DEPARTMENT OF EDUCATION AND SCIENCE

Further Review of Certain Persistent Organochlorine Pesticides Used in Great Britain

Report by the Advisory Committee on Pesticides and Other Toxic Chemicals

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CONTENTS

I. INTRODUCTION

1. Pesticides continue to play an important role in the protection of agricultural and horticultural crops, livestock, and stored food, in Great Britain. Without them farm productivity and the quality of food would fall considerably. Nor is the situation peculiar to this country. The need for increased food production in many parts of the world is still a matter for grave concern. The search for alternatives to pesticides for crop and food protection, while yielding valuable information and indications of novel approaches, does not yet provide us with many economically practical alternatives of general application.

2. It is possible to compile a list of requirements that ideally should be satisfied by pesticides designed for particular purposes. High amongst these attributes is the ability of a chemical to degrade into harmless substances after controlling the pest or disease. For some purposes, however, prolonged protection may be needed and some degree of persistence is therefore necessary if frequent applications are impracticable. The persistence of some organochlorine compounds is one of the features that has led to their world-wide use, but some concern has been expressed about those that remain stable beyond the period for which they are required to be effective in practice. Residues of such compounds may remain over long periods, not only in the area in which they have been used but in the environment as a whole. Their detection at very low levels is made possible by the continued development of highly sensitive analytical techniques.

3. In our earlier Review of the Persistent Organochlorine Pesticides (1964) (hereafter referred to as the 1964 Review) we examined the risks arising from the use in agriculture (including gardening) and food storage of aldrin, BHC (including gamma-BHC), chlordane, DDT, dieldrin, endrin, endosulfan, heptachlor, "Rhothane" and "Toxaphene". We concluded that there was insufficient evidence at that time to justify a complete ban on any of these chemicals because of possible hazards to man and wildlife but we were then agreed that "the accumulative contamination of an environment by persistent pesticides from all sources is a factor which should in future be given greater weight by all concerned in proposals for the safe use of such chemicals". Our recommendations sought an order of priority for reduction of the total usage of such chemicals in agriculture without a serious set-back to crop protection, and were accepted by the Government. We proposed that the uses of these chemicals that should be allowed to continue should, with the exception of BHC (including gamma-BHC), be reviewed at the end of three years with a view to their discontinuance. Although no restrictions were placed on the uses of DDT, we recommended that these should also be reviewed.

4. In November 1966 we announced our intention to carry out this further Review and invited interested parties and organisations to submit relevant evidence (Appendix II). The terms of reference were:

"to review the risks arising from the use of certain persistent organochlorine pesticides and make recommendations to the Government on whether their use in agriculture, gardening and food storage should continue as at present, be further restricted, or cease. The chemicals are:

aldrin	DDT	endrin
camphechlor ("Toxaphene")	dieldrin	TDE ("Rhothane")
chlordane	endosulfan	

The review will also cover the industrial and home uses of these chemicals, their use in resins, lacquers, coatings or paints and the use of DDT in thermal vaporisers". Heptachlor was subsequently added to this list after the terms of reference had been published.

Although we considered BHC (including gamma-BHC) in our 1964 Review, we recommended no restrictions on its use. We have not included it in this report except in respect to its use in thermal vaporisers, where we found it inconsistent to consider DDT without also considering gamma-BHC, and in respect to residues in food, where data for the chemical were available. Appendix IV contains information about the chemistry of the pesticides and their principal metabolites.

5. The scope of the present Review is more comprehensive than the previous one and includes the uses of the chemicals in agriculture, horticulture, home gardens, food storage, veterinary practice, and uses for other purposes, to enable us to examine all likely sources of these chemicals in the environment. These other uses have not been exhaustively investigated but we have examined those in forestry, in the protection of wood and wool, and in the fields of hygiene and public health and of retail packs for use in the home. We have given special consideration to thermal vaporiser units, because of the rather indiscriminate release of chemicals into the environment by this method of use.

6. When the Minister of Agriculture, Fisheries and Food announced the Government's acceptance of the recommendations of our 1964 Review, he requested that we should "consider and advise on any improvements and extension of present safety arrangements that may be desirable to provide greater protection against the hazards arising from the use of toxic chemicals in agriculture and food storage; in particular to consider whether stricter criteria should be applied to the approval of existing products". (Approval here refers to clearance in accordance with the Pesticides Safety Precautions Scheme and the Veterinary Products Safety Precautions Scheme—Appendix III). We accordingly reported in the "Review of the Present Safety Arrangements for the Use of Toxic Chemicals in Agriculture and Food Storage" (1967) and we have borne in mind the relevance to our present enquiry of any implementation of our recommendations in that review, particularly in respect of new legislation to control the sale and use of pesticides.

7. Since our 1964 Review, two units have been set up to collect quantitative data on the use of pesticides. The unit concerned with agriculture and horticulture is based at the Plant Pathology Laboratory, Harpenden; that covering food storage is centred at the Infestation Control Laboratory, Tolworth. Data obtained from these units have been considered in this review. Information on usage in agriculture and horticulture in Scotland was supplied by the Scottish Agricultural Colleges through the Department of Agriculture and Fisheries for Scotland (D.A.F.S.). Food storage data for Scotland were collected by D.A.F.S. on behalf of the Infestation Control Laboratory.

8. We have also taken account of further information on the distribution of the persistent organochlorine pesticides in the environment and their effect on man and wildlife. The detection of these chemicals in human tissues, human food, wild birds, marine fish, soil, water, and rain, indicates their widespread presence in living things and their environment. Such findings have been reported from many parts of the world. Only minute amounts are found in rain water, rivers, and drinking water (parts per 10^{12}*), and in many human foods (parts per 10^{9}**), but residues in human fat, and wild birds and their eggs, for example, are frequently larger—being in the range of 0·1 to 10 parts per million (p.p.m.). Even if the persistent organochlorine pesticides were to be withdrawn completely from use in Great Britain, they would be likely to continue to be present in some imported foods. The natural environment too would still contain residues resulting from previous use and to a limited extent it could also be affected by movement of pesticides (for example in air or water currents) from other countries.

9. Imported foodstuffs from crops treated with these chemicals will continue to contain residues and for some years crops grown on treated soils will be similarly affected. Since our 1964 Review, our Scientific Subcommittee's Panel on Residues of Pesticides in Foodstuffs has collected more information on residues and has completed an extensive whole-diet study designed to determine the average residues of these pesticides in the average British diet, derived, in part, from imported foods (paragraphs 72–74).

10. The presence of these organochlorine pesticides in man's environment is also established by their occurrence in the body fat of the general population of many countries, including Britain. The determination of national mean concentrations of these chemicals in human fat is now regarded as a method of measuring the degree of exposure to which a population is subjected.

11. We have reviewed a mass of published and unpublished work, in addition to the evidence submitted and the various data referred to in preceding paragraphs. We have considered the toxicological significance of the data and the desirability of the continued use of these chemicals in pest control practice. In doing this we have been very conscious of an unavoidable difference in approach to the review of aldrin, camphechlor, chlordane, dieldrin, endosulfan, endrin, and heptachlor, the uses of which were clearly restricted and defined by our 1964 Review, and to the review of DDT, a chemical in general use in many and diverse situations. Additionally, we have noted that endrin and endosulfan, while having appreciable acute toxicity, cannot reasonably be called persistent in vertebrate animal bodies, although we recognise that little information is available on their persistence in soil or the environment generally.

12. The use of highly sensitive chemical tests has shown that some organochlorine pesticides in exceedingly low concentrations are now almost universally distributed in the environment. We know of no evidence to show whether these exceedingly low concentrations have biological effects. Some kinds of wildlife, such as fishes, that are continuously exposed to concentrations of pesticides that are not quite so low, tend to have still higher concentrations of these materials in their tissues. Examination of wildlife has indicated the presence of

* 10^{12} = parts per million million.

** 10^{9} = parts per thousand million.

concentrations in water which are so low as to have been undetected by chemical analysis. We have therefore considered first the presence of these organochlorine compounds in wildlife. We have then discussed their effects on wildlife, on man, and on his food. We have also surveyed their occurrence in the environment as a whole. Finally, we have reviewed the various uses of these chemicals in commerce and the home; and in accordance with the general aim expressed in our 1964 Review—to reduce the use of the persistent organochlorine compounds in Great Britain—we have discussed the use of alternative chemicals. Although much of the information we have presented in Sections II to V is reassuring, we still think it important to reduce the overall use of the organochlorine compounds which are persistent and to employ alternative, less persistent, chemicals. While this view is based on the fact that these organochlorine compounds remain stable in the environment for long periods, we are also conscious that the further toxicological work referred to in paragraphs 85–88 is not yet completed.

II. EFFECTS ON WILDLIFE

(a) Introduction

Kind of Information Reviewed

13. Information from various sources has been assessed and has included results of investigations into suspected casualties from pesticides, observations on population changes, reports on changes in reproductive success in different species, and measurements of residues occurring in biological specimens in the field. We have also examined the results of experiments with the chemicals under review and their effects on various animals and plants. The incidence of any reported population changes or other occurrences in the field has also been compared with available information on any changes in the nature and extent of usage of pesticides under review. Although we have largely confined our attention to Great Britain, relevant information from other countries has been taken into account.

14. In attempting to make assessments of long-term effects on many species, we were aware of the considerable deficiencies in our knowledge of both the sizes of their populations and the factors which influence changes in them. Even where information suggests that a chemical or other agent is producing an identifiable and measurable effect e.g. on behaviour or reproductive success in fish or birds, it is extremely difficult to assess the likely effect on the size of the population. For these reasons our conclusions in this field are based mainly on circumstantial evidence rather than on conclusive experiments. In this section of the report we have found it convenient to gather information about chemicals under separate headings.

Population Changes and Breeding Success

15. In nature, populations of fish and other aquatic organisms are rarely assessed with sufficient accuracy for any but catastrophic changes to be observed, such as those due to sudden and accidental discharge of effluent. Because of the difficulty of observation there has been little opportunity to determine the significance of any behavioural or other effects in fish, although effects may be demonstrated

under controlled laboratory conditions. A significant proportion of a fish population normally dies of disease or other natural causes each year but few dead fishes are seen. Nevertheless, individual instances have come to light in which chemicals under review have been found to affect populations in stated localities.

16. We have not found evidence of recent widespread deaths amongst birds attributable to single or short-term intakes of the chemicals under review. Use of these pesticides as cereal seed dressings, particularly the carry over of autumn-prepared seed into spring sowing, has continued to cause casualties to wildlife locally. Some casualties in early summer also continue to occur in orchards. It has been a very difficult task to assess the importance of the residues found in the many specimens of birds that have been examined and especially the long-term significance of any behavioural or other effects in them. Predatory land birds contain, on average, larger residues than other species [Appendix V (iv)] and during recent years various field observations have been made on their populations and behaviour. As in our 1964 Review, therefore, we paid special attention to the evidence about them and in particular that concerned with observed changes in populations, in success in breeding, and in behaviour.

17. So far as populations are concerned, the evidence relating to the peregrine falcon and the sparrowhawk indicates that very marked declines commenced in about 1955 and continued until about 1963; the first signs of a recovery were seen in 1966. An enquiry relating to certain birds of prey in Britain which was undertaken in 1964 and which covered records over the period 1953 to 1963 indicated decreases in populations of the barn owl and kestrel. In the kestrel the decrease became most evident in about 1960 in eastern England where in some counties it had then become rare as a breeding species. As indicated elsewhere, the available evidence suggests that dieldrin was responsible for these reported changes. No marked changes were shown to have occurred in recent years in populations in Britain of the tawny owl and the golden eagle, or in the heron and great crested grebe which feed on freshwater fish.

18. Other kinds of change have been recorded, namely reduced thickness of eggshells, increased incidence of egg breaking by parent birds, and reduction in breeding success (though not necessarily sufficient to affect population size) in predatory birds. Within a period of about three years in the late 1940s, eggshells of peregrine falcons and sparrowhawks became thinner and have remained thinner ever since. There was a moderately close correspondence in time between these phenomena and the expansion in the uses of DDT, but this evidence is not precise enough to establish a causal relationship with certainty. Increased breakages of eggs were noted after 1950, but the year when these began is not known. Although the number of young reared decreased about that time, the population of peregrine falcons remained steady up to about 1955. The changes in eggshell thickness, in egg breakage, and in breeding success, in peregrines may have been caused by DDT (paragraph 52); but other factors which have not been investigated so fully may be relevant or even significant. Similar changes in eggshell thickness, egg breakage, and breeding success, have been recorded in the golden eagle. None of these has in fact affected the total population of eagles, but they might affect recovery from some other adverse factor. Breeding success has improved since the withdrawal of dieldrin sheep dips.

(b) Evidence on Individual Pesticides

Aldrin and Dieldrin

19. Following applications of aldrin and dieldrin to the soil there is initially a rapid decrease in residues of each chemical followed by a period of slower decline. Dieldrin appears to affect some soil micro-arthropod populations very markedly and for considerable periods of time. Different groups of animals vary in their susceptibility to the chemical and a few species appear to be particularly resistant. The change of population produced is dependent on the rate and frequency of application, actual species present, and soil type [Appendix V (i)].

20. In Great Britain some cases have come to light where mortality among fish populations due to dieldrin was attributable to industrial effluents. However, the main evidence of the adverse effects of organochlorine insecticides on fish in nature has been gathered in North America. Normally, direct uptake from water is likely to be the most important source for fish but some aquatic organisms, such as caddis larvae, have been found to accumulate dieldrin and predators feeding on them would also acquire the chemical from this source. The level of residues of dieldrin found in samples of marine and freshwater fish is shown in Appendix V (ii). Such residues may be transferred to fish-eating birds and must largely account for the residues of dieldrin found in their eggs [Appendix V (iii)].

21. Since the introduction of voluntary restrictions on certain uses of these chemicals, incidents involving the acute poisoning of seed-eating birds have greatly decreased in number, although some casualties still occur, particularly from spring-sown seed which has been prepared for autumn sowing. Much larger residues are found in predatory land birds than in other species and the periods during which the marked population declines in the peregrine falcon and sparrowhawk occurred (paragraph 17) roughly correspond with known periods of usage of these pesticides. Detailed studies since 1964 suggest that the declines were not due to factors such as decreases in food supply or in breeding sites, weather changes, intentional and unintentional human disturbance, or to the cyclical fluctuations recorded in the kestrel and barn owl. The additional data support our previous hypothesis that aldrin and dieldrin cereal seed dressings reached the predators through their prey and were an important contributory cause of the population declines. Following the withdrawal of use of these chemicals on spring-sown cereals in 1962 and the restrictions following our 1964 Review, some population increases have been observed in the peregrine falcon, sparrowhawk, and kestrel. It also seems likely that the golden eagle benefited from the ban on the use of dieldrin in sheep dips, since the reported recovery in its breeding success commenced at about that time (paragraph 18).

22. Mammals too may acquire dieldrin residues directly by eating dressed seed or treated plants. They may also acquire such residues indirectly by eating other animals containing residues of the chemical. Thus cases have been reported in which foxes and badgers may have been poisoned by eating pigeons which had consumed cereals dressed with aldrin and dieldrin. No evidence has, however, come to light to suggest that this has substantially affected the total population of these mammals.

23. There is some experimental evidence that non-fatal doses can produce effects the ecological significance of which has not yet been established (see also

paragraph 50). However, certain of the effects studied have occurred only when the dose was near to the lethal level.

Chlordane

24. Technical chlordane is available in this country for the control of earthworms, ants, cockroaches, and wasps. There are no quantitative data on the acreage of turfs and lawns treated with chlordane. Information supplied by Industry on the amounts of the chemical marketed annually in Great Britain suggests there has been a considerable increase during 1963–1966 in the sales of this chemical in home garden packs for worm control, although there has been little increase in the quantities imported annually.

25. In 1964 we considered that the use of chlordane to kill earthworms could be a potential hazard to birds and domestic animals. There is still no evidence, however, that worms poisoned in this way are at any time available to birds. When used for the control of cockroaches, ants, or wasps, chlordane appears to offer no obvious risks to other wildlife.

Endrin

26. Apart from agricultural and horticultural uses a very small quantity of endrin is applied annually under very careful supervision in specified Government stores for the control of mice. There is also some evidence that, contrary to Government advice, small amounts of endrin are used for the control of field voles and birds.

27. Although the acute oral and dermal toxicity of endrin is higher than that of most other organochlorine pesticides, it is relatively rapidly metabolised in birds and most mammals. Endrin is rarely found in tissues of birds or other animals which are examined for pesticide residues, except soon after their exposure to spray. There is evidence that worms and slugs from a field sprayed with endrin contained appreciable residues of the compound; birds might possibly obtain harmful amounts from this source. Endrin is highly toxic to fish, but we have received no reports of it being found in streams or waterways in Great Britain.

28. Although there is little evidence about the presence of this chemical in the general environment and it is rapidly metabolised in vertebrates, it can persist in certain situations, e.g. in the soil, and we have therefore considered its known uses in the same way as those of the other organochlorine chemicals.

Endosulfan

29. In our 1964 Review, no restrictions, other than those specified in the Recommendations for Safe Use, were placed on the commercial use of endosulfan, although it was suggested that its use on non-edible crops should be limited. Several laboratories have analysed a very large number of samples of tissues of birds and mammals for residues of organochlorine compounds. These analyses would have detected endosulfan residues but they were found only on very few occasions.

30. Endosulfan is highly toxic to fish but of comparatively low toxicity to birds and bees. Its acute toxicity to mammals led to its inclusion in the regulations for the protection of the operator [Appendix III (iv)].

31. Information on endosulfan residues in British soils is very sparse. Analysis of soil samples taken from a field where two applications of endosulfan had been made annually since 1960 showed residues of the chemical below 0·04 p.p.m. Similar results were obtained from analyses at other sites. We know of no instance in Great Britain where deaths of wildlife or fish were traced directly to the use of endosulfan and there is no evidence to suggest that the present low rate of usage in this country presents a hazard to wildlife. Nevertheless, as with endrin, we have thought it right to review its uses along with those of the other organochlorine compounds.

Heptachlor

32. Many species of birds and mammals (57 species since 1963) from many different habitats have been found to contain residues of heptachlor epoxide, but the source of the residues is obscure. The chemical has been implicated on several occasions, including one major incident involving the acute poisoning of birds; exposure in these instances resulted from misuse.

33. There is considerable evidence from use in Great Britain before 1962 and in the U.S.A. that heptachlor seed dressings on cereals can present an acute hazard to wildlife. Despite the voluntary withdrawal of heptachlor as a cereal dressing in Great Britain, residues of heptachlor epoxide are still detected in some wildlife tissues and the risks of acute poisoning to seed-eating birds, and presumably to predatory birds and mammals, have not entirely disappeared [Appendix V (iv)].

34. We believe that further restrictions on the use of aldrin and dieldrin cereal seed dressings could give rise to an increased interest in the use of heptachlor for such purposes. Because of the known hazards to wildlife which this relatively toxic chemical presents, we consider its use should be kept to a minimum, and any restrictions placed on the use of cereal seed dressings containing aldrin or dieldrin should equally apply to heptachlor cereal seed dressings.

TDE (“*Rhothane*”)

35. There is no direct evidence that the use of TDE in this country has caused deaths amongst wildlife, although residues of the chemical have been found in recent years in many of the bodies of British birds analysed for organochlorine compounds. It is difficult to determine the source of any TDE found since it may result from metabolism of DDT, as well as from the intake of TDE as such. In these analyses, the higher residues of the compound have occurred during the spring and early summer when TDE is mainly used. It is possible that more extensive use could raise similar issues to those that have been considered separately under DDT (paragraphs 37–55).

Camphechlor

36. There are no quantitative data available on the acreage treated with camphechlor, but the chemical has evidently not been marketed in this country in recent years. In the U.S.A., where it is used extensively, it has been implicated in several incidents involving wildlife, especially fish, other aquatic animals, and birds. Residues of camphechlor have not often been detected in the many samples of tissues of birds and mammals analysed in this country during the past few years and we do not find it necessary to comment further on its hazards to wildlife in Great Britain. However, it is possible that if this chemical had been used recently in this country the situation might have been different.

DDT

EFFECTS ON SOIL AND SOIL ORGANISMS

37. There is evidence that DDT residues persist and remain active in the soil longer than those of any other organochlorine insecticide in common use. Persistence can vary widely depending on conditions; for example, DDT can be lost much more rapidly when left undisturbed on the soil surface than when incorporated into the top soil. In the latter case, it may take 3–6 years for residues of DDT to decline by 50 per cent, but the rate of loss itself diminishes with time so that long-standing residues decline by only a few per cent per year and in one prolonged study, about 35 per cent of the DDT originally applied still remained in the soil after ten years. Commonly used rates of application of DDT have marked effects on soil invertebrates, but most workers agree that the amounts of DDT found in soils in Great Britain at present do not influence significantly the total number of soil micro-organisms or the beneficial processes such as organic turnover, nitrification and ammo-nitrification for which they are responsible.

38. Control of orchard pests accounts for much of the DDT used in agriculture in the United Kingdom and orchard soils can contain large DDT residues as a result of spray run-off [Appendix V (v)]. Earthworms ingest large quantities of soil and they form an appreciable item in the diet of some birds. From the few quantitative data available, it seems that applications of less than 25 lb DDT/acre are unlikely to have any effect on the survival of field populations of earthworms. In Great Britain, fruit growers applied an average of 2 lb DDT/acre in 1966, with a range from 0·5 to 5 lb, depending on individual spray programmes. Residues have been found in earthworms taken from orchard soils where repeated applications of DDT have been made. The actual residue levels found are related to some extent to the species of earthworms, being largest in those which live mainly in the top soil. Earthworms living close to the trunks of sprayed trees in an orchard that had received a total of 15·25 lb DDT/acre over a period of 10 years contained 13·6 p.p.m. DDT; those living 6 ft away from the trees contained 6·1 p.p.m. and those 12–15 ft away from the trees contained 3·3 p.p.m. In another location, earthworms from an orchard that had received 4 lb DDT/acre per annum applied in 2–3 doses for several years contained 16 p.p.m. DDT; total residues of about 40 p.p.m. were found in another survey [Appendix V (i)].

EFFECTS ON BENEFICIAL INSECTS

39. Soon after the general introduction of DDT it became clear that its use in some situations, especially in orchards, was leading to a resurgence of pests and to the development of secondary pests, particularly mites.

40. The effects of DDT on predators and parasite populations are probably associated both with its persistence and its wide spectrum of activity. Many parasites and predators are very susceptible to DDT and there is much variation both within and between species. In general, the use of DDT reduces both the numbers and the range of species of beneficial arthropods. Nevertheless, where it has been used over a period of time with evidence of serious effects, the 'status quo' above ground has apparently been restored a few years after the cessation of use.

41. Several investigators have considered the possibility of indirect and non-lethal effects of DDT on pest populations. It is very difficult to make conclusive

interpretations from field tests on insects and nearly all available data are based on laboratory experiments. Stimulation of egg production in red spider mites by minute quantities of DDT, recorded by several workers in Europe, has not yet been confirmed in Canada and the U.S.A. However, recent studies designed to resolve the issue suggest that the explanation may lie in the complex effect of DDT on the nutrient status of the leaf and therefore indirectly on the rate of development of female mites.

EFFECTS ON AQUATIC LIFE

42. Laboratory studies on trout show that continuous exposure to an aqueous concentration of DDT in excess of approximately 0·001 p.p.m. in hard water (250 p.p.m. calcium carbonate) kills the most sensitive individuals. Experimental evidence also shows that DDT can be accumulated by fish that are intermittently exposed to it in their water or their food, but they progressively lose the DDT when in water free from it. Impaired success in egg production and in survival of fry has been observed amongst individual fish surviving exposures which killed a substantial proportion of the population. At concentrations of DDT at which all adults survive, however, there is no evidence that egg hatch and fry survival are reduced. Although nearly-lethal exposure to DDT has been shown in the laboratory to affect the behaviour and learning ability of some fish species, it is not known whether these effects have any ecological significance in Great Britain.

43. Little information is available from Great Britain on the effects of field applications of DDT on fish. In Scotland, damage to trout was not observed in streams in a forest sprayed experimentally with 0·17 lb DDT/acre. There is evidence from other countries that large-scale applications covering whole watershed areas (not undertaken in Great Britain), and regularly repeated operations, could result in concentrations of DDT harmful to fish.

44. Under laboratory conditions, aquatic insects do not appear to be more sensitive to DDT than fish; but in the field, larvae of mayflies, caddis flies, and stoneflies, have been reported to be more adversely affected, though reported recoveries have usually been rapid.

EFFECTS ON BEES

45. DDT has been implicated only on rare occasions in bee-poisoning incidents in this country. During the years 1956–1965, when 290 samples of bees (including more than one sample from individual alleged incidents) were examined, only two incidents of poisoning by DDT were recorded.

EFFECTS ON BIRDS

46. The acute oral toxicity of DDT to birds is relatively low, the median lethal dose being in excess of 500 mg/kg for most species. Under laboratory conditions even small birds such as house sparrows and greenfinches seem to tolerate amounts in the diet far exceeding those they would normally meet. There is no evidence to suggest that acute DDT poisoning is occurring very widely amongst birds in Britain.

47. DDT is metabolised in animal tissues, and usually only a small proportion of the residues found is of the pp′ isomer. Because DDT and its metabolites can accumulate in tissues, chronic poisoning could possibly arise from the continued ingestion of small amounts in food. The assessment of any effects of

DDT on wild birds is largely dependent upon chemical analysis of specimens and interpretation of the findings in the light of relevant information obtained from experimental work. This situation rarely enables a firm conclusion to be reached on incidents in the field. It is therefore very difficult to interpret the significance of the small residues of DDT frequently found in wildlife.

48. Chemical analyses of specimens collected from various places indicate that many wild birds in Great Britain contain residues of DDT or its metabolite DDE [Appendix V (iii a), (iii b), (iv)]. The amounts found and the ratios between DDE and other metabolites in different birds and in different organs of individual birds have varied widely. Residues in birds in feeding tests have mostly been much higher than in those found dead in the field. Whilst these findings suggest that very few of the wild birds examined could have died solely from DDT poisoning, it is important to appreciate that caution is necessary because other organochlorines were often also present and, in any event, adequate experimental data are not available for most of the wild species examined. Furthermore, wild birds often experience stresses of a kind different from those that arise under controlled conditions in laboratories; residue levels which do not indicate hazard in the laboratory may however be deleterious in the field.

49. Some of the highest residues have been found in carcases, particularly of blackbirds, from orchards where DDT was known to have been extensively used [Appendix V (vi)]. Although the evidence suggests that some casualties from DDT could have occurred in such sites in particular seasons, there are no indications that such occurrences are sufficient substantially to affect populations of these birds, other than in very restricted areas.

50. There is experimental evidence that DDT can delay attainment of sexual maturity in some species of birds. This could affect breeding success in the wild by disturbing the synchronisation of breeding with the availability of food suitable for the young. Experiments have also shown that DDT (and dieldrin) can influence the endocrine system by altering the balance of steroid hormones. However, egg production, fertility, and embryo viability, are not seriously affected by DDT except at levels that affect the general physiological state of the birds. DDT or its metabolites have been found in the eggs of many species of wild birds in Great Britain; with the exception of a few samples from orchards which contained over 100 p.p.m. the levels in eggs have been below 10 p.p.m.

51. Analyses of specimens from the field show that birds of prey usually contain higher residues of DDT and its metabolites than other species. Nevertheless there is no close correlation between the declines in populations in predatory birds, particularly in the peregrine falcon and the sparrowhawk, referred to in paragraph 17, and the use of DDT. Therefore DDT does not appear to have been the principal cause.

52. Reports regarding the effects of DDT on eggshell thickness, eggshell breakage, and in production of young, have been discussed in paragraph 18. Since these reports appeared in Britain, similar observations have been reported in the U.S.A., where it has also been shown experimentally that DDT can affect eggshell thickness in some species. Other causes of thinning of eggshells are known and there is no certainty that DDT was responsible for the effects reported from the field.

EFFECTS ON MAMMALS

53. In British wild mammals, residues of DDT and its metabolites have been found in five major taxonomic groups, amongst which were herbivores, insectivores, omnivores, and carnivores, living in terrestrial, fresh-water, and marine environments [Appendix V (vii)]. There is insufficient information to allow any correlation to be drawn between residue levels found in mammals and death from DDT poisoning. Most of the residues are relatively low and it seems unlikely that British wild mammals are exposed to any risk from acute poisoning by DDT. Possible exceptions are the bats which are known to be particularly sensitive to DDT and for which the lethal dose is as low as 20 mg/kg in some species.

54. Many workers agree that the effects of repeated doses of DDT can be cumulative. Nevertheless, some excretion and detoxication of the compound does occur and experiments with rats have shown that when given in fractions over a period, a much larger total amount is required to produce the same effect as a single acute dose. Experiments with very large doses of DDT fed daily for upwards of three weeks have been shown to affect the gait of rats, but so far there is no evidence of effects on other behavioural functions. Such occurrences have not been seen in wild mammals in Great Britain.

SUMMARY OF SIDE EFFECTS OF DDT

55. A study of the above data leads us to conclude that acute poisoning of birds by DDT has occurred only in local areas of Great Britain. However, there is some evidence that DDT may produce non-lethal effects on birds (paragraph 52). Fish are very sensitive to DDT at low concentrations, but there is little evidence of harm of this kind in Great Britain. DDT can have indirect ecological effects on arthropod populations; thus, pest mites in orchards benefit if the more sensitive parasites and predators are killed by this insecticide.

III. RESIDUES IN FOOD

(a) Introduction

56. Information on the occurrence and levels of pesticide residues in foodstuffs is obtained, in the first instance, from trials undertaken by Industry. This and subsequent data from the early commercial development of a chemical are always required by the Pesticides Safety Precautions Scheme. Our main information, however, on the occurrence of residues in foodstuffs has been obtained from the studies initiated by our Scientific Subcommittee's Panel on Residues of Pesticides in Foodstuffs, set up for this purpose in 1961. The studies included selective surveys of residues in specific foodstuffs and in 1966 a whole-diet survey was initiated. In 1966–68, Public Analysts carried out a co-ordinated study of residues in foodstuffs on behalf of the County, Municipal, and District Councils Associations and some data from this investigation were made available to us. Certain manufacturers of pesticides have also surveyed the occurrence of certain residues in the diet and some of the data have been published.

57. Most of the pesticides under review have been in use since before the introduction of the Pesticides Safety Precautions Scheme and the earlier analytical methods for residues have now been largely replaced by techniques of greater specificity, sensitivity, and reliability. All analyses for the Panel on Residues of Pesticides in Foodstuffs were made using gas chromatography. Where this technique was used at or near the limit of its sensitivity, as with the milk and whole-diet samples, no other method of analysis of comparable sensitivity was available to confirm the presence and identity of all the residues indicated. Whenever possible, thin-layer chromatography or infra-red spectroscopy was used to confirm the identity of the residues.

(b) Selective Studies on Individual Foodstuffs

58. Foodstuffs were selected for study on the basis of importance in the diet, use of the pesticides upon them, and a knowledge that the pesticides tend to occur in them. Only those studies that indicated the trend of residue levels over a number of years are discussed and the results are summarised in Appendix VI, where references to dieldrin residues should be taken to include any arising from uses of aldrin.

59. Persistent organochlorine pesticides were present in each group of foods examined. The general pattern showed that the majority of the samples examined contained very low residues. Only a small number contained residues appreciably above the limits of detection and these occasional high results have been included in the calculation of the arithmetic means, which are quoted in the tables. The data have been, or will be, published in detail.

Beef kidney fat

60. The mean levels of BHC, dieldrin, and total DDT, in home produce have been consistently below 0·18, 0·07, and 0·07 p.p.m.* respectively, throughout the five years that this study has been conducted. Of the 258 home-produced samples examined, only 13 contained dieldrin residues in excess of 0·1 p.p.m. The majority of Argentinian samples contained very low residues, but a small number contained relatively high residues, the maximum for dieldrin being 2·2 p.p.m. These occasional high figures resulted in the mean levels of BHC (up to 0·70 p.p.m.) and dieldrin (up to 0·28 p.p.m.) tending to be higher in Argentinian than in home-produced beef fats, but mean total DDT residues were a little lower (up to 0·03 p.p.m.). Camphechlor and endrin have also occasionally been detected in Argentinian beef-fat.

Mutton kidney fat

61. The pattern of residues in samples from each of four sources, United Kingdom, Argentina, Australia, and New Zealand, differed one from another. Mean BHC residues were generally below 0·05 p.p.m. in samples from Australia and New Zealand, but BHC residue levels in Argentinian samples were erratic, the resulting mean levels being as high as 1·11 p.p.m. BHC residues in home produce showed a seasonal variation in 1964 and 1965, being higher in the autumn and winter quarters, following dipping in the summer, than in the spring and summer quarters. Mean levels of 0·44 and 0·43 p.p.m. were obtained in these years. The restriction on the use of dieldrin dips following the 1964

* p.p.m.=parts per million.

Review appeared to be followed by a reduction in extent of use of dips containing BHC and the means of BHC residues fell to 0·16, 0·18, and 0·17 p.p.m. in 1966, 1967, and 1968 respectively.

62. Mean dieldrin residues were consistently below 0·09, 0·02, and 0·01 p.p.m., in samples from Argentina, Australia, and New Zealand respectively. These values were considerably lower than the 0·84 and 1·1 p.p.m. found in home produce in 1964 and 1965 respectively. The seasonal variation referred to above was also detected. An unusually large proportion of the home-produced samples taken in the first quarter of 1966 contained relatively high dieldrin residues, probably due to animals being treated in the last quarter of 1965 with dips held in stock before the restrictions on the use of dieldrin dips came into operation from 1st January 1966. The dieldrin residues in the samples taken during the remainder of 1966 indicated that some of these dips were still being used, the mean level for the year being 0·44 p.p.m. Though there was a general reduction in dieldrin residues in home produce in 1967 and 1968, a few samples still contained residues of a sufficient magnitude (mean 0·24 and 0·21 p.p.m. respectively) to indicate that some of the animals had been treated with dieldrin in these years.

63. The mean levels of DDT (and its derivatives) in all samples were usually below 0·3 p.p.m. Residues were very slightly higher in New Zealand samples than in those from the other countries, probably reflecting the wide-spread use of DDT on pasture in that country up to 1964.

Butter

64. Mean residues of BHC and dieldrin were consistently below 0·08 and 0·04 p.p.m. respectively in all samples examined. Mean total DDT residues in samples from Denmark and the United Kingdom were below 0·06 p.p.m. Mean DDT residues in samples from Australia and New Zealand were clearly higher (0·20 to 0·54 p.p.m.) and showed a marked seasonal variation, being higher in the first and last quarters of the year and reflecting the treatment of pastures in those countries during spring and summer. The introduction in New Zealand in 1964 of controls over the use of DDT on pastures, appears to have led to a gradual reduction in the mean level of residues from 0·41 p.p.m. in 1964 to 0·21 and 0·23 p.p.m. in 1967 and 1968 respectively.

Milk

65. In the six-year period of this study, residues of BHC, dieldrin, and DDT, were all consistently of the order of a few parts per thousand million. The levels in dried milk indicate that about 20% of the residues are removed with the water during the dehydration process.

Eggs

66. Two studies of organochlorine pesticide residues in home-produced eggs were undertaken. In one, eggs were obtained throughout the United Kingdom from different systems of poultry husbandry. In the second study, a comparison was made of residue levels in eggs from poultry kept in buildings in which thermal vaporisers dispensing BHC and/or DDT were used, and from buildings without thermal vaporisers. Mean residues in eggs from the general survey, irrespective of husbandry systems, and from buildings without thermal vaporisers

were, in general, below 0·03 p.p.m. Where thermal vaporisers were in use higher levels of BHC (0·39 p.p.m.) and DDT (0·21 p.p.m.) were found. The occurrence of residues of dieldrin in one or two samples was traced to the use in the houses of a disinfectant containing dieldrin, and high DDT residues in other samples were due to DDT dust being applied to the birds or their nests.

Poultry meat

67. The breast and thigh muscle of birds reared under free-range and intensive systems were analysed. The mean residue levels were below 0·06 p.p.m. total BHC, 0·02 p.p.m. total DDT, and 0·01 p.p.m. dieldrin.

Carrots

68. Although considerable residues of aldrin and dieldrin (up to 1·4 p.p.m.; mean 0·16 p.p.m.) were found in the skin of carrots grown in soils that had been treated with these chemicals, the mean residues in the edible flesh were consistently below 0·01 p.p.m.

Potatoes

69. Potatoes from fields that had been treated with aldrinated fertiliser or aldrin or dieldrin dusts or sprays in the year of cropping often contained appreciable residues in the skin (up to 0·7 p.p.m.; mean 0·09 p.p.m.) but the mean level in the flesh was only 0·01 p.p.m. The occurrence and levels of the skin residues were similar, irrespective of the mode of pesticide application or whether the field had been treated for the first time in the year of cropping or in previous years. Samples from fields treated in years previous to the year of cropping occasionally contained low residues in the skin (mean 0·02 p.p.m.) but residues in the flesh were very low or not detectable.

Exploratory studies

70. The Panel on Residues of Pesticides in Foodstuffs initiated a number of small-scale studies on selected foodstuffs to determine whether there were residue problems worthy of extended examination. The foods investigated included tinned baby foods, infant diet supplements (cod-liver oil, concentrated orange juice, and dried milk), flour, breakfast cereals, jams and marmalade, strawberries, bananas from plantations that had been treated with aldrin, blackcurrants from plantations that had been treated with endosulfan and blackcurrant products (juices, jams, tinned fruit, and pie fillings), wines, spirits, and beers. With the exception of cod-liver oil and fresh blackcurrants from treated plantations, the residue levels found in these studies were of the order of parts per thousand million or less. Samples of cheese, cooking fats and oils, and fish, were also examined in 1968. The content of organochlorine pesticide residues in these products was very variable, ranging up to 0·28 p.p.m. of BHC (cheese), 0·16 p.p.m. of dieldrin (fish), and 0·41 p.p.m. of DDT compounds [Appendix VI, Table (i)].

71. In the 1967 survey initiated by the County Councils Association, some 2,500 samples of foods purchased at retail outlets throughout Great Britain were examined. 84% contained either no residues or residues below a level of 0·001 p.p.m. and less than 5% of these samples contained residues of organochlorine pesticides in excess of 0·1 p.p.m. The residues above 0·1 p.p.m. were predominantly DDT and occurred in the fats and fruits.

(c) Study of the Whole Diet

72. A study designed to determine the level of residues of pesticides in the average British diet began in October 1966. Foodstuffs offered for sale for human consumption were purchased at retail outlets in twenty-one towns throughout Great Britain, once in each quarter of the year. The foodstuffs were assigned to the following seven categories:—cereals, meats and fish, fats and oils, fruits and preserves, root vegetables, green vegetables, and milk. The foods were prepared as for table use, i.e. those that are normally eaten washed, peeled, or cooked, were so treated. The foods in each individual category were then blended in the proportion in which they occur in the total British diet. For example, the proportion of butter in the fats category was that proportion of butter in the total fats and oils consumed. Account was also taken of seasonal variations in consumption.

73. The results of this study [Appendix VI, Table (ii)] showed that the food reaching the consumer contains consistently low levels of organochlorine pesticides. The daily intakes, in μg*/kg body weight, calculated from these total-diet samples, are compared in Table 1 with the daily intakes proposed in 1967† as acceptable by the Joint Food and Agriculture Organisation (FAO)/World Health Organisation (WHO) Expert Committee on Pesticide Residues, which incorporate wide safety margins.

Table 1

	Daily intake in μg/kg body weight	*Acceptable daily intake μg/kg body weight*
DDT	0·6	10·0
Dieldrin	0·1	0·1
BHC	0·2	12·5

74. Some components of the diet contribute more to the overall pesticide intake than others. This is illustrated in Appendix VI, Fig. 1. Organochlorine residues accumulate in fats generally, and although the fats group examined in the whole-diet study comprise only a minor proportion of the diet by weight (about 5%) they nevertheless make a major contribution to the pesticide intake (about 36% of the total DDT and about 31% of the dieldrin). Over 80% of the dietary intake of DDT is from meat, fats, and fruit; the amount from cereals, all vegetables, and milk, is relatively small. With the exception of the high proportion in the fats, the dietary intake of dieldrin is more evenly distributed between the food groups. As a result of these findings the Panel on Residues of Pesticides in Foodstuffs has initiated more detailed examinations of the components of the fruits and preserves, the fats and oils, and the fish and meats, categories.

* μg=microgram.

† Report of the 1967 Joint Meeting of the FAO Working Party of Experts and the WHO Expert Committee on Pesticide Residues.

IV. EFFECTS ON MAN

Exposure

75. That the human environment contains DDT and dieldrin as well as some of the other organochlorine insecticides is apparent from the evidence that human fat contains small quantities of these compounds. The mean levels of DDT, the compound most studied, vary from country to country and the amounts in the population are somewhat higher in Great Britain than in Western Germany but less than in the U.S.A., France, Hungary, India, and Israel. The most recent survey in Great Britain suggests that the level of all these compounds is tending to fall rather than to rise (Appendix VII).

76. From studies in which known doses of DDT and dieldrin were given to volunteers it is possible to calculate the daily intakes that will give rise to the levels found in the fat; these values can then be compared with the insecticide content of human food. For DDT the mean daily intake calculated from the human fat concentration is 0·71 μg/kg body weight which correlates very well with the daily intake found in a total-diet study of 0·6 μg/kg body weight. This daily intake is well below that of 10 μg/kg body weight considered by WHO to be the maximum acceptable daily intake. For dieldrin the average daily intake calculated from the human fat concentration is about 0·1 μg/kg body weight which again correlates well with the average intake of 0·1 μg/kg body weight/day found in a total-diet study. In this case the intake is similar to that advised as a maximum acceptable daily intake by WHO, i.e., 0·1 μg/kg body weight which allows a wide safety margin (paragraph 73). In both cases we consider that for the majority of the population the body content of these two compounds probably derives mainly from the diet.

77. Other sources of DDT in the immediate human environment include insecticidal vaporisers which might contribute to the body content of DDT in individuals occupying rooms in which the devices are working for considerable periods. A potential source of dieldrin could be clothing prepared from wool moth-proofed with this insecticide. Studies on human volunteers wearing underclothing made from wool which, contrary to normal practice, had been treated with dieldrin, showed that only very minute amounts of dieldrin were absorbed. We conclude that the wearing of outer clothing made from dieldrin-treated wool would have no detectable effect on the body content of dieldrin.

78. The Poisons Reference Service has no records of reported poisoning of man from the use of vaporisers discharging gamma-BHC or DDT; nor has accidental poisoning resulted from the supply of the chemicals for use in such units. We know, however, that incidents, some with fatal results, have occurred in the United States following ingestion of lindane (gamma-BHC) pellets made for vaporisers; allergic responses have also been reported among persons exposed to the vapour from thermal units. Similar incidents could occur in this country. Ingestion, however, is a gross misuse that cannot be completely prevented even by the most stringent type of label warning; allergic responses to chemicals are fairly common and cannot be considered a special risk of this particular method of application.

Evidence from studies on people

79. There is no evidence of any adverse long-term effects of these small daily

does of DDT and dieldrin in man. Certain small, heavily-exposed groups of individuals have been studied throughout several periods of years. Men formulating DDT, whose exposure has been shown to be 1,000 times greater than that of the population of Great Britain, have been under study by the U.S. Public Health Service for 20 years and no harm attributable to DDT has been found.

80. As pointed out in our 1964 Review many people engaged in public health programmes, as well as formulators in factories, have been acutely poisoned by dieldrin without lasting effects. Since that Review we have examined the health records of over 800 men in Holland engaged in the manufacture of dieldrin including 200 with more than 4 years' continual exposure. The estimated daily exposure of this population was 50–100 times greater than that of the general population and there was no evidence of any ill-effects attributable to dieldrin at this level of exposure.

81. In other overseas countries much larger but widely-scattered groups of men have been heavily exposed to DDT during the spraying of houses in malaria eradication campaigns. While there is no evidence that any members of these spray teams have suffered ill-effects attributable to their exposure to DDT, we understand that WHO intends to undertake a long-term surveillance of some of these groups if this proves practicable.

82. There are no groups of individuals in Great Britain with an unusual occupational exposure confined to either of these insecticides on whom a long-term search for ill-effects could be pursued. In studies in the U.S.A. with DDT and in Great Britain with dieldrin, groups of volunteers receiving measured doses in excess of the daily intake of the general population have been carefully observed over periods up to 3 years and no effects attributable to the insecticides could be detected by the most sensitive clinical tests.

83. The health records of the dieldrin plant workers mentioned in paragraph 80 and of DDT formulators in the U.S.A. do not appear to be different from those of other industrial workers. The absence of evidence of mental stress or of an increased industrial accident rate even in these heavily exposed groups suggests that the behavioural changes reported in wild species or produced experimentally in laboratory animals by exposure to DDT and dieldrin do not occur at the levels in the environment to which the human population is exposed. Furthermore, this epidemiological evidence does not provide any rational support for the assumptions made in occasional reports in the medical literature of an association between trivial exposure to these insecticides and the development of neuropathies or blood dyscrasias.

