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Turning DDT into ‘Didimac’: Making insecticide products and consumers in British farming after 1945

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ABSTRACT

This paper examines the adoption of DDT and other insecticides in British farming after 1945 to consider the notion that new synthetic insecticides were taken up rapidly. It shows that the uptake of chemical insecticides during the 1940s and 1950s was slower in many agricultural sectors than accounts have often suggested, and slower than the uptake of other agrochemicals, such as herbicides. Importantly, this paper shows that the extent of use before 1965 varied a great deal according to crop or farming sector and also according to the type of insecticide product. Historians have not sufficiently engaged with the fact that farmers did not purchase the raw chemicals, DDT or BHC, they bought insecticide products – a diverse range of formulations for spraying, dusting or the treatment of seeds. This paper shows how the adoption of insecticidal products on a large scale in the post-war period resulted from various types of work by business and government. The very close relationship between state and business gained its legitimacy from its location in a historical moment in which greater output and efficiency in farming had become a national goal.

KEYWORDS

DDT; BHC; insecticides; farming; Britain; 1947 Agriculture Act; users

Introduction

Does the uptake of DDT by farmers in the post-war period require re-examination? The existence of a large scholarship on the history of DDT would suggest not. The narrative of the rise and fall of DDT appears well established – after release to the Allies during the war, DDT gained its reputation as a miracle weapon in insect control when it was used to control a typhus epidemic in Naples in 1943.¹ After the war, we are told it enjoyed a period of rapid and widespread deployment in homes, forests, farms and as part of a global campaign to eradicate malaria, before its dangers were finally brought to wide attention by Rachel Carson.² If we look for the reasons for the speed and extent of the deployment of DDT (a frequently used term to describe its use is ‘indiscriminate’), historians tell us that DDT was considered a ‘wonder weapon’ in the fight against insects as it was more potent than any existing insecticide, and it was cheap and easy to make. With respect to its agricultural use, we are told that DDT met the demand from farmers for new, and better, pest control treatments as they strived to increase production.³ While there is very little work that is concerned specifically with the use of insecticides in British

agriculture, some historians have implied that the British story is largely the same as the American one, in which rapid uptake of synthetic insecticides was driven by enthusiasm for the new chemicals amongst farmers who had heard of the wartime triumph of DDT.⁴ Others, however, have indicated that the British experience might be different. Paul Brassley has suggested that widespread insecticide use in Britain did not begin until the 1960s.⁵ Peter Morris has argued that in total, DDT was consumed on a much smaller scale in Britain in comparison to the US, although it is important to note that an analysis of the British case requires inclusion of the full range of chemicals in use, not least the BHC (benzene hexachloride) products developed by Britain's largest chemical firm, ICI.⁶

The existing scholarship does not include many statistics charting changes in the use of insecticides over time so claims about the speed and extent of uptake after 1945 lack much illustration. Historians have relied a great deal on the statements made by actors around 1945 that DDT was the 'atomic bomb of insecticides' in order to claim that uptake was widespread and attitudes were uncritical.⁷ Clearly, this raises the question of whether there has been a tendency to conflate the celebration of DDT at the end of the war with widespread use.⁸ The moment in which new synthetic insecticides such as DDT had a substantial impact on farming in Britain is highly unlikely to be 1945, or even 1950. As Svante Lindqvist and David Edgerton have pointed out, there may be decades between the moment in which an innovation is released and the time in which a technology has become so embedded that its use is routine and its impact is largest, in economic or social terms.⁹ The point is, if we wish to make claims about the transformative effects of DDT, then we should be seeking to determine how and when these chemicals became fully incorporated into farming so that they exerted their greatest influence on productivity and posed their biggest risk to the environment. Our aim in this article is to explore how insecticides came to be incorporated into farming practice in Britain, and at which point it might be correct to describe use as 'routine' or 'widespread'. Many people wrote about the novelty of DDT in the second half of the 1940s and made predictions about its power to revolutionise agriculture; this flurry of interest should not be taken as an indication of the extent to which the new chemical was in use. At this early moment in the history of DDT, the chemical existed more in the minds of the scientists, the press and the public, than it existed in the fields of Britain.

Rather than assuming that the supposedly superior technical qualities of DDT, BHC and other chemicals is sufficient explanation for their widespread use, this paper approaches the adoption of insecticides in Britain between 1945 and 1965 as something that requires investigation. It begins with an exploration of the timing and scale of uptake of insecticides in farming after 1945.¹⁰ We focus on the speed and extent of adoption of chemicals for pest control by growers of fruit, vegetable, and arable crops. This analysis confirms Brassley's suggestion that, taken as a whole, the widespread use of synthetic insecticides in British farming occurred more slowly than often implied, and later than the uptake of other practices or innovations that farmers in Britain adopted after 1945, such as new machinery and other synthetic agrochemicals. Rapid and widespread use in farming was not the accompaniment to the numerous articles marvelling at the power of DDT that emerged in the press in the second half of the 1940s. Insecticides were not even the most important component of the so-called 'Chemical Revolution' in farming in this period¹¹ – weedkillers and inorganic fertilizers were taken up on a larger scale, earlier on.

Behind the finding that the incorporation of synthetic insecticides into routine practice in agriculture took several decades to occur, the data also reveals some important features of the story of uptake. One is that the speed at which new chemical forms of insect control were adopted varied a great deal according to crop, with the growers of hops and fruit being quick to apply DDT and other synthetics in the post-war period, and the growers of cereals changing their practice more slowly. A closer look at this variation offers insight into the factors that were most important in determining the adoption of synthetic insecticides in farming in Britain. One key determining factor was whether farmers had been engaged in chemical pest control prior to the advent of DDT. Cereal growers in Britain were not great consumers of insect control products before World War Two; they farmed in ways that tried to mitigate pest problems, but generally accepted that insects might cause some loss of crop yield. For this group, DDT was not the answer to a problem, as the problem had yet to be fully formulated. The technologies that were adopted most quickly after 1945 were often substitutes for a pre-existing technology or activity and their attraction lay in the way they saved money, labour and time: tractors, inorganic fertilizers and weedkillers. In contrast, for some groups of farmers, insect control was a new activity and an additional cost. We explore the ways in which a range of historical actors set out to address the issue of how to turn farmers who had not previously engaged in chemical insect control into users of novel compounds, using unfamiliar equipment and techniques.

Another aspect of the pattern of adoption that is important is that some types of product were adopted more rapidly than others. By 'product', we refer to one of a number of different categories of formulation that had been developed for the application of insecticidal ingredients. DDT, for example, was turned into a range of products, including Didimac 25 which was created and marketed by Plant Protection Ltd. Farmers bought concentrated liquid Didimac 25 and diluted it, and sprayed it, for the control of pests, such as caterpillars on their cabbages. The scholarship on DDT tends to only refer to insecticidal spraying, but chemical manufacturers also produced smokes, dusts, granules, and dressings for seeds, each of which had been designed to control a particular pest on a particular crop. (It is important to bear in mind that DDT did not in fact kill all significant agricultural pests; one factor driving the increasing diversity of chemicals on the market in the post-war period was the search for something that controlled every pest on the farm). In terms of the types of products available: sprays were useful for applying pesticides to the leaves of plants, but they were no good for tackling soil-dwelling organisms, for example, where seed treatments might be needed. In the second half of our paper we argue that it is wrong to assume that the new insecticides, such as DDT and BHC were easy materials to use. The evidence we have – from farmers, contractors, manufacturers and government advisors – shows that many farmers found effective application of insecticides to be a complicated business in the decades after World War Two. Data on the speed and extent of uptake of synthetic insecticides, broken down by type of product, shows that some products were found to be more convenient and were taken up faster.

Widespread uptake involved the transformation of raw chemicals that could be tricky to apply effectively and were often hazardous, into carefully formulated and standardised products that were easier to deploy, and supposedly safe to use by

farmers (if they adhered to the instructions). The first two decades after 1945 constituted, in fact, a long process of scientific and technical innovation involving not just the development of products that used DDT and BHC as their active ingredient, but also the refinement of the equipment needed for application, and the development of regimes of use that farmers should follow. These regimes of use comprised instructions on how much product to use (the dosage), the right moment in the growing season for application, the need to avoid use under certain weather conditions, and the precautions that needed to be taken to protect labourers and farm animals, and then later, wildlife. The uptake of new technologies is often facilitated by networks of actors who introduce users to innovations and help them navigate the complexities of use.¹² In the case of insecticides, a socio-technical system emerged in the post-war period to support farmers as they worked to negotiate the complexity of an increasingly diverse market of products, and also the epistemological and technical demands placed upon them in selecting the right product and applying it effectively. This socio-technical system included a large network of advisors from both government and business who visited farmers and proffered advice that was tailored to the requirements of their farm. It also included industrial scientists who tested chemicals against pests and worked out the best dose and formulation, government scientists who evaluated the claims of manufacturers, and marketing experts who attempted to foster trust in products.

The activities of these people operated collectively to assert that there was a correct way to use the new insecticidal products. With reference to the scholarship produced by sociologists and historians of technology that has sought to show how ‘users matter’ for the ways in which they shape the meanings and functions of technology, this paper shows that a system emerged in Britain after 1945 to create and enforce the idea that there was a ‘right way’ to use synthetic insecticides.¹³ The goal was not just to persuade farmers to adopt a new practice or product, but also to ensure they used it in a particular way; an attempt (albeit not always successful) at shutting down too much interpretation or innovation on the part of farmers. The risks associated with incorrect use included not just the fact that the insecticide could be ineffective as a pest control agent, wasting money and eroding confidence in the new chemicals, but also the possibility of harm to farm labourers and animals. An analogy was sometimes made with medicine. Here, patients (users) submitted to the expertise of a doctor who diagnosed their ailment, identified the cure, and specified the drug regime that should be followed. A high degree of compliance with the specified regime was also required of farmers, with the added complication that they were expected to make the right initial diagnosis in their fields, under sometimes difficult conditions, and judge for themselves the right timing for application. Hence, the complex of advisors, from business and government, and the leaflets, lectures and demonstrations, that aimed to equip farmers with the knowledge they needed to improve output on their farms, including identifying pests and applying controls appropriately. This was a system that had at its heart the education and disciplining of users in order to promote a particular vision of what constituted good (safe and efficacious) use.

