid, and from them many alatae migrated to the beans during June. However, due to the cold, wet weather, aphid colonies did not build up, and counts of flower, pod and seed production on sprayed and unsprayed plots showed that the aphis attack had no effect on development of autumn sown, and little effect on the spring sown, beans.

In three small field trials at Woburn and at Rothamsted bean

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aphis control was attempted with seed and soil treatments of the systemic insecticide " Systox ". The insecticide was applied as seed dressings or as a soil treatment in the seed drill at the time of planting in early March. The seed dressings, which comprised relatively low doses of " Systox ", had no recognizable effect on the small aphid attack which developed in June and July, but the soil treatment kept the crop practically free of aphids until it was harvested in August. It is interesting that all treatments were toxic to the adult pea and bean weevil, *Sitona lineata* Linn., and markedly reduced feeding damage by this insect during May.

Effect of insecticides on the aphid–parasite–predator complex

In conjunction with the Entomology Department a preliminary attempt was made to assess the importance of certain aphid parasites and predators in reducing aphid populations on field beans and on a brassica crop. Laboratory experiments showed that 0·3 per cent w/v. calcium arsenate sprayed on aphid infested cabbages and field beans had little effect on *Myzus persicae* Sulz. and no effect on *Aphis fabae* Scop. The insecticide was, however, toxic to Braconid parasite adults and to Coccinellidae, especially the larvae. In view of this selective effect the insecticide was used to treat small plots of beans and cauliflowers at fortnightly intervals from the beginning of June. Predators were relatively scarce, and no Braconid parasites were recorded on the beans. The insecticide reduced the Coccinellid population almost to zero, but appeared to have little effect on Syrphid larvae. The *A. fabae* population rose higher than that of the untreated control plants, but the experiment was spoilt by severe phytotoxicity caused by the calcium arsenate during humid conditions in July. This phytotoxicity had not shown up in the laboratory trials.

On the cauliflowers a few colonies of *Brevicoryne brassicae* Linn. and *M. persicae* were recorded, but in both treated and control plots the numbers fell almost to zero in September, after reaching a peak of around fifty per plant in July. Occasional Coccinellid adults, Syrphid larvae and Braconid parasites were recorded on clusters of *B. brassicae*. No Coccinellid eggs or larvae were found. It seemed that unfavourable weather was responsible for the scarcity of aphids, which never became sufficiently abundant to attract significant numbers of parasites or predators.

Wheat bulb fly

Field trials on the protection of wheat against wheat bulb fly (*Leptohylemyia coarctata* Fall.) by the use of insecticides have had little success so far. M. J. Way and R. Bardner have started work on this problem. The most promising method would seem to be the control of the newly-hatched larvae at the stage where they enter the wheat seedling. To gain further information under more closely controlled conditions than hitherto, a small-scale experiment is in progress, using wheat planted in seed-boxes. Known numbers of eggs, obtained from flies kept in the laboratory, have been placed in the boxes, and the efficacy of several insecticides in various formulations in reducing the number of infested plants is being tested. For any treatment to be practical economically,

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the insecticide would probably have to be applied at the time of sowing in the autumn to control larvae which hatch in early February, and preliminary experiments on the effective persistence of soil insecticides for this length of time are being carried out. The possibility that soil insecticides might have an appreciable ovicidal action on the eggs is also being investigated. The rate of progress of the above experiments could be much greater if satisfactory methods of breeding the flies all the year round in the laboratory can be devised, and the work on this subject is described in the section on insect rearing.

Some work is being done on the structure and properties of the egg-shell, which may be of use in connection with survival in the field and the action of ovicides. Histological work is also being done in connection with the experiments on diapausing eggs.

Control of the vectors of potato virus

P. E. Burt of this department, in conjunction with L. Broadbent of the Plant Pathology Department, continued the experiments on the control of virus diseases of potatoes.

In 1951–52 an experiment was carried out in which plots of potatoes, each containing some plants infected with leaf roll and some with virus Y, were sprayed with various insecticides in an attempt to control the aphid populations and to prevent the spread of the virus diseases through the crop. The results of these experiments (see Annual Report 1952, p, 87) were encouraging, and a further experiment on similar lines was carried out in 1953.

The treatments used were a DDT suspension, and emulsions of DDT, endrin, malathon and " Systox ". Nine applications were made during the period 29th May 1953 to 4th September 1953. Modifications were made to the spraying machine used in the 1951–52 experiment according to a specification drawn up jointly by the department and the manufacturers. This has enabled much better crop coverage to be obtained, especially on the undersides of leaves. There was a very high aphid population in the control plots in July, which was effectively reduced by all the treatments, " Systox " and endrin being most effective. For example, the total aphids count on 23rd July on 120 leaves was 3,929 in the control plots, eight in the endrin treated plots and none in the " Systox " treated plots.

An estimate of the amount of virus spread will not be available until next year. Further information on this series of experiments on virus control is given in the report of the Plant Pathology Department.

Control of wireworms

The experiments started in the autumn of 1951, in collaboration with F. Raw of the Entomology Department, on the direct and residual effects of a number of insecticides on wireworms have produced interesting results. Large differences in the residual effects of the different treatments are apparent in this, the second year after treatment. The following figures have been obtained for the yields in autumn 1953 :

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Yield of grain in cwt./acre, Autumn 1953

Treatments Autumn 1951 :	Untreated	S	G	A	C	D	Mean
Mean (± 1·60) ..	21·6 *	22·9	30·2	34·6	32·9	26·7	26·5
Increase (± 1·84)	—	1·3	8·6	13·0	11·3	5·1	—

* ± 0·92.

S = BHC seed dressing at 2 oz. per bushel of the dressing.
G = 3·5 per cent BHC dust combine drilled with seed at 56 lb./acre.
A = 1·78 per cent aldrin dust combine drilled with the seed at 200 lb./acre.
C = 5 per cent chlordane dust combined drilled with the seed at 100 lb./acre.
D = 5 per cent D.D.T. dust combine drilled with the seed at 150 lb./acre.

These figures show a good correlation with the figures for wireworm population estimated by F. Raw, and the comparison is given in the report of the Entomology Department. The crops on the control plots and those originally treated with dressed seed are probably not economic, while on the plots where the insecticides were drilled in with the seed there has been a marked crop increase, good crops being obtained with BHC, aldrin and chlordane.

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