Evidence from studies on experimental animals

84. Experiments on animals can provide only presumptive evidence that similar effects will occur in man. Behaviour studies on laboratory animals reveal that DDT at some doses can have effects which disappear when the dose is reduced, yet this lower dose greatly exceeds, on a body-weight basis, the daily intake of the general population. The effects of DDT and dieldrin on the intact organism depend upon the general level of the chemical in the blood and tissues. The relation of these levels to the daily intake is determined by the capacity of the animal to metabolise and excrete the insecticide. It is apparent that lower forms of animal life may metabolise compounds like DDT much more slowly than

do mammals and birds, while among the latter the rates of metabolism may vary considerably. Thus a similar daily intake on a body-weight basis may give rise to different storage levels in the tissues because of the species differences in the rates of metabolism. This and other factors must be taken into consideration before observations on the effects of DDT, for example, on lower forms of life, are assumed to be representative of the likely effects of a similar rate of ingestion on higher species including man.

85. Evidence related to the alleged carcinogenic effects of DDT and dieldrin on rats and mice was discussed in our 1964 Review. Since then other experiments have been carried out. In the case of dieldrin, we were told of experiments in which mice had been given diets containing 10, 1·0, and 0·1 p.p.m. dieldrin. At the highest level all the mice developed tumours of the liver and the incidence was less, though appreciable, in mice on the lower doses of dieldrin. In consultation with a number of cancer experts and pathologists, we were unable to obtain common agreement as to whether these lesions represented malignant tumours which would have indicated that dieldrin had had an undoubted carcinogenic effect on these mice. Certain additional experiments were then suggested which might yield results which would help to decide whether these liver lesions were capable of autonomous growth and had the accepted characteristics of malignant tumours. Clarification on these points might be expected to help in assessing the significance of these lesions in relation to the possible carcinogenic hazards likely to involve industrial workers more heavily and continuously exposed to dieldrin.

86. In the case of DDT the results of a completely different type of experiment on mice have been reported from Hungary. Pure-line mice of one particular strain were given a diet containing DDT in amounts that produced in their fat a concentration of DDT similar to that found in the fat of the population of Hungary. These studies on mice revealed the occurrence of an unusually high incidence of leukaemia and some other tumours in the third and succeeding generations. This new type of experiment differs from the well-tried conventional method of administering the substance to be tested to young animals and continuing through their life span, in the fact that pregnant mice were exposed to DDT and the young received DDT from the day of their birth.

87. Because of the importance of DDT in the programme of eradication and control of vector-borne diseases, WHO consulted the International Cancer Laboratory, and this Laboratory has set up further experiments of a similar design in three different laboratories in order to check the findings in the Hungarian experiment. The final results of these new experiments are not likely to be available for at least two years.

88. If the original findings are confirmed a problem of interpretation will remain, because there is so little information available on the capacity of any chemical administered to mice in this way to increase the frequency of tumours and leukaemia. We do not know whether this is a toxic effect confined to DDT or one capable of being provoked by substances with a record of safety for man at least as good as that of DDT. Meanwhile, WHO is continuing to recommend the use of DDT wherever this makes an important contribution to the control or eradication of serious human disease.

Assessment

89. We consider it undesirable that the human environment should contain substances capable of producing toxic effects and whose continued presence conveys no benefits to human survival and well-being. If, however, priority is given to the removal of those substances the presence of which is known to be harmful to man, then on such a basis no high priority can presently be assigned to the removal of DDT or dieldrin. Nevertheless, we consider that evidence should be obtained by the regular determination of organochlorine residues in people and their diets, so that the situation and trends can be kept under surveillance, and we recommend accordingly.

V. DISTRIBUTION IN THE ENVIRONMENT

90. In our 1964 Review we noted that residues of the pesticides under consideration had been found in many places, sometimes far from where they were originally applied and often long after they were needed to control particular pests. We recognised the difficulties in assessing fully the possible effects of such residues and took the view that, irrespective of whether harm had actually been demonstrated, any increase in the amounts of these chemicals in the environment should as far as possible be prevented; our recommendations for reducing the use of organochlorine compounds were based mainly on this conception. In the course of the present review, we have examined new evidence on the distribution of these pesticides in soil, air, and water—important parts of the environment in which some of these pesticides are widely distributed. It has not been possible to ascertain whether there has been any increase of these compounds in the environment at large. Their widespread and continuous dissipation by means of air and water currents, animal movements, etc., leads ultimately to great dilution of concentration and hence to quantitative analytical uncertainty. For example, examination of plankton and fish may show the presence of measurable quantities of organochlorine pesticides, while the concentration of these compounds in the sea-water from which the samples were taken is likely to be well below the present limit of detection.

91. Some unchanged pesticide may be lost into the atmosphere from treated crops and especially from residues concentrated at the soil surface, and this may well be one of the mechanisms that contributes to the wide distribution of these compounds. Limited studies showed that rainwater collected over 12 months at seven widely distributed sites in Great Britain contained concentrations of the order of parts $/10^{11}$* or parts $/10^{12}$**. However, concentrations of this order would deposit only a few milligrammes per acre per year, and we do not think significant increases in the loading of soil are likely to arise from this source.

92. Pesticides find their way into soil in many ways, e.g. by direct application against soil pests, as run-off during the treatment of crops, by spray drift, or in much smaller concentrations in rainwater. Examination of soil from experimental plots and from farm land indicated that DDT residues are fairly

* Parts $/10^{11}$ is parts per hundred thousand million.

** Parts $/10^{12}$ is parts per million million.

widespread. This chemical probably remains biologically active in the soil longer than any of the other organochlorine insecticides in common use. TDE is used much less than DDT and most TDE found in the soil probably arises from the degradation of DDT. Like DDT, it is relatively persistent in the soil.

93. Following our 1964 Review, during which we considered the direct application of aldrin and dieldrin to soil, the quantities of these chemicals used on the soil in Great Britain have undergone substantial reductions. There are very few data on the levels of camphechlor, chlordane, endrin, endosulfan, and heptachlor, in soils in Great Britain. They are not at present much used and in any case, with perhaps the exception of chlordane and heptachlor, they are much less persistent than aldrin/dieldrin and DDT/DDE.

94. Examination of freshwater fish and their avian predators in Great Britain has shown water to be a route of distribution of persistent pesticides. Residues of DDT in the natural waters in Great Britain that have been examined, including those in heavily treated areas, are generally well below the threshold concentrations that would threaten survival or produce adverse effects on fish. The relatively high concentrations of dieldrin in some sewage effluents containing industrial waste might be an important element in their toxicity to fish and other aquatic organisms. Residues of organochlorine pesticides may also enter water mainly from careless disposal of containers and by direct deposition during crop spraying, and also by erosion or carriage by wind of treated soil from fields. Much of the DDT entering water in these ways is taken up by living organisms and metabolised. The processes in the ecosystem are not well understood, although it is clear that the net uptake of residues differs between species and that biodegradation occurs in both bacteria and fish.

95. Residues of organochlorine pesticides in marine organisms have been studied both to detect pesticides in the marine environment and to assess any changes in their levels. The uniformity of residues in eggs of sea birds make them particularly suitable for the latter purpose. Residues of organochlorine pesticides have been found in most of the specimens of marine organisms which have been analysed but the limited data on invertebrates and fish from British waters show that DDT and dieldrin residues are relatively low (mostly below 0·1 p.p.m.) [Appendix V (ii)]. More extensive data on the eggs of seabirds collected from colonies on the east and west coasts of Great Britain show higher levels of these chemicals (dieldrin: mostly within the range 0·1–3·0; DDE: mostly within the range 0·1–6·0 p.p.m.) [Appendix V (iii a)]. There is no evidence, however, to suggest that organochlorine compounds have had deleterious effects on British seabirds. Some animals that are important in marine food chains (e.g. the common brown shrimp) are known to be particularly sensitive to these substances but there is insufficient evidence to state whether organochlorine pesticides have affected marine invertebrates and fish. Nevertheless, the levels of insecticides in marine life in coastal waters are causing some concern. Limited studies in Britain suggest that pesticides mainly reach the sea by rivers.

96. Any environmental change which is widespread may affect man directly through his supplies of water, agricultural and other biological products, and indirectly through his opportunities for recreation and appreciation of nature. We have much evidence that DDT/TDE, aldrin/dieldrin, and to a lesser extent

other chemicals under review, can be found very widely throughout our environment. However, studies on wildlife (Appendix V), food (Appendix VI), and human fat (Appendix VII), indicate that as far as we can ascertain, the situation in these cases has not deteriorated since our previous report and, indeed, there is evidence to suggest that there has been an improvement.

97. After taking into account all available information, we have found no reason to change the view expressed in paragraph 123 of our 1964 Review that the basic problem is that certain of these pesticides remain stable over long periods, and so become dispersed in the environment. Because of their stability they can accumulate in ecosystems and as a result do harm to certain species of wildlife. We believe that the problem of persistent organochlorine pesticides in the environment is only part of the larger problem of the general pollution of the environment by man; and although important, it should be looked at in terms of the priorities stated in paragraph 89 against the background of pollution arising from industrial and domestic effluents.

98. Nevertheless, we are of the opinion that it is prudent to lower residue levels whenever possible. Sources of these residues in the environment cannot all be identified. The only certain source that can be effectively controlled is the current use of these pesticides. We therefore review in the two following sections all the major known uses of these chemicals in Great Britain to see where the amounts used could be reduced. In so doing we have drawn heavily on quantitative information supplied by the survey units at Harpenden and Tolworth and through the Department of Agriculture and Fisheries for Scotland (paragraph 7). These data are set out in detail in Appendices VIII Parts I and II, and IX. We appreciate that survey estimates of proportionally small uses of insecticides may not be very accurate, and where less than about 2% of the acreage of a crop has been recorded, the true extent of treatment may differ appreciably from the estimated figure. Data of this kind occur in Tables 2, 3, and 6, where the relevant figures are in brackets, and in paragraphs 116, 117, 128, 146, 154, and 185. In aiming to lessen current uses, we have tried to ensure that any cuts proposed cause neither interference with the production of food nor undue hardship to farmers and other users. We have kept clearly in mind the availability of satisfactory and economic alternatives. The organochlorines have been used to control many different pests, which are referred to in the following sections by their common names.*

99. In assessing whether alternative compounds are satisfactory we have taken into account the following criteria:—

(a) they must not present an unacceptable toxic hazard to man and their introduction must depend on suitable methods of use free from undue operator hazard;

(b) they must not be likely to have serious effects on wildlife;

(c) they must compare well with the reviewed chemical in controlling the pest, as judged by carefully conducted experiments, preferably supplemented by evidence from commercial use;

* "Common Names of British Insect and Other Pests"—Tech. Bull. No. 6, Minist. Agric., Fish., Fd., Her Majesty's Stationery Office, London, 1968.

(d) they must not be unduly expensive in relation to benefit, though we accept that compared with DDT they are not likely to be as cheap. However, the cost of the pesticide itself may sometimes represent only a small proportion of the total cost of a control operation. Organochlorine compounds, by virtue of their persistence, often need only one application, which need not be timed as accurately as with less persistent chemicals;

(e) they must be acceptable as regards properties such as volatility, compatibility with other pesticides, and phytotoxicity.

100. In some cases, alternative compounds are available which are little more costly or little less effective. In other cases, where no suitable substitute is known, it is hoped that pesticide manufacturers will eventually produce some acceptable alternatives. However the process of discovery, test, production, and promotion, of a new pesticide is very expensive and takes a long time. We must therefore recognise that pesticide manufacturers are not likely to find it economic to seek out and develop alternatives if they are to be used only on a few minor crops or only against occasional pests. For these situations the organochlorines, which are widely used for other purposes, are probably irreplaceable.

VI. COMMERCIAL USES

(a) Agricultural and Horticultural Uses

101. The present uses of aldrin, dieldrin, endrin, endosulfan, heptachlor, chlordane, and camphechlor, in agriculture and horticulture cleared under the Pesticides Safety Precautions Scheme, are considered in paragraphs 102–132.

Aldrin and Dieldrin

WHEAT

As a liquid seed dressing (aldrin)/dry seed dressing (dieldrin) on winter-sown wheat (up to the end of December) where there is a real danger of attack by wheat bulb fly, at a rate of up to 0·8 oz active ingredient per bushel (aldrin) or 1·2 oz active ingredient per bushel (dieldrin).

102. In recent years some 230,000–240,000 acres of wheat have been grown annually in England and Wales under conditions which can attract a damaging level of wheat bulb fly when the pest is unusually abundant. When this happens, treatments have been estimated to save the production equivalent to about 84,000 acres of winter wheat, valued at some £3·3 millions. In Scotland, damage may occur on 10,000 to 20,000 acres, mainly in the eastern wheat-growing areas. During 1962–64, in England and Wales, about 290,000 of the 2·1 million acres of wheat were sown with seed dressed against wheat bulb fly. In 1965/66, when 2,171,000 acres of wheat were grown in England and Wales, wheat bulb fly was particularly abundant, and about 278,000 acres were sown with treated seed: some 97,000 acres with aldrin or dieldrin, and 181,000 acres with high-strength gamma-BHC. In the same year in Scotland where over 98,000 acres of wheat were grown, about 15,000 acres were sown with dieldrin-treated seed and 300 with aldrin-dressed seed. In 1962–64 about 30,000 acres of wheat in England and Wales were treated annually with aldrin sprays or dusts to give additional

protection against wheat bulb fly: in 1965/66 about 43,000 acres of wheat were given insecticidal field treatments, mostly as organophosphorus sprays applied in the spring for wheat bulb fly control. Field treatments were not recorded in Scotland in 1965/66.

103. Although the voluntary restrictions resulted in very considerable improvements, some casualties still occur amongst seed-eating birds, mainly from sowing in January and February of seed held over from the autumn due to unsuitable sowing conditions. Furthermore, some residues from the use of these chemicals as cereal seed dressings almost certainly find their way into predatory species.

104. Gamma-BHC seed dressings have proved less effective than aldrin or dieldrin dressings for wheat bulb fly control, particularly on peat soils. There are, however, other effective seed dressings, namely chlorfenvinphos and ethion, which cost about the same per acre as aldrin and dieldrin. We have therefore considered whether these organophosphorus compounds are acceptable alternatives, in which event we would recommend the withdrawal of aldrin and dieldrin as cereal seed dressings.

105. Both these organophosphorus compounds are scheduled poisons and call for special precautions in use. We are particularly concerned about possible additional risks which may arise to people engaged in seed dressing operations in the many establishments currently undertaking this work, in the event of an immediate withdrawal of the less acutely toxic organochlorine compounds. We feel that the safety aspects of the use of the organophosphorus alternatives have not yet been adequately appraised (paragraph 285) and, in view of the continuing importance of wheat bulb fly, we cannot recommend the immediate withdrawal of the organochlorine dressings in favour of the available organophosphorus alternatives. We therefore recommend that the possibility of withdrawing the use of aldrin and dieldrin as cereal seed dressings for use against wheat bulb fly should be continuously assessed by the Advisory Committee, with a view to the withdrawal of these compounds as soon as is practicable.

POTATOES

As a spray or dust on potatoes for the control of wireworms, (*aldrin*) *at a rate of up to 48 oz of active ingredient per acre in the case of sprays and 67 oz active ingredient when dusts are applied. As a spray on potatoes for the control of wireworms,* (*dieldrin*) *at a rate of up to 44 oz active ingredient per acre.*

106. In the late 1950's to early 1960's, fertilisers containing aldrin were used to protect potatoes from wireworm damage. These fertiliser mixtures were voluntarily withdrawn in 1964 and although aldrin and dieldrin are still available as soil sprays and dusts, the cost of wireworm control has increased because an extra operation is now required to treat land at risk. This increased cost, together with the better publicity for more careful use of pesticides, has led to an appreciable decline in the use of aldrin and dieldrin on potatoes as will be seen from Table 2. These chemicals are little used on early potatoes.

107. Many field trials have been carried out on alternatives to organochlorine compounds for wireworm control. Certain organophosphorus compounds give

Table 2

Year	Total acreage of second-early and maincrop potatoes in England and Wales	Acreage treated with aldrinated fertilisers	Acreage treated with aldrin sprays*	Acreage treated with dieldrin sprays
1964 . .	460,200	67,300	21,400	(700)†
1965 . .	454,200	(2,000)†	35,600	(1,400)†
1966 . .	416,300	NIL	20,500	(NIL)†
1967 . .	450,800	NIL	26,000	(100)†

Notes: * 2—4% of the acreage was treated with aldrin dust.
† see paragraph 98.

partial control of wireworms, particularly where low populations are involved, but there is still no satisfactory alternative for the control of high populations. In view of this and the fact that there is little direct hazard to wild birds and mammals from this use, we conclude that aldrin should be retained for the control of wireworm on potatoes, at least for the present. However, since aldrin affects beneficial insects in the soil, a substitute is highly desirable and we hope that the search for alternatives will continue. A few growers use dieldrin sprays for wireworm control although the material is more expensive. Such use is declining and we recommend its withdrawal.

BRASSICAS

As a dip, spray, drench or dust on brassicas for the control of cabbage root fly, (aldrin) at a rate up to 42 oz of active ingredient per acre. As a dip, spray or drench on brassicas for the control of cabbage root fly, (dieldrin) at a rate up to 21 oz active ingredient per acre.

108. Cabbage root fly is a common and often serious pest of brassicas. In 1966 138,300 acres of brassicas were grown in England and Wales for human consumption (Table 3). Of these, 46,200 acres were treated with aldrin or dieldrin seed dressings or transplant dips. Additionally some 282,000 acres of brassicas were grown for seed and stock feed (compared with 327,000 in 1964) but these were not treated against cabbage root fly. About 200 acres of mustard and 200 acres of other brassica seed crops were sprayed with dieldrin in 1966 for the control of blossom beetles.

Table 3

1966	Acreage grown	Acreage treated with aldrin or dieldrin	% treated
Spring cabbage	25,500	(900)†	4
Other cabbage	33,500	9,000	27
Brussels sprouts	36,300	17,300	48
Broccoli, cauliflower and kale .	43,000	19,000	44
	138,300	46,200	

Note: † see paragraph 98.

109. In the absence of control measures, cabbage root fly might take the equivalent of production from over 25,000 acres in England and Wales. Drench applications have become uneconomic and practically all the use is as a pre-planting dip, about one-third of the treated plants receiving aldrin and two-thirds dieldrin, often at a rate considerably below the maximum permitted and sometimes as low as 0·3 oz per acre.

110. There are several reliable alternative chemicals available and chlorfenvinphos, diazinon, mecarbam, and thionazin, have given good control of the pest and are approved for this use.* They are dearer than aldrin and dieldrin but the overall increase is relatively small in terms of the total value of the crop. However, none of the alternatives is really effective as a root dip. Aldrin and dieldrin are still useful in areas where resistance is not yet a problem but resistance of the fly to aldrin and dieldrin is now well established in areas in the southern half of England and growers are already using some of these alternatives successfully. In general, although the alternatives are adequate as sprays and drenches, the lack of a suitable dip leads us to accept the retention of aldrin and dieldrin dips on brassicas to control cabbage root fly, at least for the immediate future.

NARCISSUS

As a narcissus bulb dip for the control of narcissus bulb fly at a rate up to 6 oz active ingredient in 20 gallons of water (aldrin or dieldrin); or as a dust applied to the drills when planting out, at a rate up to 7 lb active ingredient per acre (aldrin); or as a spray applied to the drills when planting out at a rate up to 3 lb active ingredient per acre (aldrin).

111. In England and Wales, approximately 7,500 acres of daffodils (Narcissus), were grown in 1966. The total acreage has not changed greatly since 1963, when it was estimated that 600 acres were given aldrin or dieldrin treatment and a similar acreage is believed to have been treated in 1966. The normal rates of application are below the maximum permitted, i.e., 2·5–3 lb per acre, whether applied as a dust or spray.

112. Narcissus bulb fly is a real problem only in the south-west region of the country and inability to control it could lead to a rapid decline in the industry in those parts. As yet, there are no satisfactory alternatives that provide the long persistence necessary for the control of this pest. The bulb dip and spray treatment applied to the drills are least likely to add to pesticides in the environment and aldrin is almost invariably used in the dip because it is much cheaper than dieldrin. We consider that adequate control can be achieved by retaining only the spray and dip uses of aldrin. We therefore recommend that the dieldrin dip and aldrin dust should be withdrawn.

ORNAMENTALS

As a dust on compost used for potting ornamental plants for the control of vine-weevil, (aldrin or dieldrin) at rates up to 2 oz of 1·25% dust per bushel of potting compost.

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* Under the Agricultural Chemicals Approval Scheme.

113. There are very few data available on the extent of this use. Between 15 and 30 acres of cyclamen, a plant susceptible to damage, are thought to be grown out of a total of 200 acres of pot plants. BHC has given less reliable control than aldrin or DDT, but there has been no recent experimental work owing to the lack of suitable experimental sites. There are no proven alternatives and we make no objection to the continued use of aldrin dust for compost application for vine weevil control.

BARLEY

As a spray or dust, to control leatherjackets on those spring barley varieties which are known to be susceptible to DDT, (aldrin) at a rate up to 24 oz active ingredient per acre in the case of sprays and up to 45 oz active ingredient per acre when dusts are applied.

114. In England and Wales in most years, about 92% of barley is spring-sown and in 1965–1966, a total of 5,787,400 acres of barley was grown. It is estimated that in an average year about 121,000 acres of barley may be affected, but only 25,000–30,000 acres may justify treatment for leatherjacket control, and about half this acreage is likely to be sown with DDT-susceptible varieties. Some of the newer barley varieties are also susceptible and the acreage of susceptible varieties may increase over the next few years. Estimates made by the Advisory Service suggest that 16,000 acres of cereals were chemically treated against leatherjackets in 1965–1966, and nearly 5,000 of these received aldrin. In Scotland in 1965, out of a total of 558,500 acres of barley grown, only 3,600 acres are believed to have been treated with aldrin spray.

115. As an alternative to aldrin, a DDT bait which is not phytotoxic to DDT-susceptible varieties can be used but is unpopular with growers because of the difficulties of application. BHC cannot be used if the barley is to be followed in a year or so by potatoes or other root crops which are likely to be tainted; it has, in any case, given inconsistent results. The organophosphorus insecticides fenitrothion, chlorfenvinphos, and parathion, have given effective control of leatherjackets in experiments. Fenitrothion is not marketed for agricultural use in the United Kingdom at present and we cannot cost it against aldrin; parathion spray is comparable in cost to aldrin, and chlorfenvinphos is more expensive. Fenitrothion is the safer alternative; we cannot recommend parathion sprays because of operator hazards, but parathion granules are acceptable on safety grounds. There is limited evidence at present on the effectiveness of parathion granules against leatherjackets in the field, though further data are being obtained in field trials by the Advisory Service. We conclude that at present aldrin is the only available satisfactory alternative to DDT for susceptible varieties of barley. Although applications of aldrin in the spring suggest a possible hazard, no evidence has been found of harm to wildlife from these uses. We therefore accept that these uses be retained until a satisfactory alternative is available.

STRAWBERRIES

As a spray or dust, to control strawberry seed beetle on strawberries, (aldrin) applied not less than three weeks before harvesting of the crop commences, at a rate up to 80 oz active ingredient per acre.

116. Strawberry seed beetle is a local and sporadic pest and strictly necessary usage of aldrin is believed to be very limited. Of 15,800 acres grown in England and Wales in 1965, 650 acres were treated with aldrin and about 200 acres were treated with dieldrin. In 1966 only about 10% of reported damage claimed to be due to seed beetles was thought to be genuine. The remaining damage was shown to be caused by linnets. Baits based on malathion or fenitrothion with crushed oats are effective in killing beetles and reduce damage to the fruit but the control is not so good as that obtained with aldrin; the baits have a relatively short persistence and cannot be used as preventive treatments; and in any case fenitrothion is not commercially available (paragraph 115). Nevertheless, in view of the fact that an alternative is available we recommend that aldrin should be withdrawn for this use.

HOPS

As a spray or dust, to control hop root weevil on hops, (aldrin) at a rate up to 24 oz active ingredient per acre.

117. During 1964–1966, about 20,700 acres of hops were grown in England and Wales annually. At the beginning of this period, aldrin was used on perhaps 100 acres, declining to some 40 acres. Hop root weevil is a sporadic pest and the area treated indicates that very little aldrin is used. Gamma-BHC dust is a possible alternative but experimental evidence is limited and we accept that aldrin be retained for the control of hop root weevil until a suitable alternative is found.

BEANS

As a dry seed dressing on the seed of dwarf (French, kidney) beans (Phaseolus vulgaris) *and runner beans* (P. multiflorus) *to control bean seed fly, (dieldrin) at a rate up to 0·75 oz active ingredient per 28 lb of seed.*

118. Table 4 refers to acreages of green (dwarf and runner) beans grown in England and Wales in 1964–1966:

Table 4

Year	*Acreage grown*	*Acreage sown with dieldrin-dressed seed*
1964 . .	19,000	8,000
1965 . .	17,300	7,800
1966 . .	18,400	11,900

119. Bean seed fly can do serious damage to green bean crops, especially in seasons when seed is sown early and germination is slow. Resistance of this pest to dieldrin has already occurred extensively in the United States and was reported in England in 1965, and it is important to develop alternatives in case this resistance spreads. Trials in the past suggest that fenitrothion, diazinon, and chlorfenvinphos seed dressings are as effective as dieldrin and more effective than gamma-BHC, though in some trials chlorfenvinphos was phytotoxic (applied to seed 38 days before drilling). Further trials are in progress. However,

these organophosphorus compounds are not yet commercially available in suitable formulations, and until they are we accept that this use of dieldrin be retained.

SUGAR BEET

As a dry seed dressing on rubbed and graded sugar beet seed for precision drilling, (dieldrin) at a rate up to 3·6 oz active ingredient per cwt.

120. Wireworms are by far the most important pests of seedling sugar beet, the annual loss from this source being greater than that from all other seedling pests of sugar beet together. Effective control can be achieved by dieldrin seed dressings and from 1964 to 1967 the acreage sown with dieldrin-dressed seed rose from 68% to 97% of the total acreage sown (Table 5). This increase is almost entirely due to the increase in the use of rubbed and graded seed and hence a greater need to ensure an undamaged stand of plants. The use of heptachlor on this crop has ceased and the use of gamma-BHC has diminished.

Table 5

Year	*Total acreage sugar beet in England and Wales*	*Heptachlor-treated seed*		*Gamma-BHC-treated seed*		*Dieldrin-treated seed*	
		Acreage	*% total*	*Acreage*	*% total*	*Acreage*	*% total*
1964	432,400	26,800	6	94,900	22	298,100	68
1965	445,900	NIL	0	92,000	21	338,900	77
1966	439,100	NIL	0	80,500	19	345,400	80
1967	451,900	NIL	0	8,600	2	422,200	97

121. A large number of alternatives has been tried, the only success being achieved with gamma-BHC, although this was only effective against low wireworm populations. Gamma-BHC is phytotoxic to polyploid seed and cannot therefore be used on the 5% of rubbed and graded sugar beet seed which is polyploid. Since there is no satisfactory alternative to dieldrin for the treatment of sugar beet seed under modern conditions to protect it from damage from high wireworm populations and because the rate at which dieldrin is used for this purpose is very low, we accept that this use should continue.

ONIONS

As a dry seed dressing on onion seed for the control of onion fly, (dieldrin) at a rate up to 0·6 oz active ingredient per lb of seed.

122. In 1966, of 4,900 acres of dry onions grown, about 200 acres were sown with dieldrin-treated seed; 3,300 acres of salad onions included 150 acres grown from treated seed. Dieldrin seed dressings give good protection from onion fly although organophosphorus insecticides show promise as alternatives. There is insufficient experimental evidence at present on the effectiveness of these organophosphorus alternatives, and experimental sites are difficult to find. Nevertheless field work is in progress. We accept that this use of dieldrin be retained, at least for the present.

SPINACH

As a dry seed dressing on spinach seed for the control of bean seed fly, (dieldrin) at a rate up to 3·6 oz active ingredient per cwt.

123. This minor use was added to the accepted uses in 1965. There is no information on the current extent of use of dieldrin for this purpose but it is thought that up to 100 acres of spinach are liable to attack by bean seed fly and in view of the relatively small acreage involved, and since no satisfactory alternative is available, we accept that this use be retained.

Endrin and Endosulfan

BLACKCURRANTS

On propagating stock and non-fruiting blackcurrant bushes for the control of the blackcurrant gall mite.

On fruiting blackcurrant bushes (endrin) applied not later than immediately before flowering.

On fruiting blackcurrant bushes (endosulfan), the maximum rate and frequency of application per crop per season in terms of active ingredient being: two applications, one at first open blossom stage and one three weeks later, each at 8 fl. oz (e.g. 40 fl. oz of a 20% w/v proprietary liquid formulation) per 100 gal high volume application; if applied medium or low volume, the quantity of active ingredient used per acre should not exceed that which would have been applied high volume.

124. Of 13,800 acres of blackcurrants grown in 1965 in England and Wales, about 900 acres were treated with endrin and 10,800 acres with endosulfan. In Scotland in 1966, of 250 acres grown, it is estimated that 0·5 acre was treated with endrin and a further 0·5 acre with endosulfan.

125. Lime sulphur is an alternative to endrin and endosulfan for the control of blackcurrant gall mite (big bud) but there is a phytotoxic risk under some conditions, making it unacceptable for use in the eastern and south-eastern counties. Endosulfan used in this way also controls capsid bugs and blackcurrant leaf midge. Under the circumstances we accept that these uses of endrin and endosulfan be allowed to continue.

NARCISSUS

On narcissus grown under glass for the control of bulb scale mite (tarsonemid mite).

126. About 170 acres of bulbs are forced annually under glass in England and Wales. Enough endosulfan was used by glasshouse growers in 1965 to treat 280 acres (some more than once) and enough endrin to treat 140 acres once. There are no really effective alternatives to endrin and endosulfan for controlling bulb scale mite under glass and we accept that this use be retained.

ORNAMENTALS

On ornamentals grown under glass for the control of cyclamen mite (strawberry mite or tarsonemid mite).

127. No really satisfactory alternative is available, and we accept that this use of endrin and endosulfan be retained.

STRAWBERRIES

On strawberry plants after the whole of one season's crop has been picked and before the next season's flowers open for the control of strawberry mite.

128. In England and Wales in 1965, of 15,800 acres of strawberries grown, about 300 acres were treated with endrin. Endosulfan was used little, if at all. The mite is more troublesome in some areas where two crops are taken each season from certain varieties. Endrin and endosulfan cannot be recommended between the first and second crops and the mite is therefore difficult to control. Dicofol is sometimes used as an alternative because of the shorter interval required between last application and harvest. Because the pest does not require routine treatment we accept that endrin and endosulfan be retained for this purpose.

BLACKBERRIES

On blackberry canes at pre-blossom stage to control blackberry mite, (*endrin*).

129. Of an estimated 1,300 acres grown in 1965 in England and Wales, 200 acres were treated with endrin to control blackberry mite. No satisfactory alternatives are known and we accept that endrin be retained for this use.

APPLES

On apple trees, for the control of insect pests, (*endrin*) *provided it is applied not later than one week after 80% petal fall.*

130. About 5% of the apple growers in south-east England used endrin in 1967. Several organophosphorus compounds are effective against the pests controlled and we therefore recommend that this use of endrin be discontinued.

Heptachlor

WHEAT

SUGAR BEET

As a dry seed dressing on winter-sown wheat (*up to the end of December*) *where there is a real danger of attack from wheat bulb fly, at a rate not to exceed 0·8 oz of active ingredient per bushel* (*e.g. 2 oz per bushel of a 40% proprietary dry seed dressing*).

As a dry seed dressing on rubbed and graded sugar beet seed for precision drilling at a rate not to exceed 5 oz of active ingredient per cwt (*e.g 12 oz per cwt of a 40% proprietary dry seed dressing*).

131. Since 1964 the use of heptachlor as a cereal seed dressing has been subject to the same restrictions as aldrin and dieldrin though supplies have not been commercially available. As with aldrin and dieldrin, heptachlor can be hazardous to wildlife when used as a cereal seed dressing, and there are effective alternatives (paragraph 104) which do not have this disadvantage. Until the hazards to operators who apply these alternatives as liquid formulations are known (paragraph 285), we do not consider that we should recommend the withdrawal of heptachlor for use on winter-sown wheat. In this respect it should be given

the same consideration as aldrin and dieldrin (paragraph 105). This applies equally to heptachlor as a dressing for sugar beet seed.

Chlordane and Camphechlor

132. Chlordane and camphechlor are cleared under the Pesticides Safety Precautions Scheme for the control of earthworms in turf and lawns; chlordane is also cleared for the control of ants in home gardens. However we have no evidence on the extent of their use. We regard carbaryl as an acceptable alternative for the control of earthworms but because it is less persistent, more frequent treatments are necessary. There are other alternatives which could replace chlordane as an ant killer. Since there is no evidence to suggest that the present uses of these compounds are having a significant effect on wildlife, we accept that the present recommendations be retained for the time being.

DDT

133. DDT is a pesticide with a very wide range of uses and since neither DDT nor its immediate breakdown products are systemic to any important extent, residues are unlikely to occur in food unless DDT has been applied directly to the edible part of the crop.

134. In some cases, for example the control of aphids, proven alternatives are available and offer better control than DDT, and here recommendations have been relatively easy to make. Despite a great deal of work there are many pests for which no satisfactory alternative to DDT has been discovered. This is sometimes due to the difficulty of predicting attacks, which means that experiments to prove alternatives cannot be planned with any certainty of result. For some pests, small-scale experiments have indicated promising compounds but these have not always been followed up by extensive trials on a commercial scale. Sometimes suitable formulations of promising insecticides have not become commercially available. In the following paragraphs we consider, in some detail, uses of DDT against many specific pests of certain crops and where we have not made a specific recommendation we accept that DDT should continue to be available for that use.

135. In coming to the conclusions set out in paragraphs 136–183 we are very conscious of the great difficulty of applying the general criteria outlined in paragraph 99 if each use of DDT has to be decided entirely on efficiency. We realise particularly that in recommending the withdrawal of a few of the many uses of DDT its retention for the remaining purposes makes possible its continued use for those purposes for which it has been withdrawn. If the Pesticides Safety Precautions Scheme becomes mandatory, this situation will present a very real problem for enforcement authorities.

136. In our 1964 Review it was estimated that about 255,000 acres of crops, out of a total of 8,318,800 acres in England and Wales, were treated with DDT sprays or dusts. The results of surveys in 1965–1966 are given in Table 6. In the detailed considerations that follow, decreases in certain uses of DDT are evident and we believe that there is a slight trend towards the use of organophosphorus compounds as alternatives.

Table 6

Crop	Acreage grown in 1965–1966 rounded to the nearest hundred		Acreage believed treated with DDT	
	England and Wales	Scotland	England and Wales	Scotland
Wheat	2,171,400	98,500	(0)†	2,400
Barley	5,287,400	558,500	(1,500)†	51,100
Oats	426,500	431,700	(0)†	31,600
Potatoes	416,300	141,700	2,500‡	900
Sugar beet	439,100	8,900	5,000‡	3,500
Other roots	170,400	+	7,200	+
Brassicas (edible)	103,700	4,900	11,900	T
Brassicas (stock)	282,000	223,300	(2,000)†	1,800
Peas	133,600	4,100	17,300	(0)†
Root vegetables	46,400	800	10,900	(0)†
Mustard	17,000	0	600	0
Soft fruit	38,300	9,100	17,700	5,900
Top fruit*	142,300	0	101,200‡	0
Hops	20,300	0	(400)†	0
Nursery stock	5,400	1,100	400	T
Forests	844,000	1,096,000	1,200	0
TOTALS	10,544,100	2,578,600	179,800	97,300

Notes: T less than 100 acres.
* apples, pears, plums and cherries excluding cider apples and perry pears.
\+ included in data for stockfeed brassicas as they are mainly turnips and swedes.
† see paragraph 98.
‡ 1967 estimates.

CEREALS

137. Leatherjacket populations were declining in 1964 and 1965 and such damage as occurred was mainly in the northern and south-western counties and Wales to crops other than wheat. This is because wheat is normally autumn-drilled on land ploughed-out before crane fly eggs have been laid or before they have hatched. In 1968 populations of leatherjackets were increasing again and treatments on wheat may possibly become more necessary. In 1962–1964 it was estimated that about 47,000 acres of barley were given field treatments mainly for leatherjacket control. The 1962–1963 and 1963–1964 estimates suggested that 12,500 acres of oats were given field treatments against frit fly and leatherjackets. Leatherjackets are a consistently serious pest of cereals in all parts of Scotland and damage was extensive in certain areas in four years out of the ten during the period 1951–1960.

138. As noted in paragraph 114, it has been estimated that about 121,000 acres of barley may be affected by leatherjackets in an average year. In England and Wales about 322,000 acres of barley were sown on ploughed-out grassland in 1963–1964 and 1964–1965, and over the period 1962–1966 it was estimated that an average of 25,000 acres of barley warranted treatment against leatherjackets each year. Overall, it seems that something between 25,000 and 30,000 acres of barley may justify treatment in an average year. About 40% of the acreage in 1962–66 was sown with DDT-susceptible varieties but this proportion is likely to increase over the next few years and aldrin is the only currently

available chemical for use when such varieties are due to be followed within a year or so by potatoes or carrots which could pick up residual taint from a BHC field treatment. A possible alternative to aldrin is a DDT bait which is not phytotoxic to barley; but baiting is not popular with farmers (paragraph 115). The Advisory Entomologists estimated that in 1965–1966 only 16,000 acres of cereals were chemically treated against leatherjackets. DDT was thought to have been applied to 5,600 acres and DDT-baiting was estimated to have been done on 240 acres. These estimates do not differ in a statistically significant way from the estimate in Table 6 (paragraph 136).

139. The arguments against alternatives to aldrin for control of leatherjackets in spring barley are discussed in paragraph 115 and are equally relevant to this use of DDT.

GRASSLAND

140. With one or two exceptions, grassland pests are believed to be economically important only during the period of establishment of young leys, when wireworms, leatherjackets, frit fly, various caterpillars, and some aphids, may cause damage. In a survey in 1966 representing about 1,000,000 acres of permanent and 500,000 acres of temporary grass, none of the surveyed grass was treated with organochlorine insecticides in that year and it seems reasonable to conclude that grassland is rarely treated at the present time. DDT is usually recommended at present on the rare occasions when control of leatherjackets or frit fly is necessary.

141. For the control of timothy fly on seed crops the alternatives available offer better control than DDT. Under normal circumstances and on present evidence therefore, we consider that there should be no need to treat grassland with DDT. There can be rare occasions when this may be desirable and the situation may be different for grass seed crops but on balance we recommend that DDT should be withdrawn for use on grassland.

POTATOES

142. Since most first-early potatoes are lifted before aphid attacks develop, DDT is not generally used on this crop. On second-early and maincrop varieties the use of DDT for aphid control has declined rapidly from 10,100 acres in 1964 to approximately 2,500 acres in 1967. Very little spraying for aphid control is carried out in Scotland but data from the Potato Marketing Board indicate that DDT is still very occasionally used for this purpose. There are many, more effective, organophosphorus alternatives available in liquid and granular formulations and we recommend that DDT should be withdrawn for the control of aphids on potatoes.

143. Colorado beetle has so far not established itself in this country and the last outbreak occurred in 1952. DDT is effective as an eradicant, and on some occasions in the past potatoes were sprayed on a large scale with this compound as a precautionary measure in areas where outbreaks occurred. Such spraying, however, has not been necessary since 1955. Colorado beetle is potentially a very serious pest and the country must be kept free of it. Although carbaryl, azinphos-methyl, and phosphamidon, are possible alternatives, they are untried for this purpose in this country and since DDT is known to be effective, it must continue to be available if the need arises.

BRASSICAS

144. Flea beetles are a serious pest of all brassica crops and can be controlled with gamma-BHC seed dressings except for exceptionally severe attacks when DDT may be used. DDT can also be used for controlling attacks on occasions when the seed has not been dressed. Gamma-BHC spray is an effective alternative but cannot be used on the very small acreage of radishes and turnips grown for early bunching because of the risk of taint.

145. BRASSICAS FOR HUMAN CONSUMPTION. In 1966, 1,000 acres of spring cabbage, 3,500 acres of other cabbages, and 6,900 acres of Brussels sprouts, in England and Wales are believed to have been treated with DDT. Kale and sprouting broccoli were treated on a small scale. Radishes, edible turnips, and swedes, were grown on about 10,000 acres and about 800 acres are believed to have been treated with DDT in 1966. Serious attacks by the cabbage white butterfly, diamond-back moth, and cabbage moth, are sporadic but are normally controlled by DDT, though some organophosphorus insecticides, when correctly timed, can give control.

146. STOCK-FEED BRASSICAS. Turnips and swedes grown for stock feed may be attacked by root flies, midges, and caterpillars. Serious attacks are usually sporadic, e.g., diamond-back moth in 1959, and treatment is rarely economical on such low value crops. About 280,000 acres of kale, rape, and cow cabbage, are grown annually in England and Wales and are not normally treated with insecticides other than gamma-BHC seed dressing. A survey in 1966 indicated that about 200 acres of kale received DDT treatment. The application of some organophosphorus insecticides, correctly timed, can give control of these pests.

147. SEED CROPS. Apart from flea beetle attacks on seedlings the main pests are blossom beetles and seed weevils. In England and Wales about 6,000 acres of mustard are grown annually for seed of which about 600 acres are believed to have been treated with DDT in 1965 and 1966. About 16,000 acres of oil seed rape were grown in 1968 but there is little information on the use of DDT on this crop. A survey in the south-eastern region in 1966 indicated that 70% of crops were sprayed with DDT for control of blossom beetle. A similar survey in 1967 showed that only 10% of crops were sprayed with DDT, 10% being treated with BHC and 40% with malathion. These results are unlikely to be representative of the national situation and it is thought that, excluding the southern counties, a smaller proportion of crops is sprayed. There are no recent data on treatments applied to the 1,500 acres of stock feed brassica seed crops or to the 2,300 acres of the edible brassica seed crops.

148. Sprays of DDT may be necessary before flowering to control infestations of blossom beetle. BHC, malathion, or azinphos-methyl, are effective alternatives but the two organophosphorus materials are more expensive. These pesticides also give some control of seed weevil, which DDT does not, but the timing of application for this pest is probably more critical than with dieldrin. On balance, it is considered that the use of DDT for blossom beetle control could be discontinued and we so recommend.

OTHER VEGETABLE CROPS

149. About 349,000 acres of vegetable crops for human consumption were grown in England and Wales in 1966. Many of these were high-value cash crops

for which growers have a greater incentive to ensure that losses through pest damage are minimal.

150. PEAS. DDT is used to control pea and bean weevil, pea midge, pea aphid, and pea moth. It may also be used to control cabbage thrips which in England and Wales occasionally causes severe stunting in the seedling stage. Surveys by the Pea Growing Research Organisation (PGRO) show that about 21,400 acres were treated with DDT in 1964, 14,700 in 1965, and 17,300 in 1966. However, data from another survey in 1966 suggest that as many as 32,000 out of 133,600 acres of peas may have been treated with DDT compared with the PGRO estimate of 17,300 acres. In many cases the large processing firms employ field staff who advise contract growers on treatments and the PGRO survey may reflect a more discriminating use of DDT due to this element of supervision.

151. In 1966 about 6% of the acreage was treated with DDT for weevil control. This treatment, for which there is no satisfactory alternative, is often confined to headlands and is occasionally justified when heavy attacks occur on seedlings, particularly in unfavourable growing conditions. We accept that the use of DDT on peas should continue for the occasional control of weevil.

152. Pea moth is important in some areas every year. It is difficult to remove damaged peas mechanically from vining crops and it is important to protect those crops that will be flowering during the period of pea moth activity. DDT was used on less than a quarter of the acreage for the control of the pest in 1966. Azinphos-methyl and carbaryl are satisfactory but more expensive alternatives. Field trials are continuing with other materials, including fenitrothion, which also give results comparable to DDT. Pea midge is increasing in importance. About 700 acres of peas were treated with DDT for midge control in 1966 and current work indicates that malathion, azinphos-methyl, mevinphos, and carbaryl, are as effective as DDT. Pea aphid requires control in some seasons and systemic organophosphorus sprays give better control than DDT. Cabbage thrips is a sporadic pest and only occasionally needs controlling on pea crops; there are no data on the acreage treated. The pest can be controlled by any of a number of organophosphorus insecticides. We recommend that the use of DDT on peas for the control of all these pests should cease.