Why did this particular complex of actors emerge in the post-war period in Britain? Why did the socio-technical system that supported insecticide use have the character that it did? Studies of users do not always engage with wider political and economic contexts,

but these contexts were key in the case of insecticides and British farming. One of the most striking features of the apparatus that worked to facilitate the uptake of insecticides in Britain after World War Two was the very close relationship that existed between government and the agrochemicals industry. Increasing productivity on British farms became national policy in peacetime with the passing of the 1947 Agricultural Act which set targets for the expansion of certain products, including cereals.¹⁴ Government declarations on the role that domestic agriculture would play in ensuring greater self-sufficiency in food and improving Britain's balance of payments position, spoke of the need of farmers to adopt innovation and reduce waste. Close collaboration between industry and government was celebrated by officials as the means to achieve the aim of modernising British farms. The post-war period, was then, a time in which the search for profit by chemical manufacturers aligned with a national programme of agricultural expansion and an appeal for farmers to operate with greater efficiency. As one commentator put it in 1952, 'in Britain today scientist, farmer and industrialist cooperate to achieve an aim beneficial to all – the control of pests and the raising of production'.¹⁵

From celebrity to mundanity

In this section, we consider the data that was collected on the uptake of insecticides in British farming after the end of World War Two in order to evaluate the idea that DDT was adopted rapidly by British farmers.¹⁶ Determining a good measure of use is not easy; the data that is available on the uptake of insecticides in Britain after the end of World War Two is often piecemeal and the result of a variety of approaches to measuring the application of chemicals.¹⁷ Nonetheless, the information we have tells a remarkably consistent story, and one that is supported by other types of source, including oral testimony. The statistics that were compiled up to around the mid-1960s showed the area of crops treated with various pesticides, from which we can estimate the proportion of farmland treated. From this data, we can see that the coverage of farmland in Britain by synthetic insecticides did not reach anything like completion in the first two decades after 1945. There were exceptions, involving particular crops and types of insecticide, but insecticides are not shown in the data to have been important for every sector of British farming before the 1970s. A major Royal Commission report on agricultural pollution showed that 'pesticide treatment of crops' was almost universal by the mid 1970s, but even at this point insecticides were not used as widely as they would be in later years.¹⁸ The reason is that 'pesticides' was a category that included both herbicides and insecticides, and the adoption of the former occurred more quickly and extensively than the latter. Behind the headline finding that it took at least three decades after the end of World War Two before the use of insecticides can be described as widespread or routine across all of British farming, there are some important patterns in the data that require attention if we are to grasp how synthetic insecticides were deployed.

There are no comprehensive official figures on the use of pesticides in Britain before 1965, when the Ministry of Agriculture, Food and Fisheries established a Pesticide Survey Group (PSG). Even after this, overall coverage is intermittent as surveys tended to be focussed on particular sectors, and do not provide a cross-farming-sector overview before the mid 1970s. The information that is available does show, however, that pesticide use in Britain was fairly limited between the end of the Second World War

and the mid-1950s. In 1953, the Working Party on Precautionary Measures Against Toxic Chemicals Used in Agriculture (often referred to as the Zuckerman Committee),¹⁹ emphasised 'that at the moment only relatively small proportions of the total acreage of crops are treated'.²⁰ They later estimated that in 1953, 'about 2.6 million acres were treated with crop-protective chemicals'.²¹ There seem to be some omissions here,²² but the Working Party proposed that at a time when there were 18 million acres of arable land in Great Britain perhaps 15 percent of cropland was sprayed with pesticides. Of those 2.6 million acres, 'about 2 million were treated with hormone weedkillers'.²³ And only 346,000 acres were sprayed with insecticides, of which only around a third were treated with DDT. In 1959, the rural constituency MP Alan Farr used his maiden speech in Parliament to discuss the problems of chemical sprays and he estimated that since the Zuckerman report of 1953, the acreage sprayed had doubled to 5 million acres.²⁴ By this measure, which again included both herbicides and insecticides, no more than a third of British arable farmland was being sprayed by pesticides by the end of the 1950s.

It is important to note from this that figures published on 'pesticide' use can be misleading as a guide to the uptake of chemicals such as DDT as this information often combined data on weedkillers, fungicides and insecticides.²⁵ The more detailed information available to us shows that weedkillers were adopted significantly more quickly, and on a larger scale, than insecticides in the first two decades after 1945. If there was a post-war 'chemical revolution' in agriculture, it was not driven by DDT in the way that has been suggested.²⁶ The relatively rapid adoption of weedkiller was most likely as the new synthetic herbicides such as 2,4-D, were a convenient alternative to labour-intensive practices that had previously been used on many farms in Britain, such as weeding by hand, or horse-harrowing.²⁷ As we will show later, extensive pest control was not necessarily practised by growers of field crops before World War Two and so the new synthetics did not represent a cheaper or more convenient alternative in the same way.

This brings us to the next aspect of insect control that is revealed by the data. Insecticide use varied a great deal according to crop in the 1940s and 1950s. [Chart 1](#) shows the acreages of various crops grown in Britain and the proportion that was estimated to be treated with insecticides c. 1962–64.²⁸ Some minor crops were extensively treated, with multiple applications, while the major field crops received a lot less chemical treatment. Farmers of high-value crops, such as hops and fruit had often made investments in spraying equipment for the application of pest treatments during the interwar period.²⁹ These producers readily moved over to using the new synthetic insecticides and should be considered the early adopters of DDT and BHC in Britain. In other sectors, however, notably cereal production, where the value of the crop was less than in the case of fruit or hops, most farmers did not own spraying apparatus in 1945 and there was not necessarily any well-embedded culture of pest control. As one agrochemical industry advisor who grew up on a farm said of his parents, 'I don't think they had a sprayer until probably ... into mid '60s, I suppose ... nothing was done about pest control ... it just took its course'.³⁰ In 1960, a National Farmers Union representative told a weed control conference that treating crops with chemicals was 'if not something unnatural, at least something very different from all traditional husbandry practice'.³¹

Apart from significant variation between different farming sectors in terms of the speed of uptake of insecticides, the data available also shows that some insecticide products were adopted much more rapidly than others. During the 1950s, the most

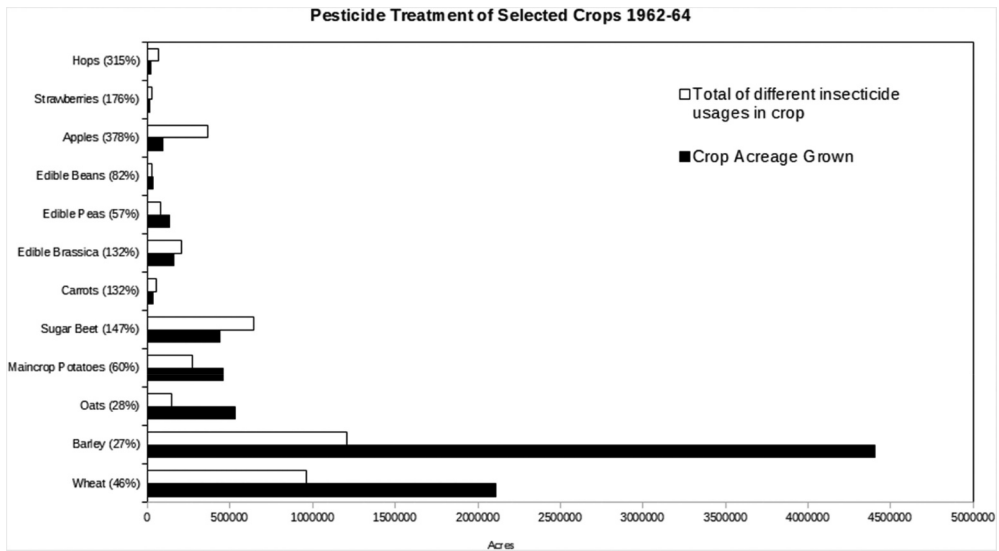


Chart 1. Pesticide Treatment of Selected Crops in England and Wales, 1962–1965 showing total basic acreages receiving both seed treatments and sprays. Chart by authors based on data provided in C. Potter, A.H. Strickland and R. Bardner, 'The use of pesticides and fungicides for plant protection in British agriculture', in *Chemicals and the Land in Relation to the Welfare of Man, Proceedings of a Symposium held at the Yorkshire Institute of Agriculture* (Yorkshire Agricultural Society: 1965).

widely used insecticides were seed dressings, usually comprising the insecticide, BHC, combined with mercury as a fungicide, and coated onto seeds before planting. In 1958, about 2 million acres of British arable crops were reckoned to be treated with insecticidal seed dressings, 'greatly exceeding the combined acreage of crop treated by all other methods of application'.³² By the early to mid 1960s, insecticides were applied to 3 million acres as seed dressings, but only 1.4 million acres as sprays or dusts.³³ Seed dressings have been largely ignored by historians, aside from their effects on wildlife, nor were they counted in early official estimates. Clearly, the preference shown by farmers for this particular type of insecticidal product requires explanation. It is also important to note from this the fact that this history of insecticidal seed treatments is not a history of DDT, but the widely used alternative, BHC.³⁴ The early history of synthetic insecticides in arable farming in Britain is therefore not a history of the deployment of DDT.

The official data gathered in Britain indicates that the 1960s and 1970s were the key period when pesticide application was becoming standard practice in most sectors. Discounting fodder, forage and seed crops, by 1975, 99 percent of crops in England and Wales were calculated to have been treated with pesticide at least once,³⁵ although overall pesticide usage continued to rise after this, as crops were often treated multiple times and these figures cover both weedkillers and insecticides.³⁶ The moment at which synthetic insecticide use became routine is probably later. According to agricultural historian John Martin, expenditure on pesticides in Britain peaked in the mid-1980s.³⁷

Understanding that the uptake of insecticides did not occur rapidly across all sectors of farming in Britain raises the question of how British farmers came to view synthetic insecticide use as an essential part of their repertoire of activities. It requires us to

consider the work that had to be done before farmers of cereals, for example, moved from a place where they accepted in some years a pest problem might reduce yields, to one in which they were using new equipment and new products to carry out novel operations against insects on their farms.