153. BEANS. Bean aphid, a major pest of dwarf and runner beans, is now usually controlled with organophosphorus sprays or granules but in 1964 and 1965 a few growers included DDT as an added but unnecessary precaution. Pea and bean weevil on broad beans was controlled by DDT sprays and 1966 survey data indicate that about 1,000 acres were given field treatment against weevil. However, the available PGRO data suggest that 400 acres were treated in 1964 and that DDT may not have been used at all in 1966. This may reflect differences in pest control practice between contract and non-contract growers (paragraph 150). In our view, there is no justification for spraying beans with DDT for aphid control but it may sometimes be necessary for the control of weevil during the early stage of growth. We recommend accordingly.

154. CARROTS, PARSNIPS, AND CELERY. The organophosphorus compounds developed as alternatives to dieldrin for the control of carrot fly have not always given a sufficiently acceptable degree of control on crops left in the soil into the

autumn or over the winter and many such crops grown for processing have been rejected. Since the restrictions on dieldrin, DDT has been used to supplement organophosphorus granule treatments for the control of the second-generation carrot fly, and in 1966 about 8,600 acres of carrots received two applications in late summer or autumn and about 400 acres received three applications.

155. Experience with DDT sprays in the 1950's prior to the availability of dieldrin, suggests that a very high degree of control of late attack by carrot fly is unlikely to be achieved by these supplementary DDT treatments. In any case, DDT sprays are aimed mainly at killing adult flies before they can lay all their eggs. On the other hand, although dieldrin can act in this way, its main action is in killing the larvae as they move in the soil. Diazinon as a spray or granules, though less persistent, might be substituted for DDT possibly with a similar degree of control, but the cost would be much greater.

156. Celery is also liable to be damaged by carrot fly, and leaf miner and capsids are other significant pests. In 1966, out of 5,400 acres of celery grown in England and Wales, about 350 acres were believed to have been sprayed with DDT. There are adequate organophosphorus alternatives for the control of these pests although these are more costly.

157. ONIONS, LEEKS, AND OTHER VEGETABLES. There are no major pests of onions and leeks that require treatment with DDT. Thrips are a minor pest but satisfactory alternatives to DDT are available. The use of DDT on all other vegetables grown outdoors appears to be small, although about 40 acres of sage received DDT for capsid (sage bug) control in 1966.

158. SUGAR BEET AND MANGOLDS. Aphids, flea beetle, and mangold fly, are the main foliage pests of economic importance. Carrion beetle, sand weevil, thrips, capsids, and various moth caterpillars, can be regarded as minor or sporadic pests. Foliage treatments with DDT will control all these pests. Among the soil pests, wireworms, leatherjackets, and cutworms, are damaging, and pygmy mangold beetle, millepedes, and symphylids, are of increasing economic importance. DDT treatments are applied against all these pests.

159. Field use of DDT on sugar beet in England and Wales has declined over three years from 46,000 acres in 1964 to 5,000 acres in 1967. Sprays for combined control of mangold fly and aphids were applied to about 400 acres in 1966, compared with 55,000 acres in 1964, and about 2,000 acres were treated in 1966 against flea beetle attacks compared with 9,800 acres in 1964. The other foliage pests (except aphids) occurred only on a few hundred acres each year. In 1966 DDT was used on about 1,100 acres against millepedes, pygmy mangold beetle, and symphylids, which might otherwise have damaged the seedlings, and in 1967 on 200 acres mainly against pygmy beetle.

160. Several organophosphorus compounds give better overall control of aphids and mangold fly but there is no satisfactory and cheap alternative to DDT for the control of flea beetle and the other leaf-eating beetles, and no experimental work on alternatives is in hand. Gamma-BHC is a satisfactory alternative for the control of wireworms and leatherjackets. No experimental work is in hand on alternatives for the control of cutworms, and trials in 1967 on pygmy mangold

beetle, millepedes, and symphylids, proved fruitless. Further work is in progress on the last two pests.

161. The use of DDT on these crops for combined aphid and mangold fly control is clearly declining and is being replaced by an increased use of organophosphorus insecticides and we recommend that DDT should be withdrawn for the control of aphids on sugar beet and mangolds. However, there is no satisfactory alternative for leaf-eating beetles and cutworms. In Scotland organophosphorus compounds have not yet replaced DDT for mangold fly control to anything like the extent in England and Wales. Almost all the sugar beet grown in Scotland is grown in eastern Scotland and about 3,500 acres (more than 40% of the total acreage in Scotland) were sprayed with DDT in 1966.

TOP FRUIT

162. APPLES. Pesticides usage on apples is complicated by the need to control a range of pests present at different times of the season and to integrate such treatment with the use of fungicides. About 65,000 acres of dessert and culinary apples, out of a total of 86,000 acres in commercial orchards in England and Wales, were believed to have been treated with DDT in 1967. About 63,000 acres were treated pre-blossom, the remainder being treated only post-blossom. The main pests for which DDT may be used in commercial orchards are shown in Table 7.

Table 7

Bud Stage	*Pests*
Pre-blossom Bud burst—mouse ear . .	Tortricids; aphids
Green cluster	Tortricids; winter moth; aphids; capsid bugs
Post-blossom Petal fall	Fruitlet mining tortrix
Fruitlet stages	Various tortricids and codling moth

163. *Pre-blossom pests.* In 1967, DDT was used pre-blossom on 63,000 acres of apples in England and Wales. In the past, aphids have been controlled with gamma-BHC and DDT but systemic organophosphorus pesticides are normally used now and give better control. Winter moth and tortricid caterpillars are well controlled by DDT but azinphos-methyl, phosalone, and carbaryl, are effective alternatives and the organophosphorus compounds also give some control of aphids. DDT sprays applied at green cluster also control capsids but although some organophosphorus compounds have been tested as alternatives, the results so far are inconclusive. There is some evidence that carbaryl is effective against capsids.

164. Winter washes were originally used to control many of the pre-blossom pests now controlled by spring sprays but use of winter washes has been declining in recent years and only 10% of orchards surveyed in 1967 were so treated. A general return to winter spraying is unlikely.

165. We conclude that there are now adequate pre-blossom alternatives for caterpillar control but these are more expensive. DDT is not necessary for

aphid control and the alternative systemic organophosphorus compounds are much more reliable. Alternatives for capsid bug control cannot, however, be confidently recommended without further evidence. Attacks by common green capsid have become more frequent in recent years and are not predictable in any particular orchard. Because the hatching period of this pest more or less coincides with the blossom period of the widely grown Cox and Bramley varieties, pre-blossom sprays need persistence similar to that of DDT as well as low toxicity to bees; petal-fall sprays of organophosphorus pesticides, though giving a good kill, may not prevent fruitlet damage during the blossom period.

166. There are numerous minor pests of apples such as apple blossom weevil, apple capsid, and fruit rhynchites, all rarely seen in commercial orchards now but known to be controlled effectively by DDT. It is difficult to predict whether these pests would again become important if they were not controlled by the alternatives proposed for the main pests. On balance, therefore, we accept that DDT should be retained as a pre-blossom spray.

167. *Post-blossom pests.* In 1967, DDT was used post-blossom on nearly 16,000 acres of apples in England and Wales. Fruitlet-mining tortrix is a locally sporadic pest and is controlled by DDT or TDE at petal fall. Carbaryl is effective but can be used only if crop thinning is also required and there is no possible risk to bees. Observations on other tortricids suggest that organophosphorus pesticides should be effective but no trial results are available.

168. Two sprays of DDT may be required to control codling moth and/or fruit tree tortrix. Azinphos-methyl, phosalone, and carbaryl, are effective alternatives which give a better control of tortrix than DDT, and many growers are already using them. They are more expensive but the organophosphorus chemicals will also control non-resistant fruit tree red spider mites and in some orchards would replace the acaricide(s) necessary where DDT or TDE is used in the post-blossom programme. The latter chemicals, used at this time, have the undesirable effect of eliminating predators of fruit tree red spider mite.

169. We believe that the post-blossom use of DDT against codling moth and fruit tree tortrix moths should be discontinued as soon as this can be arranged. The higher costs of the organophosphorus and carbamate alternatives could be offset against the risks which may be associated with the more persistent materials. The incidental control of red spider mite with organophosphorus alternatives is an additional advantage and may help growers to accept the withdrawal of DDT for these uses. As with DDT all the satisfactory alternative pesticides are toxic to arthropod predators, carbaryl being more toxic than DDT.

170. PEARS. About 10,000 acres of pears out of a total of 16,200 acres grown in England and Wales were believed treated with DDT in 1967. Spraying programmes for pears are less well defined but in general the position is similar to that for apples, where a potential risk of capsid and winter moth damage makes difficult the elimination of pre-blossom DDT treatments at present. Pear midge is a minor pest in commercial orchards and seldom needs treatment.

171. CHERRIES AND PLUMS. In England and Wales in 1967, about 5,800 acres out of a total of 9,800 acres of cherries received DDT, mainly for the control of cherry fruit moth. There is little experimental evidence on alternatives but by inference from results obtained on apples, DDT could probably be replaced by

organophosphorus compounds. As with other top fruit, control of plum aphids is now normally done with organophosphorus sprays; although alternatives to DDT might be found for the control of plum fruit moth, plums are a low-value crop and in general will not bear the cost of expensive treatments for pest control.

SOFT FRUIT

172. The results of a survey of the usage of DDT on commercial soft fruit grown in England and Wales in 1965 are shown in Table 8.

Table 8

Estimated Acreages	*Straw-berry*	*Logan-berry*	*Rasp-berry*	*Black-berry*	*Goose-berry*	*Currants* Black	Red
Grown . .	15,800	700	1,400	1,300	5,100	13,800	200
Treated . .	6,800	200	300	100	2,800	7,400	70

173. Most of the strawberry acreage treated was for the control of strawberry tortrix and common green capsid. At present there is no alternative that can be recommended, although recent trials suggest that malathion, phosmet, azinphos-methyl, trichlorphon, phosalone, and fenitrothion, could be equally effective. There is also a small but important use of DDT against blossom weevil and, although in some trials several organophosphorus compounds were equally effective, there are no proven alternatives to DDT except for TDE (paragraph 186). Wingless weevils are a minor pest and gamma-BHC soil treatment is a reliable alternative to DDT. A potential problem in strawberry-runner beds is the leafhopper vector of 'green petal' virus, for which DDT offers the best control at present.

174. DDT is often used to control raspberry beetle and in Scotland, which accounts for more than 80% of the raspberry production in Great Britain, 80% of the acreage is treated routinely with DDT against this pest. Malathion and derris are reliable alternatives. Shoot borer is a sporadic and unimportant pest also controlled by DDT but azinphos-methyl is an effective alternative. In view of the existence of suitable alternatives there seems no reason why the use of DDT on raspberries should continue and we recommend accordingly.

175. DDT is normally used to control blackcurrant sawfly. Trichlorphon, malathion, and azinphos-methyl, seem possible alternatives. Capsid bugs usually controlled with DDT are also killed by endosulfan which is often used for the control of blackcurrant leaf midge. Magpie moth and clay-coloured weevil are minor pests but there is no alternative treatment to DDT for the latter. Gooseberry sawfly is usually controlled with DDT but malathion and derris are reliable alternatives, malathion giving better control than DDT. On balance we consider that the use of DDT on gooseberries is not necessary and could be withdrawn.

HOPS

176. Hop flea beetle and hop capsid are controlled with DDT, although its use is on a small scale and appears to be declining. In 1964, 1,540 acres in England were believed to have been treated with DDT; in 1966, this had decreased to

370 acres. There is little recent experimental evidence on alternative chemicals for the control of hop pests. Experience with related species of insects on fruit suggests that alternatives may be hard to find but that gamma-BHC would be useful early in the season.

OTHER HORTICULTURAL CROPS

177. Weevils on nuts are controlled with DDT and about 700 acres out of some 1,000 acres grown in England were believed treated in 1966. No alternatives are known for the control of this pest.

EDIBLE CROPS GROWN IN GLASSHOUSES

178. Pests of tomatoes, against which DDT is currently used, are tomato moth (now rarely seen), leaf miner, and whitefly. DDT is used as a smoke or spray against the moth and no alternative treatment can at present be recommended. Leaf miner can be better controlled by gamma-BHC and by parathion smokes (which are highly toxic) than by DDT. Whitefly can be controlled acceptably by malathion and diazinon, though both cost more than DDT. Woodlice and millepedes can be controlled by soil treatment with DDT (which cannot be applied to cucumbers because of phytotoxicity) and also by parathion drenches soon after planting; but parathion is a highly toxic compound and the precautions which must be taken add considerably to labour costs. Cutworms can damage glasshouse lettuce and DDT is often used as a soil treatment on this crop. Soil pests in general are sporadic under glass and it is likely that the high dosage believed to be used occasionally is seldom necessary on more than a few square yards. We understand that DDT is rarely used on mushrooms.

NON-EDIBLE CROPS GROWN IN GLASSHOUSES AND NURSERY CROPS

179. Ornamentals, including shrubs, roses, chrysanthemums, and outdoor herbaceous plants generally have a high cash value and although the national incidence of such pests as vine weevil, thrips, and various caterpillars, may not be high, substantial financial losses may occur if outbreaks are not effectively controlled. DDT is the most widely used insecticide for the control of some of these and certain other general insect pests of ornamentals. For most of the pests reliable alternatives are available, some at a cost equal to or lower than DDT treatment. Generally gamma-BHC is effective; malathion and trichlorphon are also acceptable alternatives. Other organophosphorus compounds appear promising, but pending the results of further trials they cannot be regarded as reliable alternatives. However there are no reliable alternatives to DDT for the control of caterpillars.

BASKET WILLOWS

180. BHC/DDT mixtures are very effective against the very many willow foliage pests, applied once or twice as a summer spray to the tips of the growing crop. The total area sprayed is not likely to be more than 500 acres in any one year and the area sprayed at any one time is rarely over five acres. Trials for three seasons have shown that malathion is acceptable as an alternative for some pests, for example aphids.

FORESTRY

181. DDT has a variety of uses in forestry, its persistence being its most desirable characteristic. Generally speaking the economics of forestry seldom

allow even a single application of chemicals to young conifer crops. On the few occasions when it has been necessary to save crops from destruction by pine looper moth, spraying has been done with DDT, for which alternatives are not available. DDT is also used occasionally as a transplant dip against pine weevil and the pine shoot beetle. BHC dips are being tried for the control of these two pests. BHC spray would be as effective as DDT for the control of chafer beetle but this pest does not generally require treatment.

182. Although DDT is likely to be used against foliage pests such as moth, sawfly, and leaf beetle larvae, in the event of an attack requiring treatment trichlorphon would be a good substitute providing that the whole population requiring treatment was present at the time of application. The most successful alternative does not have the persistence of DDT and crop yields in forestry cannot support repeated applications of chemicals.

GENERAL

183. We appreciate that there are other pests of a minor or sporadic nature against which DDT has occasionally been used in the past. Examples of such pests are saddle gall midge and hessian fly on cereals; swift moth, grass moth, leaf weevil, and antler moth, on grass and pasture; and capsid bugs, millepedes, and potato flea beetle, on potatoes. There is little evidence to show that DDT has been effective in controlling them.

TDE ("*Rhothane*")

Provided there is a minimum interval of fourteen days between last application and harvesting, the use of TDE on apples, pears, loganberries, raspberries and strawberries should not present a hazard to consumers. There is insufficient information to enable recommendations to be made on the safe use of this chemical on other edible crops.

APPLES

184. Of 96,700 acres of mature dessert and culinary apples grown in 1965 in England and Wales, some 12,000 acres were treated with TDE compared with 82,500 acres treated with DDT. In 1967, less than 7,000 acres of apples out of 86,000 acres of mature commercial fruit grown received TDE, all applied post-blossom. As in the case of DDT, there are good alternatives to TDE for pre-blossom control of caterpillars and aphids on apples. There is, however, no conclusive evidence that these alternatives will be adequate for the control of apple blossom weevil, apple capsid, and the common green capsid, although as in the case of DDT (paragraphs 163–169) several organophosphorus compounds show promise. There are equally effective alternatives to TDE for use against codling moth and fruit tree tortrix in June and July and this use of TDE should therefore be discontinued.

PEARS

185. Approximately 16,200 acres of mature pears were grown in England and Wales in 1967. In 1965 it was estimated that 600 acres of pears received TDE, and no cases of use of TDE on this crop were found in the 1967/68 survey.

STRAWBERRIES

186. TDE is used to control strawberry blossom weevil, as is also DDT (paragraph 173). No detailed information is available on the current extent of

its use, which is believed to be small. The results of some trials in 1966 suggest that malathion, trichlorphon, azinphos-methyl, and fenitrothion, are at least equally effective, but except for DDT there are no proven alternatives to TDE.

GENERAL

187. It seems to us that in view of the relationship of TDE to DDT, the two chemicals should be treated similarly and we consider that the use of TDE post-blossom on apples and pears and on loganberries and raspberries should cease as soon as this can be arranged. We accept that the remaining currently agreed uses of TDE on strawberries and pre-blossom on apples and pears be allowed to continue. TDE is used on non-edible crops but we have no information on the extent.

(b) Food Storage Uses

188. It is sometimes difficult to decide whether a proprietary product is intended for use in this field or for purposes outside the scope of the Pesticides Safety Precautions Scheme. Many products bear labels that could be construed as applying to both purposes. For example, pesticides may be used to control insects that contaminate food, but they may also be used on refuse tips for the control of nuisance pests. In the latter case they would be considered to be outside the Scheme. Even so, the uses during the commercial storage, processing, and transport of food, and in the home kitchen and larder, are relatively easy to identify, have mostly been considered under the Pesticides Safety Precautions Scheme, and are covered by published recommendations on safe use.

189. Compared with agriculture there is little quantitative information on the extent of use of pesticides in the food storage and domestic fields. Any use of these chemicals must add to levels in the environment, but the evidence available (Appendix IX) shows that the uses under consideration constitute only a small fraction of the total.

190. There is no evidence that heptachlor, endosulfan, camphechlor, or TDE, are currently used in food storage practice in Great Britain. Only a few pounds of endrin are used annually in this field as a rodenticide in certain specified Government-owned stores. Consequently, only uses of aldrin, dieldrin, chlordane, and DDT, have been considered. We noted that formulations used in food storage generally contain a higher percentage of the active ingredient in "ready-for-use" preparations than those commonly used in agriculture and horticulture. Such preparations are also used in closer proximity to man's living spaces and to his food before consumption.

Aldrin

191. Our 1964 Review recommended that the use of aldrin in food storage practice should cease. A subsequent request from Industry revealed that the insecticidal content of some lacquers consisted of mixtures of aldrin and dieldrin, although the total content of active ingredient was the same as for the dieldrin lacquers. To meet this contingency Departments agreed that this particular use of aldrin could be permitted.

Dieldrin

192. Uses of this pesticide are restricted to application by professional operators against cockroaches and ants. For this purpose, dieldrin is formulated as a dust, as concentrates for dilution and use as aqueous sprays, as "ready-for-use" oil-based sprays, as smoke generators, and in the form of lacquers and pigmented paints. We consider that the present recommendations covering safe use of these formulations are generally adequate. We are unable to find sufficient justification, however, for the continued use of dieldrin smoke generators except in areas, such as roof spaces and heating ducts, where persons or food will not come into contact with deposits of the chemical.

193. There is a continuing but small use of pigmented gloss paints containing dieldrin by pest control servicing companies for application mainly to ships' store rooms and galleys. Nevertheless, we feel that the recommendations covering the use of resins, lacquers, coatings, and paints, containing dieldrin should be revised to indicate more clearly the surfaces to which such formulations may be applied.

194. Since our 1964 Review several new insecticides have been evaluated against cockroaches. Of these, the carbamate insecticide arprocarb and the organophosphorus compounds diazinon and fenitrothion appear the most promising. However, there is insufficient field experience in the use of these newer insecticides and we accept that dieldrin should continue to be available to control cockroaches and ants indoors.

Chlordane

195. Chlordane is used principally to control ants. There is also some use of the chemical in cockroach control and for the destruction of wasp nests. It is sold in only a small range of formulations and the quantity used annually in the food storage field is small. Although alternative, less persistent, insecticides exist, we feel that any curtailment of the present use of chlordane might be reflected in an increased use of dieldrin. We therefore accept that there should be no change in existing uses.

DDT

196. DDT is formulated for a wide range of uses against insect pests of food at some stage in its storage or processing before consumption. Such formulations include dusts, hand-held aerosol packs, space sprays for use in mist and fog generators, smoke generators, "ready-for-use" oil-based sprays, and concentrates for dilution with water for surface spraying. It is also included in pigmented emulsion paints and in lacquers and there is a relatively small but useful application as a rodenticidal tracking dust. The recommendations for safe use of DDT so far issued under the Pesticides Safety Precautions Scheme cover all the above methods of application, except for rodenticidal tracking dusts and in emulsion paints and lacquers. We consider that the use of DDT in paints and lacquers should be discontinued.

197. Although we have very few data on the quantities applied, DDT is no longer used to any great extent against insect pests during the commercial storage of food and it has largely been replaced by less persistent contact insecticides, by use of fumigants, and generally by higher standards of hygiene.

It is, however, included in many preparations to control flies in restaurants, industrial canteens and kitchens, shops, food factories, slaughterhouses, and in animal houses on farms. There is also a continuing use in these places against cockroaches, silver fish, crickets, and similar pests of food.

198. Certain insect populations have been reported to be resistant to DDT but we consider that the incidence of these is unlikely to have any appreciable effects on the amount of DDT used in food storage practice during the next few years. Fear that resistance might develop in houseflies has led to some abandonment of DDT in favour of less persistent chemicals such as dichlorvos, trichlorphon, fenitrothion, diazinon, and pyrethrins. These alternatives are invariably more expensive and, being generally less persistent, have to be applied more frequently.

199. Smoke generators are fairly widely used and are permitted where food is present, provided it is protected by packaging not more permeable than jute sacking. Because DDT is so persistent in the environment, in food, and when absorbed by man, we believe that continued use of DDT smoke generators is undesirable in situations where food and/or cooking utensils could be contaminated. We conclude that the recommendations should be amended to restrict the use of DDT smoke formulations to empty bins, chutes, conveyors, and other machinery used for the storage or transport of raw grain or oilseeds. Smoke formulations should only be used when the spaces to be treated are inaccessible for conventional spraying with less persistent insecticides such as malathion. We therefore propose the withdrawal of the present permitted use of DDT smoke formulations:—

(a) in empty bins, chutes, conveyors, and other machinery which handle or store processed foods;

(b) on stowages where foodstuffs, such as cocoa, flour, groundnuts, etc., packed in jute sacks are present;

(c) in industrial kitchens, canteens, and restaurants.

200. There is no evidence that oil-based sprays containing DDT are currently used in food stores and the published recommendations should accordingly be amended to remove this use.

Thermal Vaporisers

GENERAL

201. In 1965 we considered the use of thermal vaporisers discharging DDT, gamma-BHC, or mixtures of these two chemicals. We were concerned about the inadequacy of the advice given by manufacturers and distributors of thermal vaporising units to prevent misuse. We were not convinced that there was a genuine need for the continued use of such units for the control of insect pests, in view of the resulting indiscriminate distribution and deposition of the insecticides. Since the units had been in use for over 20 years without any known case of harmful effects on man, domestic pets, or livestock, and because there was very little evidence available to suggest that they had significantly added to the total amounts of these chemicals in the environment, it was agreed that no case existed for an outright ban on such vaporisers. Nevertheless, our recommendations severely limited the rates of emission from thermal vaporisers for continuous or intermittent operation and brought the position in Great

Britain very much in line with that in the U.S.A. It was agreed to reconsider the use of vaporisers in three years.

202. In the paragraphs that follow we have considered all the current uses of thermal vaporisers with special reference to DDT, taking gamma-BHC into account where appropriate. We have therefore reviewed uses of vaporisers, e.g., in living rooms and bedrooms, which are outside the terms of reference of the two Safety Schemes. Although vaporisers are used in glasshouses and some livestock premises, we have found it convenient to consider the subject as a whole within this section, except for home uses which are discussed later in paragraphs 257–265. In considering the role of vaporisers in indoor pest control we have taken into account the existence of alternative methods which, combined with improved hygiene, enable equally good control of insect pests to be achieved. However, such alternative methods are often more costly and require more effort.

203. There has been a small decline in the use of vaporisers during recent years and at least two firms actively engaged in this field in 1963 no longer market them. Only a few manufacturers of vaporisers have undertaken to meet the requirements of the Pesticides Safety Precautions Scheme and some of the other distributors appear to have failed to follow the recently published recommendations for safe use of thermal vaporisers. The 1967 review of the Scheme suggested compulsory licensing of all pesticidal products for use in agriculture and food storage and we feel that such action should result in greater control of, and co-operation from, firms manufacturing or distributing vaporisers. We recommend accordingly.

METHODS AND EXTENT OF USE

204. At least eight types of vaporisers are available in the United Kingdom (all of which use gamma-BHC). One of the most popular units may also use DDT alone or mixed with gamma-BHC. Units are used principally for the control of flies, but are also available for use against food storage pests, clothes moths, cockroaches, and aphids and mushroom flies in horticulture. Vaporisers are installed in a great variety of premises, including food premises, intensive poultry houses, calf-rearing houses, offices, shops, mills, warehouses, hospitals, institutions, and the home. Important factors in the choice of this method of pest control are the ease with which it can be achieved in some circumstances, the low labour costs, and the minimum maintenance required. The use of vaporisers is obviously attractive to occupiers of premises affected by legislation requiring more or less continuous control of insect pests.

205. Although the published recommendations sheets give maximum vaporisation rates for gamma-BHC and DDT under various circumstances, they do not cover the method of vaporisation and the safety of the vaporising units themselves. We were aware that the devices on the market ranged from well-designed and constructed thermostatically-controlled units intended particularly for continuous operation, to rather crude devices intended primarily for intermittent operation.

POSSIBLE HAZARDS

206. The present recommendations for safe use do not cover applications in animal husbandry. Thermal vaporisers are very useful for fly control in live-

stock premises and there is no evidence that they cause any clinical effects in the animals. However, there are relatively few meaningful data on the levels of insecticidal residues which may be found in meat and dairy products when units are installed in cattle sheds, poultry houses, piggeries, or dairy barns. Since such use adds to the total exposure to organochlorine compounds we consider that appropriate recommendations should be published. Some workers consider the use of vaporisers in laboratory animal rooms is undesirable in view of the possible metabolic interference these compounds may produce in experimental animals. In our view the decision upon what, if any, method of insect control is permissible in such animal rooms must be the responsibility of the investigators concerned.

207. The possible risks to man from vaporisers can arise from inhalation of the vapour, contact with insecticidal deposits, or ingestion of residues in food.

208. The rate of output of insecticides by vaporisers designed for intermittent use is relatively high and the ultimate dosage applied to a space is determined solely by the period for which the unit is operated. People operating these devices could suffer brief exposure to unnecessarily high air concentrations of the chemical. We consider such units generally unsuitable for use in premises in which people live or work, or where livestock or unprotected foods are exposed. Even with thermostatically controlled devices which, properly adjusted, prevent overdosing of a space, there is inevitably a concentration gradient in the vicinity of the device and people working in close proximity to it may inhale more insecticide than the mean output per unit volume of the total space may suggest.

209. Local contamination of surfaces with DDT and/or gamma-BHC can occur when units are poorly designed, badly sited, or have been operating for long periods. Vapour may condense on the outside of some units, or on the electrical connections close to it. The present recommendations, which contain advice on correct siting of units, will markedly reduce some of the risks associated with contact with insecticidal deposits resulting from the use of thermal vaporisers. Without some control over the supply of these devices, it is difficult to see how the general public can be protected from the special risks involved in handling units which, because of their design, may become heavily contaminated on the outside.

RESIDUES IN FOOD

210. Residues in foods can arise:—

(a) by absorption of the vapour and particles produced while the unit is in operation;
(b) by absorption of the vapour slowly given off from deposits on walls, floors, furniture, etc., after units have been operated; and
(c) by contact with contaminated surfaces.

211. Experimental results indicate that unless foodstuffs are enclosed in impermeable wrappings or containers, some uptake of vapour occurs when they are stored in rooms in which vaporisers are operating. The amount of such uptake increases with the period of exposure and is diminished by paper, plastic or other wrappings, all of which provide some degree of protection. We consider

also that there may be a risk of contamination through faulty handling even if food is wrapped. Some loss of insecticidal residues, particularly of gamma-BHC, occurs when food is processed and/or cooked. The present safety recommendations advise that vaporising units should not be used if food remains more than 12 hours in the treated area, unless it is protected by impermeable packaging. If this is done, residues arising from the direct absorption of vapour by foods should be very low. Nevertheless, we consider that the occurrence of DDT in food should be avoided whenever possible. We recommend that this chemical should not be vaporised when open food (other than a growing crop) is present.

212. Residues may occur in food products derived from livestock that have been exposed to thermal vaporisers. We noted that cage birds exposed to gamma-BHC vapour can acquire exceptionally high residues of the chemical on their feathers and consider it likely that a similar phenomenon may occur with poultry. There is some evidence, for example, that the meat and eggs of poultry reared in intensive houses in which vaporisers are continuously operated may contain appreciable residues of DDT and/or gamma-BHC. We consider that these vaporisers should not be used continuously in intensive poultry houses. We had no comparable data on residues resulting from use of vaporising units elsewhere in the animal husbandry field. We consider that data should be obtained on the residue levels of gamma-BHC in the flesh, organs, or products of animals exposed continuously or for long periods to gamma-BHC vapour from thermal units.

213. Since deposition of the chemical, whether DDT or gamma-BHC, is largely on horizontal surfaces, a small amount of insecticide will inevitably be transferred to food from surfaces on which it is prepared and from the utensils used. Such residues in food are generally not likely to be important, but unacceptable residues may result in the uncommon circumstances when gross contamination of a surface occurs. A special risk arises from the possibility of crystalline insecticidal deposits falling into food or food containers, but this risk is easily avoided by good hygiene.

CONCLUSIONS

214. The amount of DDT vaporised in thermal units is only a minute fraction of the total DDT used in all the various fields. We have referred in paragraphs 208, 209, and 213, to situations where local contamination may arise, and we recognise the possibility that the proportion of the chemical so applied that may be absorbed by man and livestock may well be higher than from other types of application. For these reasons, and because of its persistence once absorbed, we consider that DDT should not be vaporised in the presence of people or animals. The existing recommendations should also be amended so that food other than growing crops is not exposed to DDT vapour at any time, unless protected by impermeable packaging. We consider too that, because of the contamination of surfaces which occurs, DDT should not be vaporised in rooms where food is sold, prepared, served, or eaten, whether or not people or food are actually present at the time the chemical is vaporised.

215. Because gamma-BHC is metabolised relatively rapidly by animal tissues, its use does not seem to present the same potential hazard as DDT. Nevertheless, the steady emission of gamma-BHC vapour from a thermal generator, or from

the continuously renewed deposits so produced, appears to us to convert this insecticide in such circumstances into the equivalent of an environmentally persistent type. We therefore recommend that the use of vaporisers discharging gamma-BHC should be withdrawn in those parts, or combination of parts, of buildings in which residents or workers may be exposed to low vapour concentrations for more than a normal 8-hour working period. This would constitute a ban on the use of vaporisers in sleeping quarters and living rooms, in hospital wards, and in similar situations.

216. In all other premises, e.g., shops, restaurants, bacon factories, dairy units, etc., where people work, or animals or human or animal foods are regularly exposed, vaporisers discharging gamma-BHC should be operated only when there is a justifiable need for prophylactic measures and control of existing infestations. They should not, for example, be maintained in use during seasons of the year when insects are not troublesome. A thermostatic control should be inserted in all vaporisers.

217. To date, only dichlorvos has been suggested as a direct replacement for gamma-BHC and DDT in thermal vaporisers. We have noted that in many cases where vaporising units were formerly used to control flies, they have been successfully replaced by either better hygiene, periodic aerosol spraying with pyrethrins or pyrethrins/dichlorvos mixtures, dichlorvos resin strips, trichlorphon, diazinon, or gamma-BHC sprays; or a combination of two or more of these. There has recently been a growing interest in other methods of insect control and these may replace vaporisers in some types of premises. We welcome all these trends. We are well aware, nevertheless, that such methods are often less economical and more laborious than the use of vaporisers and that the installation of thermal vaporisers often appears to be an attractive and simple method to those responsible for insect control within premises.

(c) Veterinary Uses

218. Chlordane, endosulfan, endrin, heptachlor, TDE, and camphechlor, are not used in veterinary practice and following our 1964 Review, sheep dips containing aldrin or dieldrin have not been commercially available since January, 1966.

219. Sheep dips containing aldrin or dieldrin were used on a large percentage of sheep dipped in 1963 and 1964 but by 1966 sales of these dips had dropped to nil. Over the same period, sales of dips containing DDT remained steady at a relatively low level.

220. Surveys of sheep dips involving the use of organochlorine compounds were carried out in Great Britain in 1965–1966 and the results are summarised in Table 9.

Table 9

Year	*Dieldrin* %	*BHC* %	*DDT* %	*Total use of organochlorine compounds* %
1965 . .	78·1	58·0	1·4	94·0
1966 . .	19·2	29·8	1·1	43·3

221. In many instances dips contained more than one organochlorine compound. Nevertheless the total use of these chemicals fell by over 50% during the period surveyed. During the same period, the use of organophosphorus compounds increased considerably and a carbamate compound came into use for the first time in 1966.

222. It has been reported to us that there has been criticism by farmers in southern and western districts of Britain that the organophosphorus sheep dips used as alternatives to dieldrin have compared unfavourably with it. The evidence presented indicated that unsatisfactory protection had usually resulted from faulty dipping techniques. We conclude that if organophosphorus compounds are used correctly they will provide effective control of the sheep blowfly although possibly at greater cost to the farmer.

223. We considered other veterinary uses of organochlorine compounds but the information indicated that these compounds have a very limited use outside sheep dips. In view of the restricted veterinary use of these compounds we consider that the contribution to the general amounts in the environment is insignificant and conclude that there is no need to make any change in present recommendations for use in this field.

(d) Other Uses

224. We referred in paragraph 5 to the more comprehensive scope of the present Review and in this section we deal with uses at present outside the Safety Schemes. For this purpose we had available a report of one of our Working Parties which recently gave preliminary consideration to such uses.

225. Under the Pesticides Safety Precautions Scheme, difficulties often arise in deciding whether a particular pesticide product whose main use is outside agriculture and food storage should be notified. Thus the label on the product may recommend its use in industry, in the home, and in public health. Although the product is known to be effective against pests of food, the label may make no mention of its use in food storage or in the kitchen or larder. Users of such pesticide products are:—

(a) contracting companies who provide a service in domestic homes, retail stores and shops, offices, hospitals, institutions, ships, and premises;
(b) organisations who purchase supplies in bulk for servicing their own premises, e.g. Government departments, local authorities, shipping lines, department stores, etc.;
(c) manufacturers who process or pre-treat their goods, e.g. carpets and woollen clothing, before sale to the public.

226. The evidence available to us focussed our attention on uses for:—

(a) the control of pests of hygiene and public health;
(b) the protection of wood;
(c) the protection of carpets, clothing and other goods containing wool.

Hygiene and Public Health

227. Many formulations, some containing DDT, are used to control pests of the person (e.g. lice, bed bugs, parasitic mites, etc.), or to safeguard public health.

Local authorities commonly use DDT and gamma-BHC to control flies and other insects on refuse tips and this may have contributed to the emergence of strains of flies resistant to these insecticides. There is a need for such uses to be more limited and authorities are urged to cover tips with soil instead of resorting solely to the use of insecticides. Some local authorities use DDT and possibly other organochlorine insecticides to improve amenities, e.g. to control midges or mosquitoes in holiday areas, flies on foreshores, etc. The amount of chemical used in this way at any particular time may be substantial but this practice is employed only occasionally and in limited areas. Although no reliable quantitative data are available a questionnaire sent in 1964 to 1,505 local authorities indicated that DDT, gamma-BHC, dieldrin, and chlordane, were in widespread use (Appendix IX). A detailed study of the use of pesticides by local authorities is currently in progress.

228. Programmes to control insect and other nuisance pests are often carried out with care by specialised and expert personnel. The pesticides are supplied to specification by manufacturers who are usually members of the British Pest Control Association or the British Agrochemicals Association.

229. As far as we are able to judge no direct risks arise from the use of organochlorine compounds to control pests of hygiene and public health. Some environmental residues must occur but we know nothing of their extent.

Protection of Wood

230. The use of pesticides in forestry is considered in paragraphs 181 and 182. Pesticides are also used to treat logs and sawn timber in yards, for the preservation of structural woodwork, and to protect furniture in the home and in depositories. Some useful information about these activities was given to us by the Forest Products Research Laboratory and the British Wood Preserving Association. Dieldrin has been used for application to logs and sawn lumber for 10–15 years. Some 17 tons were used in 1962, but by 1966 only 2 tons were used. Over the same period, the use of gamma-BHC increased from 1·5 tons to 24 tons.

231. Operator risks could conceivably arise during the dipping and "pickling" of timber in timber yards and when application is made in confined spaces, e.g. lofts of houses and other buildings. Relatively skilled staff are frequently employed in these tasks and we obtained no evidence of harm to them.

232. There is the possibility that these processes may result in a distribution of the pesticides in the environment. This could occur in timber yards whenever the dipping tanks (of several hundred gallons capacity) are emptied and the accumulated sludge is dispersed either through the drains and sewers, or taken away by a disposal contractor, or left in a corner of the yard. Although we are not aware of any incidents arising from such sources, we consider that more information should be obtained on the disposal of this sludge.

233. It was also suggested to us that problems might arise from shavings or sawdust from treated timber used for animal or poultry bedding. Only a very small part of such shavings and sawdust would bear residues and we doubt if this is a significant hazard.

234. Although wildlife might be secondarily affected by the practices referred to in paragraphs 230 and 232 above, we found no authenticated instances of harm arising from the use of organochlorine pesticides for the protection of timber.

Protection of Wool

235. Most of the evidence for this part of our enquiry came from the Wool Industries Research Association, the Dyers and Cleaners Research Association, and various companies interested in the manufacture or sale of chemicals to protect woollen goods against insect pests. Goods are mothproofed primarily to protect them during manufacture, transit, or storage, up to the time of sale but carpets and some other furnishing fabrics are usually treated to give protection throughout the useful life of the goods. In 1960 it was reported that mothproofing was carried out on about 70% of wool and wool-blended carpets, slightly under 50% of hand-knitted textiles and knitting wool, about 40% of machine-knitted textiles, about 10% of blankets, and less than 5% of woollen and worsted piece goods. Dieldrin was the chemical most favoured for the purpose.

236. The chemicals may be applied during the manufacture of yarns, cloth, etc., during dry-cleaning or similar processes, or by members of the public using retail formulations applied directly to made-up articles. This last type of application is considered in paragraph 264.

237. The stage of proofing against moths depends on the particular process or agent employed. The proofing agents include non-specific insecticides such as dieldrin and some others used specifically for mothproofing and with which we are not concerned in this review. All of the agents employed are removed to some extent by washing, dry cleaning, and wearing, and as a protection against such losses, manufacturers normally recommend initial impregnation with amounts in excess of those needed for short-term proofing.

238. When dieldrin is used for mothproofing, the application technique is important. If the chemical is applied simply by dipping in solutions of the insecticide in organic solvents, the deposits are apparently left mainly on the surface of the wool fibres and are easily removed by washing and dry-cleaning materials. However, when dieldrin is applied as a hot aqueous emulsion under specified conditions, it is absorbed into the fibres and becomes relatively resistant to washing and dry cleaning. Formulations supplied by the manufacturer carry detailed instructions to ensure maximum fixation of dieldrin in the fibres and they advise against any treatment of underclothes or baby clothes.

239. Although in the early 1950's mothproofing of garments and other articles was offered as a regular service by many dry cleaners, usually by direct application of DDT, enquiries undertaken in 1964 indicated that such proofing was then no longer carried out. The manufacturers of dieldrin-based proofing agents did not advise their use in this way. More recently, firms offering self-service, coin-operated, dry cleaning have been advertising mothproofing as one of the services included in the process. We understand that DDT is the only one of the pesticides under review used for this purpose.

POSSIBLE HAZARDS

240. We have examined the possibility of absorption of chemicals by man from impregnated clothing or contact with carpets that had been proofed. From the evidence referred to in paragraph 77 we concluded that there would be no hazard to man from dieldrin-treated wool made into *outer* clothing and we are of the opinion that the treatment of carpet yarns by recommended industrial processes is also acceptable. However, in view of the lack of fastness resulting from the application of DDT during dry cleaning, we recommend that this use should be discontinued.

241. We were informed by the manufacturers of dieldrin that for some years they had been measuring the content of organochlorine pesticides in lanolin and certain allied goods produced in England and also those imported from overseas. These materials are derived from the cleanings of raw wool and investigations were connected with enquiries into the fate of dieldrin used in sheep dips. The low residues found two or three years ago are likely to have declined in view of the voluntary ban on dieldrin for use in sheep dips. Whilst we are not prepared to declare that these low residues could be harmful, they might result in an unnecessary uptake of dieldrin by the human body because lanolin is occasionally applied to the skin, either on its own, or as an ingredient in cosmetic preparations.

EFFECTS ON THE ENVIRONMENT

242. Some of the uses and processes detailed in paragraphs 236 to 239 lead to residues in sewage and rivers. Thus, recent work has revealed cases of dieldrin escaping in industrial effluents in very low but biologically significant concentrations. DDT, too, has been found in industrial effluent, and both chemicals in sewage from towns. One company concerned with the moth-proofing of woollen goods has examined the dieldrin content of sewage and river water in the two areas where their operations are largely concentrated. In one area it was estimated that 3·5 tons were used annually, and in the other 5 tons. No other single area in Great Britain would be likely to account for as much as one-tenth of this total. The Water Pollution Research Laboratory has begun a survey of organochlorine insecticides in industrial and town effluents. In particular dieldrin tends to be present in areas where carpets or other woollen goods are impregnated with it for moth-proofing. Dieldrin has been found in carpet-factory effluent in Scotland at up to 0·4 p.p.m. and in certain streams in the West Riding of Yorkshire at nearly one part per thousand million, a concentration that could be fatal to some trout if maintained for three months or more. Such streams, however, are often too polluted with industrial wastes and in other ways to sustain fish; so that any effects of dieldrin may become important to fish only when the water passes into relatively uncontaminated streams. (Such could occur with the River Stour, which below the Kidderminster carpet-factory area is too polluted in other ways to sustain fish, but which subsequently runs into the River Severn.)

243. Since dieldrin is a very effective moth-proofing agent, with no effective long-lasting substitute, its use should not be avoidably curtailed; but its release in effluent should be controlled and its entry into water courses restricted increasingly as other contaminants are reduced. The river authorities and the

industries involved are aware of the possibilities of danger to fish and other forms of wildlife from these effluents. Experiments indicate that the removal of grease and solids from effluent may result simultaneously in a reduction or removal of dieldrin residues. The practical possibilities of this work should be further studied.

244. Dieldrin has also been found in concentrations up to 60 p.p.m. in dried sludge from sewage works in towns where impregnation of wool is undertaken. This sludge is used on the land in some areas. A further possible entry for dieldrin into the environment comes from the occasional use as fertilisers of ground-up wool shoddy and wool trimmings from carpet factories. We recommend that a study should be made to determine the quantities of dieldrin likely to be released in this way.

VII. HOME USES

(a) Home Garden Uses

245. In our 1964 Review we recommended that all current home garden uses of aldrin, dieldrin, and heptachlor, should cease as soon as this could be arranged. Although we are aware of the possibility of a small number of packs still being in the hands of distributors, no formulations of these chemicals for the home gardener are now being produced. Endrin and endosulfan have never been available to the home gardener. Chlordane and camphechlor are used in home gardens as earthworm killers but, as stated in paragraphs 25 and 36, there is no evidence to suggest that the use of these compounds is having a significant effect on wildlife; therefore we see no reason to change the present recommendations.

246. DDT is widely available to the home gardener either alone or in mixtures with other chemicals such as gamma-BHC or certain organophosphorus compounds. The booklet 'Garden Chemicals' published by the Royal Horticultural Society in 1967 names 66 products of which 41 are based on DDT alone, the remainder being mixtures with other chemicals. The Ministry of Agriculture, Fisheries and Food's booklet 'Chemicals for the Gardener' lists 26 approved DDT products of which 13 are based on DDT alone, the remainder being mixtures with gamma-BHC or organophosphorus compounds.

247. The recommended uses of these products are against pests of a range of plants, from ornamentals in the widest sense to vegetables and fruit. We believe that the main use of insecticides in gardens in this country is against pests of ornamentals and that use on edible crops is of secondary importance. Apart from the keen amateur gardener who may be able to identify pests and diseases and who is interested in treating a specific problem, gardeners generally look for a 'cure-all' for pest control and the wide-spectrum insecticidal activity of DDT appears, at first sight, to fulfil this requirement. Immediate treatment is sometimes required to prevent unsightly leaf damage by such common pests as caterpillars and capsids, and by using DDT the gardener can preserve the appearance of his plants.

248. However, aphids are the main garden pest and it is against these that most garden insecticides are used. We have already stated (paragraph 142) that DDT is not necessary for the control of aphids; organophosphorus compounds such as malathion, trichlorphon, dimethoate, and menazon, will give better results.

249. Although we estimate that the use of DDT in the home garden may be only about 5% of the total amount used in agriculture and horticulture, it must contribute to the distribution of this chemical in the general environment and in very many situations throughout the country. Little is known about the effects of DDT on common garden birds in this country but there is no evidence to suggest that bird populations in gardens have declined in recent years (paragraph 46).

250. We believe that the garden pests against which it is essential to use DDT are of relatively minor importance and that, if DDT were withdrawn from the range of chemicals available to the home gardener, he would not be put to a serious disadvantage. We therefore recommend withdrawal of these uses as soon as this can be arranged.

(b) Home Kitchen and Larder Uses

251. The need to protect foods and the home from disease organisms, including those carried by insects such as flies, demands good hygiene and occasionally the use of pesticides. There is no distinct range of products in small packs intended exclusively for use in the home kitchen or larder and we do not claim to have identified all the products that have such a use. Some of the chemicals appear on the market in very many formulations for a variety of purposes (as dusts, powders, impregnated strips, window-cleaning preparations, furniture polishes, etc.).

252. It is difficult to assess the risks associated with small-scale use in the home. Although certain formulations such as insecticidal paints can result in lengthy exposure, many applications are made only when a specific need to control insect pests arises (e.g. in warm spells when ants are swarming). Consequently users may suffer only occasional exposures. However, domestic users are often unaware that their use of pesticides can sometimes involve a risk of contaminating prepared food immediately before it is eaten and intakes from this field of use may well contribute to the body-content of organochlorine compounds in some individuals. We consequently deprecate the fact that some of the formulated products for use in the home carry no information on their active ingredients and some carry little or no precautionary labelling.

253. The control of relatively minor uses of pesticides in the home presents special difficulties, because many of the product labels give advice for the control of a wide range of insect pests (of food, hygiene, wool, and gardens, etc.) and many of these purposes fall outside the scope of the Pesticides Safety Precautions Scheme. A possible way of dealing with these products might be to require them to carry warning statements such as 'Do not use in the kitchen or larder'. Another way would be to include all pesticides used in the home in the Pesticides Safety Precautions Scheme. To cover the different categories of household uses, such as against pests of wool and of hygiene, separate recommendations sheets dealing with the uses involved might then be issued similar to those that are now devoted to "Home Kitchen and Larder Use".

Chlordane

254. In the domestic field chlordane is used mainly to control ants, wasps, and occasionally cockroaches. We consider that recommendations covering the domestic kitchen and larder uses of chlordane should be agreed and published.

Dieldrin

255. Dieldrin can be used in the home kitchen against cockroaches and tropical species of ants. These insects are rarely found in private houses and, when they do occur, householders often request help from local authorities or professional servicing companies. We are particularly concerned at the ready availability to the householder of small packs, including aerosol formulations, containing dieldrin. Whilst many of these are labelled to apply principally to pests not generally associated with the kitchen or larder, many are ambiguously worded (e.g. 'use against ants', or 'to control wasps, mosquitoes and other flying insects'). We find it difficult to believe that products so labelled will not be used against flies in the home kitchen. Alternative insecticides are available that will adequately eradicate small-scale infestations of cockroaches and ants and we consider that there is no need for small packs containing dieldrin to be available to the general public for the control of these insects in the home kitchen or larder. We recommend accordingly.

DDT

256. We cannot be sure that we know of all the uses of DDT in this field (paragraph 252). Some products known to contain DDT, however, are not labelled as adequately as those dealt with under the Safety Schemes. Furthermore, in some instances it is doubtful whether some of the uses (e.g. in decorative paints and lacquers, in window-cleaning fluids and floor polishes) are effective. While there is no evidence that DDT used in the home kitchen or larder results in direct harm to householders or substantial residues in food, it provides a greater opportunity for contact with, and absorption of the chemical by, man. As there are various non-persistent pesticides available that are no more hazardous to handle and store than DDT, we consider that the use of any formulation of DDT, including thermal vaporisers with or without gamma-BHC, in the home should cease, and we so recommend.

(c) Other Home Uses

257. Reference has been made elsewhere to commercial uses outside the Pesticides Safety Precautions Scheme (paragraphs 225–244). A similar situation arises in the home.

258. We have already referred to the use of DDT for the control of pests of the person (paragraph 227). Application in the form of dusting powder, ointments, shampoos, etc., is either by medical order or prescription, or expressly by local authorities. There is obviously a risk of skin absorption of the chemicals so applied but we believe that very few people are exposed in this way and, in total, so little chemical is involved that the risk, if it exists at all, is negligible. Furthermore, it is likely that so far as such products are manufactured, sold or supplied for use by direct application to the person or to animals for the prevention of disease, safeguards could be applied under the Medicines Act, 1968.

259. The principal organochlorine chemicals used against nuisance pests, e.g. mosquitoes, midges, flies, and wasps, are DDT and gamma-BHC, although dieldrin and chlordane are used to some extent. Household packs containing the first two chemicals are sold in shops ranging from pharmacies to self-service supermarkets. There is often an extended chain of distribution between manufacturer and retailer and few of those engaged in this trade have any allegiance to specialist associations.

260. We found it impossible to obtain a worthwhile estimate of the total quantity of the chemicals under review which are supplied and used in this way. We are unable, therefore, to assess the risks fully but we consider that the labelling of such packs is often far from adequate or informative and in some cases it may be positively misleading.

261. For the control of wood-boring insects, small builders and private householders frequently use "ready-for-use" preparations in small packs. Although many products contain dieldrin or DDT, we found it difficult to obtain accurate data on the identity and quantities of the insecticides involved. The British Wood Preserving Association issued a questionnaire to members in 1965. Nine formulating firms sent replies indicating that a total of 44–45 tons of gamma-BHC and 1·5–2 tons of dieldrin were marketed annually in retail packs on the domestic market. We were unable to calculate the proportion of the total retail trade that this represents.

262. As with household packs for use against nuisance pests (paragraph 259), we found that the labelling of packs for the control of wood-boring insects is often inexplicit, both as to active ingredients and directions for safe use.

263. A fairly wide range of proprietary products also carries recommendations for household use against clothes moths. Many of these packs contain dieldrin or DDT, but the active ingredients are rarely indicated on the labels.

264. The deposits of dieldrin or DDT on fabrics resulting from the direct spraying of solutions or from simple dips are not firmly held and it seems likely that they would be more easily absorbed through the skin of the wearer than those arising from commercial treatment. They would also be more easily removed by washing, thereby contributing to environmental residues via drainage systems. Although the total amount of active ingredients involved appears to be small, we feel that the distribution and sale of those containing dieldrin and DDT should cease.

265. Manufacturers frequently claim that thermal vaporisers are effective against clothes moths in wardrobes or clothes cupboards in bedrooms. We consider this use to be undesirable and unnecessary and, for reasons similar to those expressed in paragraphs 207 to 213, we consider that thermal vaporisers should not be used for pest control in the home.

(d) General Observations on Other Commercial and Home Uses

266. Following restrictions in uses of some of the organochlorine compounds in agriculture and horticulture, it is likely that other commercial and home

uses may now be contributing a significant fraction of the amount in the environment. This may particularly apply to dieldrin since 1964.

267. We have noted a lack of information on the amounts of pesticides used outside the agricultural and food storage field. This applies particularly to the persistent chemicals under review and we therefore recommend that more accurate information should be obtained.

268. In considering the problems of adequate labelling and control of supply (paragraph 253) we conclude that the proposed Pesticides Bill should cover all pesticide products in small packs sold for any domestic use, whether it be outdoors in the garden or anywhere indoors, and we recommend accordingly.

VIII. DISCUSSION

General

269. For this further Review of the Persistent Organochlorine Pesticides we have considered a large volume of new information obtained since our 1964 Review. In the main this new information covers the toxicology of the chemicals, the residues detected in man, in foodstuffs, in wildlife, and in the general environment. We have also considered the published experimental evidence of the biological effects of these chemicals in an endeavour to relate the significance of any laboratory results to possible effects in the field.

Organochlorine compounds in the environment

270. We have kept in mind, and have adhered to, our considered opinion expressed in the 1964 Review that when considering proposals for the safe use of pesticides more importance ought to be attached to undesirable aspects of persistence in the environment and even prolonged persistence itself. We therefore looked closely at usage in all the fields covered by the Pesticides Safety Precautions Scheme and also examined uses of those chemicals that were outside our remit in 1964. We cannot claim to have covered all aspects of the latter, because of lack of data on some, but we believe that we have covered the main ones, such as use in public health and hygiene, the protection of wood and woollen goods, and in thermal vaporiser units.

271. Further detailed investigations since our 1964 Review have shown that organochlorine compounds are present in the environment more widely than had previously been demonstrated; and it is clear that this is true of DDT/TDE, aldrin/dieldrin, and to a lesser extent some of the other chemicals under review. This does not necessarily mean, however, that the situation is deteriorating; insufficient data are available from the earlier years to allow an effective comparison. Many of the data on which our conclusion rests are referred to either in the body of this Report or in the Appendices and relate to many sectors of the environment. Some of the chemicals under review have been detected in air, rain, soil, land and marine fauna, and often at locations far removed from the original sites of application.

272. There is a growing concern about what may be called the general pollution of the environment arising broadly from the development of new technological

processes and the problems of disposal of wastes. It is not within our terms of reference to consider this larger problem of which the presence of traces of pesticides in the environment is only a part. Nevertheless, the contribution made by pesticides attracts much attention because it can be identified and attributed to known uses. We return to the question of distribution of pesticides in the environment in paragraphs 283 and 292.

Effects on wildlife

273. Coming to the wildlife considerations it would appear that of the chemicals under review only aldrin/dieldrin and DDT could at present appear to be of significance in this country. There is no doubt that the restrictions that we recommended on the use of aldrin, dieldrin, and heptachlor, as cereal seed dressings in spring, have resulted in a great decrease in the number of incidents of acute poisoning of both seed-eating and predatory birds. The timing of reported declines and subsequent partial recovery in populations and in the breeding success of certain predatory species also lends support to the view that the effects were influenced by changes in usage of aldrin, dieldrin, and heptachlor.

274. We find little evidence to suggest that acute DDT poisoning is occurring on any significant scale amongst birds in Great Britain. Some casualties, however, have occurred in areas of intensive use, e.g., orchards in some seasons.

275. Observations in Great Britain and North America recently revealed that a decrease in eggshell thickness and an increase in egg breakage by parent birds, especially among predators, occurred in the late 1940s, about the time that DDT was introduced commercially on a substantial scale. Some decrease in the success of rearing young occurred about that time but the populations of peregrine falcons and sparrowhawks remained steady until about 1955, when a steep decline was attributed to dieldrin. There is other evidence of DDT affecting eggshell thickness, egg breakage, and breeding success, but none that it has reduced populations. Nevertheless, it might hinder the recovery of a population reduced by other causes.

276. In this country, residues of DDT in those natural waters examined have been generally well below the levels likely to affect survival of fish. Although some species are sensitive to continuous exposure to DDT, there is little to show that egg production, hatchability, or survival of fry, are seriously affected when adult fish are exposed to non-lethal concentrations. Fish populations, however, are rarely studied with sufficient accuracy for the effects of chronic toxicity to be determined. Circumstances leading to large-scale pesticide applications to whole watershed areas have so far not arisen in Great Britain, nor, in our view, are they likely to occur. Consequently we do not envisage the possibility of the occurrence of lethal concentrations in fresh water from such operations. There is some concern about possible effects of organochlorine pesticides on coastal marine fauna.

277. There is evidence that DDT residues persist and remain active in the soil longer than other organochlorine insecticides in common use but it has been shown that, even where applications of DDT or dieldrin have regularly been made to the soil, the residue levels measured have seldom exceeded the equivalent

of a single application. Dieldrin, however, like any chemical or mechanical treatment, appears to affect some elements of soil micro-arthropod populations very markedly and for considerable periods of time. Nevertheless, most of the workers on this subject in Britain have considered that the resultant effects are not important to agriculture or the general environment.

278. There are indications that organochlorine insecticides can produce both direct and indirect effects which may be of ecological significance to insects. Observations have shown that the adverse effect of DDT on natural enemies is sometimes an important factor in resurgence of some pests and the development of secondary pests. DDT has been rarely implicated in bee poisoning incidents in this country.

279. The other organochlorine compounds are so little used in Great Britain that their effects on wildlife are thought to be insignificant. Endrin and endosulfan are more acutely toxic than the other organochlorine compounds reviewed but they are rapidly metabolised in birds and most mammals. For endrin there is some evidence of its persistence in soil.

Residues in food

280. The new evidence on residues in food, mainly from studies on specific commodities, including the whole-diet study, undertaken by our Residues Panel (paragraphs 60–74) and supplemented by data from other sources, has shown that some of the chemicals under review can be found in many of the components of our diet whether produced at home or abroad. In the main, the residues found are consistently low and there is evidence to indicate that the levels of DDT (and its derivatives), aldrin/dieldrin, and BHC, in the British diet, appear to be declining. However, a few samples of home-killed mutton in 1967 and 1968 contained residues of dieldrin in the fat of sufficient magnitude to indicate that the animals had been treated with dieldrin in each year, despite the general withdrawal of dieldrin sheep dips. Little information is at present available on how farm animals in Britain acquire the very small residues of persistent organochlorine compounds that are sometimes found, except in some instances where animals have been treated directly. There is some evidence that the residues may be derived in part from imported animal feedingstuffs, but there is no information on how they may otherwise appear in the food chain.

281. The levels of DDT and BHC are well below the maximum acceptable daily intakes recommended by the World Health Organisation (WHO). The levels for dieldrin are of the same order as the maximum but it must be clearly recognised that the WHO calculations incorporate very large safety factors (paragraph 73).

282. We referred in our 1964 Review to the presence of some of these chemicals in human body fat. The continuing surveys since 1964 suggest that the residue levels in human fat are also falling (paragraph 75). It is possible that the decline in dieldrin can be attributed partly to the reduction in use arising from the restrictions recommended in our 1964 Review. We continue to import about half of our food including meat, butter, and fats, and it is clear that any restrictions in the use of organochlorine pesticides at home cannot eliminate these chemicals from our diet. In view of what we have reported about the

distribution of these compounds in the environment, we can now be certain that the bulk of the intake results from the consumption of foods containing residues.

Consideration of current uses of organochlorine compounds

283. We have drawn attention to our conclusions on the overall distribution of some of these compounds in the general environment (paragraphs 96, 97) and have referred to this situation in relation to man (paragraph 89). We considered that one approach to reducing them, although only locally, since the problem is global, would be by the careful examination of all known current uses in Great Britain.

Agricultural and horticultural uses

284. In this examination we have taken account of the scale of use of the organochlorine compounds, the availability of alternative chemicals that can compete in efficacy and cost, and of the hazards offered by such alternatives. We feel that those alternatives that might present acute hazards should be formulated in such a way, e.g. granular formulations, as to reduce such risks and we note that such chemicals are much less likely to persist in the environment. We have also given careful attention to recommended uses of organochlorine compounds that, in many cases, have been partly superseded by other chemicals.

285. Most of the equipment and associated machinery in current use in seed dressing establishments was designed for the application of dry formulations of compounds, which if taken up by man, do not rapidly produce toxic effects. Although there is no evidence of immediate ill-effects when used with organochlorine compounds, the process is inherently a dusty one and usually results in some exposure of operators. This exposure and the associated hazards are much reduced if liquid dressings are employed in equipment designed for their use. We welcome the trend towards the use of liquid rather than dry seed dressings, whatever the chemicals used, and we recommend that departments take any necessary steps to encourage the change to liquid formulations. Nevertheless sufficient time will be needed for seed dressing establishments to equip themselves with adequate machinery for applying dressings without hazards to the operators.

286. There are, nevertheless, effective alternatives to organochlorine compounds, of relatively low toxicity, that could be used in many situations. In the case of DDT, however, we recognise the difficulty of finding efficient, safe, and cheap alternatives, and manufacturers are unlikely to find it economic to develop alternatives unless resistance becomes widespread, or the very wide use of DDT is restricted. Our recommendations, if implemented, should result in a reduction in the overall use of DDT in agriculture and horticulture. Resistance to the chemical is developing, but its rate of spread cannot be predicted; as resistance develops alternatives will, in any case, have to be found.

287. Our examination of the agricultural and horticultural uses of aldrin, dieldrin, endrin, endosulfan, heptachlor, camphechlor, and chlordane, has led us to advise the withdrawal of some recommended uses of certain of these chemicals whenever they are no longer required, where resistance is developing, or when satisfactory alternatives are available.

Food storage uses

288. In examining the extent to which uses of these compounds in the food storage and domestic fields contribute to their occurrence in the environment we have noted the absence of adequate quantitative data. However, we believe that only DDT, aldrin/dieldrin, and chlordane, are used to any extent in food storage. Although resistance of food storage pests to DDT has been reported, we do not think that this will have an appreciable effect on the amount likely to be used in food storage practice during the next few years.

Thermal vaporisers

289. We believe that the use of DDT in vaporisers is unlikely to contribute significantly to the general distribution of this chemical in the environment. However, local contamination can arise in certain situations and we have therefore recommended that DDT should not be vaporised in the presence of persons, animals, or unwrapped food, or where food is sold, prepared, served, or eaten.

290. Although gamma-BHC was not within our terms of reference we considered it in the special case of thermal vaporisers. It is less persistent than DDT but because vaporisers produce continuously renewed deposits we consider it wise to discontinue the use of vaporisers dispensing this chemical in situations where people may be continuously exposed to vapours for periods of more than eight hours. This amounts to a withdrawal of use in living rooms and sleeping quarters and in hospital wards and similar situations.

Other uses

291. Under the present Pesticides Safety Precautions Scheme difficulties repeatedly arise in deciding whether a pesticide product whose main use is outside the agriculture and food storage field should be notified. Thus, although a product label may recommend its use in industry, in the home, and in public health, it may make no mention of its use in food storage or in the home kitchen and larder. So far as we can judge, no direct risks to man are created by the use of organochlorine compounds to control nuisance pests. Undoubtedly some contribution to the total amounts in the environment must arise, but we have no measure of the extent at present. It is important to know the quantities of these chemicals used for this purpose.

292. DDT and dieldrin have been found in industrial effluent and in sewage from towns. In particular, dieldrin tends to be present in localities where impregnation of wool is undertaken and could be a cause of hazards to fish and other forms of wildlife. Methods may now be available for reducing or removing dieldrin residues from such effluents and these methods should be further studied.

293. We have not learnt of any direct harm from the use of organochlorine compounds for the protection of timber.

Home garden uses

294. Home gardeners seem to use insecticides mainly against aphids on ornamental plants and we believe that the garden pests against which it is really necessary to use DDT are, in any case, less important. DDT is a poor aphicide with adverse effects on aphid predators; organophosphorus alternatives

give much better aphid control. As a contribution to lowering organochlorine pesticide residues in the environment we have therefore recommended that DDT should be withdrawn from use in home gardens as soon as this can be arranged.

Other home uses

295. Organochlorine compounds available on a small scale for use in the home comprise many different formulations and uses. We found it impossible to obtain estimates of the quantities of active ingredients involved and difficult, therefore, to assess the risks. We deprecate the fact that some of the products for use in the home carry no information about their active ingredients and others carry little or no precautionary labelling; we consider that the sale of these inadequately labelled products should cease. We also consider that the distribution and sale of household packs containing aldrin and dieldrin and carrying recommendations for use against clothes moths should cease; and that thermal vaporisers should not be used for pest control in the home. We hope that the proposed Pesticides Bill will cover all pesticide products in small packs sold for any use in the home, whether indoors or outdoors, including gardens.

Summary of discussion

296. In concluding our discussion on the outcome of this Review we wish to emphasize some very important points. Firstly the detection of these compounds in some sectors of the environment at levels as low as a few parts per million million has been made possible by the very sensitive techniques now available. The use of these methods has shown that the more stable of these chemicals may accumulate in soils, though residue levels seldom exceed the level of a single application. Measurable amounts of dieldrin and DDT can be detected and confirmed in human body fat. There is therefore no doubt that the general population is being exposed to these chemicals but we have no evidence that this results in any adverse effects on man. Furthermore, the evidence we have about current exposure suggests that the levels in human body fat are not rising, and may be falling, and does not suggest that there are likely to be dangers in the long term, but clearly it would be wise to maintain a continuous check on the situation. We must remain in some doubt about the interpretation of the data on laboratory animals referred to in paragraph 86, the implications of which could be so important that we believe these data must be discussed, and agreement on their interpretation reached, on an international basis.

297. We consider that the presence in the environment of persistent pesticides, even at low concentrations, is undesirable and we believe we should try to reduce amounts of these chemicals in the environment. We consider that the monitoring of levels of these chemicals in man, his food, wildlife and the physical environment should continue. We have not been able to estimate reliably the total cost of our recommendations. We appreciate that growers may have to pay a few tens of thousands of pounds more per annum for alternative pesticides, which are unlikely to be as cheap as the organochlorines, even when increased use leads to price reductions. There are other factors, such as capital, labour costs, new application techniques, and possibly increased numbers of applications, on which our survey units (paragraph 7) have been unable to obtain reliable information. We believe that more work is needed on these factors, and on cost/benefit analysis of the insurance use of pesticides.

298. We feel that, on balance, there is no case at present for the complete withdrawal of any of the chemicals under review. However, we shall continue to keep the situation under examination. As alternative pesticides are discovered and become commercially established, we shall consider the remaining uses of these organochlorine pesticides in the normal operation of the Safety Schemes.

299. Finally, we wish to make it clear that the line we have followed and the recommendations we have made in this Review are based on our assessment of the situation in Great Britain, and particularly in respect to the presence in the environment of these chemicals arising from their use in this country. Various factors, including the recommendations in our 1964 Review, have led to an estimated fall of about 25% in the total tonnages of aldrin, dieldrin, DDT, and TDE, used in agriculture and horticulture annually in Great Britain. Our present recommendations, if accepted, could lead to a further reduction of about 20% and we estimate that in the early 1970's we might be using only about half the quantities of these compounds that were used annually in the early years of the present decade. There is, of course, concern in other countries about the presence of pesticides in the environment; the extent to which account is taken of this elsewhere must clearly depend on the situations in countries which face problems in agriculture, public health, hygiene, and living conditions, which may be quite different from our own. Thus, in tropical countries where food production is vital and there is a high incidence of mortality from insect-borne disease, the hazards to wildlife and the presence of minute residues in human fat may rightly be regarded as relatively unimportant. On the other hand, people in temperate countries with high living standards, and no threat from insect-borne disease, may reasonably be more concerned about the undesirable aspects of persistent pesticides. This attitude is exemplified by the recent action of the governments of Sweden, Denmark, and Norway, who have announced their intention of restricting, to varying extents, uses of certain of the organochlorine pesticides, particularly DDT. Our own conclusions and recommendations follow a compromise based on a careful consideration of the present situation in Great Britain. We look to continued co-operation from Industry and the farming community if our recommendations are to achieve their objective.

IX. RECOMMENDATIONS

We recommend that for:

Agriculture and horticulture

300. Existing uses, covered by recommendations published under the Pesticides Safety Precautions Scheme, should continue, except for the following which should cease as soon as can be arranged or as otherwise indicated:—

(a) Aldrin, dieldrin and heptachlor seed dressings to control wheat bulb fly; heptachlor seed dressings on sugar beet. The possibility of withdrawal should be continuously assessed by the Advisory Committee, with a view to the withdrawal of these compounds as soon as is practicable (paragraphs 105, 131).

(b) Dieldrin sprays for control of wireworm attacking potatoes (paragraph 107).

(c) Aldrin and dieldrin spray, drench, or dust, on root and leaf brassicas against cabbage root fly (paragraph 110).

(d) Dieldrin dip and aldrin dust for control of narcissus bulb fly (paragraph 112).

(e) Aldrin spray and dust on strawberries for the control of strawberry seed-eating beetle (paragraph 116).

(f) Endrin on apple trees (paragraph 130).

(g) DDT on grassland (paragraph 141), brassica seed crops (paragraph 148), peas (except for weevil control) (paragraphs 151, 152), post-blossom on top fruit (paragraphs 169, 170, 171), raspberries (paragraph 174), gooseberries (paragraph 175); and for aphid control on all crops (paragraphs 141, 142, 152, 153, 161, 165, 170, 171, 180).

(h) TDE ("Rhothane") post-blossom on apples and pears, and on loganberries and raspberries (paragraph 187).

Food storage practice

301. (a) Insecticidal smoke generators containing dieldrin should not be used except in areas, such as roof spaces and heating ducts, where persons or food will not come into contact with deposits of the chemical (paragraph 192).

(b) Recommendations sheets should be amended to indicate more clearly the surfaces to which pigmented coatings containing dieldrin may be applied (paragraph 193).

(c) The use of paints and lacquers containing DDT should be discontinued (paragraph 196).

(d) Smoke generator formulations of DDT should be restricted to use in empty stowages or stowages where any food present is protected by sheeting or impermeable packaging; and to use in empty bins, shutes, or conveyors, for the transport or storage of raw grain or oilseeds, when these are inaccessible for conventional spraying with less persistent chemicals (paragraph 199).

(e) Reference to oil-based sprays containing DDT should be deleted from the recommendations sheets (paragraph 200).

(f) Any legislation that may be introduced for the sale and use of pesticides should include provisions covering the sale and use of all thermal vaporising equipment designed to discharge the pesticides under review (paragraph 203).

(g) Thermal vaporisers, irrespective of the chemical discharged, should not be operated unless there is a justifiable need for use, either as a prophylactic measure or for control of an existing infestation. They should not be used when open food is present (paragraphs 211, 216).

(h) More data should be obtained on the residue levels of gamma-BHC in the flesh, organs, or products of animals exposed continuously or for long periods, to gamma-BHC from thermal vaporisers (paragraph 212).

(i) The recommendations for safe use of thermal vaporisers discharging DDT, gamma-BHC, or mixtures of these two chemicals should be amended to include the following:

(1) DDT alone or in mixtures, should not be vaporised in rooms where food is sold, prepared, served, or eaten; or when persons, animals, or unprotected foods, are present (paragraph 214);

(2) gamma-BHC should not be vaporised in the living, eating, or sleeping, quarters of buildings, e.g. hospitals, institutions, hotels, etc., in which any resident or worker may be exposed to the continuously generated vapour for more than a normal 8 hour working period (paragraph 215);

(3) all thermal vaporisers should be thermostatically controlled. Vaporisers should be used in food premises, other work places, or premises where animals or animal foods are generally exposed, *only* to control actual infestation (paragraph 216).

Veterinary use

302. There is no need to make any changes in the existing veterinary recommendations (paragraph 223).

Other use

303. Because of the very great advantages of the organochlorine compounds in the fields of hygiene and public health, timber preservation, and the industrial moth-proofing of wool, both to individuals and to the community, hasty restrictions should not be placed on any of these non-agricultural uses unless there are reasonable grounds for believing that risks do arise but:

(a) DDT should not be used in commercial dry cleaning, including coin-operated establishments (paragraph 240).

(b) A study should be made of the disposal of sludge from timber-preserving tanks; of the practical possibilities of removing dieldrin from effluent from factories in which the chemical is applied to woollen yarns and fabrics; and of the use of sewage sludge, wool shoddy, and wool trimmings from carpet factories, as fertilisers; and when such data are available, the problem should be reassessed (paragraphs 232, 243, 244).

(c) A knowledge of the total quantities of each of the organochlorine pesticides devoted to these non-agricultural uses is highly desirable and accurate information should be obtained (paragraph 267).

Home garden use

304. Because the home gardener would not be put to a serious disadvantage if preparations containing DDT were no longer available to him, the existing uses of DDT in home gardens should cease as soon as this can be arranged (paragraph 250).

Home kitchen and larder use

305. (a) Safety precautions covering the use of chlordane as an insecticide in the home kitchen or larder should be agreed and published (paragraph 254).

(b) Dieldrin formulations in small retail packs should be withdrawn (paragraph 255).

(c) DDT for control of insect pests should be withdrawn (paragraph 256).

(d) Thermal vaporisers discharging DDT and/or gamma-BHC should not be used (paragraph 256).

Other uses in the home

306. (a) The sale of dieldrin and DDT in retail packs for the home moth-proofing of woollen goods should cease (paragraph 264).

(b) Thermal vaporisers discharging DDT and/or gamma-BHC should not be used (paragraph 265).

(c) Proposed legislation should control the labelling and supply of all domestic packs of pesticides (paragraph 268).

We further recommend that:

307. (a) All remaining uses of the chemicals under review should be kept under constant surveillance by the Pesticides and Veterinary Products Safety Precautions Schemes and replaced wherever possible by use of less persistent pesticides (paragraph 298).

(b) Residue levels in people, their diets, wildlife, and the environment, should be kept under surveillance (paragraph 89).

(c) The contribution to the environmental levels of dieldrin resulting from industrial uses of aldrin and dieldrin should be examined, and the relative advantages of these insecticides and of available alternative chemicals evaluated (paragraphs 266, 267).

(d) Further research should be done on the toxicological and ecological significance to wildlife of pesticide residues in the environment. This should include more precise observations on the field effects of chlordane, so that the real hazards of its small scale-use, particularly to soil invertebrates and birds, can be assessed (paragraphs 14, 25).

(e) More work should be done on the factors associated with the field use of pesticides, and on cost/benefit analysis of the use of pesticides as an insurance against the possibility of crop loss (paragraph 297).

308. None of our recommendations for restrictions should apply to research workers who might need to use these pesticides as standards in developing new pesticides.

X. ACKNOWLEDGEMENTS

309. We should like to express our thanks to those individuals and organisations who submitted evidence to us.

310. We wish to record our indebtedness to our Scientific Subcommittee under the Chairmanship of Dr. M. Cohen; to its joint Secretaries, Mr. J. A. R. Bates and Mr. D. S. Papworth; and to the Pesticides Usage Survey Groups at the Plant Pathology Laboratory and the Infestation Control Laboratory who prepared the valuable papers on usage reproduced at Appendices VIII and IX to our report. We also acknowledge the help given to us by our Secretary, Mr. J. A. Brown, and Assistant Secretary, Mr. N. J. Pickerin, in the final drafting of this Review.

APPENDIX I

Membership of the Advisory Committee on Pesticides and Other Toxic Chemicals and of its Subcommittees

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The following served on the Subcommittee during the period of the review:—

Professor E. Boyland, D.Sc., Ph.D., Chester Beatty Research Institute, University of London

Professor R. J. Fitzpatrick, Ph.D., B.Sc. (Physiol.), D.Sc. (Vet.Sci.), Faculty of Veterinary Science, University of Liverpool

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P. N. M. Moore, Esq., formerly Secretary to the Advisory Committee on Pesticides and Other Toxic Chemicals

A. B. Paterson, Esq., D.Sc., Ph.D., M.R.C.V.S., D.V.S.M., F.R.I.C., Central Veterinary Laboratory, Ministry of Agriculture, Fisheries and Food

APPENDIX II

Organisations and Individuals who submitted Evidence

(i) *Organisations*

Government:

Nature Conservancy (Natural Environment Research Council)

Non-Government:

Association of British Manufacturers of Agricultural Chemicals (now the British Agrochemicals Association)

Berk Ltd.

British Veterinary Association

Council for Nature

Food Manufacturers' Federation

Hercules Powder Co. Ltd.

Hoechst Chemicals Ltd.

Horticultural Advisory Council

Industrial Pest Control Association (now the British Pest Control Association)

Joint Committee of the Royal Society for the Protection of Birds and the British Trust for Ornithology on Toxic Chemicals, in collaboration with the Game Research Association

Lennig Chemicals Ltd.

Marks and Spencer Ltd.

National Association of Corn and Agricultural Merchants

National Farmers' Union

Nuclear Stock Association Ltd.

Shell International Chemical Co. Ltd.

The Compound Animal Feeding Stuffs Manufacturers' National Association Ltd.

Velsicol Chemical Corporation

(ii) *Individuals*

Dr. T. T. Baird, Deputy C.M.O., Ministry of Health and Social Security Services, Northern Ireland

D. V. Butt, Esq.

Dr. T. Walsh, Director, Agricultural Institute, Dublin

APPENDIX III

Government Schemes on Safety and Efficacy of Pesticides

A brief description is given below of the three Government schemes in existence which deal with the use of pesticides in agriculture and food storage, and of the Agriculture (Poisonous Substances) Act, 1952.

(i) *Pesticides Safety Precautions Scheme (formerly known as the Notification of Pesticides Scheme)*

This is a voluntary Scheme, agreed between the associations representing the pesticide manufacturers and the Agriculture and Health Departments in Great Britain, whereby manufacturers have undertaken to notify the Ministry of Agriculture, Fisheries and Food before marketing new chemicals or recommending a new use of an existing chemical. Manufacturers have to provide extensive data which include details of the physical, chemical and biological properties of the chemical compound, its persistence, the products into which it may break down, and its mode of action. Details of experimental work on its toxicity to mammals and (where available) to man are called for, as well as information on its likely effects on wildlife including birds, bees, and fish. Methods of analysis, medical data, and any particulars of its uses in other countries are also required.

These data and all other available information are considered by the Advisory Committee on Pesticides and Other Toxic Chemicals, and its Scientific Subcommittee. Provided it is satisfied that adequate practicable safeguards can be applied to protect the user of the chemical, the consumer of the treated crops, and wildlife generally, the Advisory Committee makes recommendations for the safe use of the chemical which, if accepted by the Government Departments concerned, are published and widely distributed. It is a condition of clearance that the manufacturers must include the recommended precautions and restrictions on the label of the product. If the Committee is not satisfied that the tests and trials were adequate, it can require the manufacturers to carry out further experimental work. The Advisory Committee and Departments also have power to review the safe use of any chemical at any time, in the light of new evidence.

(ii) *Veterinary Products Safety Precautions Scheme*

This Scheme, which was introduced after consultation with the professional and commercial organisations concerned, is designed initially to cover those veterinary products on sale direct to farmers. In respect of those products, it operates broadly on the lines of the Pesticide Safety Precautions Scheme. The Advisory Committee on Pesticides and Other Toxic Chemicals receives scientific advice about these products from a Veterinary Subcommittee.

(iii) *Agricultural Chemicals Approval Scheme*

This is a voluntary Scheme under which proprietary brands of crop protection chemicals (insecticides, fungicides, and herbicides) can be submitted for official "approval" of their biological efficiency. The purpose of the Scheme is to enable users to select, and advisers to recommend, efficient and appropriate crop protection chemicals for use against particular pests and to discourage the use of unsatisfactory products. The Scheme covers only those chemicals used for the control of plant pests and diseases, for the destruction of weeds, for growth regulation, and other crop protection purposes. It does not cover rodenticides, or pesticides used for food storage, veterinary, or domestic purposes.

The Scheme is operated by the Agricultural Chemicals Approval Organisation on behalf of the Agricultural Departments of the United Kingdom. "Approval" is granted by the Organisation for specific uses, under United Kingdom conditions, only when the Organisation is satisfied that the product fulfils the claims made on the label, and these are subject to constant review.

The Scheme does not deal directly with operator and consumer safety requirements, but "approval" of the efficiency of a product containing a new chemical cannot be given until it has first been considered and cleared for safety under the Pesticides Safety Precautions Scheme. "Approved" products (as distinct from those cleared only for safety under the Pesticides Safety Precautions Scheme) bear the "A" symbol on the label. A "List of Approved Products and their Uses for Farmers and Growers" is issued annually.

(iv) *Agriculture (Poisonous Substances) Act, 1952*

This Act is designed to protect agricultural workers by ensuring that they are supplied with, and use, protective clothing when working with the more toxic pesticides, i.e. those included in Regulations made under the Act. These "regulated" pesticides are listed in the Second Schedule to the Agriculture (Poisonous Substances) Regulations, 1966–69; the First Schedule shows the types of protective clothing required when particular operations are carried out. These Regulations are amended from time to time, on the advice of the Advisory Committee on Pesticides and Other Toxic Chemicals.

APPENDIX IV

Persistent Organochlorine Pesticides and their Principal Metabolites of Interest

(Where appropriate, names conform with British Standard 1831 : 1969)

Aldrin

Technical aldrin contains approximately 95 per cent of the compound HHDN, which is the principal active insecticidal ingredient. Residues in plants, soils and animal tissue are converted into HEOD (see dieldrin) by epoxidation and this is the stable residue: the rate of conversion appears to be greatest in animal tissue. For this reason it is convenient to consider aldrin and dieldrin residues together as dieldrin.

BHC

BHC (benzene hexachloride) exists in a number of isomeric forms of which gamma-BHC is the principal insecticidal compound. The gamma-isomer is available as the pure isomer (lindane), or as technical grades of BHC containing various proportions of gamma-BHC from about 13 per cent upwards. It is rather less persistent than some other of the organochlorine pesticides, beta-BHC being the most persistent of the principal BHC isomers.

Camphechlor ("Toxaphene")

Camphechlor is prepared by chlorinating technical camphene to a chlorine content of about 68 per cent (corresponding to "octachlorocamphene") and is a mixture of several individual compounds.

Chlordane

Technical chlordane is a mixture of a number of compounds the principal of which are the isomers alpha- and beta-chlordane; these together account for from 60 to 75 per cent of the technical material.

DDE

See DDT.

DDT

The principal active insecticidal ingredient of technical DDT is the isomer pp′-DDT (approximately 70 per cent), other isomers including op′-DDT; a small proportion of TDE isomers is also present. Residues in animal tissue are slowly dehydrochlorinated to pp′-DDE and this compound may account for as much as 70 per cent of the pp′-DDT originally present in the animal organism. DDT, DDE and TDE and their individual isomers may be determined separately in residue analysis but it is sometimes convenient to express the overall results as a single "total DDT equivalent" figure.

Dieldrin

Technical dieldrin contains approximately 85 per cent of the compound HEOD, which is the principal active insecticidal ingredient. Residues of HEOD in plants, soils and animal tissue are relatively stable.

Endosulfan

Technical endosulfan (also known as "Thiodan") consists of two principal isomers, endosulfan A and endosulfan B; the former predominates in the ratio of about 4 : 1 but the latter is the more persistent and so may occasionally predominate in endosulfan residues. Both isomers are slowly converted into the same relatively inactive compound, endosulfan alcohol.

Endrin

Endrin is similar to HEOD (see dieldrin) both chemically and toxicologically but although they have the same formula they are quite distinct substances and may be distinguished in analysis and in other ways. The basic difference between HEOD and the active ingredient of endrin lies in the internal spacial configuration of otherwise identical molecules. (Aldrin on epoxidation always gives rise to dieldrin, not endrin).

Heptachlor

Technical heptachlor contains 70 to 75 per cent of the principal active insecticidal ingredient heptachlor. Like aldrin, it epoxidises in plants, soil and animal tissue to a compound, heptachlor epoxide, which is analogous to HEOD (dieldrin) in chemical structure.

Heptachlor Epoxide.

See heptachlor.

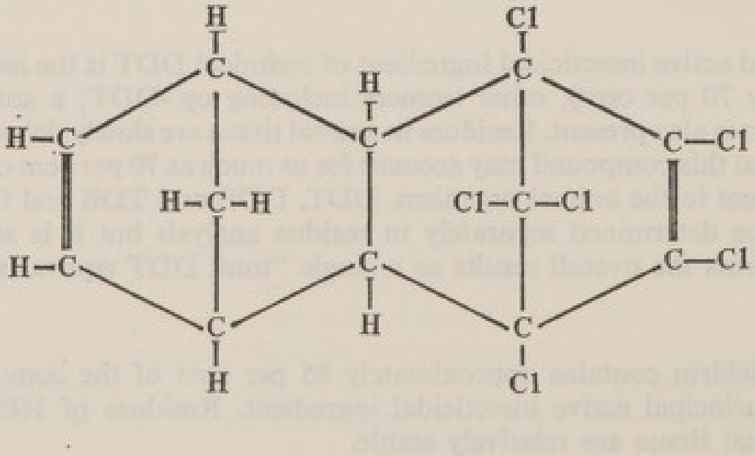
TDE ("*Rhothane*")

TDE is chemically similar to DDT, the technical material consisting mainly of pp′-TDE. As indicated under DDT, some TDE residues may be derived from the small TDE content of technical DDT; in addition, however, there is some evidence that TDE residues may also arise by the reduction of DDE residues, themselves derived from DDT by dehydrochlorination. At the same time, TDE residues may arise from the direct use of TDE. Another compound, dehydrochlorinated pp′-TDE, is also found; this has the same relationship to pp′-TDE that pp′-DDE has to pp′-DDT.

Aldrin (HHDN)

1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-*exo*-1,4-*endo*-5,8-dimethanonaphthalene.

$C_{12}H_8Cl_6$ mol. wt. 365 58% Cl



Camphechlor ("*Toxaphene*")

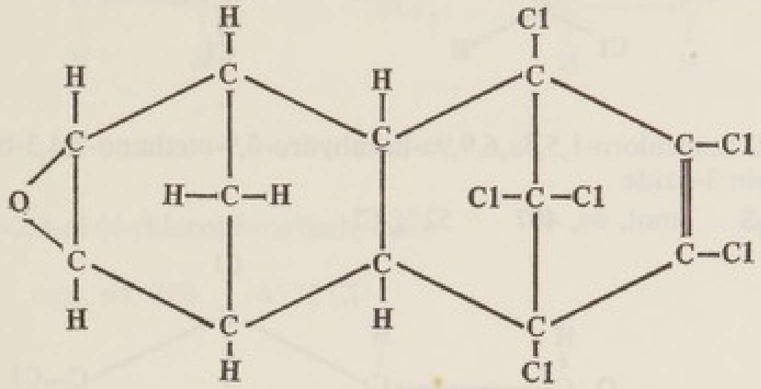
Chlorinated camphenes. "Octachlorocamphene" mixed compounds

$C_{10}H_{10}Cl_8$ mol. wt. approx. 414 67–69% Cl

Dieldrin (HEOD)

1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-*exo*-1,4-*endo*-5,8-dimethanonaphthalene.

$C_{12}H_8Cl_6O$ mol. wt. 381 56% Cl



Endrin

1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-*exo*-1,4-*exo*-5,8-dimethanonaphthalene.

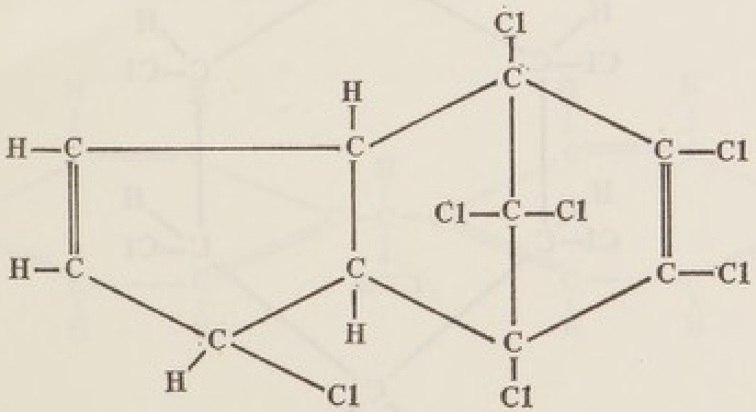
$C_{12}H_8Cl_6O$ mol. wt. 381 56% Cl

Chemical formula: same as for dieldrin.