Some commentators of the 1950s described farmers in Britain as naturally conservative in their attitudes towards innovation.³⁸ Importantly, however, as Brassley has previously discussed, British farmers were not slow to adopt new technology in the two decades after 1945.³⁹ For example, farmers became major purchasers of artificial fertilisers⁴⁰ in the post-war decades,⁴¹ spending far more than they did on pesticides.⁴² On the whole, they also embraced mechanisation. In 1946, there were about 180,000 tractors and 3,200 combine harvesters on farms in England and Wales; in 1956 there were 426,000 tractors and 31,000 combines.⁴³ Yet farmers do not seem to have purchased sprayers as enthusiastically. According to one estimate, in 1946, excluding fruit sprayers, 'there were only 3,440 wheeled and tractor-mounted sprayers on farms in England and Wales', and about 32,900 by 1956.⁴⁴ While the rate of increase for sprayers was higher than that for tractors, the actual number of spraying machines in operation was much smaller (the rate of increase does not, of course, tell you the absolute numbers in existence). To put the available figures into context, in 1946 there was about one 'wheeled and tractor-mounted sprayer' for every 100 farms over five acres in size, compared to one tractor for every two farms. In 1956, it was more like one sprayer for every 10 farms, whereas there were one and a half times as many tractors as there were farms.⁴⁵ British farmers were willing to invest in new technology on a substantial scale after 1945, but the available sources strongly suggest that the adoption of synthetic pesticides was not occurring on the same scale as that of other innovations between 1945 and 1960.

Counting insects, creating pests, calculating costs

Before the Second World War, routine pest control in Britain was mainly confined to the fruit and hop growing sectors. Writing in the 1970s, the influential ICI economist George Ordish reflected that during the 1920s and 1930s pesticides were,

only used on the high value per acre crops, fruit, hops, market garden and glasshouse produce. Field crops, with two exceptions, were hardly treated at all, the exceptions being turnips and other brassicas which might be dusted with derris compounds against the flea beetles, and the seed-dressing of cereals. Treatment was too expensive for most other crops.⁴⁶

In the case of wheat, oats and barley, the relatively low value of the crop meant farmers did not generally invest their time in pest control or buy equipment. It is unlikely that most farmers in this sector received news of the release of DDT and BHC with eager anticipation in 1945. The question that emerges from the data available on use is how Britain's arable farmers were persuaded to adopt new insecticidal products over the course of the 1940s and 1950s if they had not previously engaged in chemical insect control on any significant scale. In this section, we show how government and business worked to foster a culture of pest control by helping farmers to visualise the insect pests on their land, and by putting a value on the losses that farmers might incur. A turn to

surveying the prevalence of pests and assessing the costs of insect damage was driven by wartime exigency and then a programme of national agricultural expansion in the post-war period.

Plant-eating insects are not necessarily pests from the perspective of a farmer, an insect only becomes a pest when its activities can be shown to reduce the value of a crop.⁴⁷ The definition of an acceptable level of insect/pest, however, varies; the value of apples may be affected by any visible imperfection, but this is not the case for oats. During the 1940s entomologists in Britain, both those employed by firms that promoted insecticide use and those engaged by government, worked to bring insect pests in Britain to the greater attention of farmers. Increasing the visibility of pests through farm surveys, handbooks and other literature was an important first step in encouraging farmers in sectors not generally occupied with insect control to take steps to limit damage and loss. Government and business combined to meet the goal of identifying economically important pests, developing reliable control methods and persuading farmers to adopt them. The key context for this collaboration was the 1947 Agriculture Act which set targets for increasing domestic output in farming. Government promoted the idea that the goal of greater self-sufficiency in food was to be achieved by expansion in cultivated land, a process begun before the war, and improvements in farming efficiency. Farmers were given various incentives after 1947 such a guaranteed minimum price for their crops, and grants for farm improvements. Historians suggest that price stability produced by the act helped encourage farmers to make investments to increase outputs, including taking measures to control pests.⁴⁸

While the close relationship between government scientists and farming advisors, and the agrochemical industry, has subsequently been criticised by writers, it was claimed at the time as a partnership that was essential for the project of feeding the nation at a point when rationing was still in place and Britain's poor economic position made imports difficult. The rhetoric that pesticides were an illustration of the way that science 'served the needs of humanity' was important in legitimizing the collaboration between the state and business. Chemical manufacturers, government scientists, spraying contractors and farmers could all claim to be playing their part in increasing national self-sufficiency in food, as well as helping to feed the world. The key context to understanding the uptake of pesticides after 1945 was the particular entanglement of state-led programmes and the ambitions of the chemical industry that characterised post-war Britain. This was a moment in which the aims of business aligned with a political vision of agricultural transformation.

The collaboration between business and government worked in various ways after 1945, including bringing pests to the attention of farmers. The Ministry of Agriculture and Fisheries (MAF) estimated the density of major pests of cereals, brassicas, and root crops by surveys across England and Wales (Scotland and Northern Ireland had their own authorities), aiming to link levels of 'infestation' with figures on the loss of yield. Armed with information from the surveys, advisors from MAF's National Agricultural Advisory Service (NAAS) would be able to tell farmers which of their fields had high levels of a particular pest so that they might modify their practice, and then increasingly during the 1950s and 1960s, use one of a number of insecticide products. While these surveys were intended to provide evidence that would underpin advice and action, they also had the effect of making visible something that had often been unseen or ignored.

The aim was to assess the number of insects with the potential to cause trouble that were present in the soil, in the hedgerows, on stems and under leaves: these surveys produced pests.

The first major survey of an insect pest in Britain was the National Wireworm Survey that ran between 1939 and 1942.⁴⁹ Wireworms are the larvae of soil-dwelling species of the click beetle and they harm crops by eating roots, including potatoes, and burrowing into the seeds and stems of cereals. Click beetles prefer to lay their eggs in grassy ground and so regular cultivation can reduce the level of infestation. The timing of the national wireworm survey was significant as wireworm grew as a problem as uncultivated land was ploughed up for food production during the war. The aim of the wireworm survey was to sample fields and determine the level of wireworm infestation. Farmers could then avoid sowing vulnerable crops in locations where pest densities were assessed as high, reducing waste of effort.⁵⁰ Similar surveys for England and Wales were begun in 1946 to study the density of other pests considered to be of economic importance: cabbage aphid, mangold fly, leatherjackets and frit fly.⁵¹ These surveys were coordinated by the MAF's Plant Pathology Laboratory at Harpenden; the most important government laboratory for the investigation of agricultural pests and their control in this period, and one that had a close relationship with industry.

The government-funded pest surveys of the 1940s can be seen as attempts to map the prevalence of pests that threatened crops which had not traditionally been subject to chemical treatment, in contrast to the pests of orchards and glasshouses. The wider goal was to improve the efficiency of farming. The idea that crop protection formed part of the farmer's duty was deployed by both the government and firms that hoped to sell insecticides or spraying services during the 1940s and 1950s. The company Pest Control Ltd published a handbook for farmers in 1950 with the aim of persuading them to use the contract spraying services of the firm. It warned that, 'a farm which has become infested with weeds and a breeding ground for pests of all kinds is not merely a farm half-farmed, but it is a capital asset which has become seriously depreciated'.⁵² Pest Control Ltd instructed farmers to consider the costs of failing to tackle the pests that plagued them, 'Even moderately severe outbreaks of greenfly [on peas] may cut down yields by 4 to 5 cwt per acre, which at present prices means a loss of £10 to £13'.⁵³ The company produced its figures on the potential cost of pest damage by extrapolating from the results of its work with individual farmers.

The idea that Britain's farmers needed greater exposure to figures on the financial cost of pests if they were to be persuaded to make investments in insect control was taken up by George Ordish in his influential book of 1952, *Untaken Harvest*. Ordish was an agricultural economist who worked for Plant Protection Ltd, the subsidiary of the chemical firm ICI, at its Fernhurst Research Station.⁵⁴ *Untaken Harvest* described the insect problem that American and British farms were facing, before estimating the financial loss to farmers in Britain of neglecting pest control. Ordish used a cost/benefit analysis to argue that farmers needed to be told that spending x amount of money on insecticides would ultimately save them y. Apart from making good financial sense, Ordish also invoked the notion that making use of pesticides formed part of a farmer's

duty to farm efficiently. Farmers were engaged in a contract with the government in which they received unprecedented levels of support, and in turn they were expected to reduce waste.

The guaranteed price assumes a certain standard of efficiency in farming, and it includes a certain amount of routine plant protection work. If, in return for the guaranteed price, a farmer does not farm efficiently ('in accordance with the principles of good husbandry'), he can be penalised, and even deprived of his farm.⁵⁵

The power of Ordish's argument lay in the way he put a monetary value on the loss of yield due to insect pests. This approach was also promoted by A.H. Strickland, a government entomologist who joined the Plant Pathology Laboratory in 1950 with the mission of transforming its methods. Strickland wished to see a more accurate calculation of the losses experienced by farmers in Britain through improvements in the techniques and approaches used by the Laboratory.⁵⁶ During the 1950s, Strickland re-orientated the national pest surveys towards a smaller number of more accurate studies that would begin to map the relationship between pest density, yields and a complex range of factors encompassing weather conditions, water content of the soil, the size of field and the growth stage of the crop. In addition, insect pests and insecticides were studied in experimental plots at the Laboratory. In both cases, there was often close collaboration between MAF scientists and the insecticide companies, who passed on samples of their products and spraying equipment.⁵⁷ The systemic insecticide Schradan, for example, was used in 1955 to create control plots in an experiment investigating the impact of aphids on the yield of sprouts. Demonstrating the shift towards quantifying the damage done by pests, Strickland reported the results by saying, 'it is now clear that cabbage aphid has, over the past 10 years, cost the sprout grower between £ ½ m. and £1 ½ m. per annum, the average annual loss being £868,000. In acreage equivalents this means that the aphid annually destroys the marketable yield of about 7,500 acres'.⁵⁸

During the 1950s, the results of pest surveys and experiments at the Plant Pathology Laboratory informed the advice that NAAS gave to farmers, in person, and in the increasingly large number of pamphlets on common agricultural pests and diseases produced by MAF. Advisors could now survey a farmer's field to tell him how much of a threat the presence of certain insects were to his crops, in quantitative terms. The figures generated by the work of entomologists and NAAS advisors also informed the claims of manufacturers of insecticides, in their advertisements in the farming press, and in their handbooks and product guides. British farmers of the 1950s could be in no doubt about the nature of the insect threat that hid in their fields and on their plants. By the 1950s this threat had an economic value attached to it, and farmers were increasingly exhorted by both government advisors and salesmen to purchase pest control products or services using figures that suggested how much money they could save. By the late 1950s, the pest problem in Britain had gained an unprecedented visibility; it was drawn on maps, quantified in tables, and it was costed in terms of expenditure and yields. The construction of insects as pests was the creation of a target for action. While we might co-exist with insects, perhaps unwittingly, pests require a response of some sort. In the case of insects of agricultural significance, the use of insecticides and the construction of pests became mutually supporting ventures over the course of the 1950s.

Making products and providing services

The adoption of synthetic insecticides by farmers was not fuelled by increasing awareness of the extent and cost of pest damage alone. Large-scale take-up of the new synthetic insecticides by British farmers in the post-war period required the adoption of many new practices, ones that had not previously been part of their calendar of activities. The expanding sector of cereal growing, for example, did not have a well-established culture of chemical pest control before the Second World War. Farmers had little experience of purchasing insecticidal chemicals or services, they did not necessarily own spraying equipment, and they had scant knowledge of the sort of regime required to tackle pests in their fields, in terms of the mode, or timing, of chemical application.

We might expect that the history of the increasing use of insecticides in Britain after 1945 to be mainly a story of educating farmers, beginning with the work done to construct insects as economically significant, but tractable, pests, as outlined in the previous section. While this is true to some extent, focussing on advice and education would miss the important fact that the chemicals available in 1945, DDT and BHC, were not yet fully formed agricultural products. The raw chemicals of DDT and BHC were not used by farmers on their fields; these chemicals needed to be tested on a range of pests to determine their efficacy; compounded into dusts, solutions, smokes and seed treatments; and an appropriate spraying, drilling, or dusting regime determined.

This section is concerned with the scientific and technical work that was done by the agrochemicals sector to turn 'difficult to use' raw chemicals into something more like the ideal of 'easy to use' products after 1945. It shows that for actors in the 1940s, using DDT and BHC as pest control agents was neither straightforward, nor necessarily cheap when we consider the cost of spraying equipment, and widespread use was dependent on the resolution of a number of scientific and technical issues.

Many of the early obstacles to the uptake of insecticides on British farms can be illustrated by examining the story of the company Pest Control Ltd. Pest Control Ltd was formed in 1939 by two entomologists, Dr Walter Ripper and Sir Guy Marshall. Prior to forming the company with Marshall, Ripper had worked for the US Department of Agriculture researching the natural predators of pests that posed a threat to crops that had been imported to the USA from Europe.⁵⁹ Marshall was an eminent government entomologist who had been head of the Imperial Institute of Entomology before retiring to go into business with Ripper. Between 1940 and 1950 the company's business model was one in which it did the work of selecting insecticides and spraying on behalf of farmers, on the basis that applying chemicals was difficult and hazardous, and the cost of purchasing equipment was high.⁶⁰ Pest Control Ltd was initially formed to take advantage of the wartime drive to increase agricultural production which, coupled with a shortage of farm labour, offered an opportunity for a firm willing to offer contract services for dealing with weeds and insects. In the post-war period, the company looked to sell its services to growers of the whole range of crops that were cultivated in Britain, both those such as fruit, where spraying was already well established, and those where it was not. The company foresaw a market amongst cereal producers for its services on the basis that these farmers, who had little experience of chemical spraying, were unlikely to purchase the necessary equipment themselves as they might only need to use it once per season.⁶¹

Ripper's vision for Pest Control Ltd was that it would act as, 'consulting entomologists and spraying contractors', providing a service akin to that of a doctor, 'It would diagnose the trouble, prescribe the remedy, provide the chemicals and carry out the operations necessary for a cure'.⁶² Pest Control's business was predicated on the notion that using insecticides correctly was difficult, and the easiest thing for a farmer to do was to call in an expert to undertake the work for him. Even expert entomologists needed to resolve a number of problems, however. One issue was determining if any of the available chemical treatments was actually effective against the insect pests the company had identified as a target. It turned out that DDT and BHC did not kill all the insects that farmers might encounter; DDT was better with some, and BHC was better for others, and there were some insects that were not much affected by either. As ICI magazine stated in 1951, 'No one will decry the splendid achievements of DDT . . . but it soon became evident that it was not the universal entomological panacea that world-wide publicity had first tended to make it appear'.⁶³

Testing synthetic insecticides against the wide range of insect pests that were present in British farms was a time-consuming process and even when chemicals seemed effective in killing pests, new problems could emerge. Experiments with BHC were done by ICI's agrochemicals' subsidiary, Plant Protection Ltd at its Jealott's Hill Research Station from 1942, where it was tested against various pests of hops, fruit, and field crops. Crops grown in experimental plots were cooked in a kitchen at Jealott's Hill and served to employees of the company, and this led to the discovery of the problem of BHC 'taint'; a musty or brick-like flavour that was particularly pronounced in potatoes.⁶⁴ The subsequent trials of BHC carried out by the company focussed on cereals, where the problem was not found.

Aside from matching a chemical to a pest, firms who had purchased or manufactured DDT and BHC for agricultural use had to determine the right dose of chemical, and whether to produce the treatment as a dust, smoke, or solution of some type. As an article in the *Fruit Grower* noted in 1946, 'The chemical DDT is not a finished insecticide; it needs to be "compounded" for use in the form of dusts or for application as a wet spray in the form of suspensions or emulsions'.⁶⁵ Pest Control Ltd. reported that their laboratory research in the early years after the Second World War amounted to nothing more than the 'formulation of chemicals'.⁶⁶

Identifying the best type of formulation was important as this affected how well the insecticide adhered to, or covered, a plant,

Dusts are prepared by combining a quantity of the insecticide with an inert diluent such as talc, clay, pyrophyllite or calcium silicate. A wettable powder is usually made by adding a wetting agent to a dust, which when mixed for use, forms a suspension in water. To make a liquid formulation, an insoluble insecticide must first be dissolved in an organic solvent and then either made up as an emulsion concentrate or as a miscible liquid, both of which form an emulsion when diluted with water for use. The quantity of actual insecticide in the formulation is varied to give concentration products of differing percentage. Formulation therefore allows insecticides to be applied either as dusts or as sprays. It allows very small amounts of actual insecticides being applied to large areas . . . The addition of wetters and spreaders helps to give a better cover of the insecticide on the plant. Formulation may also increase the effectiveness, penetration and the persistence of the insecticide. It may also affect its speed of action and sometimes even the species of insect controlled.⁶⁷

Alongside the work done to turn raw chemicals into pesticide treatments, Pest Control Ltd needed to master the operation of spraying equipment, which for field crops frequently comprised a large boom sprayer that could be towed or attached to a tractor. Spraying insecticides and weedkillers required consideration of a host of issues: nozzle type, droplet size, boom height, spray pattern and spraying angles. An insecticide had to be mixed in the correct proportion with water by operators in the field and then run through a machine at the right rate to give good coverage. This was not necessarily a straightforward process, as shown by this article on the problems facing farmers, from 1949,

To the scientist in his laboratory, one part in 1,000, 10,000 or more, presents no difficulty, but to the farmer with his primitive measuring tins, a gallon to an acre is frightening. Things of such power as this seem almost atomic and he fears that the smallest error will certainly lose him his crop and a major one blow him sky high.

The apparent slowness by farmers, landowners and horticulturists to adopt many of the new products of the agricultural chemist must have been disappointing to the discoverers of these wonders. But this reluctance to try something new is not so much conservatism, but rather that most of these new products have presented mechanical problems difficult for the would-be user to solve.⁶⁸

Early pesticide sprayers were high-volume machines that applied 300 gallons or more of diluted pesticide an acre.⁶⁹ Often expensive, the large quantities of water they required made them heavy and difficult to use in the field. Writing in 1951, E. Hick, head of ICI Fernhurst's Machinery Development Section, declared that 'Agricultural spraying has progressed slowly because of the huge amount of water required'.⁷⁰

Apart from the challenge of identifying an insect and matching it to the right treatment, Pest Control's business as a contractor was based on the notion that farmers would be reluctant to meet the costs of purchasing and operating their own spraying equipment, and that applying pesticides was difficult. In addition, the chemicals that were used in the 1940s could be very dangerous. The emergence of a new generation of herbicides and advances in spraying technology by the early 1950s, eventually forced the company to change its business model, 'Pest Control recognized, reluctantly and late, that the arrival of low volume spraying machines and "safe" herbicides would eventually remove a large part of the company's contracting base and machines'.⁷¹

The 1940s and early 1950s were a time in which both large chemical firms in Britain with a significant research capacity, such as ICI, and smaller companies selling services to farmers such as Pest Control Ltd., were engaged in the process of testing and trialling chemicals such as DDT and BHC in laboratories and fields with a view to identifying their uses, and the optimal method of deployment. Addressing the scientific and technical problems that were an obstacle to rapid take-up required work. Making insecticide use easier and cheaper involved the development of standardised formulations of chemical and carrier, tailored to a particular crop and pest, along with improvements in spraying technology. The obstacles that a farmer might face when contemplating pest control in the 1940s are illustrated by the success of a contractor such as Pest Control Ltd., who took on the epistemological and technical burdens associated with insecticide use. The development of a range of standardised products containing insecticidal ingredients and better technologies of application subsequently contributed to the decline of

the company's work as a contractor. While many of the early problems were resolved by the 1950s, a new form of complexity then emerged as the number of products available grew substantially, not least as new insecticidal chemicals were discovered and released. If farmers, rather than contractors, were to be the key actors in the application of insecticides then the next challenge was ensuring that they chose the right product and used it in the right way.