Heptachlor

1,4,5,6,7,10,10-heptachloro-4,7,8,9-tetrahydro-4,7-methyleneindene

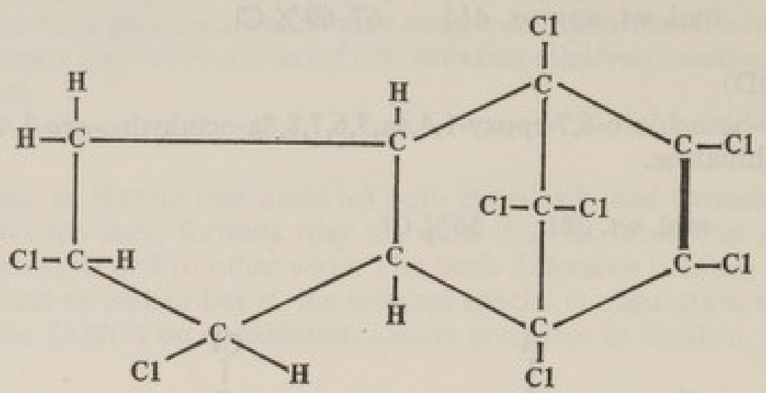
$C_{10}H_5Cl_7$ mol. wt. 373·5 67% Cl



Chlordane

1,2,4,5,6,7,10,10-octachloro-4,7,8,9-tetrahydro-4,7 methyleneindane

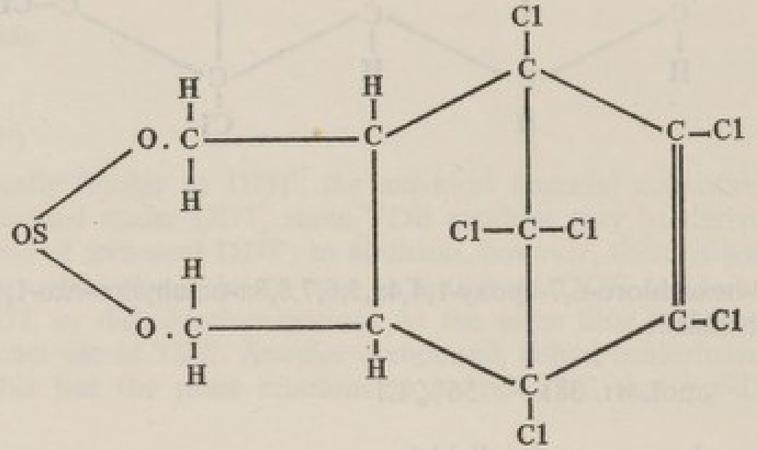
$C_{10}H_6Cl_8$ mol. wt. 410 69% Cl



Endosulfan

6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-6,9-methano-2,4,3-benzo [e] dioxathiepin 3-oxide

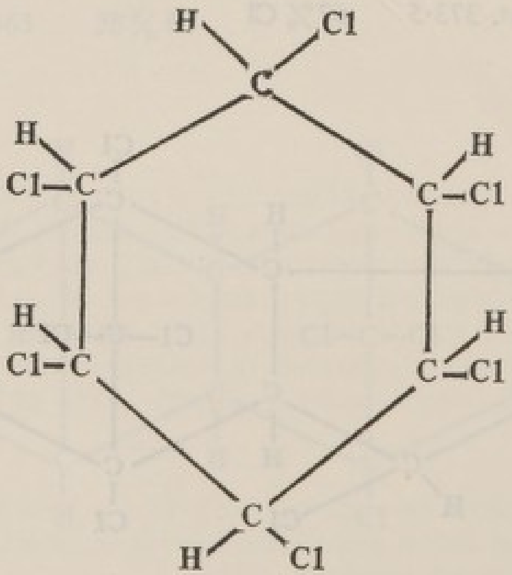
$C_9H_6Cl_6O_3S$ mol. wt. 407 52% Cl



Gamma-BHC

gamma-1,2,3,4,5,6-hexachlorocyclohexane

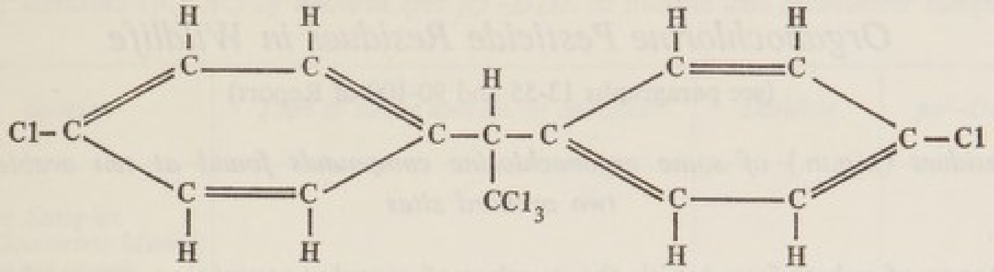
$C_6H_6Cl_6$ mol. wt. 291 73% Cl



pp′-DDT

1,1,1-trichloro-2,2-di-(4-chlorophenyl)ethane

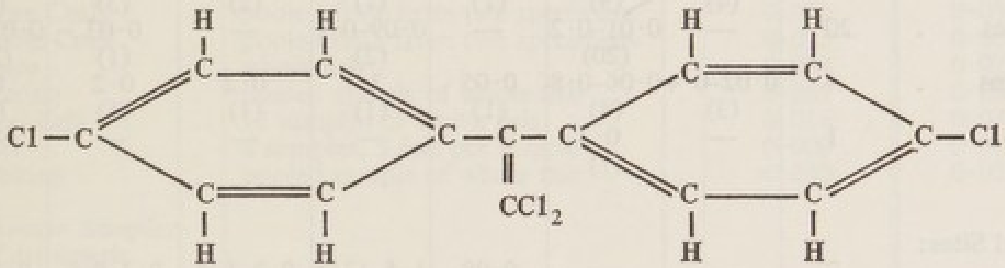
$C_{14}H_9Cl_5$ mol. wt. 354·5 50% Cl



pp′-DDE

1,1-dichloro-2,2-di-(4-chlorophenyl)ethylene

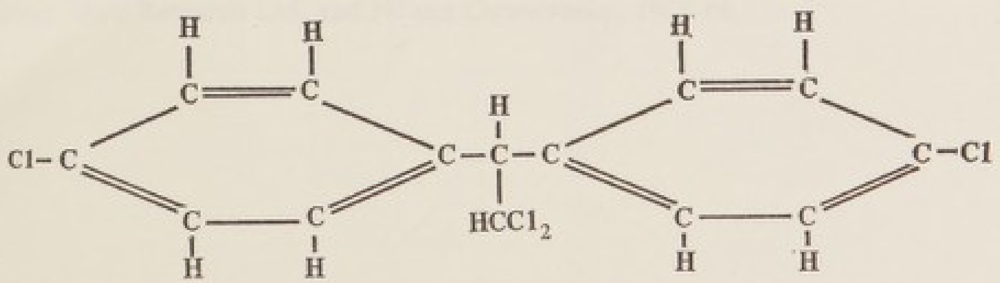
$C_{14}H_8Cl_4$ mol. wt. 318 45% Cl



TDE ("*Rhothane*")

1,1-dichloro-2,2-di-(4-chlorophenyl)ethane

$C_{14}H_{10}Cl_4$ mol. wt. 320 44% Cl



APPENDIX V

Organochlorine Pesticide Residues in Wildlife

(see paragraphs 13-55 and 90-100 of Report)

(i) *Residues (p.p.m.) of some organochlorine compounds found at ten arable and two orchard sites*

Range of values found with the number of samples containing measurable quantities in parentheses

Sample	*No. of samples analysed*	*Aldrin*	*Dieldrin*	*Gamma–BHC*	*pp′–DDT*	*op′–DDT*	*pp′–TDE*	*pp′–DDE*
Arable Sites:								
Soil . .	10	0·03–0·7 (4)	0·03–0·7 (9)	0·01 (1)	0·04–0·7 (7)	0·04–0·08 (2)	0·03–0·05 (3)	0·02–0·2 (6)
Beetles .	20	—	0·01–0·2 (20)	—	0·09–0·1 (2)	—	0·03 (1)	0·02–2·2 (20)
Worms .	4	0·02–0·4 (3)	0·06–0·8 (4)	0·05 (1)	2·1 (1)	0·2 (1)	0·2 (1)	0·9 (1)
Slugs . .	1	—	0·3 (1)	—	—	—	—	—
Orchard Sites:								
Soil . .	2	—	—	0·08 (1)	1·5–13·3 (2)	0·2–1·2 (2)	0·3–0·6 (2)	0·3–2·1 (2)
Beetles .	2	—	—	—	0·5 (2)	—	0·09–0·1 (2)	2·6–4·6 (2)
Worms .	2	—	—	0·3 (1)	11.7–30.4 (2)	0·9–1·6 (2)	1·5–2·9 (2)	2·1–6·5 (2)
Slugs . .	3	—	—	—	5·3–23·8 (3)	0·4–2·6 (3)	1·2–9·9 (3)	0·4–3·4 (3)

Source: Davis, B.N.K. and Harrison, R.B. (1966), *Nature*, 211, 1424–1425.

(ii) *Residues (p.p.m.) of dieldrin and pp'-DDE in marine and freshwater samples*

Species	*Type of tissue and no. of samples*	*Dieldrin*	*pp'–DDE*
Marine Samples (Geometric Means)			
Serrated wrack (*Fucus serratus*) .	pooled sample	0·001	0·002
Oar weed (*Laminaria digitata*) . .	pooled sample	0·001	0·003
Microzooplankton	pooled sample	0·020	0·030
Sea Urchin . .	pooled sample	0·027	0·050
Mussel . .	pooled sample of flesh . . .	0·023	0·024
Cockle . .	pooled sample of flesh . . .	0·018	0·012
Limpet . .	pooled sample of flesh . . .	0·009	0·003
Macrozooplankton (Crustacea) .	pooled sample	0·160	0·160
Lobster . .	pooled flesh from two specimens .	0·024	0·024
Shore Crab . .	pooled flesh from two specimens .	0·025	0·037
Edible Crab . .	pooled flesh from two specimens .	0·015	0·061
Plaice . . .	whole fish	0·038	0·023
Herring . .	pooled sample of whole fish . .	0·057	0·080
Sand Eels . .	12 samples of whole fish .	0·016	0·026
Cod . . .	6 samples, 3 fish per sample . .	0·009	0·012
Whiting . .	pooled sample of whole fish . .	0·040	0·021
Freshwater Samples (Arithmetic Means)			
Perch . . .	muscle—four specimens . .	0·015	0·078
Pike . . .	muscle—two specimens . . .	0·030	0·090
Stickleback . .	whole fish—four specimens . .	0·196	0·122
Roach . .	liver—seven specimens . . .	0.207	0·696
Bream . .	liver—three specimens . . .	0·449	1·111
Chub . . .	liver—one specimen . . .	0·183	0·023
Minnow . .	whole fish—three specimens . .	0·261	0·108
Loach . . .	whole fish—one specimen . .	0·005	0·049
Dace . . .	muscle—five specimens . .	0·139	0·089
Eel . . .	liver—fourteen specimens . .	0·274	0·325

Source: Shell Research Ltd. and Nature Conservancy, 1965–66.

(iiia) *Residues (p.p.m.) of dieldrin and pp'-DDE in the eggs of seabirds, Great Britain 1963–67*

Species	Locality	Year	No. analysed	Dieldrin Range	Dieldrin Arithmetic Mean	pp'-DDE Range	pp'-DDE Arithmetic Mean
Sandwich Tern	Scolt Head, Norfolk	1963	3	0·2–0·5	0·3	1·0–1·5	1·2
		1964	8	Tr–1·5	0·4	0·3–1·1	0·7
		1965	11	0·1–2·2	0·9	0·7–3·1	1·4
		1966	20	ND–0·4	0·2	0·4–1·9	0·9
		1967	10	0·1–0·2	0·1	0·3–0·8	0·6
Common Tern	Scolt Head, Norfolk	1964	8	0·1–0·3	0·2	0·2–1·4	0·8
		1965	10	Tr–0·2	0·1	0·2–1·1	0·7
		1966	10	0·1–0·6	0·3	0·4–0·9	0·6
		1967	10	Bulked	0·2	Bulked	0·4
Oystercatcher	Scolt Head, Norfolk	1963	2	0·1–0·4	0·3	0·2–1·2	0·7
		1964	10	0·1–0·4	0·2	0·2–1·1	0·5
		1965	10	0·2–0·6	0·4	0·5–1·4	0·9
		1966	9	0·2–0·4	0·3	0·4–2·0	1·0
Kittiwake	St. Abbs Head, Berwick	1963	5	Tr	Tr	Tr–0·2	0·1
		1965	4	Tr	Tr	0·2–0·4	0·3
		1966	6	Tr–0·1	0·1	0·1–0·5	0·3
		1967	7	Bulked	0·1	Bulked	0·2
Kittiwake	Mull of Galloway, Wigtown	1965	4	ND	ND	0·5–0·8	0·7
		1966	5	0·2–0·6	0·3	0·6–2·2	1·3
		1967	6	Bulked	0·2	Bulked	0·7
Guillemot	St. Abbs Head, Berwick	1963	4	0·1–2·0	0·6	1·5–4·0	2·4
		1965	5	0·1–0·3	0·2	1·1–2·0	1·4
		1966	4	0·1–0·8	0·3	1·6–2·1	1·8
		1967	8	Bulked	0·1	Bulked	0·7
Guillemot	Mull of Galloway, Wigtown	1965	5	0·4–1·4	0·9	2·7–6·5	4·4
		1966	11	0·1–0·6	0·3	1·8–6·2	3·7
		1967	7	Bulked	0·3	Bulked	2·0
Razorbill	St. Abbs Head, Berwick	1963	1	1·6	1·6	2·9	2·9
		1965	3	0·4–1·8	1·2	2·3–3·1	2·6
		1966	5	0·3–0·6	0·4	0·9–2·2	1·5
		1967	5	Bulked	0·5	Bulked	1·0
Razorbill	Mull of Galloway, Wigtown	1965	6	0·3–1·0	0·5	2·1–3·1	2·6
		1966	8	0·4–3·0	1·2	1·8–5·4	3·4
		1967	6	Bulked	0·5	Bulked	1·1
Shag	St. Abbs Head, Berwick	1963	2	2·5–3·3	2·9	3·1–4·3	3·7
		1967	5	Bulked	1·0	Bulked	1·6
Shag	Mull of Galloway, Wigtown	1965	2	1·2–3·3	2·3	1·6–3·9	2·7
		1966	6	0·9–4·2	2·6	2·3–7·9	5·0
		1967	6	Bulked	1·6	Bulked	2·2

ND—none detected. Tr—trace. *Source:* Nature Conservancy.

(iii b/1) *Geometric mean concentrations (p.p.m.) of dieldrin and pp′-DDE in eggs of sea birds nesting in Northumberland in 1965*

Species	*Locality*	*No. of eggs*	*Dieldrin*	*pp′–DDE*
Shag	Farne Islands	6	1·38	1·19
Kittiwake	Farne Islands	6	0·15	0·31
Herring Gull	Farne Islands	5	<0·02	0·34
Lesser Black Backed Gull .	Farne Islands	6	0·43	0·63
Sandwich Tern . . .	Farne Islands	6	0·30	0·64
Common Tern . . .	Coquet Island	5	<0·02	0·04
Roseate Tern . . .	Coquet Island	5	0·15	0·55
Guillemot	Farne Islands	5	0·60	1·88
Puffin	Farne Islands	5	0·33	0·40
Cormorant	Farne Islands	4	0·57	1·97

Source: Royal Society for the Protection of Birds.

(iii b/2) *Geometric mean concentrations (p.p.m.)* of dieldrin and pp′-DDE in eggs of sea birds nesting in Northumberland, Berwickshire or Fife in 1965*

Species	*Locality*	*No. of eggs*	*Dieldrin*	*pp′–DDE*
Shag	Farne Islands	56	1·24 (1·08–1·43)	1·97 (1·75–2·21)
	Isle of May	10	1·33 (0·93–1·89)	2·50 (1·77–3·52)
Kittiwake	North Shields	26	0·10 (0·08–0·13)	0·25 (0·21–0·29)
	Farne Islands	2	0·08 0·14	0·15 0·28
Sandwich Tern	Farne Islands	8	0·17 (0·12–0·25)	0·75 (0·52–1·08)
Razorbill	St. Abbs Head	3	0·35 (0·07–1·73)	0·64 (0·12–3·37)
Guillemot	St. Abbs Head	3	0·11 (0·005–0·26)	1·30 (0·84–2·00)
Puffin	Farne Islands	1	0·30	0·17
Cormorant	Farne Islands	5	1·22 (0·52–2·84)	3·80 (2·30–6·31)

* Confidence limits of mean (P=0·05).
Source: Shell Research Ltd.

(iv) *Average residues (p.p.m.) (arithmetic means) of organochlorine pesticides in the livers of avian predators*

Year	*No. spec.*	*Alpha BHC*	*Beta BHC*	*Gamma BHC*	*Hepta-chlor epoxide*	*Diel-drin*	*pp′–DDE*	*pp′–TDE*	*pp′–DME**	*pp′–DDT*
					Sparrowhawk					
1963	11	—	0·3	0·01	0·7	2·24	12·71	0·27	—	0·46
1964	8	—	0·23	—	0·28	1·5	10·18	1·22	0·25	0·3
1965	9	—	0·25	—	0·64	4·13	20·3	0·7	0·1	0·07
1966	8	—	—	—	2·12	1·46	11·17	0·28	—	0·1
					Kestrel					
1963	20	—	—	0·04	2·58	5·2	7·3	0·8	0·05	0·13
1964	28	—	0·1	0·1	1·4	3·07	4·3	0·3	0·09	0·08
1965	60	—	0·01	0·03	0·4	2·44	3·9	0·27	—	—
1966	9	—	—	—	2·3	5·8	5·51	0·32	—	—
					Tawny Owl					
1963	12	—	0·02	—	0·20	0·5	4·3	0·01	—	0·01
1964	14	—	—	0·01	0·25	0·19	3·43	—	—	0·11
1965	29	—	0·01	—	0·21	1·55	20·63†	0·26	0·01	0·06
					Barn Owl					
1963	7	—	—	—	1·30	1·32	8·1	0·52	—	0·11
1964	23	—	0·07	—	0·90	2·36	4·33	0·45	0·05	0·05
1965	30	—	—	—	0·57	3·56	3·58	0·22	—	0·01
1966	7	—	—	—	0·02	1·18	2·04	0·08	—	0·01
					Heron (Adults)					
1963	6	—	—	—	0·1	1·05	46·85	4·30	0·66	0·03
1964	17	0·05	0·1	0·005	0·24	2·17	21·02	0·36	—	0·08
1965	4	—	—	—	—	4·82	10·12	0·37	—	0·15
					Heron (Nestlings)					
1964	3	—	—	—	0·06	0·40	0·79	—	—	—
1965	20	—	0·005	—	0·07	5·57	23·24	1·11	0·07	2·24
1966	39	—	—	—	—	4·94	5·47	—	—	—
					Great Crested Grebe					
1963–6	15	—	0·1	0·03	—	0·89	12·17	0·97	0·08	0·27

* 1–chloro–2, 2–di–(4–chlorophenyl) ethylene.

† Includes one very exceptional specimen with 200 p.p.m.

Source: Nature Conservancy.

(v) *DDT residues (p.p.m.) in arable and orchard soils*

(a) *Arable soil* (62 sites)

pp′-+ op′ - DDT residues	
0·01 (or not detected)	30 sites
0·01 – 0·1	11 sites
0·10 – 1·0	17 sites
1 – 2	4 sites
2	0 sites

(b) *Orchard soil*

	pp′–+op′–DDT Soil		
	Around trunk	*Perimeter*	*Inter row*
Tree A	71·0	3·3	3·6
" B	9·6	2·9	1·6
" C	14·8	2·7	2·7
" D	14·2	2·8	2·6
" E	23·6	8·9	7·7
Average	26·6	4·1	3·6

Sources: (*a*) Wheatley, G. A., Hardman, J. A. and Strickland, A. H. (1962), *Pl. Path.*, *11*, 81–90; Wheatley, G. A., unpublished communication.

(*b*) Stringer, A. and Pickard, J. A. (1964), *Rep. Agric. hort. Res. Stn. University of Bristol*, 1963, 127–131.

(vi) *Residues of DDT and metabolites (p.p.m.) in birds from orchards (1965–67)*

Species	Tissue	pp′–DDT	pp′–DDE	pp′–TDE	Other chemicals
Blackbird 1 . .	Muscle	114·0	180·0	114·0	Not found
	Liver	0·0	222·0	145·0	,, ,,
	Brain	16·0	50·0	9·3	,, ,,
,, 2 . .	Muscle	26·0	86·0	60·0	,, ,,
	Liver	0·0	300·0	250·0	
	Brain	47·0	53·0	20·0	
,, 3 . .	Muscle	34·0	204·0	70·0	
	Brain	36·0	86·0	14·0	
Pheasant 1 . .	Muscle	0·0	6·3	9·4	
	Liver	0·0	37·2	45·5	
,, 2 . .	Muscle	5·0	8·4	2·7	
	Liver	0·0	91·0	60·0	
,, 3 . .	Muscle	4·7	6·2	10·6	
	Liver	0·0	24·0	48·0	
Blackbird 1 . .	Muscle	0·0	9·0	10·0	
	Liver	0·0	27·0	31·0	
,, 2 . .	Muscle	6·2	22·0	27·0	
	Liver	0·0	44·0	43·0	
,, 3 . .	Muscle	26·0	70·0	92·0	
	Liver	0·0	91·0	125·0	
Tawny Owl . .	Muscle	10·0	37·0	206·0	
	Liver	0·0	42·5	325·0	
Mistle Thrush . .	Muscle	223·0	37·0	30·7	
	Liver	110·0	95·0	220·0	
Pheasant hen (shot) .	Muscle	0·4	0·3	0·0	
	Liver	0·2	1·5	0·0	
	Brain	2·2	2·3	0·0	
	Fat	2·9	2·7	0·0	
Pheasant cock (shot)	Muscle	0·0	0·1	0·0	0·2 BHC
	Liver	0·0	0·7	0·0	0·1 BHC
	Brain	0·0	0·0	0·0	0·3 BHC
Bullfinch 1 . .	Liver	0·0	0·08	0·20	
	Muscle	0·0	0·04	0·0	
,, 2 . .	Liver	0·0	0·16	0·11	
	Muscle	0·0	0·13	0·0	
Pheasant (found dead)	Muscle	0·0	4·65	2·10	Negative for organophosphorus poisoning
	Liver	0·0	49·20	24·00	
	Kidney	0·0	18·0	8·0	

Continued (vi)

Species	*Tissue*	*pp′–DDT*	*pp′–DDE*	*pp′–TDE*	*Other chemicals*
Thrush 1 . .	Muscle	14·5	75·0	20·0	
,, 2 . .	Muscle	6·3	133·9	9·1	
	Liver	—	440·0	28·0	
,, 3 . .	Muscle	3·5	210·0	62·5	
	Liver	5·1	366·6	121·6	
Partridge 1 . .	Muscle	8·0	3·8	7·6	
	Liver	—	15·5	32·5	
,, 2 . .	Muscle	10·0	3·6	7·3	
	Liver	—	17·1	33·3	
Song Thrush 1 .	Muscle	30·0	65·0	20·0	
	Liver	—	116·6	50·0	
Mistle Thrush 1 .	Muscle	1·6	20·0	1·1	
	Liver	—	46·0	2·8	
Blackbird 1 . .	Muscle	—	250·0	79·0	
	Liver	—	900·0	268·0	
,, 2 . .	Muscle	—	27·5	16·0	
	Liver	—	107·0	53·5	
Starling 1 . .	Muscle	—	3·2	0·4	
	Liver	—	4·9	0·4	

Source: Infestation Control Laboratory, Ministry of Agriculture, Fisheries and Food.

(vii) *Residues of DDT and its metabolites (p.p.m.) found in British mammals (1963–66)*

Species and (no. of specimens)	*Tissue*	*pp′–DDE*	*pp–′TDE*	*pp′–DDT*
Hedgehog . . . . (2)	Liver	0·03	0·02	0·02
Mole . . . . . (1)	Liver	0·02	<0·02	<0·03
Natterer's Bat . . . (1)	Liver	0·03	0·2	0·2
Pipistrelle Bat . . . (1)	Body	1·7	0·9	1·5
,, ,, (1)	Liver	2·8	1·7	1·5
Long Eared Bat . . . (1)	Body	2·1	0·9	1·3
Rabbit . . . . (1)	Liver	—	—	—
Grey Squirrel . . . (1)	Liver	—	—	—
	Kidney	—	—	—
Red Squirrel . . . (1)	Mixed viscera	0·30	0·27	—
Water Vole . . . (1)	Liver	<0·001	<0·001	<0·006
	Fat	<0·04	<0·01	<0·13
,, ,, . . . (1)	Muscle	Trace	—	—
Short Tailed Vole . . (1)	Liver	0·03	<0·08	<0·03
Bank Vole . . . . (2)	Body	—	—	—
Otter . . . . . (1)	Liver	—	—	—
	Muscle	—	—	—
,, ... (1)	Liver	0·9	0·3	—
Badger . . . . (2)	Liver	<0·01	0·15	<0·01
Polecat . . . . (1)	Liver	—	—	—
Weasel . . . . (1)	Liver	0·03	<0·01	0·03
,, (1)	Fat	0·93	0·15	0·20
Stoat* . . . . (14)	Liver	0·11	0·17	<0·01
(5)	Fat	2·33	0·16	0·43
Fox* . . . . . (12)	Liver	0·08	0·05	0·02
(1)	Fat	0·07	0·01	<0·03
Grey Seal · . . . (1)	Liver	0·34	—	—
Common Dolphin . . (1)	Liver	0·13	—	—
	Blubber	1·28	—	—

* Figures quoted are arithmetic means.

Source: Nature Conservancy.

APPENDIX VI

Organochlorine Pesticide Residues in Foods

(see paragraphs 56–74 and 90–100 of Report)

(i) *Mean levels of organochlorine pesticide residues (p.p.m.) in foods*

Food	*Country of origin*	*Year*	*No. of samples*	*Total BHC isomers*	*Dieldrin*	*Total DDE/TDE/DDT*
Beef kidney fat	United Kingdom	1964	66	0·05	0·07	0·07
		1965	59	0·04	0·06	0·07
		1966	63	0·05	0·04	0·07
		1967	36	0·18	0·03	0·04
		1968	34	0·04	0·03	0·03
	Argentina	1963	12	0·03	0·12	—
		1964	13	0·15	0·28	0·02
		1965	22	0·13	0·08	0·01
		1966	21	0·50	0·15	0·02
		1967	37	0·65	0·10	0·03
		1968	7	0·70	0·08	0·03
Mutton kidney fat	United Kingdom	1964	128	0·44	0·84	0·06
		1965	107	0·43	1·1	0·05
		1966	101	0·16	0·44	0·11
		1967	76	0·18	0·24	0·06
		1968	77	0·17	0·21	0·16
	Argentina	1964	12	0·22	<0·01	0·09
		1965	17	1·11	0·05	0·24
		1966	24	0·39	<0·01	0·01
		1967	26	0·35	0·09	0·03
	Australia	1964	6	<0·01	<0·01	0·06
		1965	15	0·01	0·01	0·08
		1966	11	<0·01	0·02	0·09
		1967	7	<0·01	<0·01	0·19
		1968	16	<0·01	0·01	0·17
	New Zealand	1964	10	<0·01	<0·01	0·16
		1965	12	0·05	<0·01	0·28
		1966	23	<0·01	<0·01	0·10
		1967	31	<0·01*	<0·01	0·24
		1968	45	0·01	<0·01	0·33
Butter	United Kingdom	1964	18	0·05	0·03	0·05
		1965	18	0·04	0·03	0·04
		1966	13	0·07	0·02	0·05
		1967	22	0·07	0·03	0·05
		1968	16	0·08	0·03	0·06
	Australia	1964	45	0·03	0·01	0·41
		1965	45	0·02	0·01	0·25
		1966	53	0·01	0·01	0·54
		1967	35	0·01	0·01	0·27
		1968	20	0·01	0·01	0·26

* 1·01 p.p.m. if one result of 32 p.p.m. is included. This figure was excluded when calculating the mean as it was felt that such a high level would not result from normal agricultural use.

Continued (i)

Food	*Country of origin*	*Year*	*No. of samples*	*Total BHC isomers*	*Dieldrin*	*Total DDE/TDE/DDT*
	Denmark	1964	24	0·05	0·04	0·05
		1965	24	0·04	0·03	0·05
		1966	24	0·05	0·03	0·04
		1967	12	0·05	0·03	0·04
		1968	9	0·01	0·02	0·06
	Ireland	1966	5	0·07	0·03	0·10
		1967	6	0·05	0·02	0·05
		1968	6	0·07	0·04	0·06
	New Zealand	1964	45	<0·01	0·02	0·41
		1965	40	0·01	0·01	0·38
		1966	57	<0·01	0·02	0·28
		1967	49	<0·01	<0·01	0·21
		1968	51	0·01	0·01	0·23
Fresh milk	United Kingdom	1963	50	0·003	0·003	0·004
		1964	60	0·003	0·003	0·005
		1965	85	0.005	0·003	0·005
		1966	75	0·006	0·003	0·004
		1967	77	0·004	0·002	0·0035
		1968	76	0·002	0·001	0·002
Dried milk	United Kingdom	1966	18	0·039	0·011	0·028
Eggs (excluding samples from houses with thermal vaporisers and from DDT-treated birds or nests)	United Kingdom	1965 } 1966 }	163	0·02	<0·01	0·03
		1966	52	0·03	0·01	0·04
		1967	162	0·03	<0·01	0.04
Eggs (from houses with thermal vaporisers)	United Kingdom	1967	106	0·39	0·03	0·21
Eggs (from DDT-treated birds or nests)	United Kingdom	1967	18	0·03	<0·01	1·70
Poultry meat	United Kingdom	1965 and 1966	51	0·06	<0·01	0·02
Carrots (from dieldrin treated fields)	United Kingdom	1963 to 1965	147	Skin 0·04	0·16	—
				Flesh <0·01	<0·01	
Strawberries (from aldrin-treated plantation)	United Kingdom	1965	11	—	<0·01	—
Cod-liver oil (refined)	Arctic	1966	15	0·09	0·16	1·65
Orange juice (concentrated)	—	1966	20	0·001	0·002	0·001

Continued (i)

Food	*Country of origin*	*Year*	*No. of samples*	*Total BHC isomers*	*Dieldrin*	*Total DDE/TDE/DDT*
Tinned baby foods	United Kingdom	1967	22	0·003	0·001	0·008
Cheese	—	1968	128	0·05	0·01	0·03
Lard	—	1968	13	0·03	0·02	0·17
Cooking oils and fats	—	1968	16	0·01	<0·01	0·04
Suet	—	1968	7	0·06	0·03	0·08
Olive oil	—	1968	8	0·05	<0·01	0·11
Fish	—	1968	68	0·004	0·007	0·032
Flour	—	1968	27	0·018	0·001	0·009
Breakfast cereals	—	1968	20	0·004	<0·001	0·002
Jam and marmalade	—	1968	32	<0·001	<0·001	0·007
Blackcurrants (from endosulfan treated plantations)	United Kingdom	1966 1967	4 3	0·31 p.p.m. total endosulfan 1·17 p.p.m. total endosulfan		
Blackcurrant	United Kingdom	1967				
Jam			10	0·017 p.p.m. total endosulfan		
Juice			7	—		
Pie fillings			4	0·029 p.p.m. total endosulfan		

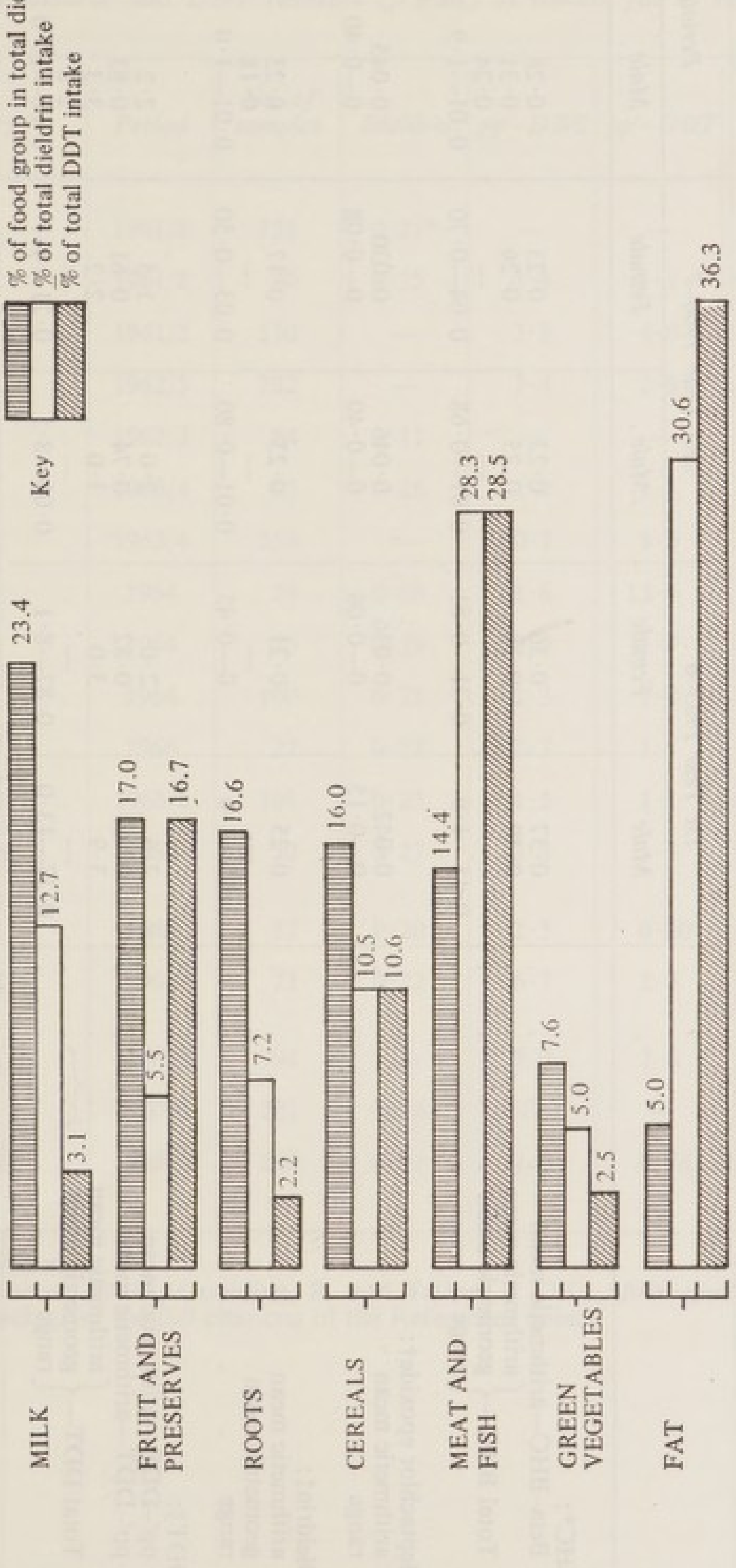
Source: Residues Panel of Scientific Subcommittee.

(ii) *Mean levels of organochlorine pesticide residues (p.p.m.) in food groups in the whole diet*

Food group	*Sampling period*	*Total BHC isomers*	*Dieldrin*	*Total DDE/TDE/DDT*
Cereals	1966 4th qtr.	0·016	0·0025	0·017
	1967 1st qtr.	0·0185	0·003	0·021
	2nd qtr.	0·011	0·002	0·016
	3rd qtr.	0·008	0·0025	0·016
Meat	1966 4th qtr.	0·027	0·010	0·063
	1967 1st qtr.	0·0165	0·0085	0·0555
	2nd qtr.	0·0075	0·009	0·049
	3rd qtr.	0·012	0·0095	0·0295
Fats	1966 4th qtr.	0·105	0·027	0·239
	1967 1st qtr.	0·064	0·028	0·219
	2nd qtr.	0·049	0·021	0·202
	3rd qtr.	0·045	0·019	0·169
Fruits and preserves .	1966 4th qtr.	0·0095	0·0015	0·026
	1967 1st qtr.	0·004	0·0015	0·03
	2nd qtr.	0·002	0·001	0·016
	3rd qtr.	0·0025	0·001	0·032
Root vegetables . .	1966 4th qtr.	0·005	0·003	0·0055
	1967 1st qtr.	0·003	0·0015	0·0035
	2nd qtr.	0·003	0·0025	0·003
	3rd qtr.	0·004	0·002	0·009
Green vegetables . .	1966 4th qtr.	0·0065	0·0035	0·009
	1967 1st qtr.	0·007	0·002	0·012
	2nd qtr.	0·006	0·002	0·014
	3rd qtr.	0·005	0·001	0·016
Milk	1966 4th qtr.	0·004	0·0025	0·004
	1967 1st qtr.	0·004	0·002	0·0035
	2nd qtr.	0·003	0·0015	0·003
	3rd qtr.	0·0025	0·0015	0·0035
Whole diet . . .	1966 4th qtr.	0·014	0·005	0·03
	1967 1st qtr.	0·0115	0·0045	0·03
	2nd qtr.	0·008	0·0035	0·025
	3rd qtr.	0·0075	0·0035	0·025

Source: Residues Panel of Scientific Subcommittee.

Figure 1. *Organochlorine pesticide residues in the whole diet—distribution of DDT and dieldrin in the various dietary components*



Source : Residues Panel of Scientific Subcommittee

APPENDIX VII

Organochlorine Pesticide Residues in Human Fat

(see paragraphs 75–100 of Report)

(i) *Distribution of organochlorine pesticide residues in human fat (p.p.m.) in adult population of Great Britain*
(1965–6: 57 males, 30 females; 1966–7: 100 males, 61 females)

	1st Year 1965–6		2nd Year 1966–7		Period 1965–7	
	Male	Female	Male	Female	Male	Female
BHC*:						
Beta-BHC—arithmetic mean	0·37	0·36	0·23	0·23	0·28	0·28
Total BHC—arithmetic mean	0·40	0·38	0.25	0·26	0·31	0·30
Total BHC—geometric mean	—	—	—	—	0·24	0·25
Total BHC—range	0·11—1·9	0·21—0·81	0·01—0·68	0·04—0·70	0·01—1·9	0·04—0·81
Heptachlor epoxide†:						
arithmetic mean	0·042	0·036	0·046	0·030	0·045	0·032
range	0—0·15	0—0·08	0—0·40	0—0·08	0—0·40	0—0·08
Dieldrin‡:						
arithmetic mean	0·25	0·21	0·23	0·17	0·23	0·18
geometric mean	—	—	—	—	0·18	0·15
range	0·05—1·0	0—0·45	0·01—0·80	0·03—0·50	0·01—1·0	0—0·50
DDT§:						
pp′-DDE—arithmetic mean	2·6	2·0	2·0	1·5	2·2	1·6
pp′-DDT—arithmetic mean	0·98	0·82	0·74	0·61	0·83	0·68
Total DDT—arithmetic mean	3·9	3·0	3·0	2·2	3·3	2·5
Total DDT—geometric mean	—	—	—	—	2·8	2·2
Total DDT—range	0·37—13·0	0·87—8·1	0·08—8·5	0·21—4·7	0·08—13·0	0·21—8·1

* The arithmetic means for total BHC isomers in the 1963–4 survey (Egan et al., 1965) were: male 0·43 p.p.m., female 0·40 p.p.m.
† In the 1963–4 survey (Egan et al., 1965) a trace of heptachlor epoxide, not exceeding 0·10 p.p.m., was detected in most samples of both sexes.
‡ The arithmetic means for dieldrin in the 1963–4 survey (Egan et al., 1965) were: male 0·27 p.p.m., female 0·23 p.p.m.
§ The arithmetic means for total DDT in the 1963–4 survey (Egan et al., 1965) were: male 3·7 p.p.m., female 2·7 p.p.m.
Source: Abbott, D. C., Goulding, R. and Tatton, J. O'G. (1968), *Brit. med. J. 1968, 3,* 146–149.

(ii) *Mean dieldrin and DDT residues (p.p.m.) in human fat in various countries*

Country	Period	No. of samples	Dieldrin	pp′-DDE	pp′-DDT	Reference
U.K. . . .	1961/2	131	0·21*	—	—	Hunter et al. (1963)
U.S.A. . .	1961/2	30	0·15	3·8	1·1	Dale & Quinby (1963)
U.S.A. . .	1961/2	130	—	7·8	4·0	Quinby et al. (1965)
U.S.A. . .	1962/3	282	—	7·4	2·9	Hoffman et al. (1964)
U.S.A. . .	1962/3	64	0·11	—	—	Hoffman et al. (1964)
U.K. . . .	1963/4	65	0·26	2·0	1·1	Egan et al. (1965)
Israel . .	1963/4	254	—	10·7	8·5	Wassermann et al. (1965)
India . . .	1964	24	0·03	11·6	13·6	Dale et al. (1965)
U.S.A. . .	1964	25	0·29	6·9	1·7	Hayes et al. (1965)
U.K. . . .	1964	100	0·21	2·3	1·0	Robinson et al. (1965)
Canada . .	1966	27	0·22	2·7	1·1	Brown (1967)
U.K. . . .	1965/6	101	0·23	1·5	1·1	Cassidy et al. (1967)
New Zealand .	1966	52	0·27	3·8	1·5	Brewerton & McGarath (1967)
Denmark . .	1966	17	0·20	2·5	0·60	Weihe (1966)
U.S.A. . .	1966	71	0·22	6·7	2·8	Fiserova-Bergerova et al. (1967)
U.S.A. . .	1962/6	994	—	7·0	2·6	Hoffman et al. (1967)
	1962/6	221	0·14	—	—	
U.K. . . .	1965/7	248	0·21	2·0	0·78	Abbot et al. (1968)

* Geometric mean.

Source: Abbott, D. C., Goulding, R. and Tatton, J. O'G., *Brit. med. J. 1968, 3* 146–149, which gives the full citations of the References noted.

APPENDIX VIII

PART I

Survey of Use of Persistent Organochlorine Pesticides in Agriculture and Horticulture in England and Wales, 1964–1967

(Prepared at the request of the Advisory Committee by Pesticides Survey Group, Plant Pathology Laboratory, Harpenden, under the general guidance of Mr. A. H. Strickland)

(see paragraphs 101–187 of Report)

INTRODUCTION

A summary of the few data available on the extent of use of the persistent organochlorine insecticides in agriculture and horticulture in England and Wales was given in Appendix E to the 1964 "Review of the Persistent Organochlorine Pesticides" (London, H.M. Stationery Office, February 1964).

The subject was considered in three parts in the 1964 Appendix: aldrin and dieldrin; chlordane, endrin, endosulfan, heptachlor and "Rothane"; and DDT and BHC. This lay-out was unsatisfactory because the organochlorine insecticides have many uses in common: aldrin, dieldrin, and BHC are all used in seed dressings; DDT and TDE ("Rhothane") are both used for caterpillar control; and so on. The various materials cannot realistically be considered in isolation. The lay-out has therefore been altered in the present report: each group of crops is dealt with in sequence and the organochlorine uses are discussed together under the relevant data tabulations.

In the 1964 Appendix the usage data were quoted as estimated crop acres believed treated, and the acreages of each treated crop grown in 1962–63 were also given. By summing the appropriate acreages it was possible to arrive at preliminary estimates of the extent to which agricultural and horticultural crop production techniques were responsible for 'environmental contamination'. The same convention is followed in the present report.

The 1965, 1966 and 1967 surveys considered here were based on sound statistical designs but their scope was limited and it was not always possible to survey crops in sufficient detail to provide very precise estimates of pesticide treatments. In general there are large proportional errors when the percentages of crops, or acreages, which are treated form only a small proportion of the total grown. Where less than about 2 per cent of the acreage of a crop has been recorded as treated, the true extent of treatment may differ appreciably from the estimated extent: *Imprecise estimates are bracketed in the tabulations, and textually, in the rest of this report.*

Deficiencies also arise from limited coverage. Generally, policy has been to survey the main centres of crop production in some detail and to raise the estimates of acreages treated with insecticides to national level on the assumption that a minority of the crop is likely to be treated by professional growers in the same way as the majority of the acreage. Data have been raised on a county or regional basis to avoid attributing relatively heavy eastern county usages to acreages in the northern or western counties which are less often treated.

The present report differs from the 1964 Appendix in three further respects. First, in many cases it has been possible to include estimates of the use of organophosphorus insecticides either for aphid control, or to control flies or caterpillars which were originally controlled with organochlorine materials. There have always been materials

—such as nicotine—which have been used to control aphids as distinct from other pests and the phrase 'organophosphorus aphid sprays' in many of the present tabulations should not be construed purely in terms of a swing away from the organochlorines. In some cases—for example in sections 2.2 and 2.3—it has been possible to separate the organophosphorus treatments into those applied against aphids (substituting in part for DDT and BHC), and those applied against other pests which, until recently, would have been routinely dealt with by organochlorine treatments.

Secondly, an attempt has been made to discuss the pests against which treatments have been applied, the need to apply the treatments, and the existence or otherwise of experimentally verified alternative chemicals. Non-chemical control methods are not discussed.

Thirdly, a summary of organochlorine insecticide usage on Forestry Commission woodlands is included. A survey of usage on privately owned woodlands is in hand but the results are not yet available.

In the pages which follow the tabulations refer to England and Wales only. In a few cases data were available from more than one source: in these cases the most reliable data have been set out in tabular form and the other data are discussed textually.

1. Farm Crops

'Farm Crops' are taken here to include those crops which are usually grown by arable and stock farmers as distinct from specialist vegetable, fruit or flower growers. The crops considered under this heading include cereals, grassland, roots, potatoes, legumes, and brassicae for stockfeed. In 1966 these crops were grown on 27 million acres (10·9 million ha) in England and Wales, of which 10·2 million acres (4·1 million ha) were under permanent grass and 3·3 million acres (1·3 million ha) were in rough grazings; excluding grass, annual farm crops covered approximately 10·4 million acres (4·2 million ha) of which almost exactly 8 million (3·2 million ha) were in cereals.

1.1 Cereal Crops

Mainly barley (5.29 million acres [2·14 million ha] in 1966), wheat (2·17 million acres [0·88 million ha]) and oats (0·43 million acres [0·17 million ha]). Mixed corn and rye were grown on less than 0·08 million acres (0·03 million ha), half in Wales and the south-western counties. From a pest control viewpoint wheat is the most important cereal and is discussed first.