Making consumers

If individual farmers were to adopt insecticides, then products needed to be convenient and reliable. Farmers would not be persuaded to adopt pest control practices on a routine basis if they had bad experiences with new products. The issue was that effective insect control required farmers to select the right product, use equipment properly and engage with the recommended regime of use, adjusting for local conditions. George Ordish noted in 1950 that the wrong application methods, poor timing, bad weather, insufficient volume of spray, or re-infestation, could all cause pest control to fail.⁷²

While chemical firms had done a great deal to make insecticide use easier during the 1940s, it became clear during the 1950s that farmers could be confused by the sheer number of products available to them. In addition, while advertising stressed that insecticides provided easy routes to higher yields, the reality was that there was an optimum way to use products so that they were effective enough to prevent serious damage by troublesome insects (and therefore farmers trusted them as pest control agents), but did not pose a risk to other crops, wildlife, and farm workers. The problem with insecticide products that entered the market is that farmers were not merely required to adhere compliantly to a set of instructions, they had to interpret some directions for use in light of the particular conditions in their fields. The creation of a market for insecticides in Britain, where farmers routinely purchased chemicals, was one in which farmers were expected to operate as informed, disciplined but also active, agents.

During the 1940s, a large research effort had produced a variety of products containing BHC and DDT, and the first organosphosphates, with the emergence of a number of proprietary names that would become well established in the insecticide market, such as Mergamma or Pestox 3. ICI launched the seed dressing Mergamma in 1949 for the control of wireworm on cereals.⁷³ Seed treatments were popular with farmers, probably as they were so easy to use. Farmers purchased seeds that had been dressed with a mixture of BHC and mercury, or dressed seeds using their own equipment, and then sowed them in the normal fashion. This form of pest control did not require the farmer to make an evaluation of the vulnerability of their crop to pests at various points over the growing season, and time a chemical intervention appropriately.

While some farmers still relied on contract spraying, increasingly farmers were buying chemicals to apply themselves, using the more convenient low-volume sprayers that had become available, such as ICI's *Plantector*. Over the course of the 1950s and 1960s the range of insecticide products grew substantially. On the one hand, work continued to create products out of the existing insecticides, each targeted at a different pest so that Plant Protection Ltd marketed Mergamma A for the control of wireworm on cereals, and Mergamma B for the control of wireworm on sugar beet and mangolds. (See [Table 1](#) for

the range of approved products containing BHC in 1957). In addition, novel insecticide ingredients were being discovered and developed as products, including the Shell insecticides Aldrin and Dieldrin.

While an individual farmer would be unlikely to be interested in the whole range of insecticidal substances, many British farms at the start of the 'modern pesticides era' still operated a mixed farming model. A farmer might be in the market for a number of different treatments, each of which would require attention to the appropriate dose, application method, and timing. A study of the 1959 ICI *Farmer's Guide to Plant Protection*, reveals not only the variety of products recommended by a single company (11 insecticides, 3 fungicides, 9 weedkillers and 8 insecticidal and fungicidal seed dressings) but also the demands that the existence of a large and growing range of products placed upon the farmer. First, the same pest might be treated differently on different crops. Cereals could be protected from wireworm by Gamma-BHC seed dressings or dust, or Aldrin dust. However, as BHC gave potatoes an unpleasant taste, the only treatment for wireworm on this crop was Aldrin dust or spray. Second, a single crop might be vulnerable to a variety of pests, each with its own chemical treatment, applied at a particular moment and in

Table 1. BHC Products in 1957. Table by authors based on information provided in, Ministry of Agriculture, Food and Fisheries, *Agricultural Chemicals Approval Scheme. List of Approved Products 1957 for Farmers and Growers* (HSMO: 1957).⁷⁴

Formulation Type	Name of Firm and Product
BHC Dusts	Plant Protection 'Abol Gamma Dust'
	Tomlinson and Hayward 'Eureka Gamma Dust'
	Murphy 'Lindex Dust'
	PBI 'Flea Beetle Dust'
	Plant Protection 'Verdocide'
	Plant Protection 'Agrocid 1 (P.P. Flea Beetle Dust)'
	Plant Protection 'Agrocid 3'
	Plant Protection 'Gammalin Wireworm Dust'
	Day, Son and Hewitt 'Flea Beetle Dust'
	Shell 'BHC Flea Beetle Dust'
BHC Sprays (Miscible liquids, emulsions and wettable powders)	Vitax 'Wireworm Dust'
	Plant Protection 'Gammalin CL (Liquid)'
	Vitax 'Vixatol 12 (Liquid)'
	Murphy 'Lindex (Wettable Powder)'
	Plant Protection 'Agrocid Dispersible Powder'
	Murphy 'Benzacolor Dispersible Powder'
BHC-Mercury combined seed treatments	Shell 'BHC Dispersible Powder'
	Baywood 'Ceregam'
	Baywood 'Ceregam 2'
	Boots 'Harvesan Plus'
	Plant Protection 'Mergamma A'
	Plant Protection 'Mergamma D'
BHC-Thiram combined seed treatments	Murphy 'Gamma-Mercury Cereal Seed Dressing'
	Baywood 'Fytolex'
	Plant Protection 'Gammasan'
BHC Smokes and generators	Murphy 'Lindex Seed Dressing'
	Plant Protection 'Agrocid Smoke Generator No. 23'
	Plant Protection 'Agrocid Smoke Pellets No. 22'
	Waeco 'Fumite Lindane Pellets'
	Murphy 'Murfume BHC Smoke (Cones)'
BHC-DDT combined smokes	Murphy 'Murfume Lindane Smoke (Generators and pellets)'
	Waeco 'Fumite DDT-Lindane Smoke (Generators and Pellets)'
	Murphy 'Murfume DDT-Lindane Smoke (Generators and pellets)'

a particular way. For beans, for example, a farmer might control aphids with the organo-phosphate insecticides Fosferno 20 or Metasystox, ‘as soon as infestation is noticed’; weevils should, ‘be destroyed at the first sign of damage’, by spraying with Didimac 25; bean seed fly could be warded off by mixing Aldrin dust into the furrow at planting; and protection against wireworm and leatherjackets could be obtained by broadcasting Aldrin or Gamma-BHC before sowing.⁷⁵

One issue that arose with the emergence of increasingly large numbers of products with their own brand names was that farmers did not always differentiate correctly between the products they were using. They complained,

The ever increasing number of chemical sprays being offered to farmers, under many trade names, may lead to confusion and incorrect selection for the job on hand, which can result in financial loss, and complete failure to achieve the desired control of weed or other pest.⁷⁶

I sometimes suspect that the trade has never really tried to dispel this aura of mystery from agricultural chemicals, and indeed, by adding a surfeit of fancy names, they have made an already complex subject a maelstrom of confusion.⁷⁷

This confusion over choosing the right product for the job was not helped by the decline in naming insecticidal ingredients alongside the brand name in advertising. See the advertisement for Mergamma from 1951, compared to one from 1954 ([Images 1 and 2](#))

The entomologist, A.H. Strickland, from the Government’s Plant Pathology Laboratory (PPL), reported the findings of a survey in 1964 that showed farmers were not always sure exactly what they had applied in their fields,

In recent surveys of the Eastern Counties 1,351 growers were approached and 139 of them admitted to not knowing what insecticides they had in fact used. A similar state of affairs was noted at PPL during the 1957 Strawberry Survey, the 1961 Soil Residue Survey, and in the small scale 1962 Potato Tuber Residue Survey ... The many brand names under which active ingredients are sold accounts for a certain element of doubt in replies to survey questions. Apart from these points, there is a certain amount of mis-use which can be attributed to ignorance or, occasionally, to the press of circumstance. Recent examples include: the use of cereal seed dressings on potatoes; the use of aldrinated fertiliser for slug control; and the use of cereal weedkiller to burn off potato haulm.⁷⁸


The fact that farmers did not always follow instructions carefully did not just result in a lack of efficacy, it also resulted in accidents.⁷⁹ In the 1950s, there was plenty of concern that insecticides were not being used as cautiously as they should be.⁸⁰ Insecticides arrived on farms in concentrated formulations that need mixing with water with the result that spillages were a problem. Farmer John Martin told a conference of business representatives and government advisors,

‘And what to do with spilled chemicals? Should they be mixed with earth - or sand - or they may be safely swilled into the nearest drain - or does the operator just go away and hope they will have evaporated by his return? Most labels offer little constructive help once one has failed to obey the bland command to “Avoid Spillage!”’⁸¹

After seven fatal cases of poisoning by the weedkiller and insecticide DNOC in the late 1940s, DNOC and the organophosphates were added to the schedule of poisons under the 1933 Pharmacy and Poisons Act.⁸² From 1949, containers for these chemicals needed

Keeping ahead with Plant Protection

*I've forgotten
what a wireworm
looks like!*



There goes a happy farmer indeed — his list of 'absent friends' has long included wireworm and smut, leaf stripe and bunt, too! One Plant Protection product puts paid to the lot of them — 'Mergamma'. As a mercurial, it controls soil- and seed-borne diseases; and as an insecticide, it means death to wireworm, thanks to the powerful 'Gammexane' gamma BHC. The first seed dressing to do this double job, it insures your crops for you at 12/- an acre. If you want to forget these pests and pestilences yourself, ask for 'Mergamma' dressed seed.

'M E R G A M M A'
the double-action seed dressing

PLANT PROTECTION LTD




Image 1. Advert for Mergamma A from 1951.

Profit from plant protection

GOOD SEED...



protect it with

'MERGAMMA' A

However good your seed, wireworm and disease can ruin your crop—even before the seedlings show. But you have no need to worry if you dress *all* your seed with 'Mergamma' A, the *original* double-action seed dressing. It gives protection against up to 600,000 wireworm per acre. The reduction of 20% in price now enables you to insure *all* your cereals against wireworm and disease.

**WHY RISK YOUR CROP
NOW THAT 'MERGAMMA'
COSTS 20% LESS?**

 **FOOD DRIVE** **Plant Protection Ltd** 

Image 2. Advert for Mergamma A from 1954.

to include warnings about their dangers and instructions for the precautions that should be followed for safe use. In 1952, the Agriculture (Poisonous Substances Act) was passed which required the use of protective clothing and other precautions when using a number of named farm chemicals. Information on the precautions that needed to be taken when handling chemicals such as DNOC were circulated through MAF leaflets. The 1952 Act was aimed largely at protecting contractors, and it was noted in a report of 1961 that farmers who were doing their own spraying were not covered by these regulations, and it was not clear if they were using the necessary precautions.⁸³ The 1961 Report on Toxic Chemicals in Agriculture and Food Storage made the observation,

The main comment made to us on the subject of worker safety was that workers were insufficiently trained and supervised in the safe use of toxic chemicals, so that some accidents occur which could have been avoided; this comment applied only to farm workers and not to employees of contractors. It was claimed that the multiplicity of trade names made it difficult for users to know exactly what they were using and whether it was covered by the Regulations. The workers' unions were of the opinion that not enough was done to enforce the Regulations; in particular, they considered the Inspectorate was too small.⁸⁴

The report found that farmers were reluctant to use protective clothing, and would, in fact, avoid a product if application required such precautions.⁸⁵

Nonetheless, farmers consumed insecticides in increasing quantities. This uptake was facilitated by a number of factors. One was that the costs and difficulties of application declined with the advent of low volume spraying. In addition, while the costs of insecticidal products could be very high at the time of their first release, these generally came down over time. Adjusted to 2017 values, treating an acre of sugar beet with Pestox 1 insecticide cost £148.24 per acre in 1950.⁸⁶ By 1960, the same crop could be treated with Metasystox, one of Pestox's successors, for only £25.94 per acre.⁸⁷ Other types of product were notably cheap from the beginning, the most cost-effective being seed treatments; Mergamma A cost farmers the equivalent of £12.48 per acre in 1952, another factor that may well have contributed to their relatively rapid uptake.⁸⁸ Historians also suggest that farmers in the post-war period became more inclined to make investments in farm equipment and new techniques as government policy provided security of income. With the passing of the 1947 Agriculture Act and the introduction of the 'deficiency payments' scheme, which provided a guaranteed minimum price for certain crops, farmers received assurance that their survival would not be threatened by any serious drop in the value of their product, a major incentive to keep on increasing output. It is worth repeating the point, however, that insecticides were still taken up more slowly between 1945 and 1960 than other innovations, such as weedkillers and inorganic fertilizers. This was not because insecticides were necessarily more expensive; a calculation of the costs of fertilizers in 1959 shows that farmers were paying a minimum of around £63.67 per acre for artificial fertilizer.⁸⁹ The slower uptake of insecticides can be explained by the fact that weeding and manuring were activities that farmers were already engaged in before the Second World War. Furthermore, herbicides were a labour-saving technology compared to manual removal of weeds, an attractive proposition at a moment when there was a shortage of agricultural workers. However, the use of chemical treatments against insects was not a well-established practice in some sectors, such as cereal growing. The adoption of insecticides by cereal or potato growers

could require the acceptance of a new imperative, new equipment, new practices, and new costs, in a way that using inorganic fertilizer did not. In the case of the latter, farmers were able to slot a new technology into an existing farming practice.

In addition, as we have pointed out, a great deal of work had to be done from 1940 onwards to make chemicals such as DDT and BHC into products that farmers might consume on a routine basis. Making products that farmers perceived as convenient and reliable was not straightforward. While a great deal of effort was committed to simplifying the process of chemical treatment – by the production of more convenient low-volume spraying equipment, for example, or the development of seed treatments and systemic insecticides – the problem remained that using a chemical product effectively often required farmers to engage with a number of different scientific and technical issues. Farmers were being asked to be an entomologist, plant biologist, chemist and engineer; they needed to identify a pest, determine the correct treatment, judge the right time for application, mix chemicals to the right formulations, set up a sprayer correctly, and take any recommended precautions.

A large amount of written information directed at facilitating the uptake of pesticides was available to farmers, if they cared to read it. The farming press contained articles that described the results of trials of new insecticides, with directions on how to get the best results. Companies such as Pest Control Ltd and Plant Protection Ltd provided farmers with handbooks and leaflets that organised treatments by crop and pest. They also sought government endorsement of their products. MAFF ran two voluntary schemes in conjunction with industry relating to the safety and efficacy of pesticides. The Scheme for the Notification of Pesticides, later the Pesticide Safety Precautions Scheme, was an arrangement in which manufacturers notified the government of any new chemical they were releasing onto the market and made available data that had been gathered on toxicity so government scientists could determine if any special precautions needed to be included in labels and leaflets. Through the Crop Protection Products Approval Scheme, later the Agricultural Chemicals Approval Scheme, manufacturers could also seek to have their products included in the Approved List. Under this scheme, government evaluated the claims of manufacturers for their products, and gave approval in the form of the 'Ministry Mark' for inclusion on product labels. The mark served as a guarantee of the efficacy of the insecticidal product. There was a view amongst government scientists that this scheme served the interests of industry more than it served farmers. Inclusion on the Approved List and the Ministry mark meant that NAAS might recommend the product to the farmers they advised.⁹⁰ MAF also gave advice on choosing and applying insecticides through the journal, *Agriculture*, and a long-running series of Pest Advisory Leaflets. The total distribution of MAFF advisory leaflets of all types was reckoned to be 2 million annually by 1955, substantially greater than 200,000 per-annum in the pre-war period.⁹¹ Pest Advisory Leaflets contained pictures of insect pests with detailed descriptions of their life cycle; they described the signs of crop damage a farmer should look out for; and they made recommendations for control and treatment.⁹²

Both government and business were engaged in attempts to educate farmers about insect pests and their control through chemical means. The problem was that, as the information for farmers became more refined and specific, they were expected to both adhere to, but also interpret, the directions available to them in light of the particular conditions on their farm. While the similarity between the

development and use of pharmaceutical and agrochemical products was noted at the time, insecticides differ slightly to the former in terms of the expectations placed upon the user. With reference to pharmaceuticals, historians have spoken of the challenge for doctors of achieving compliance, in which patients adhered to the instructions they were given about how to take their medication. In contrast, farmers were expected to be consumers who understood directions, while also making judgements about exactly how, and when to apply insecticides.⁹³

The research that was done to create insecticide products combined laboratory investigation with field trials at the research stations and experimental farms of business and government across the country. This process of trialling products in many different locations meant that the instructions for the use of insecticide products anticipated a certain ‘placiness’⁹⁴ – they contained directions to the user to consider the characteristics of both locale and moment. As the farmer John Martin explained:

It is not just a question of knowing what material to use: when and how are often just as difficult to determine, especially in our climate when no two seasons are ever alike, and conditions change from hour to hour. Selecting the right combination of material and dose rate, and timing according to the stage of growth of the crop and the pest, and the local weather, past, present and anticipated, has become steadily more difficult as the number and complexity of compounds has increased, and has placed an increasingly heavy burden of decision making on the man on the spot on the farm.⁹⁵

The fact that weather conditions could change so rapidly in Britain, and that forecasts could be unreliable, was a serious problem, ‘Spare a thought for the farmer in our climate confronted with the label that tells him to avoid using the product at least 48 hours *before* wet or dry or frosty weather’.⁹⁶

John Martin’s suggested solution to the problem of negotiating a large variety of different products, and the need to consider variables that might have a bearing on efficacy, was to ensure farmers had access to reliable one-to-one advice. Historians of British farming have said that advisors employed both by government and by business played an important role in facilitating the uptake of new practices after 1945.⁹⁷ On the government side, NAAS, formed in 1946, was an important source of advice. NAAS grew out of the county-level advisory services that had operated from the early twentieth century over the 12 agricultural provinces of England and Wales. With the passing of the 1947 Agricultural Act, NAAS had a clear remit to help farmers achieve the goal of a substantial increase in farming output in Britain. By 1955, NAAS had just over 1500 staff around England and Wales. The frontline staff were the hundreds of District Officers whose role was to work with farmers to identify the source of their problems and find solutions, sometimes in consultation with specialists at provincial headquarters.⁹⁸ In 1953, NAAS recorded 375,223 advisory visits by its members.⁹⁹

The relationship that developed between farmers and the advisors who visited them appears to have played a particularly important role in facilitating that uptake of products. What farmers wanted was somebody who not only understood the range of insecticide treatments that were on the market, but importantly, also grasped the specific conditions that existed on their farm. The instructions that accompanied pesticide products had to be interpreted by the ‘man on the spot’ in the words of John Martin, and farmers trusted individuals who they believed understood what their ‘spot’ was like.

Familiarity with the distinctiveness of the soil, crops and even the previous history of a farm was key to cultivating trust between a farmer and advisor.¹⁰⁰ This applied both to the District Officers of NAAS and also the representatives from the firms who sold chemical products or seeds to farms. Much like advisors employed by government, these salesmen were allocated a region by their company and so developed deep understandings of the distinctiveness of a particular farming neighbourhood. Brassley has noted that by calling on many farms across an area, company representatives (and also probably NAAS advisors) were able to build up a picture of the wider state of technical change within a region. Imparting this knowledge to the farmers they spoke with was, according to Brassley, 'a way to capture a potential customer's attention'.¹⁰¹ The significance for farmers of the activities of their neighbours is noted by one advisor who worked for NAAS and then its successor the Agricultural Development and Advisory Service (ADAS), entomologist Mike Saynor:

ADAS advisers identified and divided farmers into about five categories. One group would adopt new procedures before they had been thoroughly tried and tested. The second group, the 'early adopters' were sensible, progressive farmers who, once a technique was shown to be successful, would quickly adopt it. It was important to concentrate our advice on that group, the 'influencers' because the more cautious farmers in the area, the largest group, respected them and a little later would adopt the new ideas themselves. We also knew that at the other end of the spectrum, there were some farmers who would almost never adopt new ideas!