1.1.1. Wheat. In most years about 77 per cent of the wheat is winter-sown, though in the eastern counties there are areas where over 80 per cent is winter-sown. In 1962–64, when 2·1 million acres (0·8 million ha) of wheat were grown each year, it was estimated (Strickland, 1965) that about 103,000 acres (42,000 ha) were sown with aldrin- or dieldrin-dressed seed, 88,000 acres (36,000 ha) were sown with heptachlor-dressed seed (1962 and 1963), and 702,000 acres (284,000 ha) were sown with BHC-dressed seed. Insecticides applied to the soil or to standing crops included an estimated (and possibly exaggerated) 41,000 acres (16,000 ha) with aldrin and dieldrin, about 12,000 acres (5,000 ha) with BHC, and nearly 6,000 acres (2,500 ha) with DDT. Data are available for the 1965–66 cropping season from the 1966 Survey of Fertiliser Practice (SFP), and from detailed returns made by Seed Merchants to the Plant Pathology Laboratory. In considering these data (Table 1.1.1) it should be noted that SFP estimates are reliable when they relate to more than about 2 per cent of the surveyed crops; in some cases pesticides were used on less than 2 per cent of the crops and the associated errors of estimation increase rapidly as the percentages decline. For example, the 1966 SFP estimate for wheat was that $0{\cdot}3 \pm 0{\cdot}28$ per cent of the acreage was treated with aldrin, giving a mean value of 6,700 acres (2,700 ha) with confidence limits of 2,000 and 15,000 acres (800 and 6,000 ha).

Table 1.1.1. Treatments Applied to Wheat, Autumn 1965–Spring 1966

Materials	*Acreages* Believed Treated*
Wheat Bulb Fly Seed Dressings	
Containing Aldrin or Dieldrin	97,000
Containing 40 per cent gamma-BHC	181,000
Wireworm Seed Dressings	
Containing 20 per cent—25 per cent gamma-BHC	1,147,000
Field Treatments	
Aldrin	(6,700)
Organophosphorus Wheat Bulb Fly Sprays	36,500
Acreage Grown:	2,171,400

* (1,000 acres = 405 hectares)

The 1962–64 estimates indicated that about 290,000 acres (117,000 ha) of wheat were sown with seed dressed against wheat bulb fly. The 1966 data suggest that about 247,000 acres (100,000 ha) were sown with similarly protected seed in the autumn of 1965. The earlier data also indicated that about 30,000 (12,000 ha) of wheat were given field treatments against the fly, compared with about 43,000 (17,000 ha) in 1966.

1.1.1.1. The Need for these Treatments. It has been estimated (Potter, Strickland and Bardner, 1965) that 230,000–240,000 acres (93,000–97,000 ha) of wheat are normally grown under conditions which might attract a damaging level of wheat bulb fly attack in a year when the fly is unusually abundant. In such a year crop protection chemicals probably save the production equivalent of 84,000 acres (34,000 ha) of wheat worth about £3·3 million. Wheat bulb fly egg counts, which are done routinely by Advisory Service specialists each autumn in the areas where the pest is troublesome, were higher than usual in 1965: 'very heavy' in parts of Yorkshire; 'the highest ever recorded' in the eastern counties, and also in the east Midlands. There can be little doubt that the treatments applied in 1965–66 were justified.

1.1.1.2. Alternative Chemicals for Wheat Bulb Fly Control. The chemical control of wheat bulb fly has been critically examined by the Wheat Bulb Fly Panel consisting of members from the specialist branch of the Advisory Service and from Research Stations. The Panel reports as follows:—

Seed Dressings are relatively cheap (often less than 10/– per cwt [£1 per 100 kg] of treated seed), control is obtained with the minimum of insecticide, and there is some selectivity in that the materials are only applied where needed. Many field trials over the past few years indicate that there is little to choose between dieldrin, chlorfenvinphos and ethion, all of which have performed well on a wide range of soil types. Chlorfenvinphos, as a dry seed dressing, caused some delay in early plant growth but this did not affect final grain yield; control on some light, freely draining, soils was not good. Ethion did not affect plant growth. Both materials prevented some larval entry and killed some of the larvae that had succeeded in entering the plants. Diazinon gave some control on peat soils but was not effective on mineral soils, while carbophenothion was very promising but needs further field testing. None of these organophosphorus materials is yet available in approved commercial formulations.

Gamma-BHC (lindane) has continued to be less useful than dieldrin, particularly on peat soils.

Granules Applied in the Autumn. These have given rather better results than seed dressings. They are less selective than the dressings but, because little of the insecticide is in direct contact with the seed, granules are less likely to cause phytotoxic damage. They are more expensive than seed dressings (£3 to £7 per acre) (£7·4 to £17·3 per ha) and need a special applicator, but use may be justified by plant breeders and by growers of special stock seed. Three granular materials were outstanding: chlorfenvinphos, trichloronate and 'N–2790' (*O*-ethyl *S*-phenyl ethyl phosphonodithioate). Chlorfenvinphos appeared to stimulate plant growth as well as to give good control of the fly, and good results were obtained from both combine-drilled and broadcast applications. Trichloronate caused some plant damage in one trial on a fine sandy loam, but this did not occur in other trials on clay loams. N–2790 acted mainly by preventing larvae from entering the plants and in the only test done with these granules on a peaty soil it gave better results than a dieldrin seed dressing. Phorate granules have given promising results, but delayed plant emergence and caused some loss of stand.

Conclusions. The Panel only considered the insecticidal and phytotoxic characteristics of a range of alternative materials. Chlorfenvinphos and ethion seem to be reasonable substitutes for the persistent organochlorine insecticides used for wheat bulb fly control. Carbophenothion is promising, but needs further testing.

1.1.1.3. The Need for Treatments Against Other Wheat Pests. It has been estimated (Potter *et al.*, 1965) that about 500,000 acres (202,000 ha) of wheat may be at some risk from *Wireworm* damage; and that about 140,000 acres (57,000 ha) may, in an average year, be affected to some extent by *Leatherjackets*. It seems that over 1 million acres (405,000 ha) of wheat were sown with wireworm-dressed seed in 1966, and much was on old arable land with low wireworm populations.

With regard to leatherjackets, populations were declining in 1964 and 1965, and such damage as occurred was mainly in the northern and south-western counties and Wales, and to crops other than wheat. This is because wheat is normally autumn-drilled on land ploughed-out before *Crane Fly* eggs have been laid, or before they have hatched (White, 1967). Populations are now (1967) increasing again and in a year or two treatments may be more necessary.

1.1.1.4. Alternative Chemicals for Leatherjacket Control. Little work has been done on wheat. The Insecticide Usage Working Party of the Conference of Advisory Entomologists reports that fenitrothion, chlorfenvinphos and parathion have given effective control of leatherjackets in spring barley.

1.1.2. Barley. In most years approximately 92 per cent of the barley is spring-sown. In 1962–64 it was estimated that about 1·16 million acres (0·47 million ha) of barley were sown with BHC-dressed seed, and about 47,000 acres (19,000 ha) were given field treatments, mainly for leatherjacket control. The 1966 data are shown in Table 1.1.2, and it should be noted that both of the SFP estimates are bracketed and subject to sizeable errors of estimation.

Table 1.1.2. Treatments Applied to Barley, 1965–66 Crop

Materials	*Acreages Believed Treated*
Gamma–BHC Wireworm Seed Dressings	2,100,000
BHC Field Treatments	(33,600)
DDT Field Treatments	(1,500)
Acreage Grown:	5,287,400

1.1.2.1. The Need for these Treatments. It has been estimated (Potter *et al.*, l.c.), that about 1 million acres (405,000 ha) of barley may be at some degree of risk from *Wireworm* damage. This estimate referred to 1960–64, when an average of 3·7 million acres (1·5 million ha) of barley were grown annually. The grassland acreage has declined over the last few years, and the barley acreage has increased, and it may be that as much as 1·5 million acres (0·6 million ha) of barley would have justified wireworm protection in 1966.

Field treatments were partly applied against *Leatherjackets.* Potter and his colleagues estimated that about 121,000 acres (49,000 ha) of barley may be affected by leatherjackets in an average year. Since then White (l.c.) has estimated that about 322,000 acres (130,000 ha) were sown on ploughed-out grassland in 1963–64 and 1964–65, and that over the period 1962–66 an average of 25,000 acres (10,000 ha) may have warranted treatment per annum. These estimates of risk acreage are not so divergent as might appear; the Potter figure included 92,000 acres (37,000 ha) estimated to be lightly infested with populations that might affect barley yields by 3–4 per cent which it would be doubtfully profitable to try to prevent at a field treatment cost of about £1·8 per acre (£4·4 per ha), or more if much hand labour is spent in mixing and spreading baits. The balance of the Potter figure relates to an estimated 29,000 acres (12,000 ha) heavily or moderately infested with leatherjackets, in which the yield response from treatment may vary from about 7 to 26 per cent. Overall, it seems that something between 25,000 and 30,000 acres (10,000 and 12,000 ha) of barley may justify treatment in an average year. About half of this acreage is likely to be sown with DDT-susceptible varieties, and aldrin is the only currently available spray for use when DDT-sensitive varieties are due to be followed within a year or so by potatoes or carrots which would pick up residual taint from a BHC field treatment. A possible alternative to aldrin is a DDT bait mixture, which is not phytotoxic; but baiting is not popular with growers, partly because of the cost.

Aldrin did not appear in the SFP returns included in Table 1.1.2; White (l.c.) shows some estimates derived from information supplied by the Advisory Entomologists. These suggest that, in 1965–66, only 16,000 acres (6,500 ha) of cereals were chemically treated against leatherjackets, and nearly 5,000 (2,000 ha) of these acres received aldrin. DDT was applied to 5,600 acres (2,300 ha) and BHC to 4,400 acres (1,800 ha). Baiting was estimated to have been done on 2,000 acres (800 ha): about 60 (24 ha) with aldrin, 240 (100 ha) with DDT, 470 (190 ha) with BHC, and 1,200 (490 ha) with Paris Green. In the light of this more extensive information it is assumed that most of the BHC field treatments indicated in Table 1.1.2 were applied for wireworm control on heavily infested land. The Potter estimates suggest that about 30,000 acres (12,000 ha) of barley were grown annually on land heavily infested with wireworms in 1960–64, and a further 760,000 acres (308,000 ha) were grown on land with moderate wireworm populations which might have caused a 10 per cent drop in grain yield. Taking both wireworms and leatherjackets into account, the available information suggests that field treatments tend only to be applied when growers believe them to be necessary.

1.1.2.2. Alternative Chemicals for Leatherjacket Control. See summary at 1.1.1.4.

1.1.3. Oats. The 1962–63 and 1963–64 estimates suggested that about 134,000 acres (54,000 ha) of oats were sown with gamma-BHC-treated seed, and that 12,500 acres (5,000 ha) were given field treatments against *Frit Fly*, *Leatherjackets*, and *Wireworms.*

The 1966 SFP data on oats were limited, and no field treatments were applied to the surveyed crops. Additional information provided by the Advisory Service in Wales suggests that no field treatments were applied to oats in Wales in 1966. Seed dressing data are shown in Table 1.1.3.

Table 1.1.3. Seed Dressings Applied to Oats, 1965–66

Material	*Acreage Believed Treated*
Gamma–BHC Wireworm Seed Dressings . . .	130,000
Acreage Grown:	426,500

These data suggest that rather more seed oats were dressed with gamma-BHC than in the early years of the present decade, in spite of a further decline in acreage. These seed dressing data were obtained from merchants trading from Cumberland to the south coast, and from the east coast to the Welsh marches and the south-west. Recent information from Wales suggests that only about one-third of the seed is chemically dressed there.

1.1.3.1. The Need for these Treatments. The Potter estimates suggested that about half of the oat acreage may be damaged by frit fly; but field treatments need to be applied twice to ensure reasonable results and they are doubtfully economic except where late-drilled crops of special seed are concerned. The Potter figures also suggest that about 6,000 acres (2,400 ha) of oats may be at moderate or heavy risk, and about 113,000 acres (46,000 ha) may be at lesser risk, from wireworms in a normal year. About 3,000 acres (1,200 ha) may be at heavy-to-moderate, and 14,000 acres (5,700 ha) at slight risk from leatherjackets. Economic returns from treatments against any of these pests depend mainly on the pest population density in relation to the date of drilling and crop growth conditions. Generally, such information must be collected during a farm visit before a treatment benefit can be predicted.

1.1.4 Other Cereals. In 1966 approximately 66,700 acres (27,000 ha) of mixed corn and 9,900 acres (3,600 ha) of rye for threshing were grown. There are no data on treatments applied to these crops, though it seems likely that some seed dressings may have been used on them: 7,000 acres (2,800 ha) of the rye were in the eastern counties, where about a quarter of the acreage of all other cereals is sown with gamma-BHC-treated seed.

1.2. Grassland

There were about 10,195,000 acres (4·1 million ha) of permanent and 3,372,000 acres (1·4 million ha) of temporary, grassland in 1966, and 3,289,000 acres (1·3 million ha) of rough grazings. The farms visited during the 1966 SFP were representative of about 1 million acres (405,000 ha) of the permanent, and 500,000 acres (202,000 ha) of the temporary grass. None of the surveyed grass was treated with organochlorine insecticides in that year and it is concluded that grassland is rarely treated at present. The combined grassland acreage is, however, so great that a summary of the potentially important pests may not be out of place.

With one or two exceptions grassland pests are only economically important during the period of establishment of young leys, when *Wireworms*, *Leatherjackets*, *Frit Fly*, various *Caterpillars*, and some *Aphids*, may cause damage. Wireworm populations are normally low in arable land, and it may take as long as 10 or 15 years for a low arable population, of the order of 10,000 or 20,000 larvae per acre (250,000 to 500,000 per ha) to build up to a level of 500,000 or more per acre (1,200,000 or more per ha) after land is sown to grass. When old grass, or a long ley, is ploughed-out, the endemic wireworm population declines rapidly with each succeeding cultivation of the land.

In the early years of the present decade about 1,500,000 acres (607,000 ha) of grassland were ploughed-out annually. Most of this land was put to cereals, but over the years 1961–63 approximately 200,000 acres (81,000 ha) were re-seeded to grass annually, and this acreage sets a reasonable upper limit to the area of re-seeded grass which may justify treatment against wireworms if further work establishes that control is an economic proposition.

With leatherjackets, it has recently been estimated (White, l.c.), that about 300,000 acres (121,000 ha) of permanent and temporary grassland may, in an average year, support populations of the order of 500,000 larvae per acre (1,200,000 per ha). There is some evidence that this population level may be worth controlling in terms of increased dry matter yields in early summer (when the feed is most needed), but the available data are inadequate and no attempt can be made to estimate possible overall benefits from control.

Frit fly may affect ley establishment. In 1966 approximately 208,000 acres (84,000 ha) of new grass were sown without cover crops and were attractive to ovipositing flies in the late summer. About 400,000 acres (162,000 ha) were sown under nurse crops, almost exclusively under cereals. Where the cereals are also hosts of frit fly large numbers of migrating flies may be attracted to the site, and the effect of the flies on the developing ley may be masked (Webley, 1958). Oats are a preferred host of frit fly, but it is not known what proportion of the 1966 oat acreage was undersown with ley mixtures. If as much as 10 per cent of the oat crop was undersown with ryegrass ley mixtures it might be argued that, at most, 40–45,000 acres (16–18,000 ha) of under-sown leys would be at risk from frit fly. This figure, along with the figure for new grass without nurse crops, puts an upper limit of about 250,000 acres (101,000 ha) on the new grass which might, in the light of further evidence, justify some attempt at frit fly control.

Caterpillar damage to grassland is occasionally noticed, but not often enough to have been recorded in quantitative terms.

Aphids are more important grassland pests. Doodson (1967) has surveyed, and virus-tested, 112 crops of perennial ryegrass, mainly seed crops but including some leys, and has found 104 of them to be infected with Barley Yellow Dwarf virus, often with severe strains. The aphid vectors are readily controlled with organophosphorus materials.

Before these latter data were available it was estimated (Strickland, 1965 a) that pest control in grassland might show an average yield increment of 5 to 10 per cent, including new grass, and that a 20 to 25 per cent yield increment would probably be needed to tempt growers to take active control measures.

1.3. Root Crops

There are about 440,000 acres (178,000 ha) of sugar beet grown each year, and about 170,000 acres (69,000 ha) of mangolds, turnips, swedes and fodder beet for stockfeed. Sugar beet is the most valuable of these crops and is treated from time to time with insecticides. Good records are kept by the British Sugar Corporation (BSC) and the sugar beet data which follow have been prepared for the Corporation by the Agricultural Director's staff and the staff of Broom's Barn Experimental Station.

1.3.1. Sugar Beet. All sugar beet seed passes into the possession of the B.S.C. after being given appropriate pre-sowing treatment and before being supplied to the growers.

1.3.1.1. Seed Treatment. Heptachlor seed dressings have not been used since 1964, while dieldrin seed dressings have been used to an increasing extent. This is partly due to the inefficiency of currently available gamma-BHC seed dressings in protecting seedling beet from wireworm damage (Dunning and Winder, 1965). Table 1.3.1.1

shows the acreages believed to have been sown with dressed seeds. It will be noted that the total acreages are 12,000 to 15,000 (4,900 to 6,100 ha) less than the Ministry of Agriculture's June Census acreages. This is because the BSC fieldmen record actual crop acres while the June Census records relate to Ordnance Survey acreages.

Table 1.3.1.1. Sugar Beet Seed Treatments, 1964–1967

Material	*Acreages Sown with Dressed Seed*			
	1964	1965	1966	1967
Gamma-BHC	94,900	92,000	80,500	8,600
Dieldrin	298,100	338,900	345,400	422,200
Heptachlor	26,800	0	0	0
Crop Acres Surveyed:	419,800	430,900	425,900	430,800
Total Acreages Grown	432,400	445,900	439,100	451,900

1.3.1.2. The Need for Seed Treatment. Trials in 1966 demonstrated, as in earlier years, the small average benefit to be derived from dieldrin seed dressings (8–10/64 in. [3·25–4·00 mm] rubbed seed) on fields where no pests were known to be present. No alternative seed dressing that is both effective and safe from the viewpoints of plant and mammalian toxicity is available for *Wireworm* control. A range of alternatives—mainly organophosphorus insecticides—has been tested in field trials each year since 1964 with disappointing results. It is not known at present how far damage by *Pygmy Beetle*, *Millepedes*, *Symphylids*, and soil *Collembola*, is controlled by dieldrin seed dressings, but trials are planned to check this point in 1970.

Natural Seed was no longer available to growers after 1967, and all seed is now *Pelleted*, *Genetic Monogerm*, *Close-Grade Rubbed*, or *Wide-Grade Rubbed*. Approximately 19 per cent of the national acreage was sown with pelleted seed in 1967, and about 30 per cent in 1968. Before pelleting, the raw seed is dressed with dieldrin at a rate of 3·6 oz of active ingredient per cwt of seed (2 g per kg) which is equivalent to 0·08 oz of active ingredient per acre (6 g per ha) when the pelleted seed is drilled at 12·5 lb per acre (14 kg per ha), which is in turn equivalent to 2·5 lb of raw seed per acre (2·8 kg per ha). This rate of dieldrin is known to be at least as effective on pelleted seed as on raw seed in preventing wireworm damage. 0·02 oz per acre (1·5 g per ha) was tested in 1967 but was not as effective as the normal rate, nor were thionazin or N–2790 at 0·08 oz per acre (6 g per ha). Because pelleted seed is being used to an increasing extent for drilling at wide spacings, continued use of dieldrin seed dressings is considered an essential protection against wireworm damage.

A small amount of genetic monogerm seed, drilled at 2–3 lb per acre (2·2–3·3 kg per ha), and a substantial quantity of 8–10/64 in. (3·25–4·00 mm) rubbed and graded seed drilled at 5–5·5 lb per acre (5·6–6·2 kg per ha) was sown on 257,000 acres (104,000 ha) in 1966. Approximately 0·03 to 0·18 oz of actual dieldrin was thus applied per acre (2–12 g per ha). On average, seedling establishment was improved, and good protection was given against wireworm attack. Seedling establishment is most important at these low seed rates and if it cannot be ensured there will be adverse effects on the further spring mechanisation of the beet crop.

About 98,000 acres (40,000 ha) of wide-grade rubbed seed (7–11/64 in) (2·75–4·50 mm) and polyploid seed (8–12/64 in) (3·50–4·75 mm) were sown in 1966 at an average seed rate of 7·5 lb per acre (8·4 kg per ha) applying 0·24 oz of active ingredient per acre (18 g per ha). Benefits were as for the other types of seed. Additionally, polyploid varieties which are strongly recommended because they have a high sugar content, are badly affected by gamma-BHC phytotoxicity.

1.3.1.3. Foliage and Soil Treatments. The average annual acreages treated with organochlorine insecticides and their chemical alternatives over the past three years are shown in Table 1.3.1.3.

Table 1.3.1.3. Foliage and Soil Treatments to Sugar Beet

Material	*Acreages Believed Treated*			
	1964	1965	1966	1967
Aldrin	1,100	0	(10)	(0)
BHC	70	400	230	180
DDT	46,000	14,200	4,500	5,000
Dieldrin	900	0	(10)	(50)
Organophosphorus Aphid Sprays .	187,400	155,200	293,900	307,000
Acreages Grown:	432,400	445,900	439,100	451,900

Field use of aldrin, dieldrin and DDT has declined in recent years. Spraying is often done jointly for mangold fly and aphids, and several organophosphorus materials give better overall control than DDT. Organophosphorus materials are now recommended by the BSC in such cases, and this probably accounts for the decline in DDT usage.

1.3.1.4. The Need for Foliage and Soil Treatments. Foliage treatments are done to control *Beet Carrion Beetle, Mangold Fly, Mangold Flea Beetle, Sand Weevil, Capsid Bugs, Pygmy Beetle, Thrips, Cutworms, Leatherjackets* and *Aphids.* The acreages treated against these pests have varied over the years under review: sprays for joint control of mangold fly and aphids were applied to about 400 acres (160 ha) in 1966, compared with 55,000 acres (2,200 ha) in 1964; flea beetle attacks were treated on more than 2,000 acres (800 ha) in 1966, compared with 9,800 acres (4,000 ha) in 1964; and the other foliage pests (except aphids) occurred only on a few hundred acres each year.

So far as active ingredients are concerned, there is no satisfactory, cheap, and safe alternative to DDT for the control of leaf-eating beetles and cutworms, and no experimental work is in hand on alternatives. Dust formulations require excessive amounts of active ingredients for cutworm control and could probably be replaced by sprays; and BHC is a good alternative to DDT for leatherjacket control. Some DDT is used to control soil pests, though the BSC is actively discouraging the use of this material for combined control of aphids and mangold fly.

Soil treatments are applied against *Wireworms, Millepedes, Symphylids,* and *Pygmy Beetle.* In 1966 such treatments were applied on about 1,260 acres (500 ha) against these pests, DDT being used on about 1,100 acres (450 ha) against millepedes, pygmy beetle and symphylids which might otherwise have damaged the braird. In 1967 DDT was used on 200 acres (80 ha) against these pests, mainly pygmy beetle. Trial work is planned for 1967 to test the value of DDT and various alternatives for controlling these pests. In this connection, BHC treatments do not taint sugar beet as such, but taint may be significant in areas where potatoes and carrots are common crops in the rotation. BHC treatments were applied to about 110 acres (40 ha) of beet for soil pest control in 1966—mostly against wireworms—and to about 350 acres (140 ha) for the same reason, in 1965.

1.3.1.5. Summary. Heptachlor is no longer used on the beet crop. Use of DDT is declining, and is being replaced by increased use of organophosphorus insecticides for combined aphid and mangold fly control; but there is no satisfactory alternative for leaf-eating beetles and cutworms. BHC is a satisfactory soil insecticide in many cases. Dieldrin seed dressings will shortly be used on all seed at doses equivalent to 0·08 to 0·24 oz of active ingredient per acre (6–18 g per ha) depending on seed type. There is no well-tested alternative to dieldrin.

1.3.2. Other Root Crops. In 1964 it was estimated (Strickland, 1965) that about half the mangold seed was given a gamma-BHC seed dressing. Mangolds are best suited to districts where sugar beet does well, and the seed for both crops is often handled by the same merchants who use similar treatments for both types of seed. In 1964, it was also estimated that about two-thirds of the turnip and swede seed was dressed with gamma-BHC. Since 1964 some data have been collected on field treatments applied to these crops and they are shown in Table 1.3.2.

Table 1.3.2. Field Treatments to Other Root Crops, 1966

Material	*Acreages Believed Treated*	
	Turnips, Swedes, and Fodder Beet	*Mangolds*
DDT	7,200	(0)
Organophosphorus Sprays . .	(0)	6,600
Acreages Grown: . . .	130,100	40,300

1.3.2.1. The Need for these Treatments. Turnips and swedes were mainly treated in the northern and south-western counties for control of *Swede Midge*. Some DDT may also have been applied against *Flea Beetles,* which can be troublesome on crops from seed not dressed with gamma-BHC. The mangold crops surveyed in 1966 were not treated with DDT. Many of the crops were in the eastern counties, and some data were also obtained from Devon. In both areas organophosphorus sprays were applied mainly for control of *Aphids*, though *Mangold Fly* would have been controlled concurrently.

1.4. Brassica Seed Crops and Stockfeed Brassicae

About 300,000 acres (121,000 ha) of brassicae for seed and for stockfeed are grown annually. Since 1964, when 327,000 acres (132,000 ha) were grown, production has declined and only 282,000 acres (114,000 ha) were grown in 1966. These acreages exclude turnips and swedes, which are discussed in section 1.3.2.

1.4.1. Mustard for Seed, Fodder, or Ploughing-in. Crops for fodder and for green manuring are not, as far as is known, treated with insecticides. There remain about 6,000 acres (2,400 ha) of mustard grown annually for seed in recent years. Brown mustard seed crops tend to be damaged by *Cabbage Seed Weevils* and *Blossom Beetles*, but white mustards (*Sinapis alba L.*) are only damaged by the latter pests. Estimates of the extent of treatment are shown in Table 1.4.1.

Table 1.4.1. Extent of Treatments Applied to Mustard Crops

Material	Acreages Believed Treated 1965	Acreages Believed Treated 1966
BHC	300	500
DDT	600	600
Dieldrin	200	200
Organophosphorus Alternatives	1,700	1,400
Acreages Grown:	19,200	17,000

The increased use of BHC, on a declining acreage, in 1966 is believed to be due to the introduction of a new and highly efficient micronised dusting technique. SFP data suggested that about one-third of the seed mustard acreage was given DDT in 1966. Trials over the past two years have compared malathion, azinphos-methyl, fenitrothion and phosalone, with dieldrin for seed weevil and blossom beetle control. These alternatives seem to give satisfactory commercial control, though timing of applications is more critical than with dieldrin.

1.4.2. Other Brassica Seed Crops. About 2,500 acres (1,000 ha) of stockfeed brassica seed crops and 200–300 acres (80–120 ha) of seed crops of edible brassicae are grown annually. There are no recent data on treatments applied to these crops. Estimates in 1963 and 1964 (Strickland, 1965) suggested that not more than 200–300 acres (80–120 ha) were given field treatments with organochlorine insecticides: about equal acreages with dieldrin and DDT against the same pests that damage seeding mustard.

1.4.3. Stockfeed Brassicae. The 1962–64 estimates indicated that about 298,000 acres (120,000 ha) of kale, rape and cow cabbages were sown with gamma-BHC-dressed seed at a time when the annual acreage was about 350,000 (140,000 ha). The 1966 SFP data indicate that about 200 acres (80 ha) of kale were given DDT; a survey of seed rape crops done by Mr. H. J. Gould in the south-east in 1966 showed that 70 per cent of the crops of winter rape for fodder and oil, and of spring rape for oil, were treated with DDT for *Blossom Beetle* control. In a similar survey in 1967 only 10 per cent of the crops were sprayed with DDT, 10 per cent were treated with BHC, and 40 per cent with malathion. These surveys covered an area in which about 2,000 acres (800 ha) of rape were grown, and the results may not represent the national situation.

1.5. Stockfeed Legumes

About 103,000 acres (42,000 ha) of peas and beans for stockfeed were grown in 1966, with 68,000 acres (28,000 ha) in the eastern counties. Seed is seldom treated other than with fungicidal dressings: data from approximately 5,000 acres (2,000 ha) of stockfeed beans in 1965 indicated that only 50 acres (20 ha) were sown with fungicidally-dressed seed and none with insecticidally-dressed seed. Many spring bean crops are treated with organophosphorus sprays to control *Black Bean Aphid*, and a survey in the eastern counties in 1967 showed that 6 per cent of the crops had been given DDT for *Bean Weevil* control.

1.6. Potatoes

In recent years approximately 75,000 acres (30,000 ha) of first-early potatoes and 450,000 acres (182,000 ha) of second-earlies and maincrops have been grown annually.

Generally, first-earlies are less often treated with insecticides than the other varieties because they are usually harvested before noticeable pest or disease damage occurs. For convenience, all varieties are dealt with in this section though first-earlies are normally considered a horticultural crop. The available data on first-earlies are from the SFP and the 1966 Vegetable Survey (VS), the design of which is discussed in section 2. The data on second-earlies and maincrop varieties have been made available by the Potato Marketing Board (PMB) whose area staff have collected information on pest and disease damage, and on chemical controls, from growers all over the country for many years.

1.6.1. First-Early Potatoes. Over 73,000 acres (30,000 ha) were grown in 1966. The results in Table 1.6.1 indicate that about 1 per cent of the acreage was given aldrin treatment.

Table 1.6.1. Treatments Applied to First-Early Potatoes

Material	*Acreages Believed Treated*
Aldrin	(800)
Organophosphorus Aphid Sprays and Granules .	9,900
Acreage Grown:	73,100

1.6.1.1. The Need for these Treatments. Mainly precautionary treatments against *Wireworm*, *Cutworms*, and *Aphids*. A number of growers in the eastern counties informed the VS surveyors that they had applied organophosphorus materials as an insurance. Most first-early potatoes were lifted before aphid attacks developed in 1966, and no aphicides were used on the 2,400 acres (970 ha) covered in the SFP.

1.6.2. Second-Early and Maincrop Varieties. Fertilisers containing aldrin were widely used to protect potatoes from wireworm damage during the late 1950's and early 1960's. These fertiliser mixtures were voluntarily withdrawn in 1964, though aldrin and dieldrin were still available to potato growers as soil sprays and dusts which cannot be applied together with potato fertilisers in a single operation: wireworm control costs have increased because the land at risk now has to be treated in two operations. Increased costs, and better publicity for the view that pesticides should only be used when really necessary, have led to an appreciable decline in the use of aldrin and dieldrin on potatoes, as can be seen from Table 1.6.2. The use of DDT for potato aphid control has also declined in recent years; though the acreage treated with organophosphorus aphicides has increased since 1960.

The data in Table 1.6.2 may over-estimate usage by about 10 per cent. This is because those growers who are visited regularly by PMB field staff tend to be better informed about the latest production techniques than those who are not visited so regularly. The same considerations apply to the accuracy of the PMB survey data as to the SFP and VS data, and it will be noted that several of the entries in Table 1.6.2 are bracketed to denote that they are imprecise.

Table 1.6.2. Treatments Applied to Second-Early and Maincrop Potatoes

Material	Acreages Believed Treated			
	1964	1965	1966	1967
Aldrinated Fertilisers	67,300	(2,000)	0	0
Aldrin Sprays and Dusts	21,400	35,600	20,500	26,000
Dieldrin Sprays	(700)	(1,400)	(0)	(100)
BHC	(500)	(0)	(200)	(100)
DDT	10,100	5,200	(1,600)	2,500
Organophosphorus Sprays and Granules	174,000	180,100	162,800	218,400
Acreages Grown:	460,200	454,200	416,300	450,800

1.6.2.1. The Need for these Treatments. The PMB staff survey potato yields each year and assess crop quality by lifting, examining, and grading tuber samples from about 2,000 commercial crops in England and Wales. These yield samples are usually taken two or three weeks before the sampled crops are commercially harvested, and the estimates of pest damage are minimal on two counts: *Wireworm* damage is known to increase rapidly during the autumn feeding period, and field inspection does not always reveal slight tuber damage because it is not possible to remove all the adherent soil from freshly lifted tubers without washing them. Evidence obtained some years ago suggests that field estimates of wireworm damage should be doubled to provide realistic estimates of the probable position when crops are lifted two or three weeks later, and the data in Table 1.6.2.1 have been adjusted to take account of this. There remain some cases where very low levels of pest damage are not detected by the methods used in the PMB pre-harvest survey, and crops may be recorded as clean when, in fact, some damage is found at lifting. A little information was obtained on this in 1965–66, when 49 crops which had been sampled before harvest were sampled again after the tubers had been in store for several months. One-third (actually, 17) of these crops were considered free of damage at the pre-harvest survey but were found to be slightly damaged by soil pests (not exclusively wireworms) when further tuber samples were taken ex-store and washed and scrubbed before examination. On these 17 crops, washing and scrubbing ex-store revealed an average of 3·7 per cent pest-damaged tubers; and it seems unlikely, from what is known about the habits of soil pests, that more than 1–2 per cent of the tubers in these 17 crops would have shown damage at the pre-harvest survey if the samples had at that time been washed and scrubbed before examination. Such low levels of damage are hard to identify quantitatively in the field, and their routine detection would need a substantial increase in survey resources.

For the reasons set out on pages 52 and 53 of the 1964 Review of the Persistent Organochlorine Pesticides there is little point in applying a soil insecticide to land with a low wireworm population (say, fewer than 50–100,000 larvae per acre) (125–250,000 per ha) in the year of potato cropping. In the four years now under review the available data suggest that moderate or severe wireworm damage, of the order of 1 ton or more of damaged tubers at harvest out of a total yield of about 10 tons per acre (25 tons per ha), is uncommon. This level is found on about 11 per cent of the infested acreage, but in some years it is only found on 5 per cent, while in others it rises to 15 per cent. In round figures, the use of aldrin and dieldrin for potato wireworm control in the season of potato cropping might be justified on about 3,000 acres (1,200 ha) per annum: damage would be lessened from about 1 ton to about 0·25 tons of damaged tubers per acre (2·5–0·6 tons per ha) on this land, but the treated crops would still need dressing-out before bagging for the ware market.

Table 1.6.2.1. Estimated Acreages of Second-Early and Maincrop Potatoes with Visible Wireworm Damage at Pre-Harvest Survey, and Percentages of Tuber Yields with Wireworm Damage at Time of Commercial Harvest

Factor	Year		
	1964	1965	1966
Estimated Total Acreages of Crops with Visible Wireworm Tuber Damage:	31,100	25,600	16,600
Estimated Percentages of Ware Tuber Yield Damaged at Time of Harvest:	3·7	4·2	2·8

Most crops which show wireworm damage at harvest have 2–3 per cent of their tubers holed: say, 5 cwt per acre (0·6 tons per ha) out of a 10 ton (25 tons per ha) yield. This is small compared with tuber losses of 12–15 cwt per acre (1·5–1·8 tons per ha) from causes such as cracking, greening, and tuber blight. Dressing-out at a cost of about 32/– per ton, or £16 per acre on a 10-ton crop (£40 per ha on a 25-ton crop), is standard practice nowadays and it is doubtful whether the presence of a few wireworm-damaged tubers is the sole, or even the main, reason for a grower deciding whether or not to dress-out. While treatments against wireworms may not give complete protection in the season they are applied, the economic returns should be reckoned in terms of better crops in the following few seasons, and reasonable long-term benefits seem likely.

1.6.2.2. Alternatives for Potato Pest Control. Though many field trials have been done over the past few years to test organochlorine alternatives for potato wireworm control none has approached aldrin in effectiveness. With regard to *Aphids*, it has already been noted that the use of DDT is declining, and there are many more effective organophosphorus materials now available in liquid and in granular formulations.

2. Vegetable Crops

About 349,000 acres (141,000 ha) of vegetable crops for human consumption were grown in 1966. Many of these were high-value cash crops, and growers tried to ensure that losses through pest damage were minimised. While appreciable quantities of insecticides are used annually to control vegetable pests there is little information on treatments to individual crops. The usage data given below have been obtained from two sources: first, for several years the Pea Growing Research Organisation Ltd., and the major edible legume producers and their seed merchants, have collaborated with the Ministry of Agriculture in collecting seed and crop treatment data for peas and the various kinds of edible beans. Secondly, intensive statistical surveys were done with the co-operation of vegetable growers in 1966 in the five counties in England which together produce 40 per cent of the vegetables grown in England and Wales: Bedfordshire, Lincolnshire (Holland), Norfolk, Worcestershire, and Lancashire. Techniques used by growers in these counties are substantially the same as those commonly used in adjacent counties such as Cambridgeshire and the Isle of Ely, Suffolk, Gloucestershire and Cheshire, and the rest of Lincolnshire. These counties account for a further 25 per cent of the vegetable production.

2.1. Edible Legumes

These are taken to include green peas for picking and vining, dry-harvest peas, and broad, runner and French beans. About 160,000 acres (65,000 ha) were grown in 1966, half being green peas for canning, quick freezing and dehydration.

2.1.1. Peas for Human Consumption. Over 130,000 acres (53,000 ha) grown annually in recent years. Pesticide data collected through the Pea Growing Research Organisation Ltd. (PGRO) have covered 45,000–50,000 acres (18–20,000 ha) of peas annually, and the results are shown in Table 2.1.1.

Table 2.1.1. Treatments Applied to Peas for Human Consumption

Material	*Acreages Believed Treated*		
	1964	1965	1966
Seed Dressings			
Gamma–BHC	1,100	450	(0)
Dieldrin	1,000	(0)	(0)
Field Treatments			
BHC	(20)	(0)	(0)
DDT	21,400	14,700	17,300
Dieldrin	1,900	(0)	(0)
Organophosphorus Aphid Sprays	37,900	33,900	49,600
Acreages Grown:	133,800	131,200	133,600

A very high proportion of the pea acreage is sown with fungicidally-dressed seed, but the acreage sown with insecticidally-dressed seed has declined.

The 1966 VS suggests that about (100) acres (40 ha) of peas were sown with dieldrin-plus-thiram in that year.

About 13 per cent of the pea acreage received DDT over the three years under review. Data from the VS suggest that 26,000 acres (10,000 ha) may have been treated with DDT in 1966, compared with the PGRO figure of 17,000 acres (7,000 ha); in many cases the large processing firms employ field staff who advise contract growers about treatments, and it may well be that their data reflect a more discriminating use of DDT.

About one-third of the pea acreage was given organophosphorus sprays or granules for aphid control. The VS data suggest that about 35,000 acres (14,000 ha) were so treated, compared with the tabulated estimate of 47,000 acres (20,000 ha). This may again reflect expert advice given by processors' field staff, advice which may not always reach non-contract growers.

2.1.1.1. The Need for these Treatments. Wireworms, Leatherjackets, and *Millepedes* occasionally damage peas, and soil insecticide protection is needed from time to time. This need may increase if there is a continued trend to low seed rates and precision drilling.

The growers who responded to the PGRO and VS surveys applied field sprays mainly to control *Pea Aphids*, *Pea Weevil* and *Pea Moth*, and treatments were occasionally applied against *Midge* and *Thrips*. Weevil and moth respond to DDT treatment, and a noticeable feature of the 1966 data is the number of growers who applied DDT to headlands only for weevil control. Both surveys agree in suggesting that about 7 per cent of the acreage was given DDT for weevil control in 1966, the balance of the DDT was used for moth or, in a few cases, combined with an organophosphorus insecticide for aphid control. DDT was applied to about 700 acres (280 ha) for combined control of moth and midge.

The real need for these treatments cannot be estimated without more detailed information on weevil infestation levels in relation to the growth stages of the infested crops. Moth may be declining in importance because a large proportion of the vining pea crop is now sown at times which minimise damage. It is, however, important to protect those crops which flower in phase with the moth because it is impracticable to grade-out damaged peas from vined crops.

2.1.1.2. Alternatives for Pea Pest Control. Azinphos-methyl, carbaryl, and other experimental carbamate materials, have given results comparable to DDT sprays in recent field trials on pea moth control, though timing tends to be more critical than with more persistent pesticides.

2.1.2. Broad Beans for Human Consumption. The PGRO data relate to 1,000–2,000 acres (400–800 ha) of broad beans surveyed annually, and the results are shown in Table 2.1.2. For 1966, these data do not agree at all well with the answers given by individual growers to the VS surveyors: the VS data suggest that about 700 acres (280 ha) of broad beans were sown with dieldrin-treated seed, and 1,000 acres (400 ha) were given DDT field treatments against weevil. The VS data also suggest that 5,400 acres (2,200 ha) of broad beans were given organophosphorus aphid sprays in 1966. It is assumed that this again reflects differences in pest control practices between contract and non-contract growers.

Table 2.1.2. Treatments Applied to Broad Beans for Human Consumption

Material	Acreages Believed Treated		
	1964	1965	1966
Seed Dressings			
Gamma–BHC	(0)	(0)	(0)
Dieldrin	200	600	(0)+
Field Treatments			
BHC	(20)	(0)	(0)
DDT	400	150	(0)+
Dieldrin	550	(0)	(0)
Organophosphorus Aphid Sprays	5,400	8,400	7,000
Acreages Grown:	12,000	9,900	7,700

+=see textual comparisons with VS data.

2.1.2.1. The Need for these Treatments. Dieldrin seed dressings are occasionally applied to broad beans to protect the stand from *Bean Seed Fly* attack. This pest rarely if ever attacks broad beans and the practice is unnecessary. A very large proportion of the acreage is given organophosphorus sprays against *Black Bean Aphid*. Inspection of the individual survey returns suggests that, in 1964, dieldrin and DDT sprays were applied for Bean Weevil (*Sitona* spp) control; DDT is quite often mixed with an organophosphorus spray to give combined control of weevils and aphids.

2.1.3. Green (Dwarf and Runner) Beans for Human Consumption. Data on pesticide use are to-hand for 2,000–7,000 acres (800–2,800 ha) of contract crops surveyed annually, and are shown in Table 2.1.3.

Table 2.1.3. Treatments Applied to Green Beans for Human Consumption

Material	Acreages Believed Treated		
	1964	1965	1966
Seed Dressings			
Gamma–BHC	(0)	(0)	1,000+
Dieldrin	8,000	7,800	11,900+
Field Treatments			
BHC	(0)	(0)	(0)
DDT	1,500	450	(0)+
Dieldrin	500	(0)	(0)+
Organophosphorus Aphid Sprays	8,600	4,500	3,300
Acreages Grown:	19,000	17,300	18,400

+ = see textual comparisons with VS data.

The 1966 VS results suggest that only 5,600 acres (2,300 ha) of green beans were sown with dieldrin-dressed seed, and that a further (200) acres (80 ha) were sown with gamma-BHC-dressed seed. So far as field treatments are concerned, the VS data suggest that about 330 acres (130 ha) were treated with aldrin and 50 acres (20 ha) were treated with DDT, the former against bean seed fly and the latter against weevils.

2.1.3.1. The Need for these Treatments. Bean Seed Fly can do serious damage to green bean crops, especially in seasons when crops are sown early and germination is slow. The pest is readily controlled with dieldrin seed dressings, though signs of resistance were reported in 1965 (Gostick & Baker, 1966). *Black Bean Aphid* is now usually controlled with organophosphorus sprays or granules, but in 1964 and 1965 a few growers used DDT. The dieldrin sprays applied in 1964 were apparently 'spot' treatments at planting time for bean seed fly control.

2.1.3.2. Alternatives for Green Bean Pest Control. Trials in the past few years suggest that diazinon, chlorfenvinphos and fenitrothion seed dressings are as effective as dieldrin, and more effective than gamma-BHC seed dressings for bean seed fly control; but these organophosphorus materials are not commercially available in suitable formulations.

2.1.3.3. Summary. There is a continuing need to protect the headlands of some crops against weevil damage, and DDT is generally used for this purpose. A relatively small proportion of the pea crop continues to need protection against pea moth. Trials have shown that several organophosphorus materials can give good control of the moth, but timing is more critical than with DDT. Organophosphorus materials have largely replaced DDT for legume aphid control. There remains a need to protect green bean crops against bean seed fly, and alternatives to dieldrin are not available in commercial formulations. With increasingly mechanised production methods, including precision seeding, braird protection becomes more important and it is desirable that a range of materials should be available for preventive use against sporadic soil pests where cure is impracticable.

2.2. Brassicae for Human Consumption

In 1966 there were approximately 59,000 acres (24,000 ha) of cabbages, 36,000 acres (15,000 ha) of Brussels sprouts, and nearly 42,000 acres (17,000 ha) of cauliflowers, kale and sprouting broccoli, grown for human consumption. The data on pesticides used on these crops were obtained during the VS.