The ranking of farmers into different grades by NAAS shows that the ideal user of pesticides was 'sensible'; somebody who was likely to have credibility with their peers. The adoption of pesticides then both required work that we can describe as technical and also depended upon work done to create and embed networks of trust. These contacts between intermediaries and farmers fostered faith in the reliability and utility of products, while at the same time enhancing the value of advice itself.

Two processes, then, were in operation after 1945 that contributed to the gradual uptake of insecticides across the various sectors of British farming. One process was the creation of consumer products out of insecticidal chemicals. Farmers did not apply raw DDT or BHC to their crops but products like Didimac, Mergamma or PP Flea Beetle Dust. These and many other products were the result of a process of testing, formulation, and packaging up of insecticidal ingredients into something that farmers might find convenient enough to use. Apart from the scientific work to produce carefully tailored formulations, making products also involved the communication of regimes of use: how much product to use per acre, what dilution was required, when the product should be applied in relation to the growth stage of the plant or the presence of a pest, where the product should be directed and what conditions might diminish efficacy. Despite efforts to make insecticidal products convenient to use, there was enough residual complexity involved that a second process accompanied the first. This was the development of networks concerned with education and advice for the farmer; promoting the economic value of pest control, helping farmers to familiarise themselves with new activities and new technologies, and advancing an idea of 'proper use'. In Britain, the adoption of synthetic insecticides was supported by the emergence of a socio-technical system that

transcended any simple distinction between the activities of state and industry. The legitimacy of this close collaboration was derived from its location in a historical moment in which greater output and efficiency in farming had become a national goal.

Conclusion

Histories of DDT often depend upon a narrative in which the new insecticide was revealed to Britain and US during World War Two, was used to avert a humanitarian disaster in Naples in 1943 and was then embraced by farmers in the decades after 1945. After a period of widespread and rapid adoption, the wonder chemical was brought down by revelations of environmental harm by Rachel Carson. Apart from a small number of historians who have investigated the rise of industrial farming in a selection of States in America, and Paul Brassley's work on the adoption of agricultural technologies more generally in Britain, most accounts do not explore the timing and process of the uptake of DDT and other synthetic insecticides. The impression given is that the deployment of DDT by farmers does not require much explanation as the new insecticide was superior in its qualities to any existing chemical, and the post-war period was apparently marked by widespread and uncritical enthusiasm for science and technology.

Our aim here has been to treat the process of increasing deployment of DDT, BHC and other pest control chemicals as something that requires investigation. While the available sources do not provide a complete picture of change in insecticide consumption in British farming, they still reveal important things about the speed of uptake and pattern of use. The first is that the story of insecticide use differed a great deal according to the product being farmed; uptake was slower amongst farmers of field crops, than amongst fruit and hop growers. While orchardists and glasshouse owners took up chemicals, such as DDT relatively quickly, most arable farmland in Britain was not routinely treated with insecticides until at least the 1970s. This difference in the speed of uptake was related to the value of the crop and an existing culture of chemical pest control. While fruit growers were already in the habit of spraying their produce to reduce the damage due to pests before the war, persuading arable farmers to tackle insect pests required a number of things in the post-war period. One was the greater security of income that came once government underwrote the industry, another was the work done by business and government to bring pests to the attention of farmers and cultivate a culture of control. Importantly, the context to the adoption of synthetic insecticides in Britain was not some wider cultural moment in which people celebrated the modernity heralded by the release of DDT, but the rather more tangible context of a government drive to greatly increase farming productivity in the name of greater self-sufficiency. This produced a close working relationship between state and business. Insecticides were seen as a common good; a profitable product from the perspective of industry that government advisors promoted to meet their objective of increasing the output on British farms.

Another important finding of a serious engagement with insecticide adoption is that farmers did not purchase chemicals, they bought products. We have suggested that the adoption of insecticides involved various types of work to incorporate chemicals such as DDT and BHC into a range of products, designed to be deployed by farmers with relative ease. Achieving this goal involved packaging up chemicals

into smokes, dusts, sprays, and seed treatments aimed at specific pests; the determination of regimes of use; and the establishment of wider social and technical systems. The widespread adoption of some insecticide products was reliant upon developments in associated technologies, usually equipment for spraying or dusting. It also depended upon company representatives and government advisors who could help farmers navigate the complexities of identifying pests and appropriate products and interpret the directions for use according to the conditions on each farm. The two decades after 1945 can be seen as a long process of innovation, the results of which were large numbers of different insecticide products, and the institution of social and technical apparatus that supported their use.

Re-orientating our histories of DDT and BHC towards a study of products is significant as the history of the different types of products that farmers encountered were not the same. There is a preoccupation with spraying in our accounts of DDT, quite possibly because of the circulation of powerful images of use, but during the 1950s insecticide seed treatments were more frequently used on British arable farms than sprays. Insecticide seed treatments did not require farmers to purchase and master spraying equipment, adopt new practices, or ensure they applied insecticides at the right moment and in the right way. They were also both cheaper to buy as a product, and cheaper to deploy than sprays or dusts. In short, they avoided many of the problems that actors at the time said were obstacles to the swift adoption of insecticides by farmers. Recognising that the history of chemical sprays and that of seed treatments, such as Mergamma are very different allows us to grasp that there is not one single story of DDT or BHC after 1945, but a number of different histories. While it has been beyond the scope of this paper, it is very likely that the story of ecological impact and environmental harm is also different, according to the product under examination. The type of formulation and the mode of application determined the pattern of use to a far greater extent than has been acknowledged in most histories of insecticides. We would do better following the genesis and uptake of products, than organising our histories around a chemical, in order to understand the timing and pattern and implications of the use of synthetic insecticides in agriculture in the post-war period.

Notes

1. Dunlap, *DDT*, 3, 62; Russell, *War and Nature*, 127; Perkins, *Insects, Experts*, 7–10; Kinkela, *DDT and the American Century*, Ch 2; Davis, *Banned*, 40–41.
2. Dunlap, *DDT*, 3–4, 61–63; Russell, *War and Nature*, Chs. 9 and 10; Perkins, *Insects, Experts*, 13; Mart, *Pesticides a Love Story*, Chs. 1–3; Kinkela, *DDT and the American Century*.
3. Dunlap, *DDT*; Perkins, *Insects, Experts*; Sheail, *Pesticides and Nature Conservation*, 2, 17–18.
4. Sheail, *Pesticides and Nature Conservation*, ‘Farmers had heard of the way in which DDT had killed lice, flies, fleas and mosquitoes, thereby saving the lives of millions of military and civilian personnel during the war, and they demanded the application of great strides in organic chemistry to the needs of agriculture. They were not disappointed.’; Gay, ‘Before and after Silent Spring,’ 92.
5. Brassley, ‘Output and Change,’ 68–69.

6. Morris, 'A Tale of Two Nations.' The fact that patterns of pesticide use might vary according to national context (and do not necessarily conform to the experience of the USA) has not been well recognised. One good example of work showing the importance of paying attention to national political and economic context is Bertomeu-Sánchez, 'Arsenical Pesticides.'
7. Dunlap, *DDT*, 17; Perkins, *Insects, Experts*, 13.
8. Edgerton, "From Innovation to Use," and *Shock of the Old*; Lindqvist, 'Changes in the Technological Landscape.'
9. Ibid.
10. This paper is not concerned with sheep dips or cattle sprays which involve different actors and patterns of distribution.
11. The suggestion that the Chemical Revolution was an insecticide revolution is made in Sheail, *Pesticides and Nature Conservation*, v.
12. See, for example, the role of technology salesmen, in Pinch, 'Giving Birth to New Users' in *How Users Matter*; government programmes and popular media, in Lean, 'Mediating the microcomputer'; and repair technicians in Orr, *Talking About Machines*.
13. Oudshoorn and Pinch (eds), *How Users Matter*.
14. The most recent work that has documented the impact of the 1947 Agriculture Act on British farming is Brassley et al, *The Real Agricultural Revolution*, see Chapter 4 in particular. See also Howkins, *The Death of Rural England*, Part III; Holderness, *British Agriculture*, Chs. 1 and 2; Self and Storing, *The State and the Farmer*; Martin, *The Development of Modern Agriculture*, Ch 4.
15. Ordish, *Untaken Harvest*, 124.
16. The existing scholarship has either referred to the approximate total cost of insecticides applied after 1945 or noted the increasing variety of pesticide products available in order to make claims about the rapid uptake or widespread adoption of chemical pesticides. Neither are a good indicator of extent of use. See Sheail, *Pesticides and Nature Conservation*, 19.
17. For example, the earliest surveys estimated the *areas of crops* that had been pesticide treated. Later surveys estimated the *areas of pesticide* that had been sprayed onto crops ('spray acres'), to account for multiple treatments. Only sometimes are tonnages of active ingredient or percentage of crop treated given. Some treatments are missed out of some surveys. Surveys variously cover Great Britain, the United Kingdom, England and Wales, or Scotland. Categories, be they crops or pesticide types shift constantly through aggregations, splits, and the introduction or phasing out of chemicals.
18. For example, in 1974 only about 1 percent of cereals, a major sector, were treated against aphids; in 1977 it was 19 percent.
19. The 'Working Party on Precautionary Measures against Toxic Chemicals used in Agriculture' was set up in 1950 after the deaths of several agricultural workers. It was chaired by Solly Zuckerman and released reports on the safety of agricultural workers (1951), pesticide residues in food (1953), the risks of pesticides to wildlife (1955).
20. *Report to the Ministers of Agriculture and Fisheries, Health, and Food, and to the Secretary of State for Scotland of the Working Party on Precautionary Measures against Toxic Chemicals used in Agriculture*, 'Toxic Chemicals in Agriculture. Residues in Food,' (1953), HMSO, 8.
21. *Report to the Ministers of Agriculture and Fisheries, Health, and Food, and to the Secretary of State for Scotland of the Working Party on Precautionary Measures against Toxic Chemicals used in Agriculture*, 'Toxic Chemicals in Agriculture. Risks To Wildlife,' (1955), HMSO, 21.
22. For example, the fungicide figures are incomplete, and the report is focussed on spraying at a time when a wider range of insecticide application methods were in use.
23. *Report to the Ministers of Agriculture and Fisheries, Health, and Food, and to the Secretary of State for Scotland of the Working Party on Precautionary Measures against Toxic Chemicals used in Agriculture*, 'Toxic Chemicals in Agriculture. Risks To Wildlife,' (1955), HMSO, 21.
24. House of Commons Debates, *Hansard*, 20 November 1959, col. 613 cc. 1568–85.