2.2.1. Cabbages. About 25,500 acres (10,000 ha) of spring cabbages, and 33,500 acres (14,000 ha) of summer, autumn, and winter cabbages and savoys. The data are shown in Table 2.2.1. It will be seen that 'organophosphorus alternatives' are shown separately from 'organophosphorus aphid sprays' in this, and the other tables in this section. The former refers to cases where the growers questioned indicated that they had used an organophosphorus material in place of a conventional organochlorine treatment: for example, chlorfenvinphos or diazinon in place of aldrin or dieldrin for cabbage root fly control.

Survey returns suggested that there were real differences in the extent to which spring, compared with other, cabbages were treated in 1966, but that differences in treatments applied to summer, autumn and winter cabbages were small.

Because the same pests attack nearly all edible brassicae the need for treatment is considered at section 2.2.4 instead of under each crop tabulation separately.

Table 2.2.1. Treatments Applied to Cabbages for Human Consumption, 1966

Material	Acreages Believed Treated	
	Spring Cabbages	All Other Cabbages
Seed Dressings and Transplanting Dips		
Gamma–BHC Seed Dressings	7,500	6,800
Dieldrin Seed Dressings	(200)	(300)
Aldrin Dips	(400)	3,400
Dieldrin Dips	(300)	5,200
Field Treatments		
BHC	800	1,900
DDT	1,000	3,500
Organophosphorus Alternatives	(600)	1,300
Organophosphorus Aphid Sprays	5,600	21,100
Acreages Grown:	25,500	33,500

2.2.2. Brussels Sprouts. Approximately 36,000 acres (15,000 ha) in 1966, of which 71 per cent was grown in the counties covered by the VS. The pesticide data are shown in Table 2.2.2.

Table 2.2.2. Treatments Applied to Brussels Sprouts, 1966

Material	Acreages Believed Treated
Seed Dressings and Transplanting Dips	
Gamma–BHC Seed Dressings	2,500
Dieldrin Seed Dressings	2,000
Aldrin Dips	4,600
Dieldrin Dips	10,700
Field Treatments	
BHC	(400)
DDT	6,900
Endrin	(400)
Organophosphorus Alternatives	8,700
Organophosphorus Aphid Sprays	35,000
Acreage Grown:	36,300

As with cabbages, virtually all of the aldrin and dieldrin used on Brussels sprouts was applied to the seedlings at transplanting. This practice places the pesticide where it is most needed, and gives good protection against non-resistant root fly.

2.2.3. Broccoli, Cauliflowers, and Kale. There are differences in the treatments applied to kale and sprouting broccoli, to winter, and to all other cauliflowers, and these crops are shown separately in Table 2.2.3.

Table 2.2.3. Treatments Applied to Broccoli, Cauliflowers and Kale

Material	*Acreages Believed Treated*		
	Kale and Sprouting Broccoli	*Cauliflowers*	
		Winter	*Others*
Seed Dressings and Transplanting Dips			
Gamma–BHC Seed Dressings	300	(400)	(500)
Dieldrin Seed Dressings	(10)	(0)	(20)
Aldrin Dips	(10)	2,200	3,800
Dieldrin Dips	800	4,200	7,900
Field Treatments			
BHC	(20)	(200)	(300)
DDT	(10)	(500)	3,500
Endrin	(0)	(0)	(100)
Organophosphorus Alternatives	(60)	(100)	1,200
Organophosphorus Aphid Sprays	900	6,500	9,600
Acreages Grown:	2,500	19,000	20,400

2.2.4. The Need to Control Pests of Edible Brassicae. Cabbage Root Fly is a common and often serious pest of cauliflowers and broccoli and also attacks sprouts and cabbages. It has been estimated (Strickland, 1965 a) that, in the absence of control measures, this fly would annually take the production from over 25,000 acres (10,000 ha) of edible brassicae in England and Wales. When growth conditions are sub-optimal due, for example, to water stress, crop losses of 40 per cent may be suffered (Coaker, 1965). Aldrin or dieldrin pre-planting dips are commonly used to prevent attack, and protection is given in the early stages of growth by gamma-BHC and dieldrin seed dressings, which also protect the young seedlings from damage by *Flea Beetles*, *Cabbage Stem Weevil*, and *Turnip Gall Weevil*. Uncontrolled, these pests might take about 23,000 acres (9,000 ha) of production annually, mainly by flea beetles: the two weevils are seldom troublesome nowadays. *Cabbage Moth*, *Cabbage White Butterfly*, and *Diamond-Back Moth*, caterpillars are seldom serious and may on average damage less than 1 per cent of production. They are normally controlled with DDT, though some organophosphorus insecticides also give good control when correctly timed. *Cabbage Aphid* is normally controlled with organophosphorus insecticides, and nearly 60 per cent of the total acreage of edible brassicae received them in 1966.

2.2.4.1. Alternatives for the Control of these Pests. Most work has been done on alternatives for cabbage root fly control, and the following summary has been prepared by the Cabbage Root Fly Working Party of the Conference of Advisory Entomologists:

Drench applications, locally popular in the past on a relatively small acreage, have become uneconomic through labour and other problems. Dipping transplants in insecticide solutions is popular but may cause growth checks. Granule application is most promising, and hand applicators are now widely used. Granule applicators for tractor mounting are also available and these, together with the other methods, were used in trials with 17 possible alternative chemicals—mostly organophosphorus insecticides—in 1965 and 1966. The trials were done on cauliflowers, cabbages, turnips, and swedes. Chlorfenvinphos gave the best results as granules applied round the transplants, and compared very favourably with aldrin and dieldrin. Application as a band of granules before planting ('bow-wave' technique) gave variable results, but satisfactory results were obtained when the granules were applied as a band over the plants just before the fly oviposition peak. Chlorfenvinphos also gave good control when applied as a liquid drench to cauliflowers and cabbages in the field. But this material was not completely satisfactory as a root dip for cabbages and cauliflowers, and some phytotoxicity was seen; because it lacks persistence as a dip it usually needs to be followed-up with a drench treatment. Chlorfenvinphos seed dressings gave promising results with swedes in the northern counties.

Diazinon was almost as good as chlorfenvinphos when applied as a drench under some conditions, though it also lacks persistence, and while often satisfactory on cauliflowers and cabbages it was unsatisfactory on swedes.

Of the other materials tested, the best were thionazin, N–2790, and trichloronate, which gave results equal to chlorfenvinphos and diazinon in some trials. All three gave consistently good results on cauliflowers and turnips. Inconsistent results were obtained with mecarbam, azinphos-methyl, parathion and trichlorphon and disulfoton. Phorate was generally not effective.

Bromophos, ethion, fenitrothion and fenchlorphos were also tested. Ethion and fenitrothion did not show much promise. Bromophos was liable to cause severe phytotoxicity, and no significant control of cabbage root fly was obtained with fenchlorphos.

It will have been noticed, in Tables 2.2.1, 2.2.2, and 2.2.3, that about 12,000 acres (5,000 ha) of edible brassicae were treated with organophosphorus alternatives in 1966. Nearly half this acreage was treated with diazinon, about 2,000 acres (800 ha) received chlorfenvinphos, and a slightly larger acreage was treated with phorate. These treatments were, according to the growers, applied against cabbage root fly, and suggest that there is a trend away from the organochlorine insecticides for controlling this pest. This can be partly explained by increasing dieldrin resistance.

2.3. Roots for Human Consumption

Although normally considered a 'vegetable', first-early potatoes have been considered along with second-early and maincrop varieties at section 1.6. The present section covers carrots, parsnips and celery, turnips and swedes, beetroot, and radishes. About 53,000 acres (21,000 ha) of these crops were grown in 1966, half the acreage being in carrots.

2.3.1. Carrots, Parsnips and Celery. Considered together because they are all liable to be damaged by carrot fly. Nearly 27,000 acres (11,000 ha) of carrots were grown in 1966, less than 2,000 acres (800 ha) being early varieties. The 1966 VS data are shown for the three crops in Table 2.3.1.

Some correspondents consider the dieldrin data in Table 2.3.1 to be an underestimate.

2.3.1. The Need for these Treatments. Carrot Fly is widely distributed, and there is now evidence of dieldrin resistance in at least three localities in the eastern counties (Wright and Coaker, 1968). Aldrin and dieldrin were, nevertheless, used on about 13 per cent of the carrot acreage in 1966, with about one-eighth of the acreage being grown from dieldrin-dressed seed. These materials were also used on about a quarter of the celery acreage, and to a small extent on parsnips. In all three crops there is a trend to organophosphorus alternatives: about 5,300 acres (2,100 ha) of carrots were

Table 2.3.1. Treatments Applied to Carrots, Parsnips and Celery, 1966

Material	Acreages Believed Treated		
	Carrots	Parsnips	Celery
Seed Dressings			
Gamma–BHC	2,200	(0)	(0)
Dieldrin	3,400	(30)	(0)
Field Treatments			
Aldrin	(300)	(0)	(50)
BHC	(0)	(0)	2,100
DDT	9,100	600	350
Dieldrin	3,300	100	1,200
Organophosphorus Alternatives	11,100	1,700	2,400
Organophosphorus Aphid Sprays	16,100	2,600	2,700
Acreages Grown:	26,800	4,600	5,400

treated with disulfoton and 5,000 acres (2,000 ha) were treated with phorate granules; about 1,200 acres (50 ha) of celery were treated with diazinon and 1,100 acres (450 ha) were given demeton-S-methyl, mainly for carrot fly control. The organophosphorus materials would also have controlled *Carrot-Willow Aphid*, against which DDT was used on about 400 acres (160 ha).

2.3.1.2. Alternatives for Control. The Insecticide Usage Working Party of the Conference of Advisory Entomologists reports that a range of organophosphorus materials give effective control of carrot fly as granules or drenches; chlorfenvinphos, phorate, disulfoton, and diazinon are available for use on carrots, parsnips and celery.

2.3.2. Other Edible Roots. Turnips, swedes, beetroot, and radishes were grown on 16,400 acres (6,600 ha) in 1966. About 10,000 acres (4,000 ha) were in cruciferous roots, and over 6,000 acres (2,400 ha) were in beetroot. The VS pesticide data are shown in Table 2.3.1, and it will be seen that apparently no organochlorine insecticides were used on beetroot, even as seed dressings, in 1966. The counties visited in the VS grew 30 per cent of the beetroot in England and Wales, and some organochlorine insecticides may have been used in other parts of the country.

Table 2.3.2. Treatments Applied to Other Roots for Human Consumption

Material	Acreages Believed Treated	
	Cruciferous Roots	Beetroot
Seed Dressings		
Gamma–BHC	400	(0)
Dieldrin	(0)	(0)
Field Treatments		
Aldrin	300	(0)
DDT	800	(0)
Organophosphorus Alternatives	(60)	(0)
Organophosphorus Aphid Sprays	400	1,300
Acreages Grown:	9,600	6,800

3.2.2.1. The Need for these Treatments. Turnips, swedes and radishes may need protection against *Flea Beetles* and this can be provided by BHC seed dressings. Edible swedes are liable to damage by *Swede Midge*, and turnips are occasionally attacked by *Cabbage Root Fly*, *Turnip Root Fly*, and *Midge*. Midge and turnip fly are relatively more common in the northern counties. DDT treatment is usually effective against both species, though dieldrin was, and occasionally still is, used, because it gives better control. Beetroot is normally liable to damage from the same pests as sugar beet and it is interesting to note that the organophosphorus sprays used on beetroot in 1966 would have provided joint control of *Black Aphids* and *Mangold Fly*.

2.4. Onions and Leeks

2.4.1. Nearly 5,000 acres (2,000 ha) of dry harvest onions, over 3,000 acres (1,200 ha) of salad onions, and 2,000 acres (800 ha) of leeks were grown in 1966. The pesticide data are shown in Table 2.4.1.

Table 2.4.1. Treatments Applied to Onions and Leeks, 1966

Material	*Acreages Believed Treated*		
	Dry Onions	*Salad Onions*	*Leeks*
Seed Dressings			
Gamma-BHC	(0)	(40)	(10)
Dieldrin	200	150	(0)
Field Treatments			
Aldrin	(0)	250	(0)
BHC	(20)	(0)	(0)
Dieldrin	(30)	300	(0)
Organophosphorus Alternatives	(0)	(40)	(20)
Organophosphorus Aphid Sprays	(0)	(0)	(40)
Acreages Grown:	4,900	3,300	2,100

The seed dressing data in Table 2.4.1 may be underestimated since some seed merchants are understood to dress all their onion seed as a routine and the VS growers did not always have the details to-hand.

2.4.1.1. The Need for these Treatments. Onion Fly is the main insect pest of onions and leeks and is of local importance. Dieldrin seed dressings give good protection and some control can be obtained with BHC dust applied as a band, or similar treatment with aldrin or dieldrin. Salad onions seem to get greater treatment than dry-harvest onions or leeks.

2.4.1.2. Alternatives for Control. Some diazinon was used commercially as an organochlorine alternative in 1966. A trial in Lincs. (Holland) in 1966 suggested that mecarbam, chlorfenvinphos, and a new experimental carbamate, would merit further study as alternative seed dressings.

2.5. Other Outdoor Vegetables

Approximately 13,000 acres (5,000 ha) of crops such as spinach, asparagus, rhubarb, marrows, outdoor cucumbers, sweet corn, and miscellaneous herbs, were grown in 1966. The VS data suggest that about 1,500 acres (600 ha) were given sprays of organophosphorus insecticides for aphid control. About 20 acres (8 ha) of parsley were sown with BHC-dressed seed as a protection against *Carrot Fly*; and about 40 acres (16 ha) of sage received DDT for *Capsid* ('*Sage Bug*') control; overall, use of organochlorine insecticides appears to be small on these crops.

3. Fruit and Hops

In recent years about 149,000 acres (60,000 ha) of top fruit and 36,000 acres (15,000 ha) of soft fruit have been grown. There were over 96,000 acres (39,000 ha) of mature apple trees, and 36,000 acres (15,000 ha) of mature pears and plums in commercial orchards in 1962–63. Strawberries and blackcurrants accounted for nearly 30,000 (12,000 ha) of the soft fruit acres. There were 20,000 acres (8,000 ha) under hops, in the mid 1960's, but the hops acreage, and the acreage of many tree fruits, is declining.

3.1. Dessert and Culinary Apples

Fewer sprays are generally applied to cooking apples than to high quality dessert fruit, and immature trees of both kinds may only receive two or three sprays per season compared with 10 or 12 applications to mature stock. There are few data on the extent of top fruit treatments, and some estimates covering the earlier years of the present decade (Strickland, 1966) may be exaggerated because they were based on 'Spray Competition' data, and on information collected during advisory visits to holdings with specific pest problems. In 1965 a number of growers who were members of co-operative marketing organisations collaborated with Plant Pathology Laboratory in submitting details of their spray use on top fruit in that year. The co-operating growers had orchards in the west country, the south-east, and the eastern counties, and the sample is thought to be reasonably representative of about 70 per cent of the top fruit acreages in the country. A full-scale survey of commercial fruit growers was done in 1967/68, and some of the preliminary results are discussed below.

3.1.1. Fruit pesticide programmes need to control a range of insects and mites which do damage at different times in the season. Spray programmes are conventionally considered in relation to the time of application: pre- and post-blossom, and this convention has been followed by the Fruit Pests Working Party of the Conference of Advisory Entomologists in the notes appended to Table 3.1.1. In this table and in Table 3.2.1, demeton-methyl includes demeton-S-methyl and oxydemeton-methyl.

Table 3.1.1. Treatments Applied to Dessert and Culinary Apples, 1965

Material	*Basic Acreages of Mature Fruit Believed Treated*
Organochlorine Pesticides	
BHC	32,500
Chlorbenside	(100)
DDT	82,500
Dicofol	3,600
Endosulfan	(100)
TDE	11,600
Tetradifon	7,900
Organophosphorus Materials	
Azinphos-methyl	23,700
Demeton-methyl	59,000
Vamidothion	47,200
Other Organophosphorus Sprays	12,700
Other Relevant Pesticides	
Binapacryl	16,800
Carbaryl	9,400
Derris	(100)
Lead Arsenate	9,300
Lime Sulphur	6,100
Oxythioquinox	5,700
Acreage of Mature Apples Grown 1965:	96,700

The 1967/68 survey suggested that about 50,000 acres (20,000 ha) of apples were given DDT pre-blossom only; 13,000 acres (5,300 ha) were treated both pre- and post-blossom; and 2,000 acres (800 ha) were given DDT only at post-blossom.

3.1.1.1. The Need to Control Pre-blossom Apple Pests. Winter Moth and *Tortrix Larvae* are conventionally controlled with DDT. Acceptable alternatives are: azinphos-methyl and carbaryl, the latter material also being used as a fruit-thinning agent. Fenitrothion, 'Supracide' and phosalone are also effective in controlling these caterpillars. Phosalone has been cleared for such use under the Pesticides Safety Precautions Scheme. *Capsid Bugs* have also been conventionally controlled with DDT. While a range of organophosphorus materials has been tested at green cluster for capsid control, the results so far are inconclusive. Capsid control at petal fall would considerably lessen damage; but would not prevent some occurring during the blossoming period. In the past *Aphids* have been generally controlled with BHC and DDT, but the practice has become less common in recent years because better control can be obtained with many organophosphorus insecticides. *Apple Sucker* is another pest which used to be controlled by gamma-BHC, but organophosphorus alternatives are now widely used. *Apple Blossom Weevil* has been controlled with BHC and DDT, but the pest is not now seen in commercial orchards and has presumably been eliminated by DDT. The available information suggests that some of the organophosphorus insecticides would give good control if this were needed in the future.

3.1.1.2. The Need to Control Post-blossom Apple Pests. Apple Sawfly has, in the past, been controlled with BHC. Organophosphorus materials also give good control, but there is a case for alternating insecticides where growers change their brands of acaricides to lessen the risk of red spider mite strains developing which are resistant to pesticides. Nicotine gives unreliable control of sawfly. *Fruitlet Mining Tortrix* is controlled by DDT and TDE. It is locally important, and existing evidence is that organophosphorus compounds at petal fall (as for winter moth) would give effective control. *Codling Moth* and *Fruit Tree Tortrix* are also controlled by DDT and TDE. Azinphos-methyl, carbaryl and phosphamidon are effective alternatives, as well as other organophosphorus materials such as phosalone. Lead arsenate is a possible alternative but is not very efficient for codling moth control, and is not effective against tortrix caterpillars.

3.1.2. Summary of Apple Pest Controls. While further work is planned on the relative merits of alternative insecticides, and on optimum timing for pre-blossom caterpillar control, there are now adequate alternatives to DDT for these pests. Alternatives for capsid bug control cannot, however, be confidently recommended without further work: attacks by common green capsid have become more frequent in recent years and are not predictable within a given orchard. The capsid problem is complicated because the hatching period more or less coincides with the blossom period of Cox and Bramley apples, so pre-blossom sprays need persistence equivalent to that of DDT, while petal fall sprays—though giving a good kill—may not prevent fruitlet damage during the blossoming period.

The use of DDT or TDE in June and July against codling moth and fruit tree tortrix could be discontinued if it is felt that the higher cost of their organophosphorus and carbamate alternatives could be off-set against the risks which may be associated with more persistent materials. With crops as intensively treated as top fruit it is desirable to retain a range of materials in reserve against possible future development of insecticide resistance to any one group of compounds.

3.2. Pears, Plums and Cherries

3.2.1. These crops tend to be less heavily treated than dessert apples. Spray usage data, in the same terms as in Table 3.1.1, are shown for pears and plums in Table 3.2.1. With regard to cherries, there are few data available for 1965. In 1964 it was estimated that the 13,000 acres (5,300 ha) of fruiting cherries in England and Wales were often damaged by *Cherry Fruit Moth* in the absence of treatment, and that DDT was applied to approximately 10,000 acres (4,000 ha) of cherries for moth control in that year. The single cherry grower who responded in the 1965 survey, used DDT for this purpose. By 1967/68 the cherry acreage had declined to 9,200 (3,700 ha), partly because of virus diseases, and 3,300 acres (1,300 ha) were treated with DDT for fruit moth control. A further 2,600 acres (1,100 ha) were given DDT, mainly for caterpillar control.

Table 3.2.1. Treatments Applied to Pears and Plums, 1965

Material	*Basic Acreages of Mature Fruit Believed Treated*
Organochlorine Pesticides	
BHC	2,100
DDT	13,400
Dicofol	(800)
TDE	(600)
Tetradifon	(100)
Organophosphorus Materials	
Azinphos-methyl	3,100
Demeton-methyl	4,800
Vamidothion	10,200
Other Organophosphorus Sprays	4,500
Other Relevant Pesticides	
Binapacryl	(100)
Carbaryl	(100)
Lead Arsenate	(300)
Lime Sulphur	(400)
Oxythioquinox	(400)
Acreage of Mature Pears and Plums Grown 1962:	36,400

3.2.1.1. The Need for Pear Pest Control. The position is similar to that with apples, where a potential capsid problem makes the elimination of pre-blossom DDT difficult at present, though a petal fall spray with an organophosphorus material might be more effective than with apple because pears blossom earlier in the year. One trial in 1966 showed that carbaryl could replace DDT for control of *Pear Midge*, which is a minor pest in commercial orchards nowadays and seldom needs treatment.

3.2.1.2. The Need for Plum and Cherry Pest Control. Caterpillars, including *Cherry Fruit Moth*, are normally controlled with DDT and TDE. There is little experimental evidence on alternatives, but by inference from apple trials DDT could probably be replaced by organophosphorus compounds. Azinphos-methyl gave good control of caterpillars in one recent trial on plums. *Aphids* were controlled by BHC and DDT, but nowadays tend to be treated with organophosphorus sprays. *Plum Sawfly* was treated with BHC, but dimethoate and demeton-methyl are good alternatives. *Plum Fruit Moth* also responded to control with DDT. Again, there is a lack of trial evidence on effective alternatives for use in England and Wales, though azinphos-methyl has proved effective in Europe and could probably replace DDT.

3.3. Soft Fruit

3.3.1. Again there is a lack of information on the pesticide programmes followed by commercial growers. Some estimates for 1960–63 were made by Strickland (1965), and Vernon, Dennis and Tompsett (1965) published data for Somerset strawberries for 1963–64. In 1965 the Fruit Pests Working Party did a detailed survey of commercial soft fruit growers, and the results are shown in Table 3.3.1.

Table 3.3.1. Treatments Applied to Soft Fruits, 1965: Acreages Believed Treated

Materials	Straw-berries	Logan berries	Rasp-berries	Black-berries	Goose-berries	Currants	
						Black	Red
Organochlorine Pesticides							
Aldrin	650	(0)	(0)	(0)	(0)	(0)	(0)
BHC	450	(10)	330	(30)	(0)	(0)	(0)
DDT	6,800	200	300	100	2,800	7,400	70
Dieldrin	(200)	(0)	(0)	(0)	(0)	(0)	(0)
Endrin	(300)	(0)	(0)	200	(0)	900	(0)
Endosulfan	(0)	(0)	(0)	(0)	(0)	10,800	10
Tetradifon	1,400	(0)	(0)	(0)	(0)	500	(0)
Organophosphorus Materials							
Demeton–methyl	10,600	150	150	350	250	1,000	40
Vamidothion	(0)	(0)	(0)	(0)	(0)	(250)	(0)
Malathion	600	300	250	(20)	900	(50)	60
Dimethoate	1,400	(0)	150	300	(20)	(100)	(0)
Other O/P's	(10)	(0)	(0)	(0)	800	(50)	(0)
Other Relevant Materials							
Derris	(0)	50	200	(30)	300	(0)	(0)
Lead Arsenate	(300)	(0)	(0)	(0)	350	(0)	(0)
Lime Sulphur	(100)	50	(0)	(0)	600	1,900	20
Oxythioquinox	(0)	(0)	(0)	(0)	(0)	150	(0)
Estimated Acreages Grown:	15,800	700	1,400	1,300	5,100	13,800	200

In Table 3.3.1 formothion is included under dimethoate. The data in this table are known to be deficient in certain respects: dicofol, for example, was used on a small scale in Somerset and in the eastern counties for control of strawberry pests in 1965.

3.3.1.1. The Need to Control Strawberry Pests. Strawberry Blossom Weevil has been controlled with DDT and TDE. A trial in 1966 suggested that malathion, azinphos-methyl, and fenitrothion would be at least equally effective. *Strawberry Tortrix* has usually been controlled with DDT. Mevinphos is available as an alternative, and trials in 1965 and 1966 indicated that malathion, trichlorphon, azinphos-methyl, and fenitrothion were as effective as, if not superior to, DDT. *Wingless Weevils* have been controlled with aldrin, DDT, and BHC. These are sporadic, local pests nowadays and there is no information on alternative controls. *Wireworms* have been controlled with aldrin and BHC, and no alternatives are known at present. *Cyclamen Mite* has been controlled with endrin, endosulfan and dicofol, though this pest is now sporadic and does not require routine treatment; again, no alternatives are known.

Seed-Eating Ground Beetle is usually controlled with aldrin. A survey in Kent in 1966 indicated that this pest is now very local and sporadic; growers have often attributed linnet damage to seed beetle. Fenitrothion has proved effective as a pre-strawing soil treatment, but there are phytotoxic effects associated with its use. Diazinon granules need more testing, but are known to be less effective than fenitrothion except at heavy dosages. Malathion sprays have given variable but promising kills of beetles, and have stopped fruit damage, but more than one application may be needed. Taint tests are in hand. Dichlorvos is also being tested.

Baits based on crushed oats and malathion or fenitrothion are effective in killing beetles and can be placed without contaminating fruit, though their effectiveness in preventing damage has not been adequately tested. Some tests have been done with baits to assess their attractiveness to small birds: untreated grain baits were taken by wild birds, but treated grain was refused. Fenitrothion- and malathion-treated crushed oats were refused by caged house sparrows.

Further work is in hand on malathion sprays, and on baits, as alternatives to aldrin soil treatment. Aldrin is however, still the only well-tried control; but strictly necessary usage is believed to be very limited. DDT and BHC may still be needed for the control of wingless weevils, and for *Chafer Grubs*, *Swift Moth Larvae*, and *Cutworms*, though use would be on a small scale.

3.3.1.2. The Need for Cane Pest Control. Raspberry Beetle is often controlled with DDT, and malathion and derris are useful alternatives. *Cane Midge* is controlled with BHC, but organophosphorus alternatives could probably be found if suitable experimental sites become available. *Blackberry Mite* is usually controlled with endrin and no suitable alternatives are known. *Bramble Shoot Moth* is also often treated with DDT and azinphos-methyl seems a useful alternative. BHC continues to be needed for cane midge control, and endrin for mite control on cultivated blackberries.

3.3.1.3. The Need for Gooseberry Pest Control. Gooseberry Sawflies are controlled with DDT. Fenitrothion was very effective in trials in 1966, but has not yet been approved for use commercially. Malathion and derris are possible alternatives. *Capsid Bugs* have, as on apples, usually responded to DDT. In one trial in 1966 azinphos-methyl, fenitrothion and vamidothion all gave poor control of capsids, probably because they lacked the necessary persistence.

3.3.1.4. The Need to Control Pests of Currants. Blackcurrant Sawfly is controlled with DDT. Malathion and derris seem useful alternatives, and trichlorphon gave good control in one trial in 1966. *Gall Mite* is controlled with endrin and endosulfan, and the only alternative at present is sulphur; but there is a phytotoxicity risk under some conditions which makes sulphur unacceptable for use in the eastern and south-eastern counties. *Capsid Bugs* are usually controlled with DDT, and are also killed by endosulfan. Spring sprays applied at first open flower at East Malling Research Station in 1966 did not indicate that the organophosphorus materials under test were very effective in controlling the capsids. Such sprays applied at the end of the flowering period might be effective, though experimental evidence is lacking at present. *Blackcurrant Leaf Midge* is often treated with DDT or endosulfan, and results from one recent trial suggest that demeton-S-methyl and dimethoate both give good control.

There seems to be a continuing need for endosulfan on blackcurrants and endrin for use on nursery stock. With red currants capsids might respond to treatment with an organophosphorus spray. Gall mite is not troublesome on red currants.

3.4. Hops

3.4.1. The Costings Department of the Hops Marketing Board collects pesticide data annually from an appreciable sample of the commercial hops acreage. The organochlorine insecticides used on hops are shown in Table 3.4.1.

Use is on a small scale and appears to be declining, though virtually the whole of the hops acreage continues to be treated with organophosphorus materials. Tetradifon and dicofol have not been mentioned in any of the survey returns for the past four years, and if they are used at all it must be on a very small scale. This is probably because the intensive use of organophosphorus pesticides has virtually eradicated hop red spider mite.

Table 3.4.1. Treatments Applied to Hops, 1964–1966

Material	*Acreages Believed Treated*		
	1964	1965	1966
Aldrin	(110)	(60)	(40)
BHC	(0)	(0)	(60)
DDT	1,540	750	370
Acreages Grown:	20,900	20,700	20,300

3.4.1.1. The Need for Hop Pest Control. Hop Root Weevil occurs locally, and growers have found it necessary to control the pest on a hundred or two acres annually in recent years. Aldrin or gamma-BHC dusts give good control when applied to hills in early summer before earthing-up. These materials are also used to control *Wireworms* in new plantings. *Hop Flea Beetle* and *Hop Capsid* are controlled with DDT, which used to be applied, mainly in the West Midlands, for *Leafhopper* control when it was thought that they were the vectors of Nettlehead virus.

There is a lack of recent experimental evidence on alternative chemicals for the control of hop pests; but experience with related species on fruit suggests that alternatives may be hard to find.

4. Other Horticultural Crops

Horticultural crops apart from vegetables for human consumption, fruit, and hops, cover nearly 40,000 acres (16,000 ha) annually.

4.1. Flower Bulbs and Corms

4.1.1. Approximately 7,500 acres (3,000 ha) of daffodils (Narcissus), 4,600 acres (1,900 ha) of tulips, and 1,000 acres (400 ha) of other bulbs and corms were grown in 1966. Nearly 10,000 acres (4,000 ha) were grown in the eastern counties, and about 1,500 acres (600 ha) were grown in the south-west. Some data on insecticidal treatments applied to bulbs were obtained from the eastern counties in the 1966 VS, but this survey did not extend to the south-western bulb growing areas. In 1963 it was estimated that about 600 acres (240 ha) of narcissus bulbs were given aldrin or dieldrin treatment to the south-west, and information from local suppliers of farm chemicals indicates that much the same acreage was treated in 1964–65. The data in Table 4.1.1 imply a similar acreage in 1966.

Table 4.1.1. Treatments Applied to Bulbs and Corms, 1966

Material	*Acreages Believed Treated*		
	Narcissi	*Tulips*	*Other Bulbs*
Aldrin or Dieldrin	600	(0)	(0)
BHC	(0)	(10)	(0)
DDT	(0)	(10)	(0)
Organophosphorus Alternatives	1,500	700	200
Other Alternatives	(0)	(10)	300

4.1.1.1. The Need for these Treatments. Aldrin and dieldrin are used mainly to control *Narcissus Bulb Fly* which is essentially a pest in the south-west. In the opinion of local growers, inability to control this pest would lead to the rapid decline of this industry. Protection is given either as a pre-planting dip or as a soil treatment. Take-up by dipped bulbs gives a 'field dosage' of 2–2½ lb of aldrin per acre (2·1–2·6 kg per ha) after the dipped bulbs have been planted out, while direct soil treatment involves field dosages of 2–3 lb of active ingredient per acre (2·1–3·2 kg per ha).

In 1965 it was suggested that narcissus bulb fly was becoming resistant to aldrin at Ellbridge in Cornwall. Later information has not confirmed this, and aldrin continues to give consistently good protection (Woodville, 1967). Trials with alternative materials have included thionazin, chlorfenvinphos and trichloronate. None has given good protection, probably because these materials lack the persistence needed to protect bulbs for 22 months.

In the eastern counties *Bulb Scale Mite* is a problem, and over 2,000 acres (800 ha) of tulips and narcissus were planted with thionazin-dipped bulbs in 1966. About 300 acres (120 ha) of tulips and other bulbs and corms were given organophosphorus sprays for *Aphid* control; and naphthalene was used to protect gladiolus corms from *Thrips* on about 300 acres (120 ha).

4.2. Glasshouse and Nursery Crops

4.2.1. There is a dearth of information on treatments applied by glasshouse growers and nurserymen. Kingham and Gould (1964) did a postal survey of Lea Valley cucumber growers in 1960, when this crop was given an average of 10 treatments for *Red Spider Mite* control: dicofol was used by 89 per cent of the responding growers, and azobenzene by 4 per cent and tetradifon by 3 per cent. Some more recent information is available from two sources: first, limited data on treatments applied to some flower crops, to glasshouse tomatoes and lettuce, were obtained in the 1966 VS; secondly, sales data for 1965 were made available by a large organisation which supplies pesticides to the glasshouse and nursery industries. The sales data are believed to relate to 1965–66 usage on about 17 per cent of the glasshouse acreage, and on 8–10 per cent of the hardy nursery stock and 'flowers-not-under-glass'. In raising these data to national terms it has been assumed that the growers applied the materials at the rates recommended by the individual manufacturers. It should be noted that the data, in Table 4.2.1, are in 'spray-acre' terms.

Table 4.2.1. Possible Extent of Use of Organochlorine Pesticides in the Glasshouse and Nursery Industries, 1965–66

Material	*Acreages Believed Treated*	
	Sprays Dusts and Dips	*Smokes and Atomizing Concentrates*
Aldrin	360	—
Azobenzene	—	70
BHC	10,200	460
DDT	40,000	210
Dicofol	7,900	2,600
Dieldrin	10	—
Endosulfan	280	—
Endrin	140	—
Tetradifon	5,100	340
Acreages Grown:		
Crops under Glass or in Sheds	4,800	
Hardy Nursery Stock	15,100	
Flowers Not Under Glass	4,700	

Much glasshouse and nursery land is cropped more than once per annum and successive crops on the same land may be treated with the same or with different pesticides. The 'acreage' treated with DDT, for example, is nearly double the total land area used in producing the crops concerned, and it should be noted that the mean application rate was taken as 1 lb of active ingredient per acre (1 kg per ha). Some glasshouse treatments require much higher dosages: woodlouse control, for instance, may take 70–80 lb of DDT active ingredient per acre (80–90 kg per ha), though it is rarely, if ever, necessary to treat more than a few square yards at such a high rate. It should also be noted that the data on smokes and atomizing concentrates are given in acreage terms. Dosages for these materials are usually quoted as cubic feet/fluid oz of concentrate, and to make the acreage conversion it has been assumed that the average air-volume surrounding 1 acre of glasshouse crops is 439,000 cubic feet (30,000m^3/ha).

The VS data for chrysanthemums, other flower crops, glasshouse tomatoes and glasshouse lettuce, are shown in Table 4.2.1.1.

Table 4.2.1.1. Treatments Applied to Some Nursery and Glasshouse Crops, 1966

Material	Acreages Believed Treated			
	Chrysanthemums	Other Flowers	Glasshouse	
			Tomatoes	Lettuce
Aldrin	20	(0)	90	100
BHC	80	30	340	(0)
DDT	230	(0)	120	(0)
Organophosphorus Alternatives	40	(10)	100	(0)
Other Alternatives	80	40	(0)	(0)
Acreages Grown:	340	330	2,100	2,600

The chrysanthemums which were treated with BHC were given four applications, and those that were treated with DDT—usually with a DDT-plus-thiram combined spray—were given three sprays on average. Organophosphorus sprays were normally applied once to the flower crops, though the growers who used nicotine as an aphicide applied it up to three times. Single treatments were usually applied to tomatoes and lettuce.

4.2.1.1. The Need for these Treatments. Ornamentals and glasshouse crops have a high cash value and although the national incidence of such pests as *Vine Weevil*, *Bulb Scale Mite*, *Thrips*, and various *Caterpillars*, may not be high, substantial financial losses may occur if particular outbreaks are not effectively controlled. Thus, endosulfan tends to be used routinely by glasshouse rose growers to treat dormant stock against mites; and, as already noted, the Lea Valley cucumber growers need to treat frequently against *Red Spider Mite;* glasshouse growers occasionally use aldrin to control *Lettuce Root Aphid* and *Symphylids*, while indoor tomatoes sometimes need protection from caterpillars, which can also do costly damage to young chrysanthemum cuttings and other plants.

4.2.1.2. Chemical Alternatives. BHC has given less reliable control of vine weevil than aldrin or DDT, but there has been no recent experimental work due to shortage of pest material. Endrin and endosulfan are highly effective against *Cyclamen mite* but although these materials are approved for use on bulbs under glass, no official recommendation is available for use on ornamentals. Dicofol, which is about as persistent as DDT, is a less effective alternative. There are no really effective alternatives to endrin and endosulfan for controlling bulb scale mite under glass. Dicofol and tetradifon are often used for red spider mite control on flower crops, and there are many alternatives, including demeton-methyl, oxythioquinox, orthodibrom, diazinon and parathion; but nowadays the mite is frequently resistant to organophosphorus—and most other acaricidal—materials and in these circumstances it is desirable that a range of different materials should be available for use.

Mushroom Flies were often controlled with BHC, but dichlorvos is now a popular alternative, and diazinon is sometimes mixed with the compost or casing soil to control these flies. Malathion is also a useful alternative. *Symphylids* are soil pests which may damage a range of glasshouse crops, and which can be controlled with BHC, diazinon or parathion. *Woodlice* can be troublesome, especially in older glasshouses where they can survive in cracks in the brickwork and woodwork. Disinfestation may require substantial amounts of DDT. Gamma-BHC is an alternative where taint in later crops is not likely to be a problem, and other alternatives are parathion and Paris Green.

4.2.2. Summary of Glasshouse and Nursery Pest Controls. While routine pest controls tend to be applied to some glasshouse crops, such as cucumbers, roses, and all-the-year-round chrysanthemums, there are many crops which are only treated when the need arises: in a recent Advisory Service survey of the Lea Valley growers it was found that 75–80 per cent of the glasshouse growers seek a proper identification of incipient pests and diseases before applying control measures. The industry, at least in the home counties, seems to be restricting treatments to cases of real need. Certain glasshouse pests have developed resistance to some pesticides, and it is desirable that a range of different materials should remain available in these circumstances.

5. Forestry

The Forestry Commission administers 749,000 acres (300,000 ha) in England and over 375,000 acres (152,000 ha) in Wales, of which a total of approximately 947,000 acres (383,000 ha) are forest land. The Commission holds about 1,000 acres (400 ha) of forest nurseries devoted to seedling production.

In addition, there are about 520,000 acres (210,000 ha) of privately owned woodlands in England and Wales which are managed on economic principles.

5.1. Insecticides are used occasionally to control woodland pests. The most recent published summary (Bolton, 1965) indicates that BHC is used to control *Bark Beetle* infestations in log piles, and also in forestry nursery soils against *Cockchafer Larvae*. DDT is used as a transplant dip against *Pine Weevil*, and there have been occasional cases over the past 10–15 years when forest areas of the order of 1,000–3,000 acres (800–2,400 ha) have been treated with DDT against *Pine Looper*, the latest being a treatment applied to 350 acres (140 ha) in Scotland in 1957.

5.1.1. More recent data, relating to 1964–1966, have been collected by the Forestry Commission and cover the areas administered by the Commission in England and Wales. These data are summarised in Table 5.1.1, and do not include uses on private woodlands. The latter are being surveyed at present.

5.1.1.1. The Need for these Treatments. Aldrin was applied to less than 1 acre (0·4 ha) for *Cutworm* control in a forest nursery in Wales in 1964. BHC has mainly been used as a seedbed treatment, again in forest nurseries, for controlling *Cutworms* and *Cockchafers*. Small areas were sprayed with BHC for controlling *Aphids* and *Pine Weevil*, and some treatments were applied against *Ambrosia Beetle*. Apart from pine weevil, DDT was used against *Shoot Beetles*, *Sawfly*, *Sand Fly*, and *Winter Moth*. The big increase in DDT use in 1966 was mainly (780 acres [320 ha]) in the eastern counties.

5.1.1. Treatments Applied by Forestry Commission, 1964-66

Material	Acreages Believed Treated		
	1964	1965	1966
Transplanting Dips			
DDT	360	180	150
BHC	(0)	(0)	(10)
Nursery and Woodland Treatments			
Aldrin	(1)	0	0
BHC	10	10	20
DDT	220	270	1,180
All Other Insecticides	10	20	30
Acreages under Plantations:	809,300	829,100	843,500
Acreage of Forest Nurseries:	1,000	1,000	900

The other insecticides were applied against *Collembola*, *Thrips* and *Aphids* (malathion), and aphids and cutworms (carbaryl).

5.1.1.2. Alternative Chemicals. Little work has been done on organochlorine alternatives. DDT and BHC are the main materials used in controlling beetle and cutworm attacks, and from experience with agricultural and horticultural crops it may not be easy to find satisfactory alternatives. While organophosphorus systemic insecticides give good control of aphids in many horticultural tree crops these materials are seldom effective, other than in a contact sense, when used on conifers. The Commission recommends malathion for controlling aphids and collembola.

6. Summary and Some Conclusions

6.1. Summing the estimates of usage tabulated in the preceding pages gives the rounded totals shown in Table 6.1, which indicates the overall extent of use of organochlorine insecticides on outdoor crops in England and Wales in 1965–66. Glasshouse and nursery uses have not been included because the data in Table 4.2.1 can only be interpreted in 'spray-acre' terms.

Table 6.1. Estimated Total Basic Acreages of Farm and the Major Horticultural and Forest Crops Treated with Organochlorine Insecticides in England and Wales mainly in 1966

Material	Farm Crops	Vegetable Crops	Fruit and Hops	Outdoor Bulbs and Flowers	Forestry	Rounded Grand Total
Seed Dressings and Dips						
Aldrin and Dieldrin	442,000	62,000	0	300	0	504,300
Gamma-BHC	3,638,000	11,000	0	0	(10)	3,649,000
DDT	0	0	0	0	150	150
Field Treatments						
Aldrin	28,000	900	700	300	(0)	29,900
Dieldrin	200	4,900	200	(0)	0	5,300
BHC	34,300	5,700	35,500	100	(20)	75,600
DDT	15,600	46,300	113,900	200	1,200	177,200
Dicofol	0	0	4,400	0	0	4,400
Endrin	0	500	1,400	(0)	0	1,900
Endosulfan	0	0	10,900	(0)	0	10,900
TDE	0	0	12,200	0	0	12,200
Tetradifon	0	0	9,900	0	0	9,900

6.2. Farm Crops. Wheat: Chlorfenvinphos and ethion seem to be reasonable substitutes for the persistent organochlorine insecticides used to control wheat bulb fly. More work is needed on alternatives for controlling leatherjackets. *Barley:* The main insect problem is leatherjacket control and more work is needed. *Oats:* Further work is needed on alternatives for control of frit fly and leatherjackets. All *Cereals* may be damaged by wireworms and BHC seed dressings normally give good protection. *Grassland:* Is seldom or ever treated at present, but further work may demonstrate that pest control would be profitable on leys and seed crops and organochlorine insecticides would be the cheapest materials for controlling a number of grass pests. *Sugar Beet:* All seed is treated with organochlorine dressings, mainly with dieldrin, and this use is likely to become even more necessary as seed rates continue to fall and braird protection becomes more important. Use of DDT is declining, and there is increased use of organophosphorus insecticides for the combined control of aphids and mangold fly; but there is no satisfactory alternative for leaf-eating beetles and cutworms. BHC is a satisfactory soil insecticide in many cases. Dieldrin seed dressings will shortly be used on all seed at doses of less than 0·25 oz of active ingredient per acre (17 g per ha), and there is no satisfactory alternative. *Other Roots:* Need some protection from flea beetle and wireworm damage, and gamma-BHC seed dressings are normally satisfactory; DDT is used for swede midge control, and work on possible alternatives is needed. *Brassicae;* Stockfeed, and brassica seed crops, occasionally need protection from flower and seed pests, and alternative chemicals need more critical timing than conventional organochlorine controls. *Potatoes:* Protection against wireworm damage continues to be needed on a few tens of thousands of acres annually; there are no satisfactory substitutes for aldrin.

6.3. Vegetable Crops. Peas: Alternatives are available for moth control, but timing is critical; more work is needed on alternatives to DDT for weevil control. *Beans:* DDT is still needed for weevil control; alternatives have been found for bean seed fly control but they are not commercially available in suitable formulations. The increasing trend to precision seeding of edible legumes indicates that braird protection may become more important and use of insecticidal seed dressings may increase. *Brassicae for Human Consumption:* A number of pest species are normally controlled with BHC and DDT, and little work has been done on alternatives for, e.g., flea beetle control. Cabbage caterpillars can be controlled with alternatives to DDT, but timing is critical. Cabbage root fly is becoming resistant to dieldrin and many growers are already using organophosphorus materials to control it. *Roots for Human Consumption:* Gamma-BHC seed dressings continue to be needed. Carrot fly is becoming resistant to organochlorine insecticides and some growers are already using organophosphorus materials for its control. *Other Vegetables:* Further work is needed on alternatives for onion fly control; organochlorine materials are used sporadically on a number of minor vegetable crops to control a range of pests which are often of sporadic, local, importance and provide few opportunities for field experimentation on alternatives.