25. Hans Kornberg et al, *Royal Commission on Environmental Pollution, Seventh Report: Agriculture and Pollution* (1979), HMSO, 39.
26. See note 11 above.
27. Brassley also makes this point, 'Output and Change.' On the history of 2,4-D see Rasmussen, 'Plant Hormones.'
28. C. Potter, A.H. Strickland, R. Bardner, 'The use of Pesticides and Fungicide for Plant Protection in British Agriculture,' *Chemicals and the Land in Relation to the Welfare of Man*, Symposium held at Yorkshire Institute of Agriculture (1965).
29. See Grigg, *English Agriculture: A Historical Perspective*, 73 – 'The early sprays were used mainly on the more valuable plants such as fruit, hops and some vegetables.'; also Ordish, *Untaken Harvest*, 187.
30. Interview with Colin Myram (2020).
31. G.E. Limb, 'Problem of Advice and Education: The Farmer's View,' British Weed Control Conference (1960), 238.
32. M.J. Way, 'Insecticidal Seed Dressings and Soil Insecticides,' British Insecticide & Fungicide Conference (1961), 53.
33. Of these totals, some 0.4 million acres had received both seed and spray/dust treatment. C. Potter, A.H. Strickland, R. Bardner, 'The use of Pesticides and Fungicide for Plant Protection in British Agriculture,' *Chemicals and the Land in Relation to the Welfare of Man*, Symposium held at Yorkshire Institute of Agriculture (1965).
34. Other families of insecticide were later used in seed dressings alongside BHC and eventually superseded it, but it was a mainstay from the 1950s to at least the 1980s.
35. *Royal Commission on Environmental Pollution, Seventh Report*, 'Agriculture and Pollution,' (September 1979), Cmnd. 7644, 39.
36. For example, contemporary pesticide surveys show that in the early 1970s enough herbicide was applied to farmland in England and Wales to treat an area equivalent to nearly 15 million acres. The equivalent figures for insecticides, including seed treatments, were about 6.5 million acres. Sly, *Review of Usage of Pesticides in England and Wales 1971–1974*, 4–6.
37. Martin, *The Development of Modern Agriculture*, 102.
38. Ordish, *Untaken Harvest*, 58.
39. Brassley, 'Output and Change.' Abigail Woods provides an important critique of accounts of seamless adoption of increasingly industrialized farming practices, see, 'Rethinking the History of Modern Agriculture.'
40. Artificial fertilizers include a variety of synthetic products produced by the chemical industry, rather than manure from farm animals.
41. Brassley, for instance, suggests an increase in annual artificial fertiliser use from 1.4 million tonnes in the late 1930s to 6.27 million tonnes in 1960–61. Brassley, 'Output and Technical Change' 70–72; See also Grigg, *English Agriculture*, Chapter 6; and Cowling, Metcalf and Rayner, *Resource Structure of English Agriculture*, 132–136.
42. For example, in 1958 the average arable farm spent nearly nine times as much on fertiliser as on pesticide sprays and dusts, £696 compared to £79. Calculation based on figures in Ministry of Agriculture Fisheries and Food, *Farm Incomes in England and Wales 1958* (1960), HMSO.
43. MAFF, *Century of Agricultural Statistics*, 71.
44. Tom Gilling, 'Farmer-Owned Spraying Equipment,' *Sport and Country*, 17 February 1960, 166.
45. This comparison is based on data from various tables in MAFF, *Century of Agricultural Statistics*.
46. Ordish, *Constant Pest*, 187.
47. For an interesting account of the work done in the construction of a pest see Clark, 'The eyes of our potatoes are weeping.'

48. Howkins, *The Death of Rural England*, Part III; Holderness, *British Agriculture*, Chs. 1 and 2; Self and Storing, *The State and the Farmer*; Martin, *The Development of Modern Agriculture*, Ch 4; Brassley, 'Output and Change.'
49. *Report of the Advisory Entomologist's Conference*, 'Wireworms and Food Production,' (1944), MAF Bulletin no. 128.
50. D.J. Finney, 'Field Sampling for the Estimation of Wireworm Populations,' *Biometrics* (1946), Vol 2 (1) 1–7.
51. A.H. Strickland, 'Agricultural Pest Assessment. 1. – The Problem' and '2. – A Partial Solution,' *NAAS Quarterly Review* (1954), 112–117 and 156–162.
52. W.E. Ripper *et al*, *Pest Control Farmers' Handbook*, Pest Control Ltd of Cambridge (1950), 7.
53. *Ibid.*, 82.
54. Ordish went on to have a career working with the United Nations and also writing books and giving lectures as a public scientist specialising in the past and present of insect control and contemporary problems in food production.
55. Ordish, *Untaken Harvest*, 45.
56. A.H. Strickland, 'Agricultural Pest Assessment.2. – A Partial Solution,' *NAAS Quarterly Review* (1954), 156–162.
57. See the journal of the laboratory, *Plant Pathology*, for the 1950s.
58. A.H. Strickland and the Conference of Entomologists, National Agricultural Advisory Service, 'Assessment of Cabbage Aphid Damage in Commercial Brussels Sprout Crops,' *Plant Pathology* (1954), vol. 3 (4), 107–117.
59. Fisons Ltd, Agrochemicals Division, 'The History of Pest Control,' (1976), 8.
60. *Ibid.*
61. *Ibid.*, 7–11.
62. *Ibid.*, 8.
63. *The ICI Magazine*, 'BHC versus DDT: The rival insecticides,' (November 1951), 330–331.
64. Peacock, *Jealott's Hill*, 42–48.
65. *The Fruit-Grower*, 'DDT Insecticides: Ministry of Agriculture Statement,' 24 January 1946, 75.
66. Fisons Ltd., Agrochemicals Division, 'The History of Pest Control,' 11.
67. Ministry of Agriculture, Fisheries and Food, 'Farm Sprayers and their Uses,' (1961) HMSO, 35.
68. *Sport and Country*, 'Solving Modern Agriculture Problems,' 26 January 1949, 50.
69. Fisons Ltd., Agrochemicals Division, 'The History of Pest Control,' 7.
70. E. Hick, 'High- Versus Low-Volume Spraying,' *Search* (1951), 31.
71. Fisons Ltd, Agrochemicals Division, 'The History of Pest Control,' 58.
72. Ordish, *Untaken Harvest*, 59.
73. Peacock, *Jealott's Hill*, 45.
74. Ministry of Agriculture, Fisheries and Food, *Crop Protection Products Approval Scheme. Approved List, 1957* (1957), HMSO, 5–7.
75. *Ibid.*, 32–35.
76. G. Donald Bailey, 'The Farmer's View. Chemicals and the Land,' *Yorkshire Agricultural Society* (1965), 45–46.
77. G.E. Limb, 'Problem of Advice and Education: The Farmer's View,' *Proceedings of the Fifth British Weed Control Conference*. British Weed Control Council (1966), 237–242.
78. Advisory Committee on Poisonous Substances used in Agriculture and Food Storage, 'Review of the Persistent Organochlorine Pesticides,' (1964), HMSO, 46–47.
79. *Lincolnshire Standard and Boston Guardian*, 'Sprays Lethal as Guns,' 16 June 1951, 4.
80. *British Medical Journal*, 'Agricultural Poisons,' 2 April 1955, 836.
81. J.S. Martin, 'The Use of Chemicals in Modern Farming – A Farmer's View,' in T. Lewis, *The Bawden Memorial Lectures 1973–1998* (1998), British Crop Protection Council, 110 plus correspondence with authors.
82. The Research Study Group on Toxic Chemicals in Agriculture and Food Storage, 'Report on Toxic Chemicals in Agriculture and Food Storage' (1961), HMSO, 12.

83. Ibid., 8.
84. Ibid., 12.
85. Ibid., 8.
86. W.E. Ripper, *et al*, *Pest Control Farmers' Handbook*, Pest Control Ltd of Cambridge (1950), 9.
87. Plant Protection Limited, 'Price List for Merchants. 1960,' Museum of English Rural Life (MERL), CR BBO P2/B23. 17.
88. Plant Protection Limited, "Insure with 'Mergamma'" (1953), MERL, P4160 5/27.
89. West Norfolk Fertilisers, Price List, 1959, MERL CR BBO P2/B40.
90. The National Archives, London, MAF 117/428.
91. Ministry of Agriculture and Fisheries. *Report on the National Agricultural Advisory Service. The First Eight Years 1946–1954* (1955), HMSO, 51.
92. See for example, *Ministry of Agriculture, Fisheries and Food, Pest Advisory Leaflet, 'Leatherjackets,'* No. 179 (1958), HMSO.
93. For a good discussion on the scholarship on non-compliance, see Jones, "Technologies of Compliance."
94. Kohler, 'Place and Practice,' 4.
95. Martin, 'The Use of Chemicals in Modern Farming – A Farmer's View,' 109.
96. Ibid.
97. See for example Brassley, 'Agricultural Education.'
98. Ministry of Agriculture and Fisheries. *Report on the National Agricultural Advisory Service. The First Eight Years 1946–1954* (1955), HMSO, 8.
99. Ibid., 61.
100. Henke, 'Making a Place for Science.'
101. Brassley, 'Agricultural Education,' 269.

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