6.4. Fruit and Hops. There are adequate alternatives to DDT for pre-blossom caterpillar control though further work is needed on timing which is more critical than with the persistent materials. There are no suitable alternatives for capsid bug control. There is a lack of experimental evidence on capsid control, and on control of several pear and plum pests. Further work is also needed on several soft fruit pests; in particular, on the control of seed-eating ground beetle, wingless weevils, and various mites. There seems to be a continuing need for many of the persistent pesticides on fruit and the development of pesticide resistance in some species emphasises the need to have a range of materials available for use in emergencies. *Hops:* There is a lack of recent trial evidence on possible alternatives for the control of various hop pests which spend part or all of their lives in the soil; experience with related pests suggests that alternatives may be hard to find.

6.5. Other Horticultural Crops. Narcissus: Continues to need protection against narcissus bulb fly in the south-west, and there are no good alternatives to aldrin and dieldrin. Many glasshouse and nursery crops need treatment against a range of pests, and there is evidence that growers tend to seek advice before applying treatments. Certain glasshouse pests have developed resistance to some pesticides and it is desirable that a range of different materials should be available for use in emergencies.

6.6. Forestry. Use of organochlorine insecticides is on a very small scale, and mainly in forest nurseries or as transplanting dips. Little work has been done on alternatives, which may be hard to find. Organophosphorus systemic insecticides are seldom effective on coniferous trees, and BHC and malathion are often used when aphids need controlling. Aldrin and dieldrin have scarcely been used on Commission lands over the past three years.

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14/11/68.

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APPENDIX VIII

Part II

Survey of Use of Persistent Organochlorine Pesticides in Agriculture and Horticulture in Scotland, 1964–66

(Prepared at the request of the Advisory Committee by Dr. D. C. Graham, Department of Agriculture and Fisheries for Scotland, from information supplied mainly by the Scottish Agricultural Colleges.)

(see paragraphs 101–187 of Report)

Introduction

When the Advisory Committee first reviewed the persistent organochlorine pesticides in 1964, no usage data for Scotland were available for consideration. For the present review, the Committee requested that data for Scotland should also be obtained. Information on usage in Scotland was obtained from estimates made by the Advisory Officers of the three Colleges of Agriculture for all crops except sugar beet and potatoes. All the major field crops are included but no information was obtained for glasshouse crops or nursery stock. This is probably not an important omission since there were only 295 acres of glasshouses and 1,099 acres of flowers, bulbs, shrubs, etc., grown in Scotland in 1965.

The summary is divided into three parts:—1. *Usage of Aldrin and Dieldrin with a Note on Endrin and Endosulfan:* 2. *Usage of BHC and DDT:* 3. *Estimated Total Tonnages used Annually on Crops in Scotland.* The layout follows that used in Appendix E of the 1964 Report. Although this has certain disadvantages, mainly because different organochlorine insecticides have many uses in common, it is considered satisfactory having regard to the much smaller amounts of data from Scotland as compared with England and Wales and the now limited uses of aldrin and dieldrin.

No information is given in this report concerning chemical alternatives to organochlorine compounds in Scotland, but the College Advisory Officers have been investigating these for some years.

1. Usage of Aldrin and Dieldrin with a Note on Endrin and Endosulfan

1.1. Sources of Information. Usage on potatoes and sugar beet was derived from data supplied by the Potato Marketing Board and the British Sugar Corporation respectively.

All other data were obtained solely through estimates made by the County Agricultural and Horticultural Advisers of the Colleges of Agriculture in Aberdeen, Glasgow and Edinburgh. Arrangements for the usage survey were made by the College Advisory Entomologists, Dr. Shaw, Dr. MacLagan and Mr. Dunn. They also guided the County Advisers in providing the information and their help is gratefully acknowledged.

In many cases, the Advisers checked their estimates against sales information supplied by local representatives of commercial firms.

1.2. Estimates of Acreages Treated. The table gives details of acreages of crops treated with aldrin and dieldrin.

Acreages grown and acreages believed treated with Aldrin and Dieldrin Scotland, 1964-66

Crop	Acreages (1965)	*Acreages believed treated with*			
		Dieldrin		*Aldrin*	
		Sprays	*Seed dressings or plant dip*	*Sprays*	*Seed Dressings*
Wheat . . .	98,500	—	15,000	—	300
Barley . . .	558,500	—	—	3,600	—
Potatoes . . .	141,700	300	—	600	—
Edible Brassicae .	4,900	—	1,700	—	—
Sugar Beet . .	8,900	—	8,300	—	—
TOTALS . .	812,500	300	25,000	4,200	300

1.3. The Pests for which Treatment is Applied. In Scotland pest incidence from year to year is well known in general terms, largely as a result of the experience of the College Advisory Entomologists. Data for the years 1930–1960 are being collated by the Department from the Annual Reports prepared by Advisory Entomologists, and will be published in due course. This source has been drawn on freely in preparing the present report. However, precise information is lacking especially regarding the loss of yield caused by pests.

1.3.1. Cereals. Just over 15 per cent of the wheat acreage is sown with seed treated with organomercury/dieldrin or aldrin seed dressings for wheat bulb fly control. This is winter wheat grown in the East Area.

Only about 0·5 per cent of the barley acreage is sprayed with aldrin for control of leatherjackets, the majority of the crop consisting of varieties resistant to DDT, which is therefore commonly used.

1.3.2. Potatoes. Intensity of wireworm attack varies from year to year, but is rarely serious and PMB data show that very few crops are treated with aldrin or dieldrin for control of this pest. It is noteworthy, however, that the dosage rate is high.

1.3.3. Sugar Beet. Almost all the sugar beet seed is treated with dieldrin for wireworm control.

1.3.4. Edible Brassicae. Cabbage root fly is a serious pest of edible brassicae, including cabbage, cauliflower and Brussels sprouts. Severe outbreaks were recorded each year from 1950–1960 excepting 1951 and 1958. Over 40 per cent of the acreage of edible brassicae is grown from transplants dipped in dieldrin preparations. A little aldrin is also used, but this is included in the figures for dieldrin.

1.4. Endrin and Endosulfan. Of the 250 acres of blackcurrants grown in Scotland, it is estimated that in 1966 only 0·5 acre was treated with endrin and further 0·5 acre with endosulfan for big bud mite. Lime sulphur is commonly used.

2. Usage of BHC and DDT

2.1. Sources of Information. The sources of information noted at para. 1.1 also provided data on BHC and DDT usage.

2.2. Estimates of Acreage Treated. The table relates only to the major usages of BHC and DDT. These compounds are used on a wide range of pests in Scotland, just as in the rest of Britain. The acreage estimates are of areas treated annually, based on usage for the years 1964–66, in an attempt to include data for those pests which are of major importance in certain years but not in others. Acreages grown are for the year 1965.

Acreages grown and acreages believed treated with BHC and DDT, Scotland, 1964-66

Crop	Acreages (1965)	*Acreages believed treated with*		
		BHC		*DDT*
		Sprays and dusts	*Seed dressings*	*Sprays and dusts*
Wheat	98,500	400	4,900	2,400
Barley	558,500	6,100	10,300	51,100
Oats	431,700	3,300	6,700	31,600
Potatoes	141,700	—	—	900
Sugar Beet	8,900	—	600	3,500
Edible Brassicae	4,900	12	3,300	22
Stockfeed Brassicae	223,300	700	196,900	1,800
Peas	4,141	—	—	0
Carrots	823	2	793	—
Strawberries	1,902	0	—	361
Raspberries	6,908	—	—	5,531
Blackcurrants	254	—	—	0
TOTALS	1,339,800	10,500	223,500	97,200

2.3. The Pests for which Treatment is Applied

2.3.1. Cereals. The main pests are wheat bulb fly, frit fly, wireworm and leatherjackets. About 5 per cent of wheat seed is treated with a combined organomercury/BHC seed dressing mainly to control wheat bulb fly, virtually all in the East Area where it occurs as a major pest. Egg counts are made each year in this Area to enable the Advisers to warn farmers when it is necessary to use treated seed. Under two per cent of barley and oat seed is similarly treated.

The most consistently serious pest of cereals in all parts of Scotland is the leatherjacket and damage was extensive in certain areas in four years out of ten during the period 1951–1960. Most of the DDT and BHC sprays applied to cereals are for leatherjacket control but Paris Green/bran baits are still used frequently in many counties.

2.3.2. Potatoes. Very little spraying for aphid control is carried out in Scotland, but PMB data indicate that DDT is still being used for this purpose very occasionally.

2.3.3. Sugar Beet. Almost all the sugar beet in Scotland is grown in the East Area and more than 40 per cent of the acreage is sprayed with DDT for mangold fly. Organophosphorus compounds have not so far replaced DDT for fly control as in England and Wales. A little seed is treated with BHC dressing for wireworms.

2.3.4. Brassicae. Nearly 90 per cent of stockfeed brassica seed and 70 per cent of the edible brassica seed are treated with a combined BHC/fungicide seed dressing for control of flea beetles. These pests are widespread and, before the introduction of BHC, were constantly troublesome. For example, extensive and severe infestations were recorded in four years out of ten during the period 1941–1950.

Only a small acreage of brassicae is treated with BHC or DDT sprays and dusts for a variety of pests including flea beetles, cabbage root fly and cabbage caterpillars. Some growers in the North Area mistakenly spray with DDT to control "strangles" —a physiological condition.

2.3.5. Peas. Pea cultivation is largely confined to the counties of Angus, Perth and Kincardine, and although *Sitona* weevils occur, treatment for these is not considered necessary. Pea moth occurs very rarely.

2.3.6. Carrots. Almost all carrot seed is treated with a combined BHC/fungicide seed dressing for control of carrot fly. Dieldrin sprays were still being used in some instances in 1966, and it is believed that some growers had sufficient supplies to treat the 1967 crop.

2.3.7. Strawberries. Strawberries are mainly grown in the East Area, and about 20 per cent of the acreage is treated with DDT to control tortrix moth caterpillars and strawberry blossom weevil. Almost all of this is used in the Lothians.

2.3.8. Raspberries. Scotland accounts for more than four-fifths of raspberry production in Great Britain. The crop is grown mainly in the counties of Perth and Angus, and about 80 per cent of the acreage is routinely treated with DDT for raspberry beetle.

3, Estimated Total Tonnages Used Annually on Crops in Scotland, 1964–1966

In 1965, data giving consolidated dosage rates (oz technical active ingredient per acre) for each major crop were calculated and these were employed to estimate total tonnages of organochlorine pesticides used annually in England and Wales (Strickland, A. H., *Ann. appl. Biol.* **55**. 319–325, 1965).

These data have been used to estimate tonnages used in Scotland as given below.

Estimated total tonnages used annually on major crops in Scotland, 1964–66

Crop	Seed-bed and Seed Dressing treatments			Field treatments including transplant dips			
	Aldrin	*Dieldrin*	*BHC*	*Aldrin*	*Dieldrin*	*BHC*	*DDT*
Wheat	0·02	1·26	0·16	—	—	0·08	1·07
Barley	—	—	0·35	2·41	—	1·28	22·81
Oats	—	—	0·26	—	—	0·84	27·00
Potatoes	—	—	—	0·89	0·45	—	0·50
Sugar Beet	—	1·39	—	—	—	—	1·20
Stockfeed Brassicae	—	—	7·80	—	—	0·10	0·40
Edible Brassicae	—	—	0·25	—	0·12	0·02	0·05
Carrots	—	—	0·04	—	—	—	—
Strawberries	—	—	—	—	—	—	0·18
Raspberries	—	—	—	—	—	—	3·70
Totals	0·02	2·65	8·86	3·30	0·57	2·32	56·91

APPENDIX IX

Survey of Use of Persistent Organochlorine Pesticides in Food Storage and Industry in the U.K., 1964–1968

(Prepared at the request of the Advisory Committee by Pesticides Survey Group, Infestation Control Laboratory, Tolworth, under the supervision of Mr. D. S. Papworth)

(see paragraphs 188–217 and 224–244 of Report)

INTRODUCTION

In the "Review of the Persistent Organochlorine Pesticides" (London, H.M. Stationery Office, February 1964) attention was drawn to the difficulty of identifying all the contributory sources of organochlorine pesticide residues found in food. There was a lack of information on the use of these compounds outside agriculture and horticulture, particularly in food storage practice. To obtain data on the quantity of pesticides used against pests of food after import or harvest, a group was established in 1966 at the Infestation Control Laboratory, Ministry of Agriculture, Fisheries and Food, Tolworth. This group was to conduct surveys within the area of use defined by the term food storage practice, and for certain other uses, at the discretion of the Advisory Committee on Pesticides and other Toxic Chemicals.

In agriculture and horticulture, application of pesticides is often in accordance with a predetermined programme. Treatments are normally carried out within the area covered by each crop and are limited to its period of growth. The average crop yield is usually known. Such predictable uses of pesticides and also the physical isolation of individual food crops during treatment do not feature in food storage practice. Attempts to assess the quantitative usage of pesticides in food storage practice may therefore present more difficult problems.

The surveys covered by this report deal with food originating from two distinct sources, home grown and imported, but it is not usually possible to obtain details of treatments of foodstuffs before their arrival at U.K. ports. The unprocessed foods most liable to infestation or damage by rodents, insects, and mites, are cereals, cereal products, oilseeds and their products, dried fruit, edible nuts, cocoa beans, pulses, and spices. The quantity of these foodstuffs entering the U.K. market in 1967 and which therefore might have been treated with pesticides was approximately 10·5 million tons by import (Table 1). Additionally 12·9 million tons of home grown cereals also came on the market.

After harvest or import, food may be stored, processed, prepared, packed, or cooked, before reaching man or animals as food. Details of the production and throughput of some food and animal foodstuffs during these stages are published (Central Statistical Office, Board of Trade). Pesticides are mainly applied sporadically at any of these stages as and when the need arises. Because specific foodstuffs rarely remain isolated from each other it is often difficult or impossible to relate pesticide use to each commodity treated. Obtaining quantitative data in many of these situations from which meaningful results for the country as a whole can be obtained is therefore extremely time consuming when conducting surveys based on sound statistical designs.

To provide a satisfactory basis for obtaining useful data, only those situations were surveyed where all the following conditions obtained:

(a) A clearly defined field of food storage.

(b) A knowledge of the number of premises within the particular field of each national survey and in some cases the quantity of foodstuffs or other infestable produce passing through the premises.

(c) The co-operation of:—

- (i) the British Pest Control Association (BPCA) and the major pesticide servicing companies in supplying details of specific treatments;
- (ii) the respective trade, professional, and allied associations or authorities;
- (iii) the management of each enterprise within the sample.

These conditions were met with imported food and animal feeding stuffs, cargo spaces of ocean ships, the passenger sections and victualling stores of ships, farms, grain storage premises, flour mills, chocolate and confectionery manufacturers, bacon factories, tobacco manufacturers, local authorities, government buildings, and British Rail, and are covered in detail in the following paragraphs.

Surveys deferred because some of these conditions could temporarily not be met include industrial canteens and kitchens, home kitchens, slaughterhouses, provender mills, and retail food shops.

In some of the completed surveys the results showed extreme variability and the estimates of usage have large standard errors. Where estimates have been raised to give a national figure, it has been on the assumption that the rate of chemical usage is related to food throughput in the premises, but this may not be justified in all the cases surveyed. In the few areas so far examined, small and large producers within each field were represented in the sample. Pest control techniques may vary considerably, but errors from this cause were limited by stratifying the sample to include a high proportion of the large premises which produce between them the greater part of the total food production within the field.

Details of quantities of pesticides used in each field are presented in terms of active pesticide ingredients. Information has not been sought on the quantities of other substances which may also be incorporated in proprietary pesticidal formulations. It was thought desirable to retain the considerable data obtained on pesticides other than those under review so as to present a balanced view of the relative importance of the reviewed chemicals in the fields surveyed. Information on pesticides used against harmful birds and mammals has been omitted except where relevant.

1. Imported Food and Animal Feeding Stuffs

Inspection of ships and cargoes liable to infestation by insects and mites injurious to stored food and feeding stuffs is carried out by the Insect Inspectorates of the Ministry of Agriculture, Fisheries and Food in England and Wales (MAFF) and the Department of Agriculture and Fisheries for Scotland (DAFS). This work is done under the Prevention of Damage by Pests (Application to Shipping) Order 1951 as modified by a Memorandum of Arrangements between the Agricultural Departments (in consultation with the Ministry of Transport), and the Chamber of Shipping of the United Kingdom and the Liverpool Steamship Owners Association.

In 1966 and 1967 approximately 7,000 cargoes were inspected annually by agricultural departments in Great Britain and 34 per cent were found to be infested. The incidence of overall infestations in the years 1957–1966 has shown a steady decrease from the 52 per cent level of infestation of cargoes examined in 1957. This improvement and the general reduction in the degree of infestation of cargoes has resulted from the introduction of more rigorous standards of grading and export control, with appropriate pest control, in the producing countries. It has been most marked in respect of cocoa, dried fruits, and cereals.

If there are significant levels of insects and mites, recommendations may be made by the Inspectorate to control them and to prevent the spread of infestations. The need for control action on arrival is determined partly by the nature and degree of infestation, the kind of commodity, and its immediate destination after import. For example, rice cargoes from the Far East are almost always infested because of inadequate control action in the country of origin and infestation en route; all need to be fumigated and recleaned on arrival. Although oilseeds may frequently arrive heavily infested they may not require to be treated if the shipment is destined for early processing in a port mill, where suitable measures are taken to prevent the spread of infestation to other foodstuffs.

Commodities such as dried fruits, nuts, and spices, which may be retailed with little further processing, or in which the presence of insects may markedly reduce their value, are normally fumigated. It has been the practice of certain importers since 1929 to fumigate all dried vine fruits on arrival as a precaution. Occasionally control measures are carried out on ships before discharge of cargo, but usually the infested goods are unloaded into transit sheds, dockside warehouses, grain silos, or into barges where treatments are carried out. Fumigation is the most usual method adopted for such treatments.

Information on fumigations known to have been done in 1967 has been calculated from the records of agricultural departments and Table 1 shows the amounts of some imported commodities known to have been fumigated in Great Britain. Most of the treatments were done at or very soon after import, but a small percentage of the totals are for fumigations carried out on stored commodities which might have been previously fumigated since their initial import.

Unfortunately it is difficult to relate the quantity of fumigant used to the weight of food treated because the calculation of the dose to be applied at each fumigation is not usually directly related to weight but rather to volume occupied. Where the weight of commodity bears a fixed relationship to the volume of enclosure, as in the fumigation of a stack under gas proof sheets, the dosage can be expressed in terms either of the volume enclosed or of the weight of commodity. Where the loading of the space to be fumigated is variable, the dose is better obtained by adding together a space dose calculated upon the total volume of the enclosure and a commodity dose calculated upon the weight of commodity.

Additional information on the fumigation of food in Great Britain is provided in the appropriate sections of this Appendix and Table 2 summarises the fumigations of imported and home-produced commodities in 1966 which have come to the notice of agricultural departments (Infestation Control 1969). The table shows the dominance of methyl bromide for this purpose but also indicates the special role of some other fumigants.

Contact insecticides including the organochlorine insecticides under review are used by port authorities in dockside warehouses but there is no evidence they are used to any great extent. It is known that in 1967 the Port of London Authority and the Port of Bristol Authority used between them about 10 lb of pyrethrins in warehouses storing animal feeding stuffs, tobacco, and for miscellaneous insect infestations. Two port authorities used gamma-BHC in warehouses storing animal feeding stuffs at an annual rate of up to 1 cwt and 5 cwt respectively for the years 1965–67. Port authorities let warehouses to tenant firms which are then responsible for the control of pests. The use of pesticides by such firms has not yet been investigated.

Table 1. Imported infestible food fumigated with methyl bromide in Great Britain in 1967

Commodity	Total quantity imported into U.K.‡ ('000 tons)	Percentage of cargoes infested*	Approximate quantity fumigated** ('000 tons)	Approximate quantity of methyl bromide used (lb)†
Cereal products	44	37	12	2,100
Cocoa	87	78	20	1,000
Dried fruit	133	13	12	600
Edible nuts	61	19	11	1,925
Grains	8,140	20 (Grains and Pulses)	24	2,700
Pulses	150		3	150
Oilseeds	691	57	16	2,800
Oilseed products	932	65	38	11,400
Spices and flavourings	11	13	<1	<50

‡ Information from records of Statistical Office of H.M. Customs and Excise.
* From Freeman (1968).
** Information provided by Agricultural Departments. No claim is made that it is a complete record of tonnage fumigated.
† Assuming standard dosage rates and also a fixed relationship between the weight of commodity to the volume of the fumigated enclosure (see text).

Table 2. Approximate tonnage of commodities fumigated in Great Britain in 1966‡

Commodity	Methyl bromide: in craft	Methyl bromide: under gas-proof sheets	Methyl bromide: in ware-houses or fumigation chambers	Liquid fumigant mixture*	Ethylene oxide	Aluminium phosphide	Total
Cereal products	5,509	8,325	151		637		14,622
Cocoa	6,010	2,031	13,900				21,941
Dried fruit	4,074	15,797	3,784				23,655
Edible nuts	1,103	907	995				3,005
Flour		1,237			150		1,387
Grains and pulses	10,509	11,553	11,903	60,116		2,350	96,431†
Malt	2,274	300		3,030			5,604
Oilseeds	2,676	6,788	746	40			10,250
Oilseed products	22,244	39,887	110	100			62,341
Spices & flavouring		386	2				388
Miscellaneous	1,743	6,727	348	72			8,890
TOTALS	56,142	93,938	31,939	63,358	787	2,350	248,514

* Ethylene dichloride and carbon tetrachloride mixture.
† Includes 36,396 tons of home grown grain.
‡ From Infestation Control Laboratory (1969).

2. Ships

2.1. Cargo Spaces of Ocean Ships

It is usual for cargoes infested with insects and mites to be unloaded before treatment and consequently residues of insects remain in the holds of ships. A thorough cleaning of the holds is usually sufficient to remove this hazard to future cargoes but the holds may need to be fumigated or treated with insecticidal sprays or smoke generators. The holds of 600 ships were recommended for treatment in 1966 and 473 in 1967.

On many vessels routine treatments of holds are now carried out before the loading of certain food cargoes and some shipping companies have a contract with a servicing company to carry out regular pest control in their ships.

In spite of the variable treatments experience has shown that in general, especially where British ships are concerned, the recommendations or adequate substitutes are carried out. Treatments may not necessarily be done in the U.K. especially where vessels have cargo to discharge on the continent. Treatment of foreign vessels may be deferred until return to home ports.

The quantity of pesticides used in cargo spaces was estimated by asking servicing companies to provide details of treatments carried out on ships listed as having been recommended for treatment in February 1967.

Subsequent analysis of data showed it was justifiable to accept recommendations made for treatment as a means of estimating the quantities of chemicals used. The results are shown in Table 3.

Table 3. Approximate amounts of insecticides used in the cargo spaces of British ships while in British ports

Insecticide		*No. ships recommended for treatment*		*Total estimated quantity of active pesticide ingredient used (lb)*	
		1966 (379 *ships*)	1967 (295 *ships*)	1966	1967
Malathion		142	125	499	276
Gamma–BHC	(1) smoke generators	145	104	296	274
	(2) water dispersable powder	84	88		
Pyrethrins		4	1	—	—
Methyl bromide		13	5	—	—

2.2. Passenger Sections and Victualling Stores of Ocean Ships

The passenger, crew, and victualling accommodation of ships also provide an attractive harbourage for insect and rodent pests. Most shipping companies provide routine measures for pest control. New ships are often treated before delivery with dieldrin or diazinon lacquers to give more lasting protection against insect pests, especially cockroaches. Many shipping lines have contracts with servicing companies for such routine treatments and the crew may be provided with insecticides for use at sea.

Information on pesticides used in the accommodation and food stores of ships while in British ports was sought from Port Health Authorities and from five servicing companies. The data provided by the servicing companies concerned their treatments of 1,940 ships in 1967 and is given in Table 4. The use of 219 lb of dieldrin is significant as other surveys in the food storage field (apart from information supplied by local authorities) have shown this chemical to be little used. Some servicing companies have ceased to use dieldrin for the control of cockroaches on ships whether insect resistance to this chemical has been proved or not. The organophosphorus insecticide diazinon was used as the principle alternative although it has less useful persistence than dieldrin.

Table 4. Insecticides used in the accommodation and stores of 1,940 ships while in British ports during 1967

Insecticide	*Quantity (lb)*
Chlordane	5
DDT	21
Dichlorvos	9
Malathion	137
Gamma–BHC	153
Dieldrin	219
Diazinon	1,069
Pyrethrins	104
Fenitrothion	7
Arprocarb	15
Other carbamates	5

3. Grain Storage Premises

3.1. Farms

Grain grown in Great Britain is often stored on farms where it may be at risk from infestations of insects or mites although the incidence of such infestation is low. Many farmers undertake some form of routine prophylactic pesticide treatment of their grain storage premises before harvest and where the infestation risk is high insecticides are sometimes applied directly to raw grain. On the other hand. when infestation occurs, fumigants such as carbon tetrachloride and ethylene dichloride are normally used.

A sample of farms was obtained from the Agricultural Census and Surveys Branch of MAFF. The sample was confined to eleven English counties (Cambridge, Essex, Kent, Norfolk, Northants, Nottingham, Shropshire, East Riding of Yorkshire, Hampshire, Wiltshire, and Devon) and represented all types of cereal growers in England. In June 1966 the 38,346 farms growing cereals in these counties formed 30 per cent of the holdings growing cereals and produced 40 per cent of the cereal output of England and Wales. The sample of farms in Scotland was supplied by the Economics and Statistics Unit of the DAFS and represented about 4·6 per cent of the total Scottish cereal acreage.

Brief questionnaires were sent to all the holdings in the samples to ascertain whether or not insecticides were used on stored grain or in grain stores during the season 1966–67. Replies were received from 1,588 holdings in England of whom 375 reported using insecticides, and from 457 holdings in Scotland of whom 13 used insecticides. Detailed questionnaires were then completed by Survey Officers visiting 190 of the 375 English farms identified from the first enquiry. In Scotland all the 13 farms using insecticides were visited. The results are given in Table 5.

The practice of mixing malathion dust with grain is primarily a prophylactic measure to protect grain stored in premises with a history of infestation by the Saw-toothed Grain Beetle. On the farms visited which used this method it was found the average rate of application of active ingredient to the stored grain was 3 p.p.m. and the maximum 7 p.p.m. Malathion was also used to spray the walls of bins and granaries before clean grain was put into store. It is not effective against stored products moths or mites but gamma-BHC controls these pests and is used as a fabric spray for this purpose. Gamma-BHC was also used occasionally as a dust on the surfaces of stored grain and 13 of the farms visited used it in this way at an average rate of 3·3 lb of active ingredient per 1,000 tons of grain stored. The present survey showed that DDT was still used as a fabric spray by some farmers but most used malathion or gamma-BHC.

One disturbing result of this survey was the indication that dieldrin was occasionally being used to treat grain bins. This was traced to farmers who were using surplus sheep dip, but now that dieldrin is no longer available for this purpose it is to be hoped this mis-use of the chemical has ceased.

Table 5. Amounts of insecticides used to protect stored grain on 203 farms April 1966–March 1967

Insecticide	English farms (190)		Scottish farms (13)	
	No. of users*	Quantity used (lb)	No. of users	Quantity used (lb)
DDT	18 (5)	26	2	1
Dieldrin	4 (1)	<1	1	1
Gamma-BHC				
Fabric spray	97 (4)	120	5	15
Surface dust	13 (2)	11	0	0
Malathion				
Fabric spray	104 (4)	335	6	12
Admixture	29 (2)	60	1	<1
Pyrethrins	11 (1)	1	1	<1
Liquid fumigants†	6 (1)	2,600	0	0

* Figures in parentheses are the number of users who could not supply quantitative data.
† Carbon tetrachloride/ethylene dichloride and carbon tetrachloride/ethylene dibromide mixtures.

3.2. Commercial Grain Stores

Certain groups of premises which store grain for human or animal consumption did not come within the scope of the farm building or flour mill surveys and were not directly associated with provender mills or other cereal processing industries proposed for survey at a later date. To deal with this omission the following groups of commercial grain stores were included in a separate survey:

(a) Agricultural merchants' silos.

(b) Farmers' co-operative grain stores.

(c) Grain silos and transit granaries in dock areas.

The survey was carried out with the co-operation of the National Association of Corn and Agricultural Merchants, the Seed Trade Association of the United Kingdom, the National Federation of Corn Trade Associations, and the National Farmers Union.

Some difficulty was experienced in listing the premises for inclusion in the survey and a brief questionnaire was sent to 228 grain storage premises in England and Wales that might have come within its scope. Analysis of the 208 replies revealed that 98 premises and organisations could be classified in one of the three groups of grain storage premises listed above. For the purposes of the survey a grain storage premises was defined as including all individual stores owned or managed by one firm or organisation. All were asked if they used pesticides during the year ending 30th June

1968 and the 70 that reported in the affirmative were visited by insect inspectors of the MAFF to obtain further details. The collection of information is continuing.

Results received so far indicate that the 70 grain storage premises where insecticides were used handled more than 95 per cent of the total grain throughput of premises in England and Wales. Details so far available indicate that insecticide usage is similar to that in farm grain stores, and both control and prophylactic measures rely principally on fumigants, malathion, and gamma-BHC. Of the organochlorine pesticides under review only DDT was used and it was confined to a few premises, often as the only insecticide employed. For example, one co-operative grain store applied 36 lb of DDT to empty bins with a capacity of 12,000 tons of grain; no other control or prophylactic measures were taken.

Scotland was surveyed by the insect inspectorate of DAFS. All 34 grain storage premises were visited and 14 were found to be using insecticides. The details are given in Table 6.

Table 6. Amounts of insecticides used to protect grain in Scottish granaries July 1967–June 1968

Insecticide	*No. of users*	*Total quantity used (lb)*	*Quantity of grain treated (tons)*
Gamma-BHC	7	40	—
Malathion	9	200*	12,700
Methyl bromide	1	285	5,500
Liquid fumigants	4	31,700	20,000

* 114 lb admixed at 2 granaries.

4. Food Manufacturers

4.1. Flour Mills

The presence of pests in cereals and cereal products may cause taint and introduce insect fragments and frass into foodstuffs. In flour mills, very close attention is paid to hygiene to prevent contamination of end products. It is fairly general practice to fumigate sections of a mill annually to prevent build-up of endemic infestations, and this practice considerably reduces the amounts of insecticides used. Chemicals are, however, employed spasmodically in most mills to control local outbreaks of insect infestation.

Details of pesticide use in flour mills were obtained for the year ending 30th June 1966 when there were 180 flour mills in Great Britain and Northern Ireland which produced 3,675,000 tons of flour for human consumption.

Commodity Statistics Branch of the MAFF provided a sample of flour mills which represented approximately a third of all the mills and two-thirds of the final flour product. Each mill in the sample was visited to obtain data from which the raised results were obtained in Table 7. None of the contact insecticides used was applied directly to wheat or mill products in such a way that residues could be expected to arise in flour from their use.

Organochlorine pesticides under review were little used at mills. Five mills applied DDT as a dust, a wettable powder, or in smoke generators, and one mill operated five thermal vaporisers continually discharging DDT. Dieldrin was used in two mills but not in areas where it could contaminate flour.

Table 7. Amounts of insecticides, calculated from raised sample results, used in all mills in the United Kingdom, July 1965–June 1966

Insecticide	Quantity used (lb)		
	England and Wales	Scotland	Northern Ireland
DDT	29*	—	—
Dieldrin	<1	<1	—
Gamma-BHC	512	51	51
Organophosphorus insecticides	280	27	14
Pyrethrins	46	5	2
Methyl bromide	47,603	5,673	2,258
Hydrogen cyanide	3,585	—	—
Liquid fumigants†	4,751	205	172

* Includes an estimated 6 lb DDT used as a rodenticide.
† Carbon tetrachloride, ethylene dichloride, and ethylene dibromide.

4.2. Chocolate and Sugar Confectionery

The chocolate and confectionery industry uses a wide range of unprocessed food including edible nuts, cocoa beans, and dried fruit, which are subject to infestation by pests. In 1967, the year of the survey, the total intake of these three commodities by this industry amounted to 118,000 tons or nearly 14 per cent of all ingredients used.

At the time of the survey there were 111 manufacturers of chocolate and sugar confectionery in Great Britain. Information on pesticides used in this industry were obtained with the co-operation of the Cocoa, Chocolate and Confectionery Alliance and the Commodity Statistics Branch of MAFF selected a stratified sample of firms whose combined intake of unprocessed food was two-thirds of the total used by the industry. All firms in the sample were visited to obtain further details of pesticides used.

A high proportion of edible nuts, cocoa beans, and dried fruit, are treated with pesticides before arrival at the premises of the manufacturers in this industry. Treatments carried out before, at the time of import, or while in a store awaiting delivery to manufacturers, have been discussed elsewhere (see Section 1). Commodities at the premises of the manufacturers are stored under conditions where serious infestations are unlikely to develop. If treatment is necessary the utmost care is taken to ensure that raw materials and manufactured products do not have their quality impaired by contamination with pesticides. The indications are that the quantity of pesticides used is fairly small in relation to food throughput. Furthermore, there is considerable reliance on physical control measures such as electrified grid devices, wire mesh screens on windows, and double doors, which have contributed to a low incidence of infestation.

Of the organochlorine pesticides, only DDT and dieldrin were used, but confined to areas where contamination of food was unlikely. The preferred insecticides were pyrethrins and gamma-BHC for both control and prophylactic treatment. Arprocarb, diazinon, and malathion, were used to some extent and dichlorvos, rotenone, and carbaryl, used very occasionally. Fumigants were employed by few of the manufacturers visited.

4.3. Bacon Factories

There were 140 bacon factories slaughtering pigs in Great Britain in 1966, the year in which pesticide usage was recorded, and 5,123,584 pigs were processed. The Commodity Statistics Branch of the MAFF provided a sample of bacon factories which represented approximately 30% of the factories and 35% of the pig throughput.

Each factory in the sample was visited for the purpose of obtaining details of pesticide use.

In accordance with The Slaughterhouses (Hygiene) Regulations 1958 pesticides are employed in these factories primarily to control flies in areas concerned with the collection and disposal of viscera and manure. Use of pesticides is mainly outside buildings where no direct contamination of food is possible, and these have been listed separately in Table 8.

The results showed large variations between factories in the amounts of any one insecticide used both inside and outside buildings; however, the overall quantities of insecticides applied in bacon factories are relatively small compared with the throughput of food products.

Thermal vaporisers were used by three factories of those visited. The appliances at these premises discharged 8·5 lb of gamma-BHC into two carcase-handling halls and about 2 lb of DDT into one meat-cutting room during its operating period from March to October. Two more factories reported having used thermal vaporisers but at the time of the survey these had been replaced by electrified grid devices for the control of flying insects. Twelve of the factories visited had installed these devices some having one or more in each department but in general they were confined to the areas of meat preparation, pie making, and food wrapping, to control insects and prevent the risk of dying insects falling into food.

Table 8. Approximate amounts of insecticides used by all bacon factories in Great Britain during 1966

Insecticide	*Quantity used (lb)*	
	Inside buildings	*Outside buildings*
DDT	22	3
Dieldrin	1	—
Gamma–BHC	35	267
Malathion	60	67
Diazinon	35	—
Dichlorvos	14	—
Arprocarb	23	—
Pyrethrins	27	21

5. Other Industrial Uses

5.1. Tobacco Manufacturers

The major insect damage to stored tobacco can be attributed to the cigarette beetle and the warehouse moth. The ubiquitous nature of these pests necessitates constant vigilance and routine control measures wherever tobacco is stored.

The Tobacco Advisory Committee, which represents the major manufacturers in the U.K., provided the information on pesticide usage by the industry during 1965. This information is summarised in Table 9.

At that time member firms subscribing to the functions of the Committee produced about 90% of the tobacco goods consumed in the U.K. Imports of tobacco and tobacco manufactures during the year 1965 were 282 million lb. Dieldrin and gamma-BHC were the only organochlorine pesticides used. The very small amount of dieldrin used was applied exclusively as a lacquer to the inside of premises and gamma-BHC was used as a paint, spray, or in smoke generators. Spray formulations were used on the outside of cases and bales of tobacco, and on the walls, floors, and ceilings, of warehouses and factories. Great care was taken before treatment to protect tobacco from insecticide. Smoke generators were used in some warehouses in place of sprays, and in some factories under the floor boards of cigarette-making departments. Methyl bromide was widely used and applied to infested tobacco in fumigation chambers, under gas proof sheets, or in sealed infested rooms. Pyrethrins were also used quite extensively for fogging or spraying of sample rooms, warehouses, primary processing departments, and packing rooms. Small amounts of dichlorvos, diazinon, and ethylene oxide, were also used. It was not possible to determine the small amount of ethylene oxide used.

Table 9. Amounts of insecticides used by tobacco manufacturers in the United Kingdom during 1965

Insecticide	*Quantity used (lb)*
Dieldrin	19
Gamma–BHC . . .	127
Dichlorvos . . .	10
Diazinon . . .	5
Pyrethrins . . .	180
Methyl bromide . .	3,076

5.2. *Local Authority Use*

In 1964, the Advisory Committee on Pesticides and Other Toxic Chemicals, whilst investigating pesticide use in the Public Health and Industrial fields, asked the then 1,528 Local Authorities in England and Wales to give details of their annual consumption of insecticides and rodenticides. The present survey re-examined the completed questionnaires sent in by these Authorities, excluding pesticides used on humans or in parks, gardens, lakes, and on the sea shore. Although only a few Authorities provided quantitative data, 967 gave details of the pesticides used and of these 871 used insecticides. The number of Authorities using the common types of insecticides are given in Table 10. Because only a relatively small number gave sufficiently detailed information on the quantities used annually, these data were sampled statistically after stratification to give a balanced sub-sample. The totals in Table 11 were raised from these sub-samples.

The biggest single use of DDT and gamma-BHC was on refuse tips. The use of dieldrin was relatively small, but the main location of use was in close proximity to food in canteens, bakeries, etc. It is believed the use of dieldrin for control of cockroaches has diminished since 1964 due to the availability of diazinon and arprocarb.

Table 10. Insecticides used by 871 Local Authorities in England and Wales in 1964

Insecticide	*No. Authorities*
Aldrin	4
Gamma–BHC	599
Chlordane	75
DDT	647
Dieldrin	251
Malathion	349
Other organophosphorus insecticides .	19
Arprocarb	7
Pyrethrins	537

Table 11. Approximate total insecticide usage by all Local Authorities in England and Wales during 1964

Insecticide	*Quantity used (lb)*	
	England	*Wales*
DDT	21,450*	1,235
Dieldrin	170	10
Gamma–BHC	3,715	65
Chlordane	360	1
Aldrin	16	—
Malathion	1,360	70
Pyrethrins	180	20

* Includes 8,130 lb used on refuse tips.

5.3. Government Buildings

The MAFF and the DAFS are jointly responsible for the control of pests including insects and mites in Crown properties in Great Britain and provide a service for this purpose.

The type and number of insect infestations occurring in Government buildings reported in one year to the MAFF regional pests organisation in the London area are given in Table 12. The number of treatments carried out at airports and at buffer depots (which contain Government stocks of home-milled flour and other commodities) are also given individually in parentheses. About 40 per cent of the treatments were in premises storing food.

The total quantity of all insecticides used by the MAFF and the DAFS in Government buildings and airports during a twelve month period is given in Table 13. Insecticides used in prisons and borstal institutes is proportionally high compared with Government buildings as a whole and is therefore presented separately. Dieldrin was invariably used for cockroach control principally in the form of a lacquer in kitchens and food stores. It was also used as a dust in heating ducts, air vents, cavity walls, and boiler rooms, which often serve as centres of infestation. Chlordane was used against ants, often outside buildings, and to a lesser extent to control cockroaches. DDT was used primarily against flies.

Table 12. Treatments carried out by the Infestation Control London Office of MAFF during 1966 and 1967

Type of infestation		*No. infestations treated*	
		1966	1967
Kitchens, canteens, refreshment rooms, and food stores	Cockroaches	46+(20)	43+(11)
	Flies	37	19
	Ants	21	16+(1)
	Other insects	20+[6]	14+[1]
Premises not connected with stored food	Cockroaches	34+(10)	29+(4)
	Flies	27+(4)	25
	Ants	64+(8)	35+(1)
	Other insects	56	39

Figures in parenthesis: ( )—Airports, [ ]—Buffer Depots.

Table 13. Insecticides used by MAFF and DAFS in Government buildings and some airports in a twelve-month period during 1965 and 1966

Insecticide	*Quantity used (lb)*				
	Buffer depots	*Airports*	*Prisons and borstals*	*Crown properties*	*Total*
Aldrin	—	—	1	1	2
Arprocarb	—	8	9	2	19
Chlordane	1	5	21	93	120
DDT	1	—	26	40	67
Diazinon	—	—	1	2	3
Dichlorvos	—	1	5	11	17
Dieldrin	—	1	32	30	63
Endrin	3*	—	—	—	3*
Gamma-BHC	37	1	33	36	107
Malathion	1	—	8	22	31
Pyrethrins	2	1	9	11	23
Trichlorphon	—	—	1	—	1

* Used as a rodenticide.

5.4. British Rail

The Scientific Services Division of the British Railways Board provides a service to British Rail for the disinfestation of all thirty-three British Transport hotels, and 340 catering outlets at 200 stations and depots. It also provides this service for British Rail's hostels, warehouses storing infestable foodstuffs, and ships operating from Parkestone Quay. The total quantity of insecticide used in these locations during a twelve-month period in 1966–1967 is given in Table 14. The quantity of insecticide used on the ships and in warehouses storing food is unknown, but it is thought a significant proportion of the material was used in hotels, refreshment rooms, and canteens, where the risk of insect infestation requires the regular use of insecticides often in close proximity to areas of food preparation.

The Scientific Services Division is also responsible for timber preservation in some areas on railway property. It is known that dieldrin, gamma-BHC, and pentachlorophenol, were used for this purpose by the Division and by specialist contractors in 1967 but no records exist for the quantities used.

Herbicides were applied extensively by special spray trains to keep most of the 475,000 acres of running lines and sidings of British Rail free from plant growth. Details of the quantities of each herbicide used were given to the Advisory Committee by the commercial organisations applying the materials, but only on the understanding that these details would not be revealed to third parties. It is, therefore, only possible to state the total weight of all active organic herbicide materials used for this purpose in 1967 was 94 tons.

Table 14. Amounts of insecticides used by staff of British Railways Board in a twelve-month period during 1966–1967

Insecticide	*Quantity used (lb)*
DDT	480
Gamma-BHC	130
Chlordane	45
Malathion	59
Diazinon	18
Pyrethrins	4

6. Summary and Conclusions

The results of the surveys have provided data showing that in those fields of food storage examined, the quantity of pesticides used is small in relation to the quantity of foodstuff treated or at risk of contamination by pesticides. Furthermore the persistent organochlorine pesticides under review have been shown to be little used. Notable exceptions were the use of 1·5 cwt of dieldrin and 9·5 tons of DDT by Local Authorities and the use of at least 2 cwt of dieldrin in the passenger and crew sections and victualling stores in some 1,900 ships while in British ports. It is believed however that the present use of dieldrin is less than at the time of the surveys because of the availability of and a developing preference for dichlorvos, arprocarb, and diazinon.

It was satisfactory to note a small trend towards mechanical control methods such as electrified grid devices for the control of flying insects.

In general, the surveys reveal no reason for concern over the use of pesticides in the fields examined. The surveys are being continued in other fields of food storage and industrial use not included in this report.

7. Acknowledgments

The information contained in this report could not have been obtained without the goodwill and generous co-operation of Commercial Firms, Trade Associations, Local Government, and Government Departments. Particular thanks are due to the many individuals too numerous to mention who sought for and provided the quantitative details of pesticides used. Among those who either provided data or agreed to it being sought were:—

Port of Bristol Authority, Port of London Authority, Port of London Health Authority, National Farmers Union, National Association of British and Irish Millers Ltd., National Association of Corn and Agricultural Merchants, National Federation of Corn Trade Associations, Seed Trade Association of the United Kingdom, British Bacon Curers' Federation, Cocoa Chocolate and Confectionery Alliance, Tobacco Advisory Committee, British Railways Board, British Pest Control Association, Atra Ltd., Charlton Meads (Pest Control) Ltd., Chipman Chemical Co. Ltd., Contra-pest Service Ltd., Co-operative Wholesale Society Ltd., Etoxin Ltd., Fisons Pest Control Ltd., P. & O. Lines Management Ltd., Ratsouris Ltd., and Rentokil Laboratories Ltd.